Magnetism Division
Fachverband Magnetismus (MA)

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Overview of Invited Talks and Sessions

(lecture rooms HSZ 103, HSZ 401, HSZ 403, HSZ 04 and CHE 184; Poster P2)

Invited Talks

MA 1.1	Mon	10:15–10:45	HSZ 04	**Emergent magnetic monopoles and associated Dirac strings in artificial kagome spin ice** — •Laura Heyderman
MA 6.1	Mon	14:00–14:30	TRE Ma	**Quantifying Spin Hall Effects in Nonmagnetic Metals** — •Axel Hoffmann
MA 16.1	Tue	10:15–10:45	HSZ 04	**Search for a permanent electric dipole moment of an electron: Multiferroics bring us a step closer** — •Marjana Ležaić
MA 26.1	Wed	10:15–10:45	HSZ 04	**Magnetic light-matter interaction at highest frequencies** — •Tobias Kampfrath, Alexander Sell, Matteo Burresi, Dries van Oosten, Manfred Fiebig, Susumu Noda, Martin Wolf, Alfred Leitenstorfer, Kobus Kuipers, Rupert Huber
MA 35.1	Wed	14:00–14:30	HSZ 04	**Skyrmion crystals and topological transport phenomena** — •Yoshinori Tokura
MA 35.2	Wed	14:30–15:00	HSZ 04	**Discovery of an atomic-scale skyrmion lattice in an ultrathin magnet: Fe/Ir(111)** — •S. Heinze, K. von Bergmann, M. Menzel, J. Brede, A. Kubetzka, R. Wiesendanger, G. Bihlmayer, S. Blügel
MA 35.3	Wed	15:00–15:30	HSZ 04	**Skyrmion states in noncentrosymmetric magnets** — •Alexei N. Bogdanov, Andrei A. Leonov, Ulrich K. Rössler
MA 35.4	Wed	15:30–16:00	HSZ 04	**Complex Magnetic Phase Diagram of the cubic Helimagnet FeGe** — •Heribert Wilhelm
MA 35.5	Wed	16:00–16:30	HSZ 04	**Magnetoelectric effects in non-collinear magnets** — •Maxim Mostovoy
MA 47.1	Thu	10:15–10:45	HSZ 04	**Perpendicular 40 nm MgO-CoFeB Magnetic Tunnel Junction** — •Hideo Ohno
MA 53.1	Thu	14:00–14:30	HSZ 04	**From nanolithography to energy assisted writing - what is the limit to magnetic recording?** — •Bruce Terris
MA 53.2	Thu	14:30–15:00	HSZ 04	**29.5 Gb/in^2 Recording Areal Density on Barium Ferrite Tape** — •Mark Lantz
MA 61.1	Fri	10:15–10:45	HSZ 04	**Spin-dependent quantum interference within a single magnetic nanostructure** — •Dirk Sander, Hirofumi Oka, Pavel Ignatiev, Sebastian Wedekind, Guillemin Rodary, Larissa Niebergall, Valeri Stepanyuk, Jürgen Kirschner

Invited and Topical Talks of the Focus Session "Nanoparticles, Nanocrystals and Colloids" (jointly with BP, CPP, HL)

Organization: Oleg Petracic (Ruhr-Universität Bochum)

MA 2.1	Mon	10:15–10:45	HSZ 103	**Magnetic nanoparticles: fundamentals and applications** — •Andreas Hütten
MA 2.2	Mon	10:45–11:15	HSZ 103	**Directing the Self-Assembly of Nanoparticles** — •Alexander Böker
MA 2.3	Mon	11:15–11:45	HSZ 103	**Magnetic Fluids - Properties and Applications** — •Stefan Odenbach
MA 2.4	Mon	12:00–12:30	HSZ 103	**Semiconductor nanocrystals** — •Andrey Rogach
MA 2.5	Mon	12:30–13:00	HSZ 103	**Ion and pH sensing with colloidal nanoparticles: tailoring hybrid FRET-based nanobiosensors** — •Martin Oheim

Invited and Topical Talks of the Focus Session "X-ray absorption spectra - state of the art of theory and experiment" (jointly with DS, HL, MM, O)

Organization: Andreas Ney (Universität Duisburg-Essen)

MA 57.1	Thu	15:15–15:45	HSZ 403	**Simulations of X-ray Spectra using FEFF9 and OCEAN** — •John Rehr
MA 57.2	Thu	15:45–16:15	HSZ 403	**Polarisation dependent X-ray spectroscopy** — •Andrei Rogalev, Fabrice Wilhelm, Jose Goulon
MA 57.3	Thu	16:15–16:45	HSZ 403	**Theoretical description of X-ray absorption in correlated transition metal systems** — •Hubert Ebert, Jan Minar, Ondrej Sipr
MA 57.4	Thu	17:00–17:30	HSZ 403	**Paramagnetic molecules on metal surfaces: prototypes for spin-hybrid systems** — •Heiko Wende
MA 57.5	Thu	17:30–18:00	HSZ 403	**Can Carbon Be Ferromagnetic?** — •Hendrik Ohldag, Elke Arenholz, Pablo Esquinazi, Daniel Spemann, Annette Setzer, Martin Rothermel, Tilman Butz

Invited Talks of the Joint Symposium "Spin Caloric Transport" (SKM-SYST)

Organization: Christian Back (Universität Regensburg), Dirk Grundler (TU München), Sebastian Gönnenwein (Walther-Meißner-Institut Garching)

See SKM-SYST for the full program of the symposium.

SKM-SYST 1.1	Mon	14:30–15:00	TRE Ma	**On the theory of the spin wave Seebeck effect** — •Gerrit Bauer
SKM-SYST 1.2	Mon	15:00–15:30	TRE Ma	**Spin Seebeck effect in metals and insulators** — •Ken-ichi Uchida, Eiji Saitoh
SKM-SYST 1.3	Mon	15:30–16:00	TRE Ma	**Spin-Seebeck effect: Local nature of thermally induced spin currents in GaMnAs** — •Roberto Myers
SKM-SYST 1.4	Mon	16:00–16:30	TRE Ma	**Heat conduction of low-dimensional quantum magnets** — •Christian Hess, Nikolai Hlubek, Patrick Ribeiro, Bernd Büchner, Surjeet Singh, Romuald Saint-Martin, Alexandre Revcolevschi
SKM-SYST 1.5	Mon	16:30–17:00	TRE Ma	**Evidence of spin polarized heat current acting on magnetization** — •Jean-Philippe Ansermet

Invited Talks of the Joint Symposium "Topological Insulators" (SKM-SYTI)

Organization: Werner Hanke (Universität Würzburg), Jürgen Kübler (TH Darmstadt), Christian Pfleiderer (TU München)

See SKM-SYTI for the full program of the symposium.

SKM-SYTI 1.1	Wed	10:30–11:00	TRE Ma	**Topological insulators and topological superconductors** — •Shoucheng Zhang
SKM-SYTI 1.2	Wed	11:00–11:30	TRE Ma	**Dirac Fermions in HgTe Quantum Wells** — •Laurens Molenkamp
SKM-SYTI 1.3	Wed	11:30–12:00	TRE Ma	**Interaction, disorder, and quantum criticality in Z_2 topological insulators** — •Alexander Mirlin
SKM-SYTI 1.4	Wed	12:00–12:30	TRE Ma	**Disorder and Interactions in Topological Insulators** — •Allan H. MacDonald
SKM-SYTI 1.5	Wed	12:30–13:00	TRE Ma	**Tunable multifunctional topological insulators in ternary Heusler and related compounds** — •Claudia Felser, Stanislav Chadov, Lukas Müchler, Jürgen Kübler, Shou Cheng Zhang, Xiaoliang Qi, Hai-Jun Zhang

Invited Talks of the Joint Symposium "Diffusionless Transformations in Magnetic and Ferroelectric Bulk and Thin Films" (SKM-SYDT)

Organization: Sebastian Fähler (IFW Dresden), Dietrich Hesse (MPI Halle), Eberhard Wassermann (Universität Duisburg-Essen)

See SKM-SYDT for the full program of the Symposium.

SKM-SYDT 1.1	Thu	10:30–11:00	TRE Ma	**Domain boundaries as active elements in multiferroics and martensites: steps towards Domain Boundary Engineering** — •Ekhard K.H. Salje
SKM-SYDT 1.2	Thu	11:00–11:30	TRE Ma	**Intermediate Phases in Perovskite Solid Solutions** — •Ian Reaney, Clive Randall, David Woodward
SKM-SYDT 1.3	Thu	11:30–12:00	TRE Ma	**Adaptive martensite and giant strain effects in multiferroics** — •Ulrich K. Rössler
SKM-SYDT 1.4	Thu	12:00–12:30	TRE Ma	**Nature of magnetic coupling in Ni-Mn-based martensitic Heusler alloys** — •Mehmet Acet, Seda Aksoy, Eberhard F. Wassermann, Lluis Manosa, Antoni Planes
SKM-SYDT 1.5	Thu	12:30–13:00	TRE Ma	**Orthorhombic to tetragonal transition of $SrRuO_3$ layers in $Pr_{0.7}Ca_{0.3}MnO_3/SrRuO_3$ superlattices** — •Michael Ziese, Francis Bern, Ionela Vrejoiu, Eckhard Pippel, Elizaveta Nikulina

Sessions

MA 1.1–1.1	Mon	10:15–10:45	HSZ 04	**Micro- and Nanostructured Magnetic Materials I/ Spin Structures - Invited Talk**
MA 2.1–2.5	Mon	10:15–13:00	HSZ 103	**Focus Session "Nanoparticles, Nanocrystals and Colloids" (jointly with BP, CPP, HL), Organization: Oleg Petracic (Ruhr-Universität Bochum)**
MA 3.1–3.8	Mon	11:00–13:00	HSZ 401	**Bio- and Molecular Magnetism**
MA 4.1–4.9	Mon	11:00–13:15	HSZ 403	**Magnetic Coupling Phenomena/ Exchange Bias**
MA 5.1–5.7	Mon	11:00–12:45	HSZ 04	**Spincaloric Transport**
MA 6.1–6.1	Mon	14:00–14:30	TRE Ma	**Spin Pumping/ Spin Hall Effects - Invited Talk**
MA 7.1–7.5	Mon	14:30–17:00	TRE Ma	**SKM-SYST: Spin Caloric Transport (jointly with TT, HL)**
MA 8.1–8.8	Mon	14:45–17:00	HSZ 103	**Magnetic Particles/ Clusters I**
MA 9.1–9.8	Mon	14:45–17:00	HSZ 401	**Magnetic Materials I**
MA 10.1–10.8	Mon	14:45–17:00	HSZ 403	**Magnetization Dynamics I**
MA 11.1–11.8	Mon	14:45–17:00	HSZ 04	**Multiferroics I: Structure and Phase Transitions (jointly with DF, DS, KR, TT), Program coordination: I. Mertig, M. Fiebig**
MA 12.1–12.9	Mon	17:00–19:15	HSZ 103	**Magnetic Particles/ Clusters II**
MA 13.1–13.8	Mon	17:00–19:00	HSZ 401	**Magnetic Materials II**
MA 14.1–14.8	Mon	17:00–19:00	HSZ 403	**Magnetization Dynamics II**
MA 15.1–15.7	Mon	17:00–18:45	HSZ 04	**Multiferroics II: Strain and Composites (jointly with DF, DS, KR, TT)**
MA 16.1–16.1	Tue	10:15–10:45	HSZ 04	**Multiferroics III: Exotic Properties - Invited Talk (jointly with DF, DS, KR, TT)**
MA 17.1–17.4	Tue	10:30–12:30	TRE Ma	**SKM Dissertation Prize**
MA 18.1–18.6	Tue	10:45–12:15	HSZ 04	**Multiferroics IV: Exotic Properties and Dynamics (jointly with DF, DS, KR, TT)**
MA 19.1–19.111	Tue	10:45–13:00	P2	**Poster I (Bio- and Molecular Magnetism/ Magnetic Particles and Clusters/ Micro- and Nanostructured Magnetic Materials/ Magnetic Materials/ Multiferroics/ Magnetic Shape Memory Alloys/ Electron Theory of Magntism/ Spincaloric Transport/ Magnetic Coupling and Exchange Bias/ Magnetization Dynamics/ Micromagnetism and Computational Magnetics)**
MA 20.1–20.7	Tue	11:00–12:45	HSZ 103	**Electron Theory of Magnetism**
MA 21.1–21.7	Tue	11:00–12:45	HSZ 401	**Bio- and Molecular Magnetism II**
MA 22.1–22.8	Tue	11:00–13:00	HSZ 403	**Magnetic Measurement Methods**
MA 23.1–23.3	Tue	12:15–13:00	HSZ 04	**Magnetic Shape Memory Alloys I (jointly with MM)**
MA 24	Tue	13:30–15:15	HSZ 04	**ThyssenKrupp Dissertations-Preis 2011 der AG Magnetismus**
MA 25.1–25.6	Tue	13:30–15:00	HSZ 103	**Magnetic Shape Memory Alloys II (jointly with MM)**
MA 26.1–26.1	Wed	10:15–10:45	HSZ 04	**High Frequency Magnetic Light-Matter Interaction - Invited Talk**
MA 27.1–27.5	Wed	10:30–13:00	TRE Ma	**SKM-SYTI: Topological Insulators (jointly with TT, HL)**

MA 28.1–28.1	Wed	10:15–11:00	GER 37	**Spins in Organic Materials (jointly with DS) - Invited Talk**
MA 29.1–29.9	Wed	11:00–13:15	HSZ 103	**Micro- and Nanostructured Magnetic Materials II**
MA 30.1–30.9	Wed	11:00–13:15	HSZ 401	**Magnetic Semiconductors I**
MA 31.1–31.7	Wed	11:00–12:45	HSZ 403	**Magnetization Dynamics III**
MA 32.1–32.8	Wed	11:00–13:00	HSZ 04	**Magnetic Thin Films I**
MA 33.1–33.5	Wed	11:00–13:00	GER 37	**Focus Session "Spins in Organic Materials I" (jointly with DS)**
MA 34.1–34.9	Wed	11:15–13:30	CHE 184	**Surface magnetism I (jointly with O)**
MA 35.1–35.5	Wed	14:00–16:30	HSZ 04	**Spin Structures/ Skyrmions (jointly with TT) - Invited Talks**
MA 36.1–36.8	Wed	14:45–16:45	HSZ 103	**Micro- and Nanostructured Magnetic Materials III**
MA 37.1–37.8	Wed	14:45–16:45	HSZ 401	**Magnetic Semiconductors II**
MA 38.1–38.10	Wed	14:45–17:15	HSZ 403	**Magnetization Dynamics IV**
MA 39.1–39.1	Wed	15:00–15:45	GER 37	**Spins in Organic Materials (jointly with DS) - Invited Talk**
MA 40.1–40.7	Wed	15:00–16:45	CHE 184	**Surface magnetism II (jointly with O)**
MA 41.1–41.3	Wed	15:45–16:45	GER 37	**Focus Session "Spins in Organic Materials II" (jointly with DS)**
MA 42.1–42.10	Wed	16:45–19:15	HSZ 04	**Topological Insulators (jointly with TT, HL)**
MA 43.1–43.8	Wed	17:00–19:00	HSZ 103	**Micro- and Nanostructured Magnetic Materials IV**
MA 44.1–44.9	Wed	17:00–19:15	HSZ 401	**Magnetic Half-metals and Oxides I**
MA 45.1–45.6	Wed	17:30–19:00	HSZ 403	**Micromagnetism/ Computational Magnetics**
MA 46.1–46.9	Wed	17:00–19:15	CHE 184	**Magnetic Thin Films II**
MA 47.1–47.1	Thu	10:15–10:45	HSZ 04	**Spintronics I/ Spin-dependent Transport/ Spin Torque - Invited Talk**
MA 48.1–48.5	Thu	10:30–13:00	TRE Ma	**SKM-SYDT: Diffusionless Transformations in Magnetic and Ferroelectric Bulk and Thin Films (jointly with MM, DS, DF)**
MA 49.1–49.9	Thu	10:45–13:00	HSZ 04	**Spin-dependent Transport/ Spin Torque**
MA 50.1–50.8	Thu	11:00–13:00	HSZ 103	**Surface magnetism III**
MA 51.1–51.9	Thu	11:00–13:15	HSZ 401	**Magnetic Half-metals and Oxides II**
MA 52.1–52.9	Thu	11:00–13:15	HSZ 403	**Magnetic Thin Films III**
MA 53.1–53.2	Thu	14:00–15:00	HSZ 04	**Magnetic Storage Media, Applications - Invited Talks**
MA 54.1–54.8	Thu	15:00–17:00	HSZ 04	**Spin Excitations I**
MA 55.1–55.8	Thu	15:15–17:15	HSZ 103	**Surface Magnetism IV**
MA 56.1–56.7	Thu	15:15–17:00	HSZ 401	**Graphene (jointly with DY, DS, HL, O, TT)**
MA 57.1–57.8	Thu	15:15–19:00	HSZ 403	**Focus Session "X-ray absorption spectra - state of the art of theory and experiment" (jointly with DS, HL, MM, O), Organization: Andreas Ney (Universität Duisburg-Essen)**
MA 58.1–58.8	Thu	17:15–19:15	HSZ 401	**Spintronics II (jointly with TT, HL)**
MA 59.1–59.8	Thu	17:15–19:15	HSZ 04	**Spin Excitations II/ Spin Scattering**
MA 60.1–60.7	Thu	17:30–19:15	HSZ 103	**Spin Structures and Magnetic Phase Transitions**
MA 61.1–61.1	Fri	10:15–10:45	HSZ 04	**Surface Magnetism V - Invited Talk**
MA 62.1–62.5	Fri	10:45–12:00	HSZ 04	**Magnetic Imaging**
MA 63.1–63.99	Fri	11:00–14:00	P2	**Poster II (Surface Magnetism/ Magnetic Imaging/ Topological Insulators/ Spin Structures and Magnetic Phase Transitions/ Graphene/ Magnetic Thin Films/ Magnetic Semiconductors/ Magnetic Half-metals and Oxides/ Spin-dependent Transport/ Spin Excitations and Spin Torque/ Spin Injection and Spin Currents in Heterostructures/ Spintronics/ Magnetic Storage and Applications)**

Mitglieder-Versammlung des FV Magnetismus

Mittwoch, 16.03.2011 19:00–20:00 HSZ 04

- Bericht des Vorsitzenden
- Aussprache
- Verschiedenes

MA 1: Micro- and Nanostructured Magnetic Materials I/ Spin Structures - Invited Talk

Time: Monday 10:15–10:45 Location: HSZ 04

Invited Talk MA 1.1 Mon 10:15 HSZ 04

Emergent magnetic monopoles and associated Dirac strings in artificial kagome spin ice — •Laura Heyderman — Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

Artificial spin ice systems, consisting of two-dimensional arrangements of single-domain nanomagnets, have recently been in the focus of scientific interest since they provide an opportunity to directly study the effects of frustration [1, 2]. Our work has focused on artificial kagome spin ice, with elongated nanomagnets arranged on the kagome lattice forming an array of hexagonal rings. Synchrotron x-ray photoemission microscopy allows direct imaging of the magnetic state of each nanomagnet, having moments pointing in one of two orientations parallel to their long axis. Our recent observations demonstrate the existence of emergent magnetic monopoles and their associated Dirac strings at room temperature in a quasi-infinite nanomagnet array [3]. In an applied magnetic field, monopole-antimonopole pairs nucleate and then separate in an avalanche-type manner along one-dimensional Dirac strings, consisting of overturned dipoles. This behaviour is distinct from conventional domain growth in two-dimensional systems and results in the formation of a stripe phase towards the end of magnetization reversal. The observed hysteresis, monopole densities and 1D Dirac-string avalanches are quantitatively explained by Monte Carlo simulations and the results open the way to a controlled manipulation of magnetic charges that may lead to new spintronic devices. [1] R.F. Wang et al., Nature 439, 303 (2006) [2] E. Mengotti et al., Phys. Rev. B 78, 144402 (2008) [3] E. Mengotti et al., Nature Physics (2010)

MA 2: Focus Session "Nanoparticles, Nanocrystals and Colloids" (jointly with BP, CPP, HL), Organization: Oleg Petracic (Ruhr-Universität Bochum)

Time: Monday 10:15–13:00 Location: HSZ 103

Topical Talk MA 2.1 Mon 10:15 HSZ 103

Magnetic nanoparticles: fundamentals and applications — •Andreas Hütten — Physics of Nanostructures, Department of Physics, Bielefeld University

Our contribution highlights recent advances in synthesis, characterization, self-assembly and sensing applications of monodisperse magnetic Co and Co based alloyed nanoparticles. A brief introduction into solution phase synthesis techniques as well as the magnetic properties and aspects of the self-assembly process of nanoparticles will be given with the emphasis placed on selected applications. Here, the presentation focuses on:- Combining magnetic nanoparticles with XMR-sensor technology - Fabrication of granular magnetoresistive sensors by employment of particles themselves as sensing layers - Employing magnetic nanoparticles as reconfigurable materials in lab-on-a-chip devices.

Topical Talk MA 2.2 Mon 10:45 HSZ 103

Directing the Self-Assembly of Nanoparticles — •Alexander Böker — DWI an der RWTH Aachen e.V. — Lehrstuhl für Makromolekulare Materialien und Oberflächen, RWTH Aachen

This talk deals with the use of different interfaces as templates for the self-assembly of various colloidal particles. First, we describe classical oil/water emulsion systems, the so-called Pickering Emulsions. Here, the controlled nanoparticle assembly can lead to permeable, yet robust membranes and capsules. Furthermore, fluid interfaces as found in block copolymer nanostructures can be employed. Here, the nanoparticles may impart specific functions to the nanostructures, such as magnetism or charge transport as required in magnetic data storage media or polymer-based photovoltaic devices, respectively.

Moreover, we demonstrate that wrinkled polydimethylsiloxane (PDMS) substrates, with wavelengths on the order of only a few hundred nanometers, guide the assembly of rod-like tobacco mosaic virus (TMV) nanoparticles or spherical microgels. Wrinkled substrates with pre-aligned nanoparticles are used as inked stamps to transfer large particle arrays onto flat substrates. The characteristic spacing and form of the structures can be controlled by the properties of the stamp.

Topical Talk MA 2.3 Mon 11:15 HSZ 103

Magnetic Fluids - Properties and Applications — •Stefan Odenbach — TU Dresden, Chair of Magnetofluiddynamics, 01062 Dresden

Suspensions of magnetic nanoparticles in approriate carrier liquids - so called ferrofluids - exhibit normal liquid behaviour coupled with superparamagnetic properties. The use of appropriate surfactants for the particles enables longterm stabilisation of the suspensions making them suitable for numerous technical and even medical applications.

The peculiarity of ferrofluids is given by the fact that moderate magnetic fields in the order of 10mT can significantly change the fluids properties - e.g. their viscosity - and can also provide the possibility to control the flow of such fluids.

Within the presentation a general (partly experimental) introduction of ferrofluids, their properties and applications will be followed by a discussion of magnetic flow control for biomedical applications of ferrofluids. This problem - actually discussed within the frame of novel cancer therapies - enlightens the strong interdisciplinarity of ferrofluid reserach covering fields from chemistry over physics and engineering towards medicine.

15 min. break

Invited Talk MA 2.4 Mon 12:00 HSZ 103

Semiconductor nanocrystals — •Andrey Rogach — City University of Hong Kong

Semiconductor nanocrystals of essentially every composition can nowadays be synthesized in large quantities by inexpensive and versatile solution based approaches. They are attractive objects for use as building blocks in different functional nanostructures. We provide an overview of strongly emissive semiconductor nanocrystals synthesized in our labs and demonstrate several approaches for nanocrystals assembly. Advanced optical spectroscopy provides important insights into fundamental photophysical properties of semiconductor nanostructures. Different application aspects of functional structures based on semiconductor nanocrystals ranging from energy transfer structures to biological markers will be discussed.

Topical Talk MA 2.5 Mon 12:30 HSZ 103

Ion and pH sensing with colloidal nanoparticles: tailoring hybrid FRET-based nanobiosensors — •Martin Oheim — Centre National de la Recherche Scientifique, CNRS UMR8154; Institut National de la Santé et de la Recherche Médicale - INSERM U603; Université Paris Descartes, Laboratory of Neurophysiology & New Microscopies

In biological cells, the free cytoplasmic ion concentration ([Ca2+]i)plays important roles in a plethora of intracellular signalling cascades. One way to attain specificity and to increase the bandwidth of Ca2+ signaling is the confinement of excursions of [Ca2+]i from baseline to micro- and nanoscale domains. Due to their ephemerous nature (nm scale, ms kinetics) the experimental detection of Ca2+ microdomains has presented a major challenge to microscopists. In my contribution I will present ongoing efforts of a franco-german-american 'nanoFRET' consortium that aims at conceptualizing, designing, validating and using novel hybrid nano-particle/organic dye-based nanobiosensors for the detection of intracellular ion-concentration nanodomains. After a swift motivation of our "pointilistic" imaging approach and the presentation of the general sensor concept, I will discuss how core/shell properties, donor-acceptor distance, stoichiometry and surface effects affect sensor performance. Preliminary sensing applications of Ca2+ and protons will be presented. I shall equally discuss the challenges for loading and imaging single-nanoparticle in live cells and ways to address these.

MA 3: Bio- and Molecular Magnetism

Time: Monday 11:00–13:00 Location: HSZ 401

MA 3.1 Mon 11:00 HSZ 401

Transition from the Quantum to the Classical Limit for the Antiferromagnetic Heisenberg Model on the Icosahedron — •Nikolaos P. Konstantinidis — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

The antiferromagnetic Heisenberg model on the icosahedron, which consists of 20 triangles and belongs to the icosahedral I_h symmetry group, presents unconventional properties at the quantum and classical level. These originate in the frustrated nature of the interactions between the spins. In the quantum limit, there are non-magnetic excitations within the singlet-triplet gap and the specific heat has a multi-peak structure as a function of temperature [1]. For classical spins, the magnetization is discontinuous as a function of an external magnetic field [2]. Here the transition from the full quantum s_i=1/2 to the classical limit is investigated by progressively increasing s_i and focusing on the low-energy spectrum and the magnetization in an external field. The icosahedral I_h symmetry properties of the model are fully taken into account in the characterization of the states and show how the quantum fluctuations yield to the classical properties as s_i is increased.

[1] N. P. Konstantinidis, Phys. Rev. B **72**, 064453 (2005).
[2] C. Schröder *et al.*, Phys. Rev. Lett. **94**, 207203 (2005).

MA 3.2 Mon 11:15 HSZ 401

Geometrical Frustration in Molecular Spin Triangles with S=1/2, 5/2 — •Nicolas Yèche[1], Andrei Zvyagin[1,2], Daniel Plaul[3], Dirk Schuch[3], Winfried Plass[3], Eric Kampert[4], Til Dellmann[1], Christopher Baines[5], Gwendolyne Pascua[5], Hans-Henning Klauss[1], and Hubertus Luetkens[5] — [1]Institut für Festkörperphysik ,TU Dresden — [2]Institute for Low Temperature Physics and Engineering of the NAS of Ukraine, Kharkov — [3]Institut für Anorganische Chemie, Uni Jena — [4]Hochfeldlabor Dresden, FZ Dresden-Rossendorf — [5]Paul Scherrer Institute, Villingen, Switzerland

In the study of finite geometrically frustrated system, the simplest problems that can be considered are paradoxically some of the hardest ones to observe experimentally. Thanks to sophisticated organic ligands, independent triangles of Cu(II) ($S = \frac{1}{2}$) and Fe(III) ($S = \frac{5}{2}$) were synthesized. Investigations carried out with macroscopic (pulsed and static field magnetization) and local probe techniques (μSR and ^{57}Fe mössbauer spectroscopy) show characteristic behavior of frustrated systems. Comparison of the magnetization data with theoretical calculations indicates that the antiferromagnetic coupling in the Cu system is greater than 45K: the complex shows a single magnetization plateau up to 60T at about 1/3 of the expected saturation. As for the Fe compound, several clear magnetization steps are observed in pulsed field, hinting for a coupling constant of about 10K. Slow dynamic spin fluctuations are observed in mössbauer spectra and in the μSR measurements down to millikelvin temperatures.

MA 3.3 Mon 11:30 HSZ 401

Inelastic Neutron Scattering Studies on the 3d-4f Heterometallic Single-Molecule Magnet Mn_2Nd_2 — •Joscha Nehrkorn[1], Muhammad Nadeem Akhtar[2], Ruggero Milazzo[1], Stefan Stuiber[1], Hannu Mutka[3], Yanhua Lan[2], Annie K. Powell[2], and Oliver Waldmann[1] — [1]Physikalisches Institut, Universität Freiburg, Germany — [2]Institut für anorganische Chemie, Universität Karlsruhe, KIT, Germany — [3]Institut Laue-Langevin, Grenoble, France

The discovery of slow relaxation and quantum tunneling of the magnetization in Mn_{12}ac more than 15 years ago has inspired both physicists and chemists alike. This class of molecules, now called single-molecule magnets (SMMs), has very recently been expanded to heterometallic clusters incorporating transition metal and rare earth ions. The 4f ions were chosen because of their large angular momentum and magnetic anisotropy. Inelastic neutron scattering experiments were performed on the time-of-flight disk-chopper spectrometer IN5 at ILL on the SMM Mn_2Nd_2. A magnetic model was developed which perfectly describes all data, including the magnetic data. It was found that neither the large anisotropy nor the large angular momentum of the Nd^{III} ions is the main reason for the SMM behavior in this molecule. Our analysis of the data indicates that it is the weak coupling of the Nd^{III} ions to the Mn^{III} ions, usually considered as a drawback of rare earth ions, which enhances the relaxation time and therefore leads to SMM behavior.

MA 3.4 Mon 11:45 HSZ 401

Magnetic Model for Mn_2La_2 Developed from Spectroscopic Studies with Inelastic Neutron Scattering and Frequency-Domain Fourier-Transform THz EPR — •R. Milazzo[1], J. Nehrkorn[1], S. Stuiber[1], O. Waldmann[1], M. N. Akhtar[2], Y. Lan[2], A. K. Powell[2], H. Mutka[3], J. Dreiser[4], A. Schnegg[5], and K. Holldack[6] — [1]Physikalisches Institut,Universität Freiburg, Germany — [2]Institut für Anorganische Chemie, Universität Karlsruhe, KIT, Germany — [3]Institut Laue Langevin, Grenoble, France — [4]Swiss Light Source, Paul Scherrer Institut, Switzerland — [5]Helmholtz-Zentrum Berlin, Institut für Silizium-Photovoltaik, Germany — [6]Helmholtz-Zentrum Berlin, Institut für Synchrotonstrahlung, Germany

Molecular nanomagnets which contain several magnetic centers with a large single-ion magnetic anisotropy are of general interest, because they could lead to interesting phenomena such as single-molecule magnet (SMM) behavior. We performed spectroscopic experiments on Mn_2La_2 using inelastic neutron scattering at the direct time-of-flight disc chopper spectrometer IN5 at ILL and the newly developed frequency-domain Fourier-transform THz EPR at BESSY. Based on the experimental results a magnetic model has been developed. It will be discussed why no SMM behavior was observed, even though Mn_2La_2 exhibits a remarkably high energy barrier of about 37 K for spin relaxation. Furthermore our results can be applied to analogous clusters, with the diamagnetic La^{III} ions replaced by magnetic rare earth ions.

MA 3.5 Mon 12:00 HSZ 401

First results obtained with the new frequency-domain Fourier-transform THz electron paramagnetic resonance technique on single-molecule magnets — •Jan Dreiser[1,2], Kasper S. Pedersen[3], Joscha Nehrkorn[2], Alexander Schnegg[4], Karsten Holldack[4], Magnus Schau-Magnussen[3], Philip Tregenna-Piggott[5], Hannu Mutka[6], Hoegni Weihe[3], Jesper Bendix[3], and Oliver Waldmann[2] — [1]Paul Scherrer Institut, Swiss Light Source, CH-5232 Villigen PSI — [2]Physikalisches Institut, Universität Freiburg, D-79104 Freiburg — [3]Department of Chemistry, University of Copenhagen, Universitetsparken 5, DK-2100 Copenhagen — [4]Helmholtz-Zentrum Berlin, D-12489 Berlin — [5]Paul Scherrer Institut, Lab. for Neutron Scattering, CH-5232 Villigen PSI — [6]Institut Laue-Langevin, F-38042 Grenoble

Single-molecule magnets are molecular spin clusters exhibiting slow relaxation of magnetization. In order to understand the interplay of anisotropy and exchange interaction within these clusters, spectroscopic measurements are needed in addition to magnetization and susceptibility studies. Recently, a new frequency-domain Fourier-transform electron paramagnetic resonance technique working in the THz range (FD-FT THz-EPR) has been developed at the BESSY storage ring in Berlin. In this contribution we present first results obtained with this technique. We further discuss the THz-EPR spectra in the context of inelastic neutron scattering, magnetization and susceptibility measurements.

MA 3.6 Mon 12:15 HSZ 401

Quantum Coherence in Molecular Nanomagnets — •Joris van Slageren — Institut für Physikalische Chemie, Universität Stuttgart, Pfaffenwaldring 55, 70569 Stuttgart

The occurrence of quantum coherence in molecular nanomagnets has recently attracted a great deal of attraction. Molecular nanomagnets are exchange coupled molecular clusters of transition metal ions, bridged by ligands and encapsulated in an organic ligand shell. They can be easily and extensively modified and tuned in terms of size, spin and anisotropy by chemical synthetic means. This makes these mesoscopic systems excellently suited to the investigation of the transition between the quantum world of single particles and the classical world that we live in.

In this presentation, we will discuss quantum coherence in molecular nanomagnets and the corresponding decoherence pathways.

MA 3.7 Mon 12:30 HSZ 401

Magnetic ground state of TM-Ni binuclear complexes studied by of x-ray circular magnetic dichroism and density functional theory — •Karsten Kuepper[1], Ulf Wiedwald[1], David M. Benoit[2], Florian Mögele[3], Bernhard Rieger[4], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, Albert-Einstein-Allee 11, D-89081 Ulm — [2]Nachwuchsgruppe Theorie im SFB 569, Universität Ulm, Albert-Einstein-Allee 11, D-89081 Ulm — [3]Institut für Materialien und Katalyse, Universität Ulm, Albert-Einstein-Allee 11, D-89081 Ulm — [4]WACKER-Lehrstuhl für Makromolekulare Chemie, Technische Universität München, Lichtenbergstraße 4, 85747 Garching bei München

We investigate three planar TM-Ni-$C_{46}H_{68}N_2O_6$ (TM=Mn,Fe,Co) molecules [1] by low temperature XMCD revealing in this way the presence of uncompensated magnetic moments. The experiments have been performed at a temperature of 0.6K in order to probe the magnetic ground state properties. Theoretically, we address the energetic ordering of the different possible spin states of the bi-nuclear complexes using (zero-order) relativistic approximation density functional calculations and a triple-zeta quality basis set. These results show that medium-spin states are often favored over low-spin states for most metal combination, in qualitative agreement with our experimental observations.

[1] Florian Mögele et al., Langmuir 25, 13606 (2009).

MA 3.8 Mon 12:45 HSZ 401

Reversible chemical manipulation of the magnetic properties of Fe-porphyrin molecules on a ferromagnetic substrate — •Christian Felix Hermanns[1], Jorge Miguel[2], Matthias Bernien[1], Alexander Krüger[1], and Wolfgang Kuch[1] — [1]Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Diamond Light Source, Harwell Science Innovation Campus, OX11 0DE Chilton, Didcot, United Kingdom

Single-molecule magnets are promising building blocks for future spintronic devices. One of the key issues is to gain control over the magnetic properties of adsorbed molecules by external stimuli. We present the results of an X-ray absorption spectroscopy (XAS) study of the adsorption of NO on top of a submonolayer of Fe-octaethlyporphyrin molecules adsorbed on oxygen-covered Co films grown on Cu(001). Fe $L_{3,2}$ XAS spectra show that the adsorption of 24 L NO at 120 K does not cause any change of the oxidation state of the Fe ion, which remains in an Fe 3+ valence state. XMCD investigations before and after dosing NO reveal an antiparallel alignment of the Fe spins and the magnetization of the ferromagnetic substrate. Interestingly, after dosing NO, the Fe XMCD signal is reduced by a factor of two, while the spectral shape of the Fe $L_{3,2}$ XMCD signal is not modified. The lower Fe magnetization at finite temperatures after dosing NO can be explained by a reduction of the magnetic coupling between the Co substrate and the molecules. Thermal desorption of NO at 350 K recovers the initial Fe XMCD signal and proves the reversibility of the process. This work is supported by the DFG (Sfb 658).

MA 4: Magnetic Coupling Phenomena/ Exchange Bias

Time: Monday 11:00–13:15 Location: HSZ 403

MA 4.1 Mon 11:00 HSZ 403

Imaging of exchange bias on the nm length scale — •Julia Herrero-Albillos[1], Florian Kronast[1], Logane Bismaths[1], Christian Papp[2], and Charles Fadley[3] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany — [2]Lehrstuhl für Physikalische Chemie II, Universität Erlangen-Nürnberg, Germany — [3]Department of Physics, University of California Davis and Materials Sciences Division Lawrence Berkeley National Laboratory, USA

The direct exchange interaction at the interface between an antiferromagnet (AF) and a ferromagnet (FE) allows tailoring magnetic properties like the coercitivity and the exchange bias. At the S-PEEM in BESSY we have grown in-situ Co/FeMn bi-layer films in order to investigate the domain structure in the FE Co layer and the arrangement of magnetic moments at the interface of the AF FeMn layer. Exploiting the unique capabilities of element specific magnetic imaging by X-PEEM and a sample holder designed for imaging under applied magnetic fields (H), we were able to study the evolution of magnetic domains in the Co layer as a function of H and its layer thickness. Maps of the local exchange bias are obtained from the analysis of the space-resolved hysteresis loop images taken at different H. For samples where the FE domains are stabilized either by the AF layer or the application H upon cooling, an enhanced coercivity and exchanged bias was obtained for a critical Co thickness. In the case of Co grown without field and before the deposition of the AF, only a small exchange bias was observed which, nonetheless, mimics the as grown Co magnetization, i.e. the FE domains have been imprinted on the AF layer.

MA 4.2 Mon 11:15 HSZ 403

Domain size engineering in exchange-biased samples — •Niraj Joshi[1], Sevil Oezer[1], Pablo Stickar[2], Sara Romer[2], Miguel Marioni[2], Tim Ashworth[3], and Hans Hug[1,2] — [1]Department of Physics, University of Basel, CH-4056 Basel, Switzerland — [2]EMPA, CH-8600 Dubendorf, Switzerland — [3]NanoScan Ltd, CH-8600 Dubendorf, Switzerland

In a magnetic force microscopy experiment the magnetic tip of the MFM maps the magnetic stray field emanating from the surface (or interface) of a sample [1]. Hence, the stray field must contain sufficient information on the magnetization structure to make imaging and quantification possible [2, 3, 4]. Magnetization structures that are divergence free, homogeneously magnetized or have a large spatial wavelength however generate no stray field at all or only near the domain walls. This limits the information that can be gained from MFM experiments. In this work we demonstrated, in EB sample with F (CoPt) / AF (CoCrO) interface, how the domain size can be suitable engineered independent of the thickness of the F-film of interest. We also expect that this domain-size engineering concept can be applied for samples with an in-plane magnetic anisotropy that usually show domain sizes beyond 1 μm.

[1] P. J. A. Schendel, J. Appl. Phys., 88 (2000) 435
[2] P. Kappenberger et al., Phys. Rev. Lett., 91 (2003) 267202
[3] I. Schmid et al., Europhys. Lett., 81 (2008) 17001
[4] I. Schmid et al., Phys. Rev. Lett., 105 (2010) 197201

MA 4.3 Mon 11:30 HSZ 403

Magnetostatic coupling of 90° domain walls in FeNi/Cu/Co trilayers — •Julia Kurde[1], Jorge Miguel[1], Daniela Bayer[2], Jaime Sánchez-Barriga[3], Florian Kronast[3], Martin Aeschlimann[2], Herrmann A. Dürr[3], and Wolfgang Kuch[1] — [1]Freie Universität Berlin — [2]Technische Universität Kaiserslautern — [3]Helmholtz-Zentrum Berlin für Materialien und Energie

The magnetic interlayer coupling of FeNi/Cu/Co trilayered microstructures has been studied by means of x-ray magnetic circular dichroism in combination with photoelectron emission microscopy (XMCD-PEEM). We find that a parallel coupling between magnetic domains coexists with a non-parallel coupling between magnetic domain walls of each ferromagnetic layer. We attribute the non-parallel coupling of the two magnetic layers to local magnetic stray fields arising at domain walls in the magnetically harder Co layer. In the magnetically softer FeNi layer non-ordinary domain walls such as 270° and 90° domain walls with overshoot of the magnetization either inwards or outwards relative to the turning direction of the Co magnetization are identified. Micromagnetic simulations reveal that in the absence of magnetocrystalline anisotropy, both types of overshooting domain walls are energetically equivalent. However, if a uniaxial in-plane anisotropy is present, the relative orientation of the domain walls with respect to the anisotropy axis determines which of these domain walls is energetically favorable. This work is supported by the BMBF (05 KS7 UK1/05 KS7 KE2).

MA 4.4 Mon 11:45 HSZ 403

Exchange bias effects studied by transport measurements in Co/CoO micro and nanowires — •Francis Bern, José Barzola-Quiquia, and Pablo Esquinazi — Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig

In-plane and out-of-plane magnetoresistance (MR) of oxidized Cobalt nanowires with widths of 300nm to 5μm in a variety of geometries was measured in the temperature range from 2.5K to 250K and in fields up to ±8T. Formation of CoO on the surface leads to exchange bias

effects that were studied by MR measurements. The wires were prepared with different widths resulting in different coercive fields. This provides us with the possibility to control locally the direction of unidirectional anisotropy in zero cooling field. Besides the well known H_{EB} effect resulting in a horizontal shift of the hysteresis loop strong asymmetries and a R_{shift}= R(H)-R(-H) in the saturated field region were observed. Measurements of R_{shift} indicate a new approach to examine the exchange bias phenomenon on microscopic scale, and were compared to a model developed within a Stoner-Wohlfarth approach.

MA 4.5 Mon 12:00 HSZ 403

Antiferromagnetic coupling in combined Fe/Si/MgO/Fe structures — •Rashid Gareev[1], Frank Stromberg[2], Werner Keune[2], Heiko Wende[2], and Christian Back[1] — [1]Institute of Experimental and Applied Physics, University of Regensburg, Universitätstr. 31, 93053 Regensburg — [2]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, Lotharstr.1, 47048 Duisburg

In contrast to antiferromagnetic coupling (AFC) across metallic spacers, the AFC across tunnelling barriers from semiconductor Si [1] or insulator MgO [2] is still under discussion. Fe/Si/Fe structures demonstrate stronger AFC compared to Fe/MgO/Fe but suffer from interface diffusion. In order to decrease interdiffusion we prepared combined epitaxial Fe/Si/MgO/Fe structures with control of interfacial composition by Conversion electron Mössbauer spectroscopy (CEMS). From CEMS with 0.5 nm-thick 57Fe interface markers we detected a continuous reduction of interface diffusion upon increasing the MgO thickness from 0.3nm to 0.5nm for spacers with 0.9 nm-thick Si. MOKE hysteresis confirms AFC for these structures which increases with decrease of MgO thickness above /J/˜0.1mJ/m2. Similar structures with pure MgO spacers exhibit only weak 90°- coupling. We conclude that combined Fe/MgO/Fe structures possess enhanced AFC compared to Fe/MgO/Fe and reduced interface diffusion compared to Fe/Si/Fe. This work is supported by the Project DFG 9209379.[1]. R.R. Gareev et al, J. Magn. Magn. Mater. 240, 235 (2002); [2]. J. Faure-Vincent et al, Phys. Rev. Letts 89, 107206 (2002).

MA 4.6 Mon 12:15 HSZ 403

Room-temperature magnetocurrent in antiferromagnetically coupled Fe/Si/Fe — •Maximilian Schmid[1], Rashid Gareev[1], Johann Vancea[1], Christian H. Back[1], Reinert Schreiber[2], Daniel Bürgler[2], Claus M. Schneider[2], Frank Stromberg[3], and Heiko Wende[3] — [1]Institute of Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Forschungszentrum Jülich, Institute of Solid State Research Electronic Properties, 52428 Jülich, Germany — [3]Faculty of Physics and Center for Nanointegration Duisburg Essen (CeNIDE), University of Duisburg Essen, 47048 Duisburg, Germany

Epitaxial Si-based hybrid ferromagnet/semiconductor tunneling structures demonstrate very strong antiferromagnetic coupling (AFC) as well as unusual resonant-type megnetoresistance, which vanishes at temperatures above T≅50K. Magnetoresistance effects in Fe/Si/Fe close to room temperature (RT) were not established yet. Here, by using the ballistic electron magneto microscopy (BEMM) technique, with its nanometer-scaled locality, we managed to observe for the first time a spin-dependent ballistic magnetotransport in AFC structures. We found that the hot-electron collector current with energies above the Fe/GaAsP Schottky barrier reflects the relative orientations of the electrodes and changes from I_{cAP} ≅50 fA for antiparallel alignment to I_{cAP} ≅150 fA for the parallel one. Thus, the magnetocurrent($[(I_{cP} - I_{cAP})/(I_{cAP})]$) is near 200% at RT. The measured BEMM hysteresis loops match nicely with the magnetic MOKE hysteresis data. This work is supported by the project DFG 9209379.

MA 4.7 Mon 12:30 HSZ 403

Magnetic avalanches in mixed valence oxide spin-glass — •Michalis Charilaou[1,2], Shuangyi Zhao[3], Jörg F. Löffler[2], and Andreas U. Gehring[1] — [1]Earth and Planetary Magnetism, Department of Earth Sciences, ETH Zurich, Sonneggstrasse 5, 8092 Zurich, Switzerland — [2]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich, Wolfgang-Pauli-Strasse 10, 8093 Zurich, Switzerland — [3]Laboratory for Solid State Physics, Department of Physics, ETH Zurich, Schafmattstrasse 16, 8093 Zurich, Switzerland

We report sharp jumps (avalanches) of the magnetic moment in polycrystalline hemo-ilmenite solid solution $(x)FeTiO_3$– $(1\text{-}x)Fe_2O_3$ with $x = 0.8$ at low temperature ($T < 2.75$ K). The avalanches occur at a critical trigger-field H_{cr} upon field reversal and are symmetric on either side of the magnetization loop $m(H)$. The number of jumps increases with decreasing temperature reaching a total of 4 on either side of the $m(H)$ loop at $T = 0.75$ K. Extensive study shows that the magnetization loops at each temperature are fully reproducible and statistical analysis reveals that the intensity of the jumps decreases with increasing trigger field. Moreover, a small increase (1%) of the sample temperature can be measured right after a jump indicating the release of thermal energy.

The experimental findings indicate that avalanches in this system are due to competing exchange and superexchange Fe(II)–Fe(III) interactions.

MA 4.8 Mon 12:45 HSZ 403

Element specific analysis of magnetic anisotropy in practical Mn-based antiferromagnetic alloys from first principles. — •Sergii Khmelevskyi[1], Alexandr B. Shick[2], and Peter Mohn[1] — [1]Institute of Applied Physics, Vienna University of Technology, Makkartvilla, Gusshausstrasse, 25 — [2]Institute of Physics ASCR, v.v.i., Na Slovance 2, 182 21 Praha 8, Czech Republic

Magnetic Anisotropy Energy (MAE) and element specific contribution to MAE has been studied for practical Mn-based antiferromagnetic alloys with layered L1$_{0}$ structure in the framework of the Local Spin Density Approximation and fully relativistic torque method. It is found that the contribution to the total MAE from non-magnetic 3d and 4d-elements in MnNi and MnPd alloys is comparable to the contribution of the magnetic Mn atoms. In the 3d-5d MnIr alloy the Ir contribution is found to be dominating. The origin of this contribution from the elements with total zero atomic spin moment is linked to the calculated non-trivial spin density distributions on the corresponding atom, which gives a zero moment only on average. We have also found and discuss a strong dependence of the total and element specific contribution to MAE on the state of the magnetic order.

MA 4.9 Mon 13:00 HSZ 403

Impurity driven order in gapped magnets — •Eric Andrade and Matthias Vojta — Institut fuer Theoretische Physik, Technische Universitaet Dresden, Dresden, Germany

We study the effect of diluted nonmagnetic impurities placed in a spin-gapped magnet using an effective low energy disordered Heisenberg model for the impurity-induced spins. Our Monte Carlo simulations show the emergence of either commensurate or incommensurate magnetic order depending on the properties of the homogeneous system. A comparison with recent experiments in the Zn-doped high-temperature superconductor YBa2Cu3O6.6 is also provided.

MA 5: Spincaloric Transport

Time: Monday 11:00–12:45 Location: HSZ 04

MA 5.1 Mon 11:00 HSZ 04

Magneto Seebeck effect in Co-Fe-B/MgO/Co-Fe-B tunnel junctions — •Marvin Walter[1], Jakob Walowski[1], Vladyslav Zbarsky[1], Markus Münzenberg[1], Volker Drewello[2], Daniel Ebke[2], Günter Reiss[2], Andy Thomas[2], Patrick Peretzki[3], Michael Seibt[3], Michael Czerner[4], Michael Bachmann[4], and Christian Heiliger[4] — [1]I. Physikalisches Institut, Universität Göttingen — [2]Department of Physics, Bielefeld University — [3]IV. Physikalisches Institut, Universität Göttingen — [4]I. Physikalisches Institut, Universität Giessen

Co-Fe-B/MgO/Co-Fe-B devices showing a giant TMR effect are possible candidates for the generation of spin-currents by thermal heating. We present the observation of a magneto Seebeck effect in Co-Fe-B/MgO/Co-Fe-B magnetic tunnel junctions (MTJs). The effects could be used for thermal spin-injection and thermally driven spin-transfer torque.

The samples presented in this work consist of a minimal pseudo-spin-valve stack with sputtered Ta and Co-Fe-B layers and an e-beam evaporated MgO barrier. The MTJs are heated by a diode laser which achieves powers of up to 100 mW and is focused onto the sample in a standard confocal microscope setup. The heating is simulated by finite element methods and the experimental results are compared with ab initio calculations of the magneto-thermoelectric power and of the spin-Seebeck coefficient.

MA 5.2 Mon 11:15 HSZ 04

Experimental Study of the Anisotropic Magneto-Seebeck Effect in (Ga,Mn)As Thin Films — Matthias Althammer[1], Alexander T. Krupp[1], Thomas Brenninger[1], Deepak Venkateshvaran[1], Matthias Opel[1], Lukas Dreher[2], Wladimir Schoch[3], Wolfgang Limmer[3], Rudolf Gross[1], and •Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany — [3]Abteilung Halbleiterphysik, Universität Ulm, Ulm, Germany

In analogy to anisotropic magnetoresistance (AMR), the thermopower of ferromagnetic materials also characteristically depends on the orientation of the magnetization vector. This anisotropic magneto-thermopower – or anisotropic magneto-Seebeck effect (AMS) – has only scarcely been studied to date. Taking the ferromagnetic semiconductor (Ga,Mn)As with its large magneto-resistive effects as a prototype example, we have measured the evolution of both the AMR and the AMS effects at liquid He temperatures as a function of the orientation of a magnetic field applied in the (Ga,Mn)As film plane, for different, fixed magnetic field magnitudes. Our data show that the AMS effect can be adequately modeled only if the symmetry of the (Ga,Mn)As crystal is explicitly taken into account. We will quantitatively compare our AMR and AMS measurements with corresponding model calculations, and address the validity of the Mott relations linking the magneto-resistance and the magneto-Seebeck coefficients.

MA 5.3 Mon 11:30 HSZ 04

Ab initio calculations of spin caloritronics in magnetic tunnel junctions — Michael Czerner, Michael Bachmann, and •Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

The emerging research field of spin caloritronics [1] combines the spin-dependent charge transport with energy or heat transport. In comparison to thermoelectrics the spin degree of freedom is considered as well. We present ab initio calculations of the magneto-thermoelectric power (MTEP) and of the spin-Seebeck coefficient in MgO based tunnel junctions with Fe and Co leads. In addition, the normal thermopower is calculated and gives for pure Fe and Co a quantitative agreement with experiments. Consequently, the calculated values in tunnel junctions are a good estimation of upper limits. In particular, spin-Seebeck coefficients of more than 100μV/K are possible. The MTEP ratio exceeds several 1000% and depends strongly on temperature. In the case of Fe leads the MTEP ratio diverges even to infinity at certain temperatures. The spin-Seebeck coefficient as a function of temperature shows a non-trivial dependence. For Fe/MgO/Fe even the sign of the coefficient changes with temperature.

[1] G. E. W. Bauer, A. H. MacDonald, and S. Maekawac, Solid State Comm. 150, 459 (2010).

MA 5.4 Mon 11:45 HSZ 04

Spin injection via thermal gradients. — •Benedikt Scharf, Jaroslav Fabian, and Alex Matos Abiague — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Deutschland

The interplay between spin transport and thermoelectricity offers several novel ways of generating, manipulating, and detecting nonequilibrium spin in a wide range of materials. Here we present a phenomenological model in the spirit of the standard model of spin injection to describe the coupling of charge, spin and heat transport in electronic materials and then employ this model to analyze several different geometries: F/N and F/N/F junctions which are subject to thermal gradients. We find that temperature differences across the junctions can be used to generate pure spin currents which inject nonequilibrium spin into the N region of those junctions or extract nonequilibrium spin from it. This work is supported by the Deutsche Forschungsgemeinschaft via GRK 1570.

MA 5.5 Mon 12:00 HSZ 04

Thermally driven Magnetization dynamics in pseudo spin valve tunnel junctions — Marvin Walter[1], •Jakob Walowski[1], Vladyslav Zbarsky[1], Markus Münzenberg[1], Volker Drewello[3], Daniel Ebke[3], Günter Reiss[3], Andy Thomas[3], Patrick Peretzki[2], Michael Seibt[2], Michael Czerner[4], Michael Bachmann[4], and Christian Heiliger[4] — [1]I. — [2]IV. Physikalisches Institut, Universität Göttingen — [3]Department of Physics, Universität Bielefeld — [4]I. Physikalisches Institut, Universität Gießen

Currently, magnetic tunnel junctions are investigated as a possible memory technique for spin-transfer torque magnetic RAM. On the grounds of the pioneering work by Gravier [1], we investigate the spin-Seebeck effect in nanostructures by laser heating of pseudo spin valve tunnel junctions. The investigated tunnel junctions show a change in the thermal voltage, which originates from a temperature gradient ΔT, when both ferromagnetic layers are in the anti-parallel state. This change can be analyzed as the magneto-Seebeck effect.

We apply ultra short pulses from a Ti:Sapphire laser as a time dependent heat source on these tunnel junctions and get a time dependent ΔT. Consequently, we will be able to see how the heating influences the spin system in the parallel and the anti-parallel state. A comparison with the three-temperature model will give an insight into the time scales of the magneto-Seebeck effect, and allow us to compare the characteristic time scales of the laser heating with the Seebeck voltage.

[1] L. Gravier, et al., Phys. Rev. B **73** (2006) 024419.

MA 5.6 Mon 12:15 HSZ 04

Numerical studies of thermally driven domain wall dynamics — •Denise Hinzke, Ulrike Ritzmann, and Ulrich Nowak — Universität Konstanz, 78457 Konstanz

The understanding of the influence of thermal properties of magnetic materials on its magnetic behaviour opens new perspectives for the control of magnetic domains and domain walls. Recently it has been demonstrated that spatial temperature gradients can lead to spin accumulation via the so-called spin-Seebeck effect [1]. For the latter case two kinds of spin currents can exist in a ferromagnet; a spin polarised charge current due to electron motion or a pure angular momentum current driven by spin waves. For the latter one leads to pure thermomagnetic effects without any electron currents involved.

Two different approaches for the simulation of coupled thermomagnetic properties are introduced: the stochastic Landau-Lifshitz-Gilbert equation, applied to atomistic spin models, and the Landau-Lifshitz-Bloch equation describing the dynamics of the thermally averaged spin polarisation on micromagnetic length scales [2]. Both approaches are applied to study domain wall dynamics driven by spin currents caused by a temperature gradient. We find new type of domain wall dynamics, where pure spin currents following from a temperature gradient drag a domain wall into the hotter region.

We acknowledge financial support by the DFG through SFB 767. [1] K. Uchida et al, Nature 455, 778 (2008). [2] N. Kazantseva et al, Phys. Rev. B 77, 184428 (2008).

MA 5.7 Mon 12:30 HSZ 04

Magnon mediated heat transport — •Vitaliy I. Vasyuchka, Alexander A. Serga, Andrii V. Chumak, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

We report on measurements of heat transport mediated by a coherent magnon current in a magnetic medium. We used long-wavelength dipolar-dominated spin waves propagating along the magnetization direction in a tangentially magnetized yttrium iron garnet film. The temperature distribution in the film was visualized by means of an infrared thermography technique with a thermal sensitivity of 0.1 °C and a spatial resolution of 200 μm. A bias magnetic field of 1780 Oe was chosen to allow the effective excitation and propagation of magnons with wavevectors of the order of 100 rad/cm at 7 GHz frequency. In the presence of travelling magnons excited by applying a continuous microwave signal power of 100 mW, a strong heating of the sample (up to 23 °C) was observed around the input antenna. This heat is caused by the transfer of energy from the magnon system into the phonons. Detuning of the bias field to 1700 Oe when no magnons could be excited at the given frequency resulted in the disappearance of the observed heating effect. Comparing the obtained temperature distribution along the film with the heat profile created by a DC current in the antenna the efficiency of the travelling magnons in the process of heat transport was estimated.

MA 6: Spin Pumping/ Spin Hall Effects - Invited Talk

Time: Monday 14:00–14:30 Location: TRE Ma

Invited Talk MA 6.1 Mon 14:00 TRE Ma
Quantifying Spin Hall Effects in Nonmagnetic Metals — •Axel Hoffmann — Materials Sceince Division, Argonne National Laboratory, Argonne, IL 60439, U.S.A.

Spin Hall effects intermix spin and charge currents even in nonmagnetic materials and, therefore, offer the possibility to generate and detect spin currents without the need for ferromagnets. In order to gain insight into the underlying physical mechanism it is important to quantify the spin Hall angle γ, which is a direct measure of the charge-to-spin conversion efficiency. Towards this end we utilized non-local transport measurements with double Hall bars fabricated from gold and copper. We observe an unusual non-local resistivity that changes sign as a function of temperature. However, this results is quantitatively similar in gold and cooper, indicating that the non-local signals are not due to spin transport, suggesting an upper limit of $\gamma < 0.027$ for gold at room temperature. Therefore we developed an approach based on spin pumping, which enables us to quantify spin Hall angles with high accuracy. Spin pumping utilizes microwave excitation of a ferromagnet adjacent to a normal metal to generate a dc spin current, which can be quantified from the line-width of the ferromagnetic resonance. In this geometry voltages from spin Hall effects scale with the device dimension and therefore good signal-to-noise can be obtained even for small spin Hall angles. Using this approach we determined the spin Hall angle for a variety of non-magnetic materials (Pt, Pd, Au, and Mo) at room temperature. Financial support was through U.S. Department of Energy under Contract no. DE-AC02-06CH11357.

MA 7: SKM-SYST: Spin Caloric Transport (jointly with TT, HL)

Time: Monday 14:30–17:00 Location: TRE Ma

Invited Talk MA 7.1 Mon 14:30 TRE Ma
On the theory of the spin wave Seebeck effect — •Gerrit Bauer — Kavli Institute of NanoScience, TU Delft, Netherlands

The spin Seebeck effect, discovered by Uchida et al. [1], has been observed in various ferromagnets, such as the metal Py [1], insulating Yttrium Iron Garnet (YIG) [2], the semiconductor GaAlMn [3] and the Heusler compound Co2MnSi [4]. Possibly, the effect is caused by the non-equilibrium spin wave dynamics induced by a thermal gradient, which leads to a net spin current injected by the ferromagnet into a normal metal contact [5,6]. This mechanism appears to explain experiments on the spin Seebeck effect in YIG [2]. This talk will address new theoretical developments to understand the spin (wave) Seebeck effect.

The reported results have been obtained in collaboration with J. Xiao, K. Xia, K. Uchida, E. Saitoh, and S. Maekawa and has been support by the Dutch FOM foundation.

[1] K. Uchida et al., Nature 445, 778-781 (2008).
[2] K. Uchida et al., Nature Mater. 9, 894 (2010).
[3] C.M. Jaworski et al., Nature Mater. 9 , 898 (2010).
[4] S. Bosu et al., unpublished.
[5] J. Xiao et al., Phys. Rev. B 81, 214418 (2010).
[6] H. Adachi et al., arXiv:1010.2325.

Invited Talk MA 7.2 Mon 15:00 TRE Ma
Spin Seebeck effect in metals and insulators — •Ken-ichi Uchida and Eiji Saitoh — Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

Recent studies on spintronics and spin caloritronics have revealed that a spin current, a flow of spin angular momentum, is strongly coupled with a heat current in various magnetic systems. From both basic science and applied engineering points of view, the interplay of these two currents is of crucial importance. The spin-Seebeck effect (SSE) [1-6] is a phenomenon enabling the conversion of heat currents into spin voltage, a potential for driving nonequilibrium spin currents, in ferromagnets.

In this paper, we report the experimental observation of the SSE in ferromagnetic metals [1] and insulators [3,5]. The SSE drives a spin current flowing across an interface between a ferromagnet and an attached Pt film and the spin current is converted into electric voltage by the inverse spin-Hall effect [7] in the Pt film.

This work was supported by a Grant-in-Aid for Scientific research in Priority Area "Creation and Control of Spin Current" and Scientific Research A from MEXT, Japan.

[1] K. Uchida et al., Nature 455, 778 (2008). [2] J. Xiao et al., Phys. Rev. B 81, 214418 (2010). [3] K. Uchida et al., Nature Mater. 9, 894 (2010). [4] C. M. Jaworski et al., Nature Mater. 9, 898 (2010). [5] K. Uchida et al., Appl. Phys. Lett. 97, 172505 (2010). [6] H. Adachi et al., arXiv:1010.2325 (2010). [7] E. Saitoh et al., Appl. Phys. Lett. 88, 182509 (2006).

Invited Talk MA 7.3 Mon 15:30 TRE Ma
Spin-Seebeck effect: Local nature of thermally induced spin currents in GaMnAs — •Roberto Myers — Department of Materials Science and Engineering, The Ohio State University, Columbus, Ohio, U.S.A.

The spin-Seebeck effect refers to a spatial distribution of spins in a ferromagnetic material induced by a thermal gradient. This macroscopic spatial distribution of spins is several orders of magnitude larger than the spin diffusion length. Here we describe measurements of the spin-Seebeck effect in the ferromagnetic semiconductor, GaMnAs, and a related ferromagnetic metal MnAs. The thermally induced spatial distribution of spins is inferred from the sign and magnitude of the inverse spin Hall voltage generated from local spin currents in platinum bars that are in electrical contact with the ferromagnetic material. From an experimental point of view, GaMnAs provides unique measurement geometries since the magnetic easy axes can be engineered in different directions and the low Curie temperature makes it convenient to perform spin-Seebeck measurements across the magnetic phase transition. Using different experimental configurations we measure either the isolated spin-Seebeck signal, the planar and transverse Nernst effect, or a combination of the spin-Seebeck and Nernst effects. One of the most intriguing aspects of the spin-Seebeck effect is the observation that the spatial distribution of spins is maintained across electrical breaks revealing that the effect does not arise from a longitudinal spin current of charge carriers.

Invited Talk MA 7.4 Mon 16:00 TRE Ma
Heat conduction of low-dimensional quantum magnets — •Christian Hess[1], Nikolai Hlubek[1], Patrick Ribeiro[1], Bernd Büchner[1], Surjeet Singh[2], Romuald Saint-Martin[2], and Alexandre Revcolevschi[2] — [1]Leibniz-Institute for Solid State and Materials Research, IFW Dresden, Institute for Solid State Research, 01171 Dresden, Germany — [2]Laboratoire de Physico-Chimie de L'Etat Solide, ICMMO, UMR8182, Université Paris-Sud, 91405 Orsay, France

Some years ago, a new, magnetic mode of heat transport which occurs in low-dimensional $S = 1/2$ quantum magnets has been discovered and is intensely studied since then. The magnetic heat conductivity κ_{mag} of such quantum magnet materials can be exceptionally large (even at room temperature), dwarfs the phonon heat conduction and thereby leads to an overall magnitude of the heat conductivity which is comparable to that of metals. The analysis of κ_{mag} yields detailed information about the scattering processes which govern the magnon transport, such as scattering involving defects, phonons and magnons in the materials. After reviewing the main experimental findings, this talk focuses on recent experimental results on one-dimensional $S = 1/2$ Heisenberg chain materials. Evidence for ballistic magnetic transport and magnetic mean free paths of more than one micrometer is found in these materials, i.e. at the length scale of typical spin diffusion lengths in spintronic experiments. In our experiments we carefully study the effect of various disorder types (viz. bond disorder, magnetic and non-magnetic site disorder) on this transport phenomenon.

Invited Talk MA 7.5 Mon 16:30 TRE Ma
Evidence of spin polarized heat current acting on magneti-

zation — •Jean-Philippe Ansermet — EPFL, station 3, CH-1015 Lausanne, Switzerland

Nanomagnets of controlled geometry can be formed and contacted electrically by the method of electrodeposition in nanopores. The talk will focus on recent results, where Joule heating was used as a source of heating on a nanoscale. Evidence for thermal spin transfer torque was demonstrated (Haiming Yu, S. Granville, D. P. Yu, J.-Ph. Ansermet, Phys. Rev. Lett. 104, 146601 (2010)). Heat currents crossing the free layer of an asymmetric spin valve are shown to change its switching field. The data are accounted for with a thermodynamic model for the spin current accompanying heat transport.

MA 8: Magnetic Particles/ Clusters I

Time: Monday 14:45–17:00 Location: HSZ 103

MA 8.1 Mon 14:45 HSZ 103

Optical detection of the rotational dynamics of anisotropic magnetic nanoparticles — •Stefan Schrittwieser[1], Joerg Schotter[1], Katerina Soulantika[2], Jerome Maynadie[2], Sergio Lentijo Mozo[2], Frank Ludwig[3], Jan Dieckhoff[3], Andreas Huetten[4], and Hubert Brueckl[1] — [1]AIT Austrian Institute of Technology, Nano Systems, Vienna, Austria — [2]LPCNO-INSA, Toulouse, France — [3]TU Braunschweig, Braunschweig, Germany — [4]Bielefeld University, Bielefeld, Germany

We introduce a novel biosensor concept, which is based on anisotropic hybrid nanoparticles consisting of magnetic nanorods encapsulated by noble metal shells. It relies on highly sensitive plasmon-optical detection of the rotational dynamics of magnetic nanoparticles immersed in the sample solution, which changes when target molecules bind to the surfaces of the nanoparticles due to the increase in their hydrodynamic radii. For alignment control of the nanoparticles in suspension, we employ constant-amplitude rotating magnetic fields. The increased hydrodynamic diameter of analyte-carrying nanoparticles translates into an easily measurable phase shift. Plain Co-nanorods dissolved in toluene solution serve as model system to verify the detection principle. Those show an optical anisotropy in polarized light, which is sufficient to optically detect their mean orientation in the solution. Along with the rotational dynamics data, we also present model calculations of both the magnetic and optical properties of suitable hybrid nanoparticles along with estimates concerning their relaxation behavior and sensitivity to molecular detection.

MA 8.2 Mon 15:00 HSZ 103

Interplay between chemical and magnetic order in CoRh nanoparticles: A first principles theoretical study — •Luis Enrique Diaz Sanchez[1], Jesus Dorantes Davila[2], and Gustavo Pastor[1] — [1]Institut für theoretische physik, Universität Kassel, Heinrich Plett Str. 40, 34132 Kassel, Germany — [2]Instituto de fisica, Universidad Autonoma de San Luis Potosi, Alvaro Obregon 64, 78000 San Luis Potosi, Mexico

The ground-state magnetic properties of Co_xRh_{1-x} nanoparticles having sizes N=43, 273 and 531 atoms, and Co concentrations X = 0, 0.25, 0.5, and 0.75 are investigated in the framework of density functional theory. The role of chemical order on the magnetic behavior is quantified by considering different fully-segregated face-centered cubic atomic arrangements showing both spherical and planar CoRh interfaces: core-shell and left-right subclusters. The ground-state magnetization for each cluster is determined by using a fixed-moment method. Electron correlation effects are discussed by comparing the results of LSDA and GGA exchange-correlation functionals. All considered CoRh clusters are found to be magnetic with an average spin moment that is larger than in macroscopic alloys with similar concentrations. The effect of embedding pure Co (Rh) clusters with Rh (Co) outer shells is analyzed.

MA 8.3 Mon 15:15 HSZ 103

GMR-based real-time cell endocytosis monitoring of magnetic particles — •Astrit Shoshi, Joerg Schotter, Peter Ertl, Philipp Schroeder, Moritz Eggeling, Marcus Milnera, Verena Charwat, Florian Bellutti, Michaela Purtscher, Alexandra Keller, and Hubert Brueckl — AIT Austrian Institute of Technology GmbH; Nano Systems, Donau-City-Strasse 1, 1220 Vienna, Austria

We present a Magnetic-Lab-on-a-Chip-System (MAGLab-System) which provides a platform for on-chip cell analysis. Cell analysis is carried out by the interplay between giant magnetoresistive sensors (GMR-Sensors), superparamagnetic particles (beads) and magnetic fields in a microfluidic environment. The GMR-sensors are embedded in a silicon chip and provide electronic signals proportional to their bead surface coverage. GMR-based real-time monitoring of cell endocytosis is realized by first immobilizing magnetic beads onto the GMR-sensor surface. Second, human fibroblast cells (NHDF) are grown over the entire sensor surface to a confluent monolayer. After bead recognition, the cells start to engulf and internalize them into phagosomes. During this uptake process, the distance between the beads and the sensor increases, leading to lower stray field strengths and smaller sensor signals. Real-time monitoring of the entire dynamic uptake process is realized by reading out the sensors at appropriate time-intervals. By following a similar approach, on-chip cell migration, adhesion, detachment and magnetic manipulation have also been demonstrated successfully.

MA 8.4 Mon 15:30 HSZ 103

Template assisted self-assembly of individual and clusters of magnetic nanoparticles — Giovanni A. Badini Confalonieri[1], Victor Vega[2], Astrid Ebbing[1], Durgamadhab Mishra[1], Philipp Szary[1], Victor M. Prida[2], •Oleg Petracic[1], and Hartmut Zabel[1] — [1]Festkörperphysik, Ruhr-Universität Bochum, 44801 Bochum — [2]University Oviedo, Department of Physics, Oviedo 33007, Spain

The deliberate control over the spatial arrangement of nanostructures is the desired goal for many applications as e.g. in data storage, plasmonics or sensor arrays. Here we present a novel method to assist the self-assembly process of magnetic nanoparticles. The method makes use of nanostructured aluminum templates obtained after anodization of aluminum disks and the subsequent growth and removal of the newly formed alumina layer, resulting in a regular honeycomb type array of hexagonally shaped valleys. The iron oxide nanoparticles, 20 nm in diameter, are spin coated onto the nanostructured templates. Depending on the size, each hexagon site can host up to 30 nanoparticles. These nanoparticles form clusters of different arrangements within the valleys, such as collars, chains, and hexagonally closed islands. Ultimately, it is possible to isolate individual nanoparticles. The strengths of magnetic interaction between particles in a cluster is probed using the memory effect known from the coupled state in superspin glass systems.

MA 8.5 Mon 15:45 HSZ 103

Tight-binding theory of noncollinear magnetism in transition metal nanostructures: structural and interaction parameters dependence of clusters — •Pedro Ruiz-Díaz[1], Raúl Garibay-Alonso[1], Jesús Dorantes-Dávila[2], and Gustavo Pastor[1] — [1]Institut für Theoretische Physik, Universität Kassel, Heinrich Plett Str. 40, 34132 Kassel, Germany — [2]Instituto de Física, Universidad Autónoma de San Luis Potosí, Alvaro Obregón 64, 78000 San Luis Potosí, Mexico

A self-consistent tight-binding electronic theory of noncollinear magnetism in nanostructures is presented and applied to transition metal clusters. The electronic structure is calculated by using a realistic rotational invariant tight-binding Hamiltonian and a real-space recursive expansion of the local Green's functions. For free clusters with sizes $N \leq 13$, results are given for the ground-state local magnetic moments, magnetic order and average magnetic moments as a function of the Coulomb exchange integral J and d-band filling. A variety of qualitatively different complex noncollinear spin arrangements solutions are obtained which reveals the complex magnetic landscape in transition metal nanostructures. The onset of noncollinear magnetism is discussed by analyzing the stability of the various magnetic solutions. Structural effects are studied by considering representative compact and open geometries. Our calculations are compared with previous density-functional results. Substrate effects on the noncollinearity of the moments are discussed by considering deposited Fe_3 clusters on

Pt(111). Extensions and limitations of our work are also pointed out

MA 8.6 Mon 16:00 HSZ 103

Ab initio investigation of the role of the interatomic distances to optical spin manipulation in metallic three-center magnetic clusters — •Hongping Xiang, Georg Lefkidis, and Wolfgang Hübner — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern

Recently, laser-induced femtomagetism opened a new frontier for the faster magnetic logic devices in order to complement conventional elements [1]. The laser-induced spin flip and transfer in magnetic multicenter nanostructures have been investigated widely as an appealing alternative. Previously, we found that in the realistic three-center metallic cluster Ni$_3$Na$_2$ (3.6 Å interatomic distance), laser-induced a spin flip and transfer can be achieved within a hundred femtoseconds [2]. Here, we investigate the effect of the structural distortion of Ni$_3$Na$_2$ on the magnetic state and the speed and fidelity of spin flip and transfer by changing the interatomic distances. If we decrease the interatomic distance in steps of 0.05 Å the spin localization remains the same but the spin density decreases. When the distance reaches 3.4 Å the spin localization changes as well. Similar effects appear if we increase the distance. We further investigate these effects on the speed and the fidelity of the Λ processes.

\noindent [1] G. P. Zhang, W. Hübner, G. Lefkidis, Y. Bai, T. F. George, Nat. Phys. {\bf 5}, 499 (2009)

\noindent [2] W. Hübner, Kersten, S., Lefkidis, G., Phys. Rev. B {\bf 79}, 184431 (2009)

MA 8.7 Mon 16:15 HSZ 103

Studying the effect of particle size and organic capping on magnetic and structural properties of iron oxide nanoparticles by Mössbauer spectroscopy — •Masih Darbandi, Frank Stromberg, Joachim Landers, Carolin Antoniak, Werner Keune, and Heiko Wende — Faculty of Physics and CeNIDE, University of Duisburg-Essen, Germany

Iron oxide nanoparticles have been extensively studied and are attracting growing interest due to their unique intrinsic magnetic properties combined with the nano-size effects. It is well-known that these nanostructured magnetic materials have great potential for many useful applications ranging from information storage and electronic devices to biomedical applications and drug delivery. We have synthesized uniform-sized and crystalline iron oxide nanoparticles in high yield using a microemulsion route at room temperature. Particle size control has been attained by careful adjustment of the preparation conditions. Complementary techniques such as TEM, XRD, SEM were used for the evaluation of their structural and physicochemical properties. A particular effort has been devoted in this work to study the effect of the size and capping of these nanoparticles by Mössbauer spectroscopy at low temperature and with the application of magnetic fields up to 5 T. The sample with the smallest diameter exhibits a markedly different Mössbauer spectrum compared with bigger particles. Most importantly the separation of a surface/volume contribution for the capped nanoparticles with Mössbauer spectroscopy will be reported. Supported by DFG (WE 2623/3-1)

MA 8.8 Mon 16:30 HSZ 103

Magnetic and transport properties of Py/iron-oxide nanoparticle composite systems — •Philipp Szary[1], Giovanni A. Badini Confalonieri[1], Durgamadhab Mishra[1], Maria Jose Benitez[1,2], Mathias Feyen[2], Anhui Lu[2], Leonardo Agudo[3], Gunther Eggeler[3], Oleg Petracic[1], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Max-Planck Institut für Kohlenforschung, D-45470 Mülheim an der Ruhr, Germany — [3]Institut für Werkstoffe, Ruhr-Universität Bochum, D-44780 Bochum, Germany

We have investigated the magnetic and electrical transport properties of Permalloy/iron-oxide nanoparticle-composite systems. Ultrathin films of Permalloy (Py) have been prepared by UHV ion beam sputtering and subsequently covered by one monolayer of iron-oxide nanoparticles. Post-annealing of the samples under controlled atmospheric conditions allows us to transform the particles into a mixed wüstite/magnetite (Fe_xO/Fe_3O_4) phase [1]. Magnetometry measurements have been performed using superconducting quantum interference device (SQUID) magnetometry. M(H) magnetic hysteresis curves reveal a strong magnetic coupling between both subsystems. Moreover, magnetoresistance measurements were performed by contacting the Py layer. The results are consistent with the magnetometry data. We find that the presence of the nanoparticles significantly influences the magneto-transport behavior through the Py layer.

[1] M.J. Benitez et al., submitted (arXiv:1010.0938)

15 min. break

MA 9: Magnetic Materials I

Time: Monday 14:45–17:00 Location: HSZ 401

MA 9.1 Mon 14:45 HSZ 401

Magnetoresistance and Anomalous Hall Effect of Ferromagnetic Half-Metallic Heusler Compound Co_2FeSi — •Dirk Bombor, Oleg Volkonskyi, Christian G. F. Blum, Steven Rodan, Mahmoud Abdel-Hafiez, Anja Wolter, Sabine Wurmehl, Christian Hess, and Bernd Büchner — Leibnitz Institute for Solid State and Materials Research, IFW Dresden, Germany

Electronic transport properties of the Heusler Compound Co_2FeSi have been studied. This compound is a soft ferromagnet which is predicted to be half-metallic — this means complete spin polarization of the conducting electrons. Its resistivity behaviour in dependence of the temperature is typical for ferromagnetic compounds, and is dominated by scattering of the charge carriers at spin fluctuations. This scattering is suppressed at low temperatures due to an energy gap where this gap can be attributed to the half-metallic property of this compound. A positive magnetoresistance at low temperatures and a negative magnetoresistance at high temperatures has been observed as well as an anomalous Hall effect which is found to be driven by scattering of conducting electrons at magnetic scattering centres.

MA 9.2 Mon 15:00 HSZ 401

Magnetism of quaternary Heusler alloys — •Josef Kudrnovsky[1], Shyamal Bose[2], Ilja Turek[3], and Vaclav Drchal[1] — [1]Institute of Physics AS CR, Prague — [2]Brock University, St. Catharines — [3]Institute of Physics of Materials AS CR, Brno

The electronic properties, exchange interactions, finite-temperature magnetism and transport properties of random Ni2MnSn quaternary Heusler alloys doped with Cu- and Pd-atoms are studied theoretically by means of first-principles calculations over the entire concentration range. While the magnetic moments are only weakly dependent on the alloy composition, the Curie temperatures exhibit strongly non-linear behavior with respect to Cu-doping in contrast with an almost linear concentration dependence in the case of Pd-doping. The residual resitivity obey the Nordheim rule while the dominating contribution to the temperature-dependent resistivity is due to thermodynamical fluctuations originating from the spin-disorder, which, according to our calculations, can be described reasonably well via the disordered local moments model. The present parameter-free theory agrees qualitatively and also reasonably well quantitatively with all available experiments.

MA 9.3 Mon 15:15 HSZ 401

Structural, magnetic and electronic properties of a new silicide MnPtSi — •Monika Gamza[1,2], Sarah Ackerbauer[1], Andreas Leithe-Jasper[1], Walter Schnelle[1], Helge Rosner[1], and Yuri Grin[1] — [1]MPI CPfS Dresden — [2]Institute of Materials Science, University of Silesia, Katowice, Poland

Recent results concerning giant exchange-derived magnetoelastic coupling in a metamagnet MnCoSi (TiNiSi-type structure) [1] as well as intriguing magnetic properties of the isostructural compounds MnTX (T = transition metal element; X = Si, Ge) [2] prompted us to search for consecutive members of this family.

Here, we report on the crystal structure, electronic structure and magnetic properties of the new compound MnPtSi. The Mn K XAS

data indicate a divalent state of Mn ions. The effective moment derived from high-temperature magnetic susceptibility of $4.1\mu_B$ indicates an intermediate spin state of Mn ions. These findings have been confirmed by first principles electronic structure calculations. Thermodynamic measurements revealed two successive magnetic phase transitions at $T_C \approx 350$ K and $T_N \approx 326$ K. The FM to AFM transition is accompanied by a large magneto-volume effect ($\Delta V/V$ reaches $\sim$1.4%) and a change in Mn-Mn distances of up to 1%. The origin of the strongly anisotropic thermal expansion is analyzed.

[1] Barcza A. *et al.*, Phys. Rev. Lett. (2010) **104** 247202

[2] Eriksson T. *et al.*, Phys. Rev. B (2005) **71** 174420 and references there in

MA 9.4 Mon 15:30 HSZ 401

Ab initio modeling of Fe-Mn based alloys — •Denis Comtesse, Heike C. Herper, Mario Siewert, Alfred Hucht, and Peter Entel — Faculty of Physics - University of Duisburg-Essen, 47048 Duisburg, Germany

We present ab initio calculations of structural and magnetic properties of iron-manganese alloys over a wide range of compositions using VASP [1]. We add different amounts of carbon and silicon on complete relaxed interstitial and substitutional lattice positions and analyze the changes of the magnetic exchange interactions J_{ij}. The exchange parameters are used for Monte Carlo simulations of the Heisenberg model to extend the analysis of the magnetic behavior to finite temperatures and to determine the magnetic transition temperatures. In order to examine the influence of disorder we employed the KKR-CPA method [2] and calculated the exchange parameters for various types of disorder. We find a strong dependence of the critical temperature on the disorder and the carbon content. The disorder always tends to reduce the transition temperature. In case of high carbon concentrations, ordered systems show a strong relation between the iron-manganese composition and the transition temperature.

[1] G. Kresse and J. Furthmüller, Phys. Rev B **54**, 11169 (1996)

[2] The Munich SPR-KKR package, version 3.6, H. Ebert et al.

MA 9.5 Mon 15:45 HSZ 401

The effect of boron doping on the magnetostriction of Fe-Ga and Fe-Al samples — •Mathias Doerr[1], Claudio Teodoro dos Santos[2], Sergey Granovsky[1], Cristina Bormio-Nunes[2], and Michael Loewenhaupt[1] — [1]TU Dresden, Institut für Festkörperphysik, D-01062 Dresden, Germany. — [2]Universidade de Sao Paulo, Escola de Engenharia de Lorena, CA 116 CEP 12602-810 Lorena, Brazil.

Fe-Ga (Galfenol) based alloys are used in a number of magnetomechanical applications because of the high magnetostriction values of more than 100 ppm at room temperature. The addition of boron inhibits the crystallographic ordering of the alloys and stabilizes the disordered A2 structure that is responsible for the high striction values. Especially, polycrystalline and rapid cooled Fe-Ga-B and Fe-Al-B samples were investigated in our project. Magnetization and longitudinal as well as transversal magnetostriction measurements at temperatures of 5K, 80K and 300K show a similar effect of the amount of B as found on single crystals. Whereas the saturation magnetization is nearly the same and mainly determined by the Fe content, a dependence of the striction values on the amount of B is visible (more than 10% in the Fe-Al system). The results illustrate the influence of the stoichiometry and the preparation conditions on the magnetomechanical properties.

MA 9.6 Mon 16:00 HSZ 401

Development of magnetic moments in $Fe_{1-x}Ni_x$ - alloys — Benjamin Glaubitz, Stefan Buschhorn, Frank Brüssing, and •Hartmut Zabel — Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

$Fe_{1-x}Ni_x$ alloys have been studied intensively in the past because of their unique properties, such as the soft magnetic properties at x = 0.8 and the martensitic bcc-fcc transition at x = 0.35. The total magnetic moment as a function of alloy concentration follows by and large the Slater Pauling curve, but not in the region of the martensitic transition, where a strong drop is observed, which has been taken as a sign for strong magneto-volume fluctuations, also known as the invar effect. Using XMCD methods, we have analyzed the individual magnetic moments of Fe and Ni across the alloy concentration range, including their spin and orbital contributions, and we have compared those with the average moments determined by VSM measurements. We find a very good agreement between both methods, with the individual moments showing some fluctuations at the invar concentration but no anomaly. We will discuss the results in the light of recent theoretical predictions [1].

[1] I.A. Abrikosov, A.E. Kissavos, F. Liot, B. Alling, S.I. Simak, O. Peil, A.V. Ruban, Phys. Rev. B **76**, 014434 (2007)

MA 9.7 Mon 16:15 HSZ 401

Precursor Phenomena at the Magnetic Ordering of the cubic Helimagnet FeGe — •Michael Baenitz[1], Heribert Wilhelm[2], Marcus Schmidt[1], Ulrich K. Rössler[3], Alexei N. Bogdanov[3], and Andrey A. Leonov[3] — [1]MPI CPfS, Noethnitzer Str. 40, 01187 Dresden — [2]Diamond Light Source Ltd., Chilton, Didcot, OX11 0DE, United Kingdom — [3]IFW Dresden, Postfach 270116, 01171 Dresden

We report on detailed magnetic measurements on the cubic helimagnet FeGe in external magnetic fields parallel to the [100] direction and temperatures in the vicinity of the onset of long-range magnetic order at $T_c \approx 278$ K. Depending on the temperature and field, a helical state ($H < H_{c1}$), a conical phase ($H_{c1} < H < H_{c2}$), or the so-called A-phase were observed below H_{c2} at which the field-polarized state occurs. Precursor phenomena found above T_c display a complex succession of temperature-driven cross-overs and phase transitions. The A-phase pocket is split in at least two distinct areas, A_1 and A_2. The area A_1 at lower fields shows clear lines of transitions into the conical phase at lower temperature and into the A_2 area at higher fields. The area A_2 appears to transform continuously into the conical phase. Relying on a modified phenomenology for chiral magnets, the A_1 phase could indicate existence of a $+\pi$ Skyrmion lattice, however, the A_2 phase seems related to helicoids propagating in directions perpendicular to the applied field. We suggest that the observation of this A_2-phase can be explained by hexagonal arrays of spiral domains consisting essentially of helicoids.

MA 9.8 Mon 16:30 HSZ 401

Evaluation of magnetic anisotropy energy in a relativistic picture — •Toshio Miyamachi[1], Tobias Schuh[1], Shih-Yu Wu[2], Chein-Cheing Kuo[2], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Karlsruher Institut für Technologie, Germany — [2]Department of Physics, National Sun Yat-sen University, Taiwan

The magnetic stability of nanostructures is relied on the magnetic anisotropy energy (MAE). The MAEs of small clusters are experimentally evaluated with two different models. Firstly, the effective spin model is used for inelastic tunneling spectroscopy (ITS) [1]. In this model, only an effective spin S is treated. Secondly, the Bruno model is used for X-ray magnetic circular dichroism (XMCD), where the MAE is linked to an anisotropy of the orbital momentum L [2]. To bring these models together, we propose a relativistic model with the total angular momentum J = L + S. Within our relativistic model, the MAE of a Co single atom on Pt(111) obtained with ITS [3] is reevaluated as 13.7 meV/atom. The validity of our model is verified by comparing calculated magnetization curves with experimental ones obtained by XMCD and spin-polarized scanning tunneling microscopy [4,5].

[1] C. F. Hirjibehedin et al., Science 317, 1199 (2007)

[2] P. Pruno, Phys. Rev. B 39, 865 (1989)

[3] T. Balashov et al., Phys. Rev. Lett. 102, 257203 (2009)

[4] P. Gambardella et al., Science 300, 1130 (2003)

[5] F. Meier et al., Science 320, 82 (2008)

15 min. break

MA 10: Magnetization Dynamics I

Time: Monday 14:45–17:00 Location: HSZ 403

MA 10.1 Mon 14:45 HSZ 403

Direct observation of four-magnon scattering in spin-wave micro-conduits — Helmut Schultheiss[1,2], •Katrin Vogt[1], Philipp Pirro[1], Thomas Brächer[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Materials Science Division, Argonne National Laboratory, Argonne, IL 60439

We report on experiments which demonstrate the intrinsic nonlinear damping of spin waves due to four-magnon scattering processes in a micrometer sized permalloy stripe. The magnetization is excited by a microwave current transmitted through the shorted end of a coplanar waveguide. The excitation spectrum of the spin wave is locally probed by Brillouin light scattering microscopy for different excitation frequencies covering a range of excitation powers over three orders of magnitude. We find a transition from a pure and clean monochromatic excitation of spin waves at low microwave powers to a large broadening above a certain threshold power. The spectral distribution of the measured spin-wave intensities shows a unique profile which is in good agreement with theoretical expectations for four-magnon scattering processes.

Financial support by the Carl-Zeiss-Stiftung and the Graduate School of Excellence "Materials Science in Mainz" is gratefully acknowledged. The authors thank the Nano+Bio Center of the Technische Universität Kaiserslautern and A. Beck for sample preparation.

MA 10.2 Mon 15:00 HSZ 403

Interference of two magnon-Bose-Einstein-condensates in real space — •Patryk Nowik- Boltyk, Oleksandr Dzyapko, Vladislav Demidov, and Sergej O. Demokritov — Institute of Applied Physics, University of Münster, 48149 Münster, Germany

Since the discovery of Bose-Einstein condensation (BEC) of microwave-driven magnons in ferrite films [1] at room temperature several indirect demonstrations of the time and spatial coherence of the magnon-condensate have been published [2,3,4]. However, the most direct confirmation of the coherence is the interference of two condensates. The main distinction of magnon BEC from other BEC-systems is that it takes place at a quantum state with a non-zero wavevector, k. Due to the obvious symmetry of the system two condensates at +k and -k are simultaneously created in the same region of the real space.

Here we present the observation of the spatial inference of two condensates corresponding to +k and -k. To keep the coherence during the time of the measurement, the magnon gas was driven by microwaves continuously and two dimensional spatial interference patterns of the total condensate density in real space were mapped using the Brillouin light scattering spectroscopy. The wavevector of the condensate obtained from the spatial period of the patterns matches very well with the data of previous measurements in the phase space [4].

[1]Demokritov *et al.*, Nature 443, 430 (2006)
[2]Demokritov *et al.*, New Journal of Physics 10, 045029 (2008)
[3]Dzyapko *et al.*, Appl. Phys. Lett. 92, 162510 (2008)
[4]Demidov *et al.*, Phys. Rev. Lett. 101, 257201 (2008)

MA 10.3 Mon 15:15 HSZ 403

Dynamics of field-driven vortex walls in GMR nanostripes under the influence of transverse fields — •Björn Burkhardt, Sascha Glathe, and Roland Mattheis — IPHT Jena e.V., Albert-Einstein-Str. 9, 07745 Jena

The character of DW movement in nanostripes (l»w»d)is mainly determined by the thickness and width of a nanostripe. Two different types of domain walls, vortex (VW) or transverse walls (TW), can occur in these nanostripes. We have charcterized wide nanostripes (w = 500nm) with a thickness of 20nm. In these dimensions VW are energetically preferred. However, for fields above a critical field H_{cr} (well below the Walker field H_w) the VW is converted to a TW.

The dependence of DW velocity on the applied field was measured using the giant GMR effect between a sense layer (NiFe) and a reference layer (CoFe - part of an AAF/AF-combination). We applied field pulses to investigate the DW motion independently of the nucleation field. Short current pulses in a coplanar wave guide crossing the GMR nanostripe were used to generate the magnetic field. The parameters of field driven DW motion e.g. critical field, Walker field and mobilities in the different regions were determined. Especially the VW characteristics below H_w are rarely treated, yet. The precession period of the domain wall above H_w was estimated by means of measurements with different pulse length.

Furthermore we will show the influence of an in-plane transverse field on the DW dynamics in wide nanostripes by simulations and experimental results.

MA 10.4 Mon 15:30 HSZ 403

Generation of Domain Walls by Local Magnetic Fields — •Falk-Ulrich Stein, Lars Bocklage, Michael Martens, Toru Matsuyama, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

In recent years attention focussed on investigations of domain walls in nanowires for application in a racetrack memory [1]. While the field- and current-driven propagation of domain-walls along nanowires was the core theme in most cases [2,3], the study of domain-wall creation by local Oersted-fields has not been in focus. Mostly global fields are used to create domain walls. For devices such fields are improper because of their low efficiency, long time constants and overall impact on the magnetic structure. Our work investigates the creation of domain walls by local fields of a strip line. We present measurements of stochastic field-pulse induced domain-wall formation. From those results the strength and duration of the local fields are gained, which are required for the creation. The creation itself is investigated by micromagnetic simulations and by time-resolved measurements of the anisotropic magnetoresistance.

[1] S.S.P. Parkin, et al., Science 320, 190 (2008)
[2] G. Meier, et al., Phys. Rev. Lett. 98, 187202 (2007)
[3] L. Bocklage, et al., Phys. Rev. Lett. 103, 197204 (2009)

MA 10.5 Mon 15:45 HSZ 403

Indirect control of antiferromagnetic domain walls with spin current — •Robert Wieser, Elena Y. Vedmedenko, and Roland Wiesendanger — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, D-20355 Hamburg, Germany

Current induced domain wall motion is an important aspect in magnetism due to its potential applications in magnetic memory and logic devices. The motion of domain walls directly influenced by spin currents associated with a spin transfer torque has been studied experimentally and theoretically. However, the investigations of current driven antiferromagnetic domain walls is very limited. In this talk we propose two promising directions for experiments on the indirect control of an antiferromagnetic (AFM) domain wall. The antiferromagnetic domain wall can be shifted both by a spin-polarized tunnel current of a scanning tunneling microscope or by a current driven ferromagnetic domain wall in an exchange coupled antiferromagnetic/ferromagnetic layer system. While the manipulation using an SP-STM tip is restricted to the atomic length scale, the controlled interaction between domain walls is important for the development of new solid state devices. Furthermore, the results contribute to an improved understanding of the exchange bias effect and provide new insight into the domain wall dynamics of filled nanotubes.

MA 10.6 Mon 16:00 HSZ 403

Insights on all-optical magnetization switching by tailoring optical excitation parameters — •Sabine Alebrand, Daniel Steil, Alexander Hassdenteufel, Mirko Cinchetti, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67653 Kaiserslautern, Germany

In 2007 Stanciu et al. [1] discovered that it is possible to switch the magnetization in GdFeCo by using circularly polarized laser pulses. A phenomenological description of this effect based on the inverse Faraday Effect (IFE) was presented by Vahaplar et al. in 2009 [2]. Nevertheless until now the microscopic processes leading to all-optical switching are still unclear.

In this talk we focus on the investigation of the all-optical switching behaviour by changing the properties of the exciting laser pulse. We present wavelength- and pulse duration-dependent studies and demonstrate that all-optical switching is possible for all wavelengths in the visible range as well as for pulse durations up to almost 4 ps. In addi-

tion we show that the threshold fluence needed for all-optical switching is nearly independent on the pulse duration. We discuss our results in the context of the existing model based on the IFE and draw some conclusions with respect to possible microscopic mechanisms behind all-optical switching. This work was supportet by the EU project UltraMagnetron (NMP3-SL-2008-214469).
[1] Stanciu et al. PRL 99, 047601 (2007)
[2] Vahaplar et al. PRL 103, 117201 (2009)

MA 10.7 Mon 16:15 HSZ 403

Cherenkov-like spin wave emission by supermagnonic domain walls in ferromagnetic nanotubes — •Christian Andreas[1], Ming Yan[1], Attila Kákay[1], Felipe Garcia-Sanchez[1], and Riccardo Hertel[1,2] — [1]Institut für Festkörperforschung, Elektronische Eigenschaften, Forschungszentrum Jülich GmbH — [2]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg, CNRS UMR 7504

The micromagnetic structure of vortex walls in nanotubes is comparable to that of transverse walls in thin strips, since the orientation of transverse walls corresponds to the vorticity of vortex walls in nanotubes [1]. In spite of this similarity of their static structures, we found that the dynamic properties of these domain walls (DWs) differ significantly. Unlike DWs in thin strips, the left-right symmetry of DW mobility is broken. While head-to-head DWs with left-handed chirality lead to a Walker breakdown [2] above a limiting velocity, those with right-handed chirality can reach propagation velocities beyond the phase velocity of spin waves (about 1000 m/s). As soon as the minimum spin-wave phase velocity is reached, tails of spin waves are formed in front of and behind the DW. Such a spontaneous emission of spin waves is analogous to Cherenkov radiation emitted by charged particles moving in a dielectric medium at velocities above the speed of light. The moving DW with attached spin-wave tails reaches a dynamic equilibrium and propagates as a topological soliton afterwards.
[1] R. Hertel et al., J. Magn. Magn. Mater. 278 291 (2004)
[2] N. L. Schryer and L. R. Walker, J. Appl. Phys. 45, 5406 (1974)

MA 10.8 Mon 16:30 HSZ 403

Imaging of the spin-wave eigenmodes of a garnet-film disc — Matthias Buchmeier, •Eric R.J. Edwards, Vladislav E. Demidov, and Sergej O. Demokritov — Institute for Applied Physics, University of Münster, Corrensstraße 2-4, 48149 Münster, Germany

Macroscopic structures based on low-loss garnet films are an ideal model system for the space-resolved investigation of spin-wave dynamics. Here we investigate the dipolar eigenmodes of a garnet-film disc by means of time- and space-resolved Faraday-effect microscopy. Thanks to the macroscopic dimensions of the studied samples, we were able to reliably image spatial profiles of the modes up to very high order. Our results show that the usual classification of eigenmodes based on their consideration as a product of standing waves in two orthogonal directions is not fully applicable in the case of in-plane magnetized disc samples. We find that the spatial distributions of the dynamic magnetization for the eigenmodes are strongly influenced by the intrinsic anisotropy of the dipolar spin-wave spectrum. Moreover, this anisotropy also leads to an appearance of a fine spatial structure, whose symmetry differs from the geometrical symmetry of the samples. These experimental results are corroborated by micromagentic simulations.

15 min. break

MA 11: Multiferroics I: Structure and Phase Transitions (jointly with DF, DS, KR, TT), Program coordination: I. Mertig, M. Fiebig

Time: Monday 14:45–17:00 Location: HSZ 04

MA 11.1 Mon 14:45 HSZ 04

DFT calculation of $ACrO_3$ perovskites using hybrid functionals — •Martin Schlipf[1], Alessandro Stroppa[2], Silvia Picozzi[2], and Marjana Ležaić[1] — [1]Forschungszentrum Jülich, Peter Grünberg Institut and JARA, Germany — [2]CNR-SPIN, L'Aquila, Italy

Density-functional theory (DFT) is a very powerful tool for understanding the properties of several crystals and molecules. Novel hybrid exchange-correlation functionals, which include a fraction of Hartree-Fock exchange, improved the predictive power of DFT further. In this contribution, we have studied the $ACrO_3$ (A = Ca, Sr, Pb) perovskite compounds by DFT. These materials have recently gained a renewed interest, because they offer a rich phase-space of electronic, magnetic and structural transitions. The origins of several of these transitions are not understood, yet. In $SrCrO_3$ different authors report different electronic (metal/insulator) and magnetic (Pauli paramagnetic/Curie Weiss) configurations. It is not clear yet what is the ground state of this compound. In $PbCrO_3$ theoretical calculations predict a conducting state whereas experimentally a metal is found. We use a multi-code approach and clarify these issues from first-principles.

We gratefully acknowledge the support from HGF Nachwuchsgruppe Programme VH-NG-409.

MA 11.2 Mon 15:00 HSZ 04

Optical properties of $BiCrO_3$ — •Cameliu Himcinschi[1], Ionela Vrejoiu[2], Silvia Bahmann[1], Kannan Vijayanandhini[2], Adreas Talkenberger[1], Christian Röder[1], Dietrich R.T. Zahn[3], Alexei A. Belik[4], and Jens Kortus[1] — [1]TU Bergakademie Freiberg, Institute for Theoretical Physics, D-09596 Freiberg — [2]Max Planck Institute of Microstructure Physics, D-06120 Halle — [3]TU Chemnitz, Semiconductor Physics, D-09107 Chemnitz — [4]International Center for Materials Nanoarchitectonics, National Institute for Materials Science, Tsukuba, Ibaraki 305-0044, Japan

Multiferroic materials that simultaneously show polarization and magnetization ordering are envisaged to play a significant role in developing devices with large magnetoelectric coupling. An interesting candidate for intrinsic multiferroism is $BiCrO_3$ (BCO). In this work, the optical properties of polycrystalline BCO ceramics and epitaxial BCO films deposited on $NdGaO_3$(110) substrates are investigated by Raman spectroscopy and spectroscopic ellipsometry. The spectral changes seen in temperature-dependent Raman measurements correlate well to a structural phase transition from a monoclinic structure (space group *C2/c*) to an orthorhombic structure (space group *Pnma*) at about 420 K. The room temperature dielectric function of a 55 nm thick BCO film deposited on $NdGaO_3$ substrate is determined by analyzing ellipsometry data and exploited to estimate the BCO band-gap. The imaginary part of the dielectric function calculated by means of density functional theory shows good agreement with the experimental one. *This work was supported by the German Research Foundation DFG HI 1534/1-1.*

MA 11.3 Mon 15:15 HSZ 04

Pressure induced phase transitions in $MnTiO_3$: Insights from First Principles calculations — •Carmen Quiroga and Rossitza Pentcheva — Section Crystallography, Dept. of Earth and Environmental Sciences, University of Munich

$MnTiO_3$ crystallizes in the ilmenite structure at ambient conditions and remains stable at least up to 26 GPa [1]. A denser $LiNbO_3$ phase can be quenched from high pressure and high temperature experiments to ambient conditions [2]. Our density functional theory calculations, including an on-site Coulomb repulsion term (LDA/GGA+U), show a transition from the $LiNbO_3$ to the perovskite phase at 2.5 GPa in agreement with experiments [3]. A transition from perovskite to the post-perovskite phase ($CaIrO_3$-type) is predicted at pressures above 50 GPa. Furthermore, the magnetic coupling of the Mn ions and the possibility of spin transitions in the different phases are explored.

Funding by DFG SPP1236 (PE883/8-1) is acknowledged.
[1] X. Wu et al. Geoscience Frontiers, in press (2010).
[2] J. Ko and C.T. Prewitt. Phys. Chem. Minerals **15**, 355 (1988).
[3] N. Ross et al. Phys Chem Minerals **16**, 621 (1989).

MA 11.4 Mon 15:30 HSZ 04

Resonant Soft X-ray Scattering (RSXS) Studies on Multiferroic YMn2O5 — •Sven Partzsch[1], Stuart Wilkins[2], John Hill[2], Enrico Schierle[3], Eugen Weschke[3], Dmitri Souptel[1], Bernd Büchner[1], and Jochen Geck[1] — [1]IFW Dresden — [2]BNL Upton — [3]Helmholz-Zentrum Berlin

Multiferroic RMn_2O_5 (R = Y, rare earth, Bi) displays a complex magnetic behavior with transition into a ferroelctric phase as a function

of temperature. The intensity of the magnetic superlattice reflection $(1/2, 0, 1/4)$ displays a strong resonance at the Mn L_{23}-edge, due to the strongly increased magnetic sensitivity close to the absorption edge.

Surprisingly, we also observe that this magnetic peak also displays a strong resonance at the oxygen K-edge. The measured integrated intensity of this reflection at the Mn L_3-edge in the commensurate and incommensurate magnetic phase is essentially unchanged. At the oxygen K-edge, however, a strong drop of the temperature dependent integrated intensity is observed at the corresponding phase transition, which resembles the temperature dependence of the ferroelectric polarization. Therefore RSXS at the different edges might provide more information about the origin of ferroelectricity in these frustrated magnets.

The experimental data together with LSDA+U calculations provide evidence that magnetically driven charge transfer between oxygen and manganese plays an important role for the ferroelectricity in these frustrated magnets.

MA 11.5 Mon 15:45 HSZ 04

Dilatometric studies of the multiferroic $FeTe_2O_5Br$ — •Christian Balz[1], Mariano de Souza[1], Matej Pregelj[2], Helmuth Berger[3], Denis Arčon[2], and Michael Lang[1] — [1]Physikalisches Institut, Goethe-Universität, D-60438 Frankfurt(M), SFB/TR49, Germany — [2]Institute "Jozef Stefan", Jamova 39, 1000 Ljubljana, Slovenia — [3]Institute of Physics of Complex Matter, EPFL, 1015 Lausanne, Switzerland

We report on high-resolution directional dependent thermal expansion measurements of the novel multiferroic system $FeTe_2O_5Br$ [1]. Our results reveal two distinct phase transition anomalies centered at $T_{N1} = 11.0$ K and $T_{N2} = 10.6$ K, which coincide with the transitions observed in other quantities [2]. A rounded minimum in α_c shows that short-range magnetic correlations within the crystal layers start to develop already above T_N. At T_{N1}, the system undergoes a magnetic phase transition into the high-T incommensurate (HT-ICM) phase. Interestingly, at T_{N2}, a second phase transition into the low-T incommensurately modulated (LT-ICM) phase is observed, which is accompanied by a spontaneous electric polarization. When magnetic field is applied, the transition temperatures shift depending on the field orientation. In the case of $B \| b > 4.5$ T, the HT-ICM phase merges into the LT-ICM phase. Despite the pronounced lattice effects observed at T_{N2} at 6 T, the electric polarization is destroyed. The rich low-T magnetic phase diagram of $FeTe_2O_5Br$ will be discussed in details [2].

[1] M. Pregelj *et al.*, Phys. Rev. Lett. **103**, 147202 (2009).
[2] M. Pregelj *et al.*, Phys. Rev. B **82**, 144438 (2010).

MA 11.6 Mon 16:00 HSZ 04

Investigation of multiferroic order in M_3TeO_6 (M=Co, Mn, Ni) by second harmonic generation — •Vera Carolus[1], Thomas Lottermoser[1], Sergey A. Ivanov[2], Matthias Weil[3], Roland Mathieu[4], Matthias Hudl[4], Per Nordblad[4], and Manfred Fiebig[1] — [1]HISKP, University of Bonn, Germany — [2]Department of Inorganic Materials, Karpov' Institute of Physical Chemistry, Vorontsovo pole, 10 105064, Moscow K-64, Russia — [3]Institute of Chemical Technologies and Analytics, Vienna University of Technology, Austria — [4]Department of Engineering Sciences, Uppsala University, Box 534, SE-751 21 Uppsala, Sweden

Orthotellurates with the formula M_3TeO_6 are structurally well characterized and can be divided into six different structure types. According to this, these materials show a wide range of magnetic phases. Recently it was suggested, that in some of the orthotellurates multiferroic order is possible.

Among this are: Co_3TeO_6 (space group C2/c) and Mn_3TeO_6 ($R\bar{3}$) with two magnetic phase transitions as well as Ni_3TeO_6 (R3) with one magnetic phase transition. However, a direct proof of ferroelectricity has not been reported so far.

Here, we investigate the multiferroic order by second harmonic generation (SHG) spectroscopy. For Co_3TeO_6 we measured a intense SHG contribution in the low temperature phase below 18 K, which is a strong evidence for multiferroic order. This interpretation is supported by the observation of complex domain patterns using SHG imaging techniques.

MA 11.7 Mon 16:15 HSZ 04

Optical Spectroscopy on the triangular antiferromagnet $CuCrO_2$ — •Michael Schmidt, Zhe Wang, Franz Mayr, Vladimir Tsurkan, Joachim Deisenhofer, and Alois Loidl — Experimental Physics 5, Center for Electronic Correlations and Magnetism, Institute of physics, Augsburg University, Germany

$CuCrO_2$ belongs to the class of triangular lattice antiferromagnets and shows ferroelectricity below $T_{FE} \approx 24$ K [1] while the spins order in a proper screw [2]. Already a moderate magnetic field of 5.3 T can flop the plane of the spins and the polarization. A microscopic theory [3] explains this by the variation of the spin-orbit coupling with the metal-ligand (d-p) hybridization. Recently, electromagnons (magnetic excitations excited by electric field) have been detected in the related compound $Cu(Fe,Al)O_2$ [4] in the submillimeter range. We report on the optical excitation spectrum of $CuCrO_2$ including phonons, crystal-field excitations and magnon sidebands. The relation of magnon lifetime with the possible formation of Z_2 vortices in this system is discussed.

[1] K. Kimura et al., Phys. Rev. B 78, 140401 (2008)
[2] S. Seki et al., Phys. Rev. Lett. 101, 067204 (2008)
[3] T. Arima J. Phys. Soc. Jap. 76, 073702 (2007)
[4] S. Seki et al., Phys. Rev. Lett. 105, 097207 (2010)

MA 11.8 Mon 16:30 HSZ 04

New design for magnetoelectric switch from first principles — •Michael Fechner[1], Peter Zahn[2], Sergey Ostanin[1], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik Halle, Germany — [2]Fachgruppe Theoretische Physik, Martin-Luther-Universität Halle-Wittenberg

Saving information in a magnetic bit requires at least two stable magnetic states that can be distinguished. In conventional hard disks two opposite directions of the magnetization provide these two states. The magnetic state is changed by an external magnetic field thus writing information, whereas reading is performed by the usage of the GMR effect (giant magnetoresistance) [1]. Based on ab intio material design we propose a new hybrid magnetoelectric that allows this switching of the magnetic states by an applied electric field instead of the magnetic field. The switching in the proposed multilayer system is based on internal electronic couplings without any strain. Thus, it is a promising candidate for application in future magnetoresistive random access memory (MRAM).

[1] Baibich et al., PRL 61, 2472-2475, (1988)

15 min. break

MA 12: Magnetic Particles/ Clusters II

Time: Monday 17:00–19:15 Location: HSZ 103

MA 12.1 Mon 17:00 HSZ 103

Structural and magnetic characterization of self assembled iron oxide nanoparticles — •Durgamadhab Mishra[1], Maria Jose Benitez[1], Philipp Szary[1], Giovanni A Badini Confalonieri[1], Mathias Feyen[2], Anhui Lu[2], Leonardo Agudo[3], Günther Eggeler[3], Oleg Petracic[1], and Hartmut Zabel[1] — [1]Festkörperphysik, Ruhr Universität Bochum D -44780 Bochum — [2]Max-Planck-Institut für Kholenforschung, D-45470 Mülheim an der Ruhr — [3]Institute of Materials, Department of Materials Science D-44780 Bochum

Magnetic nanoparticles (NPs) are at the forefront of research due to their potential in applications as e.g. in biomedicine, spintronics and high density data storage. Particularly iron oxide NPs have widely been investigated for their biocompatibility and half metallic properties. In order to achieve a complete control over the various functionalities one has to obtain well defined phases of iron oxide. We synthesized 20 nm NPs following the synthesis method as described in Park et al (2004). The NPs were self-assembled after spin-coating on Si substrates in monolayers or multilayers of NPs. Various annealing conditions lead to different iron oxide phases. We characterized the monolayers by grazing incidence diffraction (GID), SQUID mag-

netometry and dark field TEM analysis. We show that in all cases a multi-phase structure is obtained with finite exchange bias between a ferrimagnetic and an antiferromagnetic phase [1].

[1] M.J. Benitez et al., submitted (arXiv:1010.0938)

MA 12.2 Mon 17:15 HSZ 103

Fe oxide nanoparticles in dispersion measured by XAS — •Anne Warland, Carolin Antoniak, Masih Darbandi, Claudia Weis, Werner Keune, and Heiko Wende — Faculty of Physics and CeNIDE, University of Duisburg-Essen, Germany

Due to the wide range of biomedical applications like e.g., targeted drug delivery and hypothermia treatment, magnetic nanoparticles are the subject of intense research. Fe oxide nanoparticles are often used as contrast enhancers in the MRI. We investigated Fe_3O_4 (magnetite) nanoparticles as they are biocompatible and their surface can be functionalized. Magnetite consists of Fe^{3+} and Fe^{2+} ions in tetrahedral and octahedral lattice sites giving rise to a clear multiplet structure in the x-ray absorption spectrum at the Fe $L_{3,2}$ edges. We synthesized Fe oxide nanoparticles using a water-in-oil microemulsion technique, which yields nanoparticles with a narrow size distribution. Bare and silica coated Fe oxide nanoparticles of a core size of 7nm dispersed in ethanol have been investigated by means of x-ray absorption spectroscopy (XAS) allowing to disentangle the contributions of the Fe^{2+} and Fe^{3+} ions and therefore, to estimate the amount of Fe_3O_4 in the particles. Due to a special experimental setup (Liquidrom chamber)[1] provided at BESSY, the particles can be measured directly in dispersion. In case of the silica coated particles a high amount of magnetite was obtained. In contrast, the bare nanoparticles showed indications of further oxidation into Fe_2O_3. -Supported by DFG(SFB 445,WE 2623/3-1) and Helmholtz-Zentrum Berlin.

[1] Aziz Bekhit E F 2007, Dissertation FU Berlin.

MA 12.3 Mon 17:30 HSZ 103

Carbon-coated NiPt, CoPt nanoalloys: size control and magnetic properties — •A. A. El-Gendy[1,2], S. Hampel[2], A. Leonhardt[2], V. Khavrus[2], B. Buechner[2], and R. Klingeler[1] — [1]Kirchhoff Institute for Physics, University of Heidelberg, D-69120 Heidelberg, Germany — [2]Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Germany

Controlled synthesis of magnetic nanoparticles with well-defined size and composition is always a challenge in material-based nanoscience. Here, we apply the high pressure chemical vapour deposition technique (HPCVD) to obtain carbon-shielded magnetic alloy nanoparticles under control of the particle size. Carbon encapsulated NiPt, CoPt (NiPt@C, CoPt@C) nanoalloys were synthesized by means of HPCVD starting from sublimating appropriate metal-organic precursors. Structural characterization by means of high resolution transmission electron microscopy, energy dispersive x-ray analysis and X-ray diffraction indicated the formation of coated bimetallic NixPt100-x and CoxPt100-x nanoparticles. Adjusting the sublimation temperature of the different precursors allowed tuning the core sizes with small size distribution. In addition, detailed studies of the magnetic properties are presented. AC magnetic heating studies imply the potential of the coated nanoalloys for hyperthermia therapy.

MA 12.4 Mon 17:45 HSZ 103

Fabrication of ferromagnetic Co/Pt nanodots on NaCl-crystals — •Mahmut Caylioglu[1], Andreas Rathjen[1], Alexander Neumann[1], André Kobs[1], Andreas Meyer[2], Robert Frömter[1] und Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]Institut für Physikalische Chemie, Universität Hamburg, Martin-Luther-King-Platz 6, 20146 Hamburg, Germany

Recently, we have successfully studied the growth of ferromagnetic Co/Pt multilayers with perpendicular anisotropy on various substrates. Utilizing SiO_2 cores of micelles as shadow mask [1] we could create ferromagnetic nanodots in the range < 20 nm [2]. For the purpose of producing nanodots in solution we have investigated the growth and nanodot fabrication on NaCl. In this talk we report on the preparation of cleaved NaCl surfaces that is necessary to get a layer-by-layer growth of the multilayer and a monomicellar coverage via spin coating of the micelles. In contradiction to the results obtained with Si and SiO_2, multilayers of composition $(Co_{0,8nm}/Pt_{2nm})_4$ have an in-plane easy plane behavior. This indicates that the interface roughness is increased resulting in a reduced interface anisotropy. In the light of our proposed study we have also produced thicker single Co films sandwiched between Pt. Nanodots made of such films are ferromagnetic and could be dissolved in water and imaged via scanning electron microscopy.

[1] A. Frömsdorf (A.Meyer) et. al., Small **3**, 880 (2007),
[2] H.Stillrich et. al. Adv. Funct. Mat **18**, 76 (2008)

MA 12.5 Mon 18:00 HSZ 103

SP-STM study of bi-atomic Fe chains on (5×1)-Ir(001) — Matthias Menzel[1], Yuriy Mokrousov[2], Robert Wieser[1], Kirsten von Bergmann[1], Elena Vedmedenko[1], Stefan Blügel[2], Stefan Heinze[3], •Andre Kubetzka[1], and Roland Wiesendanger[1] — [1]Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg — [2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich — [3]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel

The magnetism of one-dimensional structures on surfaces has been a fascinating topic of recent theoretical research, but experimental investigations have struggled with difficulties, e.g. the low amount of magnetic material or the problem of surface intermixing [1].

Here we utilize the self organization of Fe atoms on the (5×1)-reconstructed Ir(001) surface to prepare bi-atomic Fe chains [2]. Scanning tunneling microscopy was performed at $T = 8$ K using spin-sensitive Cr and Fe coated W tips. We observe no magnetic contrast in zero magnetic field, while in fields applied perpendicular to the surface the chains exhibit a periodic pattern along their axis with a wavelength of three inter-atomic distances. In agreement with density functional theory calculations and Monte Carlo simulations we can show that the magnetic ground state of the Fe chains is a 120° spin-spiral which is stabilized in external fields while it fluctuates in zero field.

[1] D.H. Wei et al. Phys. Rev. Lett. **103**, 225504 (2009).
[2] L. Hammer et al. Phys. Rev. B **67**, 125422 (2003).

MA 12.6 Mon 18:15 HSZ 103

Ab initio energy landscapes including spin degrees of freedom — •Luis Enrique Diaz Sanchez, Junais Habeeb Mokkath, and Gustavo Pastor — Institut fuer theoretische physik, Universitaet Kassel, Heinrich Plett. Str. 40, 34132 Kassel, Germany

In this work we present a systematic performance analysis of spin-polarized-first-principles (SPFP) basin-hopping (BH) calculations. The global search and local minima are calculated in the framework of spin-polarized density functional theory within the generalized gradient approximation. This formalism allow us to identify not only low-energy isomers but also their respective magnetic properties. In order to explore the configuration space collective (or shake) moves and are employed. different magnitude of random displacements are considered. The variation of the magnitude of the random displacements permit us to modulate the jumps into the different minima in the potential energy surface. Results for different initial configuration are presented: initial random-clusters created in the spirit of the big-bang method, present well know ground states geometries and configurations in which the atoms are also randomly large separated at the beginning. We will show that choosing a correct sett of move parameters the performance of the SPFP-BH is very good for small nanoalloys and that considering additional spin degrees of freedom it is possible to predict not only the most stable structural motifs, as it happens with the standard BH technique, but also isomers having different magnetic moments for the case of small FeCo composomers.

MA 12.7 Mon 18:30 HSZ 103

The role of bridge atoms in the ultrafast laser-driven spin-manipulation in charged magnetic two-center nanostructures — •Wolfgang Hübner[1], Chun Li[2], and Georg Lefkidis[1] — [1]University of Kaiserslautern and Research Center OPTIMAS, Germany — [2]Northwestern Polytechnical University, Xi'an, China

We present an *ab initio* theory of ultrafast laser-induced magnetic switching in charged magnetic two-center nanostructures via Λ processes [1-2]. To improve the spin transferability between the magnetic centers, and to fulfill the energetic requirements for the Λ process [3], a small number of bridge atoms (O and Mg) is inserted in order to connect the active magnetic centers (Fe, Co, Ni). The nature of these nonmagnetic bridges changes the overlap between the magnetic atoms. It is found that both types of bridges contribute to spin redistribution on magnetic centers, i.e. change the spin density or reverse the localization. Especially, in the spin-transfer scenario on [Fe-O(Mg)-Co]$^+$ the bridges improve the transferability between the magnetic centers due to the tilting or branching of the linear chain. We generally find that lowering the symmetry using bridging atoms facilitates spin transfer,

while spin-flip depends basically on the nature of the magnetic center.
[1] C. Li, T. Hartenstein, G. Lefkidis, and W. Hübner, PRB **79**, 180413(R) (2009)
[2] C. Li, G. Lefkidis and W. Hübner, J. Phys.: Conf. Ser. **200**, 042014 (2010)
[3] G. Lefkidis, G. P. Zhang, and W. Hübner, PRL **103**, 217401 (2009).

MA 12.8 Mon 18:45 HSZ 103

Transition metal clusters deposited on graphene: a first-principles study — •Sanjubala Sahoo, Markus E. Gruner, and Peter Entel — Faculty of Physics, University of Duisburg-Essen, 47057 Duisburg

We have studied the structural and magnetic properties of clusters (Fe, Co, Ni, Pt)$_{13,55}$ supported on graphene. Our calculations are based on density functional theory (VASP). The structural stability of the metal clusters are studied both on a pristine (defect free) and a five-member ring graphene. The calculations show that, introducing a vacancy in graphene enhances the adsorption energy of metal clusters on the substrate. In addition, the catalytic behavior of transition metal clusters are studied through adsorption of carbon monoxide molecule on the transition metal clusters. The role of graphene in affecting the adsorption of carbon monoxide molecule on metal clusters will be presented.

MA 12.9 Mon 19:00 HSZ 103

Revealing the magnetization reversal mechanism - from coherent rotation in compact to domain wall propagation in fractal islands — •Alberto Cavallin[1], Fabian Natterer[1], Safia Ouazi[1], Géraud Moulas[1], Anne Lehnert[1], Stefano Rusponi[1], Stanislas Rohart[2], Wulf Wulfhekel[3], and Harald Brune[1] — [1]IPMC, École Polytechnique Fédérale de Lausanne (EPFL), Station 3-B, CH-1015 Lausanne — [2]Laboratoire de Physique des Solides, Université Paris XI et CNRS, F-91405 Orsay — [3]Physikalisches Institut, Universität Karlsruhe (TH), D-76131 Karlsruhe

Magnetic nanostructures grown by self-assembly at surfaces are ideal model systems to explore the ultimate density limit of magnetic recording. While is it generally accepted that the magnetic ground state of nanostructures with a size of a few thousand atoms or less is monodomain, i.e., all spins are ferromagnetically aligned to a single domain, the transition state reached upon thermally activated magnetization reversal as a function of the island size and shape is debated [1,2]. This state lasts only ps and there are no techniques to image it at this time scale with the required spatial resolution of sub-nm. Therefore it can only be inferred indirectly. Our combined magneto-optical Kerr effect (MOKE) and STM measurements reveal for Co islands on Pt(111) a shape-dependent transition from the coherent rotation of all spins to the nucleation and propagation of a domain wall, going from compact to fractal islands.

References: [1] M. Bode *et al.* PRL **92** 067201 (2004)
[2] S. Krause *et al.* PRL **103** 127202 (2009)

MA 13: Magnetic Materials II

Time: Monday 17:00–19:00 Location: HSZ 401

MA 13.1 Mon 17:00 HSZ 401

Evidence of a new magnetic configuration in ferrimagnets RCo_2 — •Julia Herrero-Albillos[1], Marcela Bonilla[2], Luis Miguel García Vinuesa[2], Fernando Bartolomé[2], Celia Castán[2], Noelia Marcano[2], and Irene Calvo[2] — [1]Helmholtz-Zentrum Berlin, Albert Einstein strasse 15, 12489 Berlin (Adlershof), Germany — [2]Departamento de Física de la Materia Condensada, Instituto de Ciencia de Materiales de Aragón, CSIC-Universidad de Zaragoza, Pedro Cerbuna 12, 50009 Zaragoza, Spain.

Different experimental techniques allowed us to identify a new magnetic configuration within the paramagnetic phase of ferrimagnet $ErCo_2$. In this new magnetic ordering, coined as parimagnetism,[1] the Co net magnetic moment is aligned antiparallel to the Er and to the applied field at temperatures well above T_C and below certain flipping temperature. Magnetic short-range correlations of Co atoms within the parimagnetic state have been also established by means of small angle neutron scattering measurements. Thermopower and μSR spectroscopy measurements give also evidence about the existence of these strong correlated magnetic entities. Recently analysis carried on X-ray magnetic circular dichorism (XMCD) spectra taken in $HoCo_2$ and $DyCo_2$ have showed also the antiparallel arrangement of Co net magnetic moment respect to the rare earth in both compounds. The XMCD measurements allow us to propose a new magnetic phase diagram, for $ErCo_2$, $HoCo_2$ and $DyCo_2$. These results suggest that parimagnetism is a more general phenomenon among this ferromagnetic family. [1] J. Herrero-Albillos, et al., Physical Review B 76, 2007.

MA 13.2 Mon 17:15 HSZ 401

Magnetic properties of $Fe_{1-x}Tb_x$ thin films — •C. Schubert[1], B. Hebler[1], A. Liebig[1], F. Radu[2], M. Daniel[1], and M. Albrecht[1] — [1]Chemnitz University of Technology, Institute of Physics, Germany — [2]Helmholtz Zentrum Berlin, Department of Magnetization Dynamics, Germany

Amorphous ferrimagnetic rare earth-transition metal alloys with high perpendicular magnetic anisotropy (PMA) at room temperature (RT) are suitable for the use as pinning layers in spin valve sensor systems or in hard drive disks to overcome the superparamagnetic limit [1]. In this regard $Fe_{1-x}Tb_x$ thin films are promising candidates since their ferrimagnetic properties with respect to a chosen temperature can be well controlled depending on the Tb content.

Here we present an investigation of the structural and magnetic properties of 20 nm thick amorphous $Fe_{1-x}Tb_x$ alloy films in the composition range from x = 0.19 to 0.26. The magnetic layers are embedded in Pt seed and capping layers with a thickness of 5 and 3 nm respectively to prevent them from oxidation. All depositions were realized through magnetron sputtering on thermally oxidized Si(100) wafers. A compensation point above RT, as verified through the temperature dependence of the remanence and the coercivity, was achieved at x = 0.24. Interestingly, the magnetization reversal process changes towards lower temperatures and shows an exchange spring behavior due to an anisotropy gradient in the film. Furthermore first results on nanostructured $Fe_{1-x}Tb_x$ thin films will be presented.

[1] Fullerton et al., Appl. Phys. Lett. **77**, 23 (2000)

MA 13.3 Mon 17:30 HSZ 401

Switching processes and thermal activation in a hard magnetic FePt film — •Christian Behler, Volker Neu, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

In order to understand the switching behaviour of a granular FePt film we examined the angular dependence of the switching field and studied the thermal activation of the switching process via magnetisation relaxation measurements. The investigated film with a nominal thickness of 5 nm is grown epitaxially in $L1_0$-ordered structure. The coercive field, measured parallel to the easy axis, reaches a value of 7.4 T, which is about 70 % of the anisotropy field (10.8 T). The angular dependent switching field is in good agreement with the Stoner-Wohlfarth-Model when the above observed reduction in coercivity is included. We conclude that the switching behaviour approaches Stoner-Wohlfarth, but the nucleation starts at defects with reduced magnetic anisotropy. This result is supported by the size of the activation volume, which was determined from viscosity measurements. Compared with the grain volume the smaller activation volume also indicates that the switching process is initiated by inhomogeneous domain nucleation.

MA 13.4 Mon 17:45 HSZ 401

Magnetization reversal of interaction domains in fine-grained textured Nd-Fe-B — •Juliane Thielsch, Ulrike Wolff, Volker Neu, Ludwig Schultz, and Oliver Gutfleisch — IFW Dresden, Institute for Metallic Materials, P.O. Box 27 01 16, D-01171 Dresden, Germany

Textured nanocomposite magnets attract a lot of interest due to their potential of exhibiting higher energy products than those of currently existing rare earth-transition metal permanent magnets. In such nanostructured materials interaction domains are expected in contrast to classical magnetic domain structures that are commonly known from e.g. sintered magnets. Domain structures of this kind occur due to the magnetic coupling between grains whose sizes are about equal or smaller than the expected single-domain grain size. For hot-deformed

samples made of melt-spun Nd2Fe14B-type ribbons the existence of interaction domains due to magnetostatic coupling has been reported. We choose this system to investigate the magnetic microstructure in dependence of a magnetic field along the initial magnetization curve. Images taken with Magnetic Force Microscopy are correlated to global hysteresis measurements. We show for the first time how interaction domains evolve in a bulk magnetic system from the thermally demagnetized state to a field of 6T. The growing/shrinking of the interaction domains happens from the domain border to the inside. Hardly any reversal within one domain is visible which affirms the collective nature of those domains. At high magnetic fields domains are left that are in the range of the grain size which implies a grain by grain switching.

MA 13.5 Mon 18:00 HSZ 401

Magnetocaloric effect and thermal stability of hydrogenated melt spun La(Fe,Si)$_{13}$-compounds — •Maria Krautz, Konstantin Skokov, James D. Moore, Jian Liu, Ludwig Schultz, and Oliver Gutfleisch — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden

3d-metal based alloys with a $NaZn_{13}$-structure are of high interest for magnetic refrigeration as they show a large magnetocaloric effect by undergoing a first-order phase transition. Since only $LaCo_{13}$ is stable as a binary, the $LaFe_{13}$-phase must be stabilised by additional elements such as Al or Si. In pseudobinary La(Fe,Si)$_{13}$ alloys the magnetic transition temperature can be tuned by inserting interstitial hydrogen. In this work, almost single phase La(Fe,Si)$_{13}$ alloys produced by melt spinning and subsequent short time annealing are hydrogenated at elevated temperatures. In view of application, the hydrogen content was adjusted to cover a range of Curie temperatures. A systematic study of different particle sizes on the hydrogenation was carried out. The influence of hydrogen on the magnetocaloric properties was studied by direct adiabatic temperature change measurements and indirect methods to determine the magnetic entropy change. Finally, the stability of the hydrogenated samples is assessed.

MA 13.6 Mon 18:15 HSZ 401

HDDR - An efficient way to produce highly coercive, anisotropic Nd-Fe-B powders — •Konrad Güth, Thomas George Woodcock, Juliane Thielsch, Ludwig Schultz, and Oliver Gutfleisch — IFW Dresden, Institut für Metallische Werkstoffe, Postfach 270016, D-01171 Dresden, Germany

Nd-Fe-B sintered magnets have the highest energy product, $(BH)_{max}$, of any commercially available hard magnetic material (typically 300-400 kJ/m^3). Disadvantages of Nd-Fe-B sintered magnets are the relatively high cost and their machinability. One promising approach to achieve relatively high performance with lower material cost is to process the Nd-Fe-B powder using a hydrogen treatment at elevated temperature. This method is known as the HDDR (hydrogenation, disproportionation, desorption, recombination) process. HDDR has been shown to be an effective route to produce a $Nd_2Fe_{14}B$ powder with a highly refined grain size (about 300 nm) compared to that of the starting material (typically tens of μm). Coercivity has been shown to increase with decreasing grain size. A further, very specific advantage of the HDDR process is the texture-memory effect. This means that the refined grains within a particle exhibit a texture which is derived from the orientation of the original, coarse grain. Strong texture is necessary to maximize the remanence, yielding anisotropic polymer bonded magnets. In the current work, microstructural investigation based on SEM and XRD of different stages of the HDDR process will be given. The magnetic properties in dependence on the hydrogen pressure during processing are studied by VSM.

MA 13.7 Mon 18:30 HSZ 401

The AC transport properties of iron whiskers at 4.2 K — •Matthäus Langosch, Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, Postfach 151150, D-66041, Saarbruecken, Germany

Iron single crystals (iron whiskers) were grown as specific samples to investigate the magneto-impedance (MI) effect at low temperature. MI measurements on iron whiskers with <100> growth direction were first carried out at room temperature. The MI effect of the whiskers was observed as a function of driving current and frequency. Calculations based on the standard skin effect formalism provide the complex values of the effective circumferential permeability. Furthermore, MI measurements at low temperature were employed to investigate the AC transport properties. In addition, DC measurements were carried out to extract magneto-resistance (MR) effects from the MI data. At room temperature, the change of the impedance is about 150 % and mainly due to the skin effect. At low temperature, MR effects are taken into account.

MA 13.8 Mon 18:45 HSZ 401

Magnetic Main Group Impurities in CdS — •Pedro Bedolla-Velazquez, Peter Mohn, and Christoph Gruber — Technische Universität Wien (Computational Materials Science) Wien, Austria

With the development of magnetic semiconductors, the role of the magnetism of impurities came again into the focus of research. For d- and f-electron impurities, the situation seems to be rather clear. A new field appears when one starts to study magnetism produced by vacancies or by atoms, which usually do not carry any magnetic moments in a bulk solid. Starting from the magnetism of carbon vacancies in graphene we will present a study of CdS where S is replaced by main group elements. On the basis of ab-initio supercell calculations employing density functional theory (DFT) we investigate the behaviour of impurities (B,N,C,O,F,Al,Si,P,Ga,Ge) in wurtzite (w) and zincblende (zb) CdS lattices. It is found that the impurities prefer the sulfur position and most of them, depending on the concentration exhibit magnetic order. We find that for small concentrations (64zb/72w and 32zb atom supercells) a half metallic ferromagnetic behaviour is found. For a 16 atom supercell for both zb- and w-structure partly also unsaturated magnetic moments occur. For Si, Ge and P impurities a metamagnetic behaviour appears, which is found for the first time in p-electron systems. A field dependence of the magnetic moments in these materials may lead to new technological applications in these magnetic semiconductors as tunable spin injection materials.

MA 14: Magnetization Dynamics II

Time: Monday 17:00–19:00 Location: HSZ 403

MA 14.1 Mon 17:00 HSZ 403

Femtosecond XUV Spectroscopy of Gadolinium and Terbium — •Robert Carley[1], Björn Frietsch[1], Kristian Döbrich[1], Martin Teichmann[1], Cornelius Gahl[1], Olaf Schwarzkopf[2], Philippe Wernet[2], Frank Noack[1], and Martin Weinelt[1,3] — [1]Max-Born-Institute, Berlin — [2]Helmholtz-Zentrum für Materialien und Energie (BESSY II), Berlin — [3]Fachbereich Physik, Freie Universität, Berlin

We present recent results of time-resolved IR-pump-XUV-probe experiments on the ultrafast demagnetization of thin films of Gadolium (0001) and Terbium (0001) on Tungsten (110). The experiments are the first to be done using a newly developed high-order harmonics (HHG) XUV beamline at the MBI. The beamline delivers monochromated XUV pulses of approximately 150 fs duration with a photon energy resolution of up to 150 meV. Following excitation by intense femtosecond infrared (IR) pulses, photoemission with 35 eV photons allows us to directly probe the 4f electrons and their interaction with the valence band, both in the bulk and at the surface, to follow the ultrafast magnetization dynamics in the Lanthanide metals. As signatures of ultrafast demagnetization of the metal by the IR pulse, we see for the first time, rapid strong reduction of the exchange splitting in the valence band. This is followed by a slower demagnetization due to the spin-lattice interaction.

MA 14.2 Mon 17:15 HSZ 403

Influence of equilibrium temperature on the femtosecond magnetization dynamics of Gd — •Muhammad Sultan[1,2], Alexey Melnikov[2], and Uwe Bovensiepen[1] — [1]Fakultät für Physik, Uni. Duisburg-Essen — [2]Fachbereich Physik, Freie Uni. Berlin

Understanding the demagnetization of solids after femtosecond laser excitation requires the knowledge of the involved processes and their time scales. Previously we found by fs time resolved X-ray magnetic

circular dichroism that Gd exhibits at an equilibrium temperature T_o=120K a faster and a slower demagnetization with characteristic time scales τ_f=0.75 ps and τ_s=40 ps, respectively [1]. In this study we focus on the question how T_o affects laser induced demagnetization. We employed the magneto-optical Kerr effect to investigate the temperature dependence of both demagnetization time scales. We find that the demagnetization evolves slower in time with increasing T_o for both processes. However, in detail they show different temperature dependence. τ_f increases linearly with temperature and exhibits a larger $\frac{d\tau_f}{dT_o}$ for T_o >170K, τ_f enhanced to double between 50 and 280 K. Remarkably, τ_s increases by a factor of five in the same temperature interval and follows a continuous change that suggests a divergence at the Curie temperature T_c. These findings demonstrate that thermal spin fluctuations influence the laser induced demagnetization and tend to inhibit the demagnetization in line with an increase of spin fluctuation times if a ferromagnet reaches T_c under equilibrium conditions.

[1] Wietstruk et al, submitted arxiv.org/abs/1010.1374

MA 14.3 Mon 17:30 HSZ 403

Investigating the opto-magnetic switching in ferrimagnetic GdFeCo — •Stefan Gerlach[1], Denise Hinzke[1], Thomas Ostler[2], Roy W. Chantrell[2], and Ulrich Nowak[1] — [1]University of Konstanz, 78457 Konstanz, Germany — [2]University of York, York YO10 5DD, U. K.

It was recently demonstrated [1] that a 100 fs circularly polarized laser pulse is able to reverse the magnetization on a picosecond time scale as if the laser pulse acts as an equally short magnetic field pulse with a polarization dependent direction caused by the so-called inverse Faraday effect. However, so far this opto-magnetic switching has only been successfully demonstrated for a certain class of ferrimagnetic thin films and only for a narrow window of parameters [2].

To investigate the opto-magnetic magnetization reversal, we use Landau-Lifshitz-Bloch (LLB)-based simulations [3] combined with a two temperature model to describe the effect of a realistic femtosecond laser pulse. The ferrimagnetic properties of GdFeCo are included by a self-consistent mean-field approximation [4] to get the temperature dependent input parameters for the LLB equations. We will discuss the parameters under which opto-magnetic switching is possible and the influence of the ferrimagnetic compensation point on the switching process.

[1] C. D. Stanciu et al., Phys. Rev. Lett. 99, 047601 (2007) [2] K. Vahaplar et al., Phys. Rev. Lett. 103, 117201 (2009) [3] N. Kazantseva et al., Phys. Rev. B 77, 184428 (2008) [4] A. Gangulee, et al., J. Appl. Phys. 49, 4896 (1978)

MA 14.4 Mon 17:45 HSZ 403

Hot electron driven enhancement of spin-lattice coupling — •Marko Wietstruk[1,2], Christian Stamm[2], Niko Pontius[2], Torsten Kachel[2], Cornelius Gahl[1], Alexey Melnikov[3], Muhammad Sultan[3], Martin Weinelt[1,3], Hermann Dürr[2,4], and Uwe Bovensiepen[3,5] — [1]Max-Born-Institut Berlin — [2]Helmholtz-Zentrum Berlin — [3]Freie Universität Berlin, Fb. Physik — [4]SLAC, California, USA — [5]Universität Duisburg-Essen, Fak. für Physik

Laser induced demagnetization of elemental Gd is known to occur on the order of tens of picoseconds [1]. This slow time scale reflects the weak 4f spin-lattice coupling caused by the zero orbital momentum of the half-filled Gd 4f shell.

However, our fs time-resolved x-ray magnetic circular dichroism (TR-XMCD) measurements show that the spin-lattice coupling and thus the demagnetization rate is enhanced by excitation of the sample with an intense fs Laser pulse [2]. We conclude that the additional fast demagnetization process with $\tau < 1$ ps is driven by spin-flip scattering of hot electrons, i.e. the demagnetization time corresponds to the equilibration of excited electrons with the lattice.

These findings are supported by measurements on Tb that exhibits much stronger spin-lattice coupling, as well as on Ni, which shows a much shorter demagnetization time scale [3] but nevertheless a similar angular momentum transfer rate.

[1] A. Vaterlaus et al., Phys. Rev. Lett. **67**, 3314 (1991)
[2] M. Wietstruk et al., arXiv:1010.1374v1[cond-mat.mtrl-sci] (2010)
[3] C. Stamm et al., Phys Rev. B **81**, 104425 (2010)

MA 14.5 Mon 18:00 HSZ 403

Elastically driven ferromagnetic resonance in nickel thin films — Mathias Weiler[1], Lukas Dreher[2], Christian Heeg[1], Hans Huebl[1], Rudolf Gross[1], Martin S. Brandt[2], and •Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany

Because of magneto-elastic coupling, magnetic degrees of freedom are influenced by elastic deformation. We here demonstrate that the magneto-elastic interaction of a radio frequency (RF) surface acoustic wave (SAW) with a ferromagnetic thin film enables an all-elastic excitation and detection of ferromagnetic resonance (FMR) in nickel/lithium niobate hybrid devices. We have measured the SAW magneto-transmission in such samples at room temperature, as a function of microwave frequency, external magnetic field magnitude, and magnetic field orientation. Our data are consistently described by a modified Landau-Lifshitz-Gilbert approach [1], in which the magnetization precession is not driven by a conventional, external RF magnetic field, but rather by a purely virtual, internal tickle field stemming from RF magneto-elastic interactions. This causes a distinct magnetic field orientation dependence of elastically driven FMR, clearly observed in both simulation and experiment.

This work is financially supported by DFG via project GO 944/3-1, SFB 631, and the excellence cluster Nanosystems Initiative Munich.

[1] M. Weiler *et al.* arXiv:1009.5798

MA 14.6 Mon 18:15 HSZ 403

Structual and electronic dynamics across the Verwey transition in magnetite — •C. Trabant[1,2], N. Pontius[2], C.-F. Chang[1], T. Kachel[2], M. Beye[2,3], F. Sorgenfrei[4], W. Schlotter[3], S. de Jong[3], R. Kukreja[3], B. Bräuer[3], M. Döhler[1], S. Hossain[3], C. Back[3], A. Scherz[3], D. Zhu[3], J. Turner[3], W.-S. Lee[3], Y.-D. Chuang[3], O. Krupin[3], M. Buchholz[1], P. Vogt[1], W. Wurth[4], A. Föhlisch[2], C. Schüssler-Langeheine[2,1], and H. A. Dürr[3] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Helmholtz-Zentrum Berlin — [3]SLAC RSXS collaboration, USA — [4]Universität Hamburg and CFEL

At 123K magnetite (Fe_3O_4) undergoes a metal-to-insulator transition, the Verwey transition. It is accompanied by a transition from a charge/orbital ordered low temperature state with monoclinic symmetry to a cubic phase without electronic order. Until today the question how structual and electronic degrees contribute to this transition has remained unanswered.

Here we report on a time-resolved soft x-ray diffraction experiment performed at the LCLS. By tuning the photon energy to the oxygen 1s → 2p and Fe 2p→ 3d excitation and off resonance we studied the structural and electronic response when the insulator-to-metal transition is induced by a fs laser pulse. We observered fast and slow timescales for all energies from which we derive a picture of the IR laser pulse induced phase transition. Supported by the DFG through SFB 608 and by the BMBF project 05K10PK2.

MA 14.7 Mon 18:30 HSZ 403

Ultrafast lattice dynamics in FeRh during a laser-induced magnetic phase transition — •Florian Quirin, Michael Vattilana, Uladzimir Shymanovich, Abd-Elmonien El-Kamhawy, Matthieu Nicoul, Alexander Tarasevitch, Dietrich von der Linde, and Klaus Sokolowski-Tinten — Universität Duisburg-Essen, Duisburg, Germany

FeRh exhibits an anti-ferromagnetic to ferromagnetic phase transition upon heating to temperatures above 353 K, which is accompanied by an iso-structural increase in volume of about 1%. Recent results of time-resolved magneto-optical experiments gave indication that after intense optical excitation ferromagnetic order starts to build up on sub-ps time-scales [1,2]. We have used time-resolved X-ray diffraction with fs X-ray pulses from a laser-produced plasma to directly follow the lattice response of FeRh after optical excitation. From experimental data obtained at different starting temperatures below and above the phase transition temperature we have to conclude that the fast changes of the magnetic properties do not lead to the corresponding structural changes as under equilibrium conditions.

1 G. Ju, J. Hohlfeld, B. Bergman, R. J. M. van deVeerdonk, O. N. Mryasov, J.-Y. Kim, X. Wu, D. Weller, and B. Koopmans, Phys. Rev. Lett. 93, 197403 (2004).

2 J.-U. Thiele, M. Buess, and C. H. Back, Appl. Phys. Lett. 85, 2857 (2004).

MA 14.8 Mon 18:45 HSZ 403

Zero-field magnetization reversal of two-body Stoner particles with dipolar interaction — •Zhouzhou Sun, Alexander Lopez, and John Schliemann — Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany

In the framework of the Landau-Lifshitz-Gilbert equation, we investigate magnetization reversal in a system of two Stoner particles both subject to a static antiparallel magnetic field, and taking into account their mutual dipolar interaction. We identify an interesting regime of stable synchronized dynamics where the two particles are implementing a single information bit. Here a modified Stoner-Wohlfarth limit is obtained which shows a dramatically lower critical switching field (even including zero) and also a substantially shorter reversal time, by appropriately engineering the dipolar interaction strength between the two particles. Our analytical results are also verified by numerical simulations and thus offer new technological perspectives regarding devices for information storage and/or fast magnetic response.

MA 15: Multiferroics II: Strain and Composites (jointly with DF, DS, KR, TT)

Time: Monday 17:00–18:45 Location: HSZ 04

MA 15.1 Mon 17:00 HSZ 04

Tuning magnetism by epitaxial strain in biferroic $Fe_{70}Pd_{30}$ films — •Sandra Weiss[1], Markus Ernst Gruner[2], Jörg Buschbeck[1,3], Ludwig Schultz[1], and Sebastian Fähler[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden — [2]University of Duisburg-Essen, Theoretical Physics, Lotharstraße 1, D-47048 Duisburg — [3]ECE Department, University of California, Santa Barbara

Due to combination of ferromagnetic and ferroelastic properties magnetic shape memory alloys can be considered as multiferrorics. For the magnetic shape memory alloy Fe-Pd we could demonstrate recently, that strained epitaxial film growth allows a variation of the tetragonal distortion by 27 % [J. Buschbeck et al., PRL 103, 2009, 216101]. Density functional calculations revealed a flat energy landscape along the Bain path, explaining this soft behaviour of $Fe_{70}Pd_{30}$. Here we show that tetragonal distortions up to 43 % are possible. This exceeds the Bain transformation path connecting bcc and fcc structure. $Fe_{70}Pd_{30}$ films are produced by coherent epitaxial growth on MgO substrates covered by different metallic buffer layers. By adjusting the tetragonal distortion intrinsic magnetic properties like Curie temperature, saturation magnetisation and magnetocrystalline anisotropy can be controlled. The relevance of two mechanisms for relaxation of epitaxial strain - misfit dislocations and adaptive martensite - is discussed.

MA 15.2 Mon 17:15 HSZ 04

Strain effect on the magnetic properties of $SrRuO_3$ thin films on ferroelectric PMN-PT substrates — •Andreas Herklotz, Mikko Kataja, Ludwig Schultz, and Kathrin Dörr — IFW Dresden, IMW, Helmholtzstrae 20, 01069 Dresden, Germany

We investigate a two-component multiferroic system consisting of a ferroelectric $0.72PbMg_{1/3}Nb_{2/3}O_3$-$0.28PbTiO_3$ (PMN-PT) substrate and ferromagnetic $SrRuO_3$ (SRO) thin films. The inverse piezoelectric effect of the substrate is used to reversibly vary the strain state of the epitaxial SRO films in order to clarify the strain dependence of the magnetic film properties. Buffer films of $Sr_{1-x}Ba_xTiO_3$ are introduced to vary the as-grown state of the SRO films and to cover a wider range from compressive to tensile strain.

High resolution X-ray diffraction is deployed to structurally characterize the films and to determine Poisson's ratio of SRO, which is not known so far. SQUID magnetometry reveals that the Curie temperature is increasing with tensile strain, but starts to decrease again under high strain. Angular-dependent measurements provide that the easy axis orientation shows a complex dependence on strain and temperature. SQUID measurements on conventional substrates like $SrTiO_3$ and $LaAlO_3$ and electric transport measurements complete the data.

MA 15.3 Mon 17:30 HSZ 04

Strain effect on ferroelectric switching dynamics of epitaxial $PbZr_{0.52}Ti_{0.48}O_3$ films — •Kathrin Dörr[1], Andreas Herklotz[1], Michael Biegalski[2], and Hans Christen[2] — [1]IFW Dresden, IMW, Helmholtzstr.20, Dresden — [2]CNMS, Oak Ridge National Laboratory, TN, USA

Elastic strain is known to change ferroic properties of thin films such as the remanent polarization. Less understood and little measured is the influence of the lattice strain induced by film-substrate mismatch on the switching dynamics. In this work, reversible biaxial strain has been applied to films on piezoelectric substrates for a study of their strain-dependent ferroelectric switching. $PbZr_{0.52}Ti_{0.48}O_3$ (PZT) films have been epitaxially grown by pulsed laser deposition on piezoelectric substrates of $0.72PbMg_{1/3}Nb_{2/3}O_3$-$0.28PbTiO_3$(001) (PMN-PT) buffered with a $SrRuO_3/SrTiO_3$ double layer. Four-circle x-ray diffraction has been employed to confirm the tetragonal symmetry and to measure the lattice parameters of the films. Measurements of the characteristic ferroelectric switching time at various temperatures and strains show an increase of several percent under compression, revealing a similarly strong strain sensitivity of the switching dynamics as that of the remanent polarization. We attempt to identify the strain dependence of the domain wall velocity.

MA 15.4 Mon 17:45 HSZ 04

Fabrication and multiferroic properties of $BiFeO_3/BiCrO_3$ perovskite heterostructures — •Vijayanandhini Kannan, Florian Johann, Alessio Morelli, Miryam Arredondo, Eckhard Pippel, and Ionela Vrejoiu — Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle.

Bi-based multiferroic materials have attracted strong research interests due to the presence of sterochemical active $6s^2$ lone pair electrons in Bi^{3+} ions and high ordering temperatures, e.g., $BiMeO_3$ (Me = Fe, Cr, Mn, etc). In the present work, epitaxial films of $BiCrO_3$ and $BiFeO_3$ of different thickness (5 nm to 250 nm) were grown on $SrTiO_3$ (100) using pulsed laser deposition technique. Reciprocal space mapping XRD measurements showed that both $BiFeO_3$ (40 nm) and $BiCrO_3$ films (130 nm) are fully strained, having out-of-plane lattice constants of 4.075 Å, and 3.88 Å, respectively. The transmission electron microscopy (TEM) analysis of $BiCrO_3$(130nm)/$SrRuO_3$(16nm)/$SrTiO_3$ films revealed the presence of 45^o and 90^o domains along with the coexistence of three structurally different phases, (i) monoclinic (Space Group: C2/c) and (ii) orthorhombic (Space Group: Pnma) and (iii) an unknown monoclinic-like structure. $BiCrO_3$ film (160 nm) grown on $NdGaO_3$ (110) showed a coherent interface without any misfit dislocations or structural variants. A systematic approach on understanding the thickness evolution of these defects or strain induced structural variants of $BiCrO_3/SrRuO_3/SrTiO_3$ films is done. Furthermore, the fabrication and multiferroic properties of $BiCrO_3/BiFeO_3$ bilayers and multilayer heterostructures are investigated.

MA 15.5 Mon 18:00 HSZ 04

Microscopic Investigations of the Strain-Mediated Coupling in Magnetoelectric $Ni/BaTiO_3$ — •Robert Streubel[1], Denny Köhler[1], Lukas Eng[1], Rudolf Schäfer[2], Claudia Patschureck[2], Anja Wolter[2], Sebastian Gass[2], Stephan Geprägs[3], and Rudolph Gross[3] — [1]Institute of Applied Physics, Technische Universität Dresden — [2]Leibniz Institute for Solid State and Materials Research Dresden — [3]Walther-Meißner-Institute for Low Temperature Research

Coupling the (anti-)ferromagnetic and ferroelectric phases within magnetoelectrics allows affecting the magnetic properties by electric fields. Magnetoelectric heterostructures thus may be considered as prospective candidates for future nanoscale memory devices. However, since only a few single-phase room temperature magnetoelectrics exist with rather poor permeability values, simple composite materials, e.g. amorphous nickel on barium titanate ($Ni/BaTiO_3$) may be used for this purpose. While the macroscopic characterization by monitoring magnetic hysteresis and other effects has been thoroughly carried out, microscopic investigations elucidating the mechanism of ferroelectric/ferromagnetic coupling are still missing.

We report here on the nanoscale inspection of the $Ni/BaTiO_3$ system by PFM, MFM and MOKE. In addition, the saturation magnetization and magnetic anisotropy were measured by SQUID. Both stress and anisotropy within the amorphous Ni film have been modeled showing an excellent agreement with experimental results.

MA 15.6 Mon 18:15 HSZ 04

Magnetoelectric properties of core-shell $CoFe_2O_4$-$BaTiO_3$ composites — •Vladimir Shvartsman[1], Firas Alawneh[2], Morad Etier[1], Shiwam Tiwari[1], and Doru Lupascu[1] — [1]Institut für Materilawissenschaft, Universität Duisburg-Essen — [2]The Hashemite

University, Zarqa, Jordan

In recent years there has been growing interest in materials exhibiting the magnetoelectric (ME) effect. A large ME coupling has been achieved in composites, where a magnetostrictive phase is mechanically coupled to a piezoelectric phase. The magnitude of the ME effect in such systems depends on the properties of the phases and the type of connectivity. In particular, in core/shell-type structures, where the magnetostrictive core is surrounded by the piezoelectric shell, a large well-defined interface area should enhance the ME coupling.

We report on results of synthesis and ME characterization of $CoFe_2O_4$ - $BaTiO_3$ composites with the core-shell structure. The ceramic samples were prepared by covering cobalt ferrite nanoparticles by a shell of $BaTiO_3$ using a sol-gel technique. Scanning probe microscopy studies confirm formation of the core-shell structure with a magnetic core and piezoelectric shell. The ME effect was measured using a modified SQUID susceptometer. Though the relatively high conductivity of the samples prevents an efficient poling of the ferroelectric component, the obtained ME coefficients are comparable to those reported for similar systems. Effects of the microstructure and ratio between piezoelectric and magnetostrictive phases on ME performance are analysed.

MA 15.7 Mon 18:30 HSZ 04

Highly ordered multiferroic nanocomposite arrays: Fabrication and Properties — •Xiaoli Lu, Yunseok Kim, Silvana Goetze, Peter Werner, Marin Alexe, and Dietrich Hesse — Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany

With the resurgence of interest in multiferroics, searching for materials with high coupling coefficient becomes more and more important from both fundamental and practical point of views. We report a new type of artificial nanocomposite, $BaTiO_3/CoFe_2O_4$ (BTO/CFO) heterostructured nanodot arrays. Using a stencil of ultra thin anodic aluminum oxide (AAO) membrane and pulsed laser deposition (PLD), BTO and CFO nanodots were epitaxially grown on top of each other. The size of the nanodots can be easily tuned from 60 to 400 nm. Piezoresponse force microscopy (PFM) and superconducting quantum interference device (SQUID) were used to study the nanocomposite. The local characterization of the piezoresponse and domain structure within single nanodots may shed new light on the strain-mediated magnetoelectric (ME) coupling. The epitaxial interface and reduced clamping from the substrate in this nanocomposite promise a better elastic coupling, which makes it a good prototype for nonvolatile ultrahigh-density memory unit with multi-state data storage capability.

MA 16: Multiferroics III: Exotic Properties - Invited Talk (jointly with DF, DS, KR, TT)

Time: Tuesday 10:15–10:45 Location: HSZ 04

Invited Talk MA 16.1 Tue 10:15 HSZ 04

Search for a permanent electric dipole moment of an electron: Multiferroics bring us a step closer — •Marjana Ležaić — Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany

Although it is conjectured that the Big Bang created equal amounts of matter and antimatter, the Universe that we know consists only of matter. It is not yet clear why the Nature treats matter and antimatter in a different way. One possibility that is being intensively explored lies in the existence of a permanent electric dipole moment (EDM) of an electron. Electron's EDM would violate time-reversal symmetry leading to charge-parity symmetry violation and as a consequence, would act as a source of the matter-antimatter asymmetry. The talk will present a multidisciplinary study [1] including theoretical solid state design, consequent synthesis and characterization of a multiferroic material, $(Eu,Ba)TiO_3$, with characteristics optimized for a search for electron's EDM.

[1] K. Z. Rushchanskii, S. Kamba, V. Goian, P. Vaněk, M. Savinov, J. Prokleška, D. Nuzhnyy, K. Knížek, F. Laufek, S. Eckel, S. K. Lamoreaux, A. O. Sushkov, M. Ležaić and N. A. Spaldin, Nature Mater. **9** 649 (2010).

MA 17: SKM Dissertation Prize

Time: Tuesday 10:30–12:30 Location: TRE Ma

Invited Talk MA 17.1 Tue 10:30 TRE Ma

Chemotaxis of Sperm Cells: A generic principle for robust chemo-navigation along helical paths — •Benjamin M. Friedrich — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — Weizmann Institute of Science, Rehovot, Israel

Directed motion of biological cells in response to external cues requires coordination of cell sensation and cell motility. I discuss this interplay in the context of sperm chemotaxis and characterize a novel and universal navigation strategy. Sperm cells propel themselves in a liquid by regular bending waves of their whip-like flagellum. They can detect water-borne chemical cues released from the egg and steer their swimming paths upwards a concentration gradient. Detection of a gradient relies on temporal sampling of the concentration field along circular and helical swimming paths. I present a theoretical description of this navigation strategy and prove its robustness with respect to parameter variability and input noise. Robustness is crucial for reliable biological function and input noise might have been an evolutionary driving force in selecting cellular navigation strategies. The theory bridges the gap between experimentally well-characterized sperm chemotaxis in confined experimental geometries along circular paths and the biologically relevant case of unrestricted swimming along helical paths.

Invited Talk MA 17.2 Tue 11:00 TRE Ma

Photonic structures inspired by nature — •Mathias Kolle[1,3], Heather Whitney[2], Maik Scherer[3], Pedro Cunha[3], Moritz Kreysing[3], Jeremy Baumberg[3], and Ullrich Steiner[3] — [1]School of Engineering and Applied Sciences, Harvard University, Cambridge, US — [2]School of Biological Sciences, University of Bristol, Bristol, UK — [3]Cavendish Laboratory, University of Cambridge, Cambridge, UK

Biomimetic and bio-inspired efforts to produce novel photonic structures have attracted increasing research interest in recent years. Nature offers an enormous diversity of multifunctional micro- and nanostructures that induce outstanding, distinctive, dynamic coloration and high reflectivity. Various intriguing photonic structures have been identified on the wing cases of beetles, the scales of butterflies, the feathers of birds, in the shells of marine animals and also on the petals of flowering plants. Flora and fauna provide a huge reservoir of blue-prints for novel artificial optical materials and photonic systems. Here, we present a study of floral diffraction elements that provide a visual cue for pollinators, the development of mechanically tunable bio-inspired planar photonic elements and the artificial mimicry of the photonic structure found on the wing scales of the Indonesian butterfly *Papilio blumei*. State-of-the-art optical characterization by microspectroscopy and spectro-goniometry and optical modeling, including FDTD simulations, provide understanding of the working principles of the natural photonic elements. Artificially controlled self-assembly combined with alternative nanofabrication techniques is used in the development of the bio-inspired optical systems.

Invited Talk MA 17.3 Tue 11:30 TRE Ma

Playing with Nano-LEGO: Self-Assembly of Patchy Particles — •Daniela Kraft — Van 't Hoff Laboratory for Physical and Colloid Chemistry, Debye Institute for NanoMaterials Sciences, Utrecht University, Utrecht, The Netherlands

Self-assembly of colloidal particles into larger structures bears potential for creating materials with unprecedented properties, such as full

photonic band gaps in the visible spectrum. For such self-assembly, uniform colloids are quite limited as building blocks since their shape is the only control parameter. Much more promising in this respect are colloids with site-specific attractions. However, so far such 'patchy' colloids have only been studied *in computero* as their attainment in the laboratory has proven to be quite a challenge. Here we report two novel experimental realizations of patchy particles, focusing in particular on the simplest case of colloids with one patch only. These building blocks are used to built up new colloidal structures in solution, analogous to a 'Nano-LEGO'. The intriguing similarities between the obtained colloidal assemblies and models for molecules or surfactant micelles are discussed. We quantify the latter by employing a theoretical micelle model and compare our results to Monte Carlo and Molecular Dynamics simulations.

Invited Talk MA 17.4 Tue 12:00 TRE Ma

Controlling Excitons: Concepts for Phosphorescent Organic LEDs at High Brightness — •Sebastian Reineke — TU Dresden, Institut für Angewandte Photophysik, Dresden, Germany

Organic light-emitting diodes (OLEDs) attract much attention being a promising, energy-efficient technology with high color quality for display and lighting applications. Phosphorescence emitting materials prove to be inevitable because they can convert electrons into photons with an efficiency of one. Owing their comparably long exciton lifetime, non-linearities at high excitation levels noticeably reduce the emission efficiency (efficiency roll-off).[1] Thus, especially the understanding and optimization of OLEDs (monochrome and white) at high, application-relevant brightness – typically a few thousand candela per square meter – are of high interest.

This contribution starts with a discussion of triplet-triplet annihilation (TTA) – the process that dominates the roll-off – in an efficient phosphorescent system.[2] The results reveal that the nano-composition of the mixed film, where emitter molecules form aggregates, strongly decreases the high brightness efficiency. Based on these results, concepts for phosphorescent OLEDs will be introduced that show improved performance. Approaches to reduce TTA by altering the emission layer design as well as concepts for improved light-outcoupling will be discussed both for monochrome and white OLEDs.[2]

[1] M. A. Baldo *et al.*, Phys. Rev. B **62**, 10967 (2000).

[2] S. Reineke *et al.*, Appl. Phys. Lett. **91**, 123508 (2007) and **94**, 163305 (2009); Nature **459**, 234 (2009); Adv. Mater. **22**, 3189 (2010).

MA 18: Multiferroics IV: Exotic Properties and Dynamics (jointly with DF, DS, KR, TT)

Time: Tuesday 10:45–12:15 Location: HSZ 04

MA 18.1 Tue 10:45 HSZ 04

Polarization and magnetization dynamics of a field-driven multiferroic structure — •Alexander Sukhov[1], Chenglong Jia[1], Paul P. Horley[2], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06120 Halle/Saale, Germany — [2]Centro de Investigation en Materiales Avanzados, S.C. (CIMAV), 31109 Chihuahua, Mexico

A multiferroic chain with a linear magnetoelectric coupling induced by electrostatic screening at the ferroelectric/ferromagnet interface [1] is considered. We study theoretically the dynamic ferroelectric and magnetic response to external magnetic and electric fields by utilizing an approach based on coupled Landau-Khalatnikov and finite-temperature Landau-Lifshitz-Gilbert equations. Additionally, we make comparisons with Monte Carlo calculations. It is demonstrated [2] that for material parameters corresponding to $BaTiO_3$/Fe the polarization and the magnetization are controllable by oscillating external magnetic and electric fields, respectively.

[1] T. Cai, S. Ju, J. Lee, N. Sai, A.A. Demkow, Q. Niu, Z. Li, J. Shi and E. Wang, Phys. Rev. B **80**, 140415(R) (2009). [2] A. Sukhov, C.L. Jia, P.P. Horley and J. Berakdar, J. Phys.: Condens. Matter **22**, 352201 (2010).

MA 18.2 Tue 11:00 HSZ 04

Rare-earth induced magnetoelectric effect in multiferroic $TbMn_2O_5$ — •Naëmi Leo[1], Dennis Meier[2], Roman V. Pisarev[3], Sang-Wook Cheong[4], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn — [2]UC Berkeley, USA — [3]Ioffe Institute, St. Petersburg — [4]Rutgers University, USA

The presence of magnetic frustration and multi-dimensional magnetic order parameters leads to remarkable effects like magnetically induced ferroelectricity. Such a particularly interesting compound is $TbMn_2O_5$ due to the associated magnetic-field controllable electric polarization. The gigantic magnetoelectric coupling originates in the presence of three independent ferroelectric contributions, which can be separatedly accessed by optical second harmonic generation (SHG). Two of these contributions are related to the manganese Mn^{3+} and Mn^{4+} magnetism. The third one is attributed to the spin arrangement of the Tb^{3+} sublattice which also mediates the intricate field-dependent cross-coupling. We confirm this model by measurements taken on isostructural YMn_2O_5 with non-magnetic Y^{3+} ions.

Also we perform spatially resolved domain topography to show that the magnetic-field induced polarization reversal in $TbMn_2O_5$ does not include domain wall motion but is indeed due to a reversal of only one ferroelectric contribution.

This work was supported by the DFG through SFB 608.

MA 18.3 Tue 11:15 HSZ 04

Three-dimensional distribution of protected ferroelectric vortices in multiferroic hexagonal $YMnO_3$ — Tobias Jungk[1], •Martin Lilienblum[2], Ákos Hoffmann[1], Manfred Fiebig[2], and Elisabeth Soergel[1] — [1]PI, Universität Bonn, Wegelerstraße 8, 53115 Bonn, Germany — [2]HISKP, Universität Bonn, Nussallee 14-16, 53115 Bonn, Germany

Multiferrroics are a rich source for "unusual" forms of ferroelectric order. The spontaneous polarizations is induced by magnetism, charge order, geometric effects, etc., and may lead to novel domain states and functionalities. Here we show by piezoresponse force microscopy that ferroelectric domains in hexagonal multiferroic $YMnO_3$ form vortex-like structures around the direction of polarization. Although one would intuitively associate the sixfold character of the domain vortices to the uniaxial hexagonal structure, sixfold vortices are also present perpendicular to the direction of the spontaneous polarization. We will explain the intriguing topology on the basis of a simple geometric model. In addition, we will show how individual domain vortices are affected by application of an electric field applied along the polarization axis.

MA 18.4 Tue 11:30 HSZ 04

Poling of ferrotoroidic domains in $LiCoPO_4$ with toroidal fields — •Anne S. Zimmermann[1], Jean-Pierre Rivera[2], Hans Schmid[2], and Manfred Fiebig[1] — [1]HISKP, University of Bonn, Germany — [2]Department of Inorganic, Analytical and Applied Chemistry, University of Geneva, Switzerland

Ferrotoroidicity denotes a fourth, space- and time-asymmetric form of ferroic order with a spontaneous uniform alignment of magnetic vortices. Space and time asymmetry also relates ferrotoroidic materials to multiferroics and magnetoelectrics. After ferrotoroidic domains have been observed in $LiCoPO_4$ by second harmonic generation (SHG) experiments [1] controlled manipulation of these ferrotoroidic domains is the next step in demonstrating the ferroic nature of the toroidal state. This can be achieved by a toroidal field, i.e., a field behaving asymmetric under space inversion and time reversal, which can be realized by crossed electric and magnetic fields.

Here we report on the behaviour of ferrotoroidic domains in applied toroidal fields. The ferrotoroidic domain structure in various field experiments was investigated by phase-sensitive SHG. We demonstrate that it is possible to orient and switch the ferrotoroidic domains with an appropriate toroidal field. Furthermore the critical field strengths required to orient the ferrotoroidic domains and the relation of ferrotoroidic poling with magnetoelectric annealing are discussed. - Work supported by the SFB 608.

[1] B. B. Van Aken et. al., Nature 449, 702 (2007)

MA 18.5 Tue 11:45 HSZ 04

Time resolved measurements of the multiferroic switching in MnWO4 — •Max Baum[1], Thomas Finger[1], Jeannis Leist[2], Karin Schmalzl[3], Louis-Pierre Regnault[4], Petra Becker[5], Ladislav Bohatý[5], and Markus Braden[1] — [1]II. Physikalisches

Institut, Universität zu Köln — [2]Institut für Physikalische Chemie, Georg-August-Universität Göttingen — [3]Jülich Centre for Neutron Science (JCNS) at ILL, Grenoble — [4]Institut Nanosciences et Cryogénie, CEA-Grenoble — [5]Institut für Kristallographie, Universität zu Köln

Multiferroic materials or compounds with a strong magnetoelectric effect posses a large application potential in data storage techniques. Quite recently, systems with a peculiar spiral magnetic order were shown to directly induce a spontaneous electric polarisation and to exhibit giant magnetoelectric and magnetocapacitance effects, among them MnWO4. Neutron scattering with spherical polarisation analysis gives direct access to the chiral component of the magnetic structure which is directly linked to the electric polarisation and thus may be tunable by an electric field. In MnWO4 it is possible to drive multiferroic hysteresis loops at constant temperature as a function of the electric field. We broadened our investigations in this topic and present time resolved measurements of magnetoelectric switching. We applied stroboscopic techniques in order to investigate how fast the chiral component of the magnetic structure adapts to an instantaneously switched electric field. The time scale of the response is remarkable slow, in the range of 3 - 20 ms.

MA 18.6 Tue 12:00 HSZ 04

Time resolved reversal of spin-spiral domains by an electric field in multiferroic $MnWO_4$ — •Philip Thielen[1], Tim Hoffmann[1], Petra Becker[2], Ladislav Bohatý[2], and Manfred Fiebig[1] — [1]University Bonn, HISKP, Germany — [2]Institut für Kristallographie, Universität zu Köln

The interaction of magnetic and ferroelectric order is intrinsically strong in spin-spiral multiferroics. Here the complex magnetic long range order breaks inversion symmetry and induces a spontaneous electric polarization. The interaction allows for switching of the magnetization by means of an applied electric field and is thus of great interest for possible applications. So far there exists little information on the time scale and dynamics of the actual switching process. Here we report time resolved measurements of the reversal of spin-spiral domains in multiferroic $MnWO_4$ by optical second harmonic generation. Magnetic single-domain states are created by the application of an electric field. By reversing its polarity, a reversal of the magnetic domain state occurs. The time scale of the dynamic switching process is found to be in the ms region. Images of the domain-reversal process are obtained. The dynamic domain pattern differs substantially from that of quasi-statically switched multi domain structures.

MA 19: Poster I (Bio- and Molecular Magnetism/ Magnetic Particles and Clusters/ Micro- and Nanostructured Magnetic Materials/ Magnetic Materials/ Multiferroics/ Magnetic Shape Memory Alloys/ Electron Theory of Magntism/ Spincaloric Transport/ Magnetic Coupling and Exchange Bias/ Magnetization Dynamics/ Micromagnetism and Computational Magnetics)

Time: Tuesday 10:45–13:00 Location: P2

MA 19.1 Tue 10:45 P2

XPS investigation of a tetranuclear nickel complex — •Daniel Taubitz[1], Phalguni Chaudhuri[2], Vitaly Pavlishchuk[2], Karsten Kuepper[3], and Manfred Neumann[1] — [1]Department of Physics, University of Osnabrück, Barbarastrasse 7, D-49069 Osnabrück, Germany — [2]Max-Planck-Institut für Strahlenchemie, Stiftstrasse 34-36, D-45470 Mülheim an der Ruhr, Germany — [3]Department of Solid State Physics, University of Ulm, Albert-Einstein-Allee 11, D-89069 Ulm, Germany

Organic transition metal complexes could be potentially useful for the development of new materials in the field of molecular magnetism. In this work we report on the investigation of a tetranuclear $[Ni_4(HL)_3]^{2+}$ compound which was characterised by X-ray photoelectron spectroscopy. A comparison with similar nickel complexes will be discussed. During the X-ray spectroscopic investigation some radiation induced damage was observed and studied in more detail. It turned out that the main damage was a decomposition of the ClO_4^- anions.

MA 19.2 Tue 10:45 P2

Spin-resolved Photoelectron Spectroscopy of Mn_6Cr Single-Molecule-Magnets and of Manganese Compounds as Reference Layers — •Andreas Helmstedt[1], Aaron Gryzia[1], Niklas Dohmeier[1], Norbert Müller[1], Armin Brechling[1], Marc Sacher[1], Ulrich Heinzmann[1], Veronika Hoeke[2], Thorsten Glaser[2], Mikhail Fonin[3], Ulrich Rüdiger[3], and Manfred Neumann[4] — [1]Faculty of Physics, Bielefeld University — [2]Faculty of Chemistry, Bielefeld University — [3]Department of Physics, University of Konstanz — [4]Department of Physics, Osnabrueck University

The properties of the manganese-based single-molecule-magnet (SMM) Mn_6Cr are studied. This molecule exhibits a large spin ground state of S_T=21/2. It contains six manganese centres arranged in two bowl-shaped Mn_3-triplesalen building blocks linked by a hexacyanochromate. The Mn_6Cr complex can be isolated with different counterions which compensate for its triply positive charge. The spin polarization of photoelectrons emitted from the manganese centres in Mn_6Cr SMM after resonant excitation with circularly polarized synchrotron radiation has been measured at selected energies corresponding to the prominent Mn L_3VV and $L_3M_{2,3}V$ Auger peaks. Spin-resolved photoelectron spectra of the reference substances MnO, Mn_2O_3 and Mn(II)acetate recorded after resonant excitation at the Mn-L_3-edge around 640eV are presented as well. The spin polarization value obtained from MnO at room temperature in the paramagnetic state is compared to XMCD measurements of Mn(II)-compounds at 5K and a magnetic field of 5T.

MA 19.3 Tue 10:45 P2

Preparation of Monolayers of Mn_6Cr Single-Molecule-Magnets on different Substrates and characterization by means of nc-AFM — •Aaron Gryzia[1], Armin Brechling[1], Hans Predatsch[1], Ulrich Heinzmann[1], and Thorsten Glaser[2] — [1]Faculty of Physics, Bielefeld University, D-33615 Bielefeld — [2]Faculty of Chemistry, Bielefeld University, D-33615 Bielefeld

The preparation of a highly ordered monolayer of Single-Molecule-Magnets (SMM) is one of the main preconditions for a technical application of these molecules. The adsorption of these SMMs on surfaces is associated with difficulties due to the often low chemical stability of these molecules in the vicinity of a surface.

The used Mn_6Cr-complex [1] has a C_3-symmetry and a spin ground state of S_t = 21/2. This complex is a trication and needs therefore counter ions for electrical charge compensation. Tetraphenylborate, lactate and perchlorate came into consideration for this function.

Mn_6Cr-SMMs were prepared on different substrates by a droplet technique in air at room temperature. The samples were characterized by means of an AFM operating in non-contact mode, using tips with cone radii of approx. 2 nm.

An island-like growth was observed on SiO_2- and Si_3N_4-substrates, whereas on HOPG and mica the Mn_6Cr-SMM adsorbates preferred a layer growth. Also an influence of the used counter ions was observed on different substrates. The measured thicknesses of the layers are consistent with the Van der Waals radii of the Mn_6Cr-SMMs.

[1] T. Glaser et al., Angew. Chem., 118, 6179-6183 (2006)

MA 19.4 Tue 10:45 P2

Rare-earths-based single molecule magnets and single chain magnets — •Sabrina Haas[1], Conrad Clauss[1], Sina Zapf[1], Javier Luzon[2], Boris Gorshunov[1,3], Roberta Sessoli[2], Martin Dressel[1], and Lapo Bogani[1] — [1]1. Physikalisches Institut, Universität Stuttgart, Germany — [2]Dipartimento di Chimica e sezione INSTM, Universita degli Studi di Firenze, Italy — [3]Prokhorov Institute of General Physics, Russian Academy of Sciences, Russia

The field of molecular magnetism has allowed the observation of several interesting quantum effects. Much is nowadays known of molecular magnets made of transition metal ions but, when moving to rare-earth building blocks, little can be said, due to the complexity of such systems.

We focus in our study on the monomeric compound $[Dy(hfac)_3NIT(C_6H_4OPh)_2]$ and its one-dimensional counterpart

$[Dy(hfac)_3NIT(C_6H_4OPh)]_\infty$. These are among the most complex systems, due to the complete lack of symmetries both in the molecule and in the crystal lattice. We show that $[Dy(hfac)_3NIT(C_6H_4OPh)_2]$ shows slow relaxation of the magnetization and zero-field quantum tunnelling assisted by the nuclear spin. In particular we rely on a combined use of Frequency-domain magnetic resonance spectroscopy with backward wave oscillators and Fourier transform infrared spectroscopy, spanning a frequency range from 4 to 100 cm^{-1}. The results are compared to those obtained from ac susceptibility data and static magnetic measurements. All results are eventually compared with theoretical values obtained by CASSCF calculations.

MA 19.5 Tue 10:45 P2

Real time observation of magnetic nanobead transportation using domain walls in ferromagnetic nanostripes — •Sascha Glathe, Jörg Beinersdorf, Robert Müller, Sandra Julich, Thomas Henkel, Uwe Hübner, and Roland Mattheis — IPHT Jena e.V., Albert-Einstein-Str. 9, 07745 Jena

It was recently proposed that magnetic nanobeads can be trapped [1] and manipulated [2] by means of domain walls (DW) in magnetic nanostripes for biological applications. The bead is pinned in the vicinity of the DW due to the stray field originating from a transverse DW at the surface. We will show the reliable control of magnetic beads (SiO_2 coated $\gamma - Fe_2O_3$ particles) with a diameter of 500-1500 nm by DWs in 200*20 nm^2 Permalloy (Py) nanostripes. The Py layer was deposited by means of a UHV sputter deposition and patterned using e-Beam lithography and Ar-Ion etching. We used not-gate like structures [3] to allow for DW transportation with a rotating magnetic field, whereby the frequency of the rotating field determines the velocity of the DWs. The nanobead movement was detected by means of a dark field microscope with a 14,7 frames/s camera. We will show that the DW velocity is limited by the drag force of the nanobead in the liquid medium. From frequency dependent measurements we could estimate the drag force in dependence on the bead diameter.

[1] P. Vavassori et al., Appl. Phys. Lett., **93**, 203502 (2008)
[2] M. T. Bryan et al., Appl. Phys. Lett., **96**, 192503 (2010)
[3] D. A. Allwood et al., Science, **296**, 2003 (2002)

MA 19.6 Tue 10:45 P2

Structure and electronic properties of magnetic molecules on surfaces — •Philipp Erler[1], Samuel Bouvron[1], Sönke Voss[1], Michael Burgert[2], Ulrich Groth[2], and Mikhail Fonin[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz — [2]Fachbereich Chemie, Universität Konstanz, 78457 Konstanz

Molecular-scale spintronic devices are expected to have radically novel properties, with the added benefits of inexpensive fabrication through self-assembly, as well as chemical tunability. Single molecule magnets (SMM) representing mesoscopic systems which show magnetic bistability and rich quantum behavior are particularly interesting for applications in spin-based data storage and quantum-computing technologies.

Here we present a detailed study of structural and electronic properties of various Mn_{12} clusters chemically bound to a metallic surface, which was performed in order to find efficient preparation routes yielding intact clusters. We extensively studied the electronic properties of monolayers of Mn_{12} molecules on surfaces by means of scanning tunneling microscopy and spectroscopy at room temperature as well as by photoelectron spectroscopy. Complementary to the experiments on complex SMM molecules, the electronic properties of paramagnetic Cobalt Phthalocyanine molecules on different metallic surfaces were investigated by means of a cryogenic scanning tunneling microscope. We discuss the features in the local density of states measured at 4 K with and without having applied a high magnetic field.

MA 19.7 Tue 10:45 P2

Study of cobalt cluster films deposited by high-rate cluster source — •Björn Gojdka, Stefan Rehders, Viktor Hrkac, Venkata S.K. Chakravadhanula, Vladimir Zaporojtchenko, Thomas Strunskus, and Franz Faupel — University of Kiel, Institute for Materials Science, Kaiserstraße 2, 24143 Kiel

Ferromagnetic nanoparticles have been investigated intensively in the last decade as their properties open up a vast range of applications. In the last few years dedicated sources have been developed for the fabrication of size-selected nanoclusters, some of which are now even commercially available. However, present systems often suffer from high instrumental complexity and low deposition rates. We designed and built a cluster source with low technical complexity to deposit ferromagnetic nanoparticles with high deposition rates up to 100 nm/min. We present a study of nanocluster films which consist of cobalt nanoparticles with an average size of about 10 nm. Individual clusters and cluster films with a thickness of several hundred nanometers were investigated regarding their magnetic properties and morphology. The magnetic properties of the resulting cluster films can be tuned directly by the operation parameters of the cluster source.

MA 19.8 Tue 10:45 P2

Transition from superparamagnetism to correlated ferromagnetism in Pt capped Co nanoparticles — •Astrid Ebbing[1], Leonardo Agudo[2], Gunther Eggeler[2], and Oleg Petracic[1] — [1]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum — [2]Institut für Werkstoffe, Ruhr-Universität Bochum, 44780 Bochum

In this work we show that by capping Co nanoparticles with small amounts of Pt drastic changes of the magnetic properties can be induced. The magnetic properties were investigated using superconducting quantum interference device (SQUID) magnetometry. We find that for zero and for very small amounts of Pt (nominal thickness t(Pt) $<$ 0.7 nm) the nanoparticles behave superparamagnetic. With increasing t(Pt) the blocking temperature is enhanced from 15 K up to 110 K. However, for values t(Pt) $>$ 1 nm a strongly coupled state is encountered resembling a ferromagnet with T_c values $>$ 300 K.

MA 19.9 Tue 10:45 P2

Temperature dependent magnetorelaxometry: Comparison between theory and experimental data — •Markus Schiffler, Markus Büttner, Frank Schmidl, and Paul Seidel — Friedrich-Schiller-Universität Jena, Institut für Festkörperphysik

For investigation in the properties of magnetic nanoparticles their relaxation behavior can be used. One possibility is to perform temperature dependent magnetorelaxometry (TMRX) measurements. According to the thermal activation of the particles their relaxation behavior is determined by the energy barrier distribution. For such systems there is a theory provided by [1]. The numerical simulations presented there were done with arbitrary chosen simulation parameters. On the other hand there exist extensive data records of fractionated ferrofluids. Therefore the aim of the work presented here is to simulate the energy barrier distribution for the available data. The information used in the investigation is the anisotropy constant and the particle volume concentration. The mean volume of the particles is used for rescaling the obtained energy barriers to a temperature scale comparable with measurement results. Simulations with original volume concentrations are performed and compared with original results. The influence of agglomeration and variation of the particle volume concentration provide a shift of the energy barrier distribution to lower temperatures.

[1] Berkov, D.V., Numerical calculation of the energy barrier distribution in disordered many-particle systems: the path integral method. Journal of Magnetism and Magnetic Materials, 1998. 186(1-2): p. 199-213.

MA 19.10 Tue 10:45 P2

Are spin and orbital contributions to magnetic moments of FePt nanoparticles size-dependent? — •Luyang Han, Ulf Wiedwald, and Paul Ziemann — Institut für Festkörperphysik, Universität Ulm, A.-Einstein-Allee 11, 89069 Ulm, Germany

FePt nanoparticles (NPs) have attracted much interest due to their potential applications as well as its intriguing properties in basic research [1]. For magnetic NPs in general it is often observed that the magnetic properties deviate from the corresponding bulk behavior for diameters well below 10 nm. In this contribution we report on spin and orbital magnetic moments of FePt NPs with diameter of 3-10 nm prepared via reverse micelles [2]. X-ray magnetic circular dichroism (XMCD) reveals an increase of the ratio of orbital and spin magnetic moments after annealing at 700 °C for 30 min correlated with the emerging $L1_0$ phase. For this ratio, however, no significant size-dependence could be found. On the other hand, extended annealing above 700 °C leads to a decreasing ratio of orbital-to-spin moment. Since XMCD is quite surface sensitive, this indicates that besides the $L1_0$ phase formation annealing induced changes of the chemical surface composition may influence orbital-to-spin ratio of magnetic NPs.

[1]S. Sun, *Adv. Mater.*, **18**, 393, (2006)
[2]U. Wiedwald et al., *Beilstein J. Nanotechnol.*, **1**, 24, (2010)

MA 19.11 Tue 10:45 P2

Shift of the blocking temperature of Co nanoparticles

by Cr capping — •Melanie Ewerlin[1], Derya Demirbas[1], Leonardo Agudo[2], Gunther Eggeler[2], and Oleg Petracic[1] — [1]Experimentalphysik IV, Ruhr-Universität Bochum, 44780 Bochum — [2]Institute for Materials, Department of Materials Science, Ruhr-Universität Bochum, 44780 Bochum

We have prepared self-assembled Co nanoparticles on Al2O3 buffer layers and studied the effect of capping with various amounts of Cr onto the magnetic properties. Magnetization measurements were performed using superconducting quantum interference device (SQUID) magnetometry and structural characterization using transmission electron microscopy (TEM). The uncapped Co nanoparticles show superparamagnetic behaviour with a blocking temperature of TB=14K. The magnetic properties are strongly influenced by the Cr capping resulting in a decrease of TB for nominal thicknesses of Cr up to 0.15nm. However, for larger values 0.15 nm $<$ tCr $<$0.4nm the blocking temperature increases again. We suggest that for the first regime the Cr capping layer leads to an enhanced dissipation of magnetization, while the second regime is governed by inter-particle coupling via Cr bridges.

MA 19.12 Tue 10:45 P2

AFM-based method for imaging and magnetic characterization of isolated nanoparticles with nanometer lateral resolution — •Stephan Block and Christiane A. Helm — Institut für Physik, Ernst-Moritz-Arndt Universität, Felix-Hausdorff-Str. 6, D-17489 Greifswald, Germany

We present a new AFM-based method, which allows the simultaneous measurement of magnetic and spatial properties of nm-sized objects (nanoparticles, e.g. colloids or clusters). Thus, it becomes possible to distinguish different materials by their unique magnetism (e.g. superparamagnetism or diamagnetism). Basically, an oscillating magnetic field is applied to the sample and with a magnetic AFM-tip the surface magnetization is probed. Spatial changes of the magnetic flux density affect the vibration amplitude of the tip and thus, (dynamic) magnetic properties of the surface can be determined with high resolution.

In the present work, this new technique is applied to (diamagnetic) gold and (superparamagnetic) iron-(II,III)-oxide nanoparticles. It is shown, that the magnetic susceptibility of nanoparticles with lateral resolution of few nanometers can be resolved at least qualitatively. Additionally, the preliminary measurements show that these nanoparticles (with a diameter of less than 20 nm) can be clearly distinguished by this new method. This allows us to unambiguously identify nanoparticles in AFM measurements simply by the nature of their magnetism, which might be a very valuable tool in biochemical or biomedical methods like AFM-based immunolabeling of proteins.

MA 19.13 Tue 10:45 P2

Shape dependant oxidation of cobalt nanoparticles — •Britta Vogel, Katrin Eckstädt, Nadine Mill, Alexander Auge, Jan-Philipp Grote, and Andreas Hütten — Department of Physics, University of Bielefeld, D-33615 Bielefeld, Germany

Cobalt nanoparticles have been prepared as spheres, discs and cubes. Then the decrease of the saturation magnetisation by oxidation was determined with an AGM. The oxidation curves differ with the shape of the nanoparticles. To gain information about the oxidation processes, investigations concerning the surface of the particles were made, which exhibit an interesting connection between the shape and the oxidation behaviour.

MA 19.14 Tue 10:45 P2

Electrical characterization of intermetallic FePt nanoparticles — •Ulrich Wiesenhütter[1], Jochen Grebing[1], Bernd Rellinghaus[2], Jürgen Fassbender[1], and Artur Erbe[1] — [1]Helmholtz-Zentrum Dresden Rossendorf, D-01328 — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung, D-01069

Magnetic nanoparticles have a large potential for applications such as medical diagnosis and therapy, (bio-)sensors or magnetic recording. Conventional techniques, e.g., MFM, electron holography or Lorentz microscopy are only suited to determine magnetical properties of macroscopic particle ensembles. In order to investigate the electrical and magnetic properties of a single, free-standing FePt nanoparticle two nano-sized Au electrodes, that are fabricated by electron beam lithography, are used. The full characterization of the particle is carried out by electron microscopy and by recording current-voltage characteristics. Coulomb-blockade effects, which occur at low temperatures, can be used to determine the size and the magnetic properties of the particles.

MA 19.15 Tue 10:45 P2

Imaging of spin-torque induced magnetization dynamics in lateral spin injector configuration — •Matthias Buhl[1], Kerstin Bernert[1], Sebastian Wintz[1], Tom Henschel[1], Roland Mattheis[2], Jörg Raabe[3], Jochen Grebing[1], Kay Potzger[1], Artur Erbe[1], and Jürgen Fassbender[1] — [1]Helmholtz Zentrum Dresden Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Institut für Photonische Technologien e.V., Postfach 100239, 07702 Jena, Germany — [3]Swiss Light Source, Paul Scherrer Institut, 5232 Villigen, Switzerland

Electrical transport characteristics of structures consisting of normal metals and ferromagnetic materials depend strongly on the magnetization direction of the ferromagnets. Thus, different spin polarizations can lead to different resistance values of such structures. The absorption of spin polarized electrons in a ferromagnetic material (spin transfer torque) by domain/domain walls leads to magnetization switching or domain wall movement. This can be achieved by driving a current perpendicular to the plane of the ferromagnet (CPP) or in the plane (CIP). In this experiment we investigate the magnetization behavior of ferromagnetic nanopillars located between two lateral spin injectors in the CIP configuration. Using Scanning Transmission X-ray Mircoscopy (STXM) these studies will give more insights in the switching behavior and dynamics. Technological applications can mostly be found in memory structures, where the magnetization can be stored and read out.

MA 19.16 Tue 10:45 P2

Magnetization reversal in dipolarly coupled PdFe nanodot arrays — •Derya Demirbas, Melanie Ewerlin, Frank Brüssing, Oleg Petracic, and Hartmut Zabel — Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

We have studied a 2-dimensional XY macrospin model system by fabricating nanodot arrays from Pd1-xFex with low Fe-concentrations x $<$ 15 % as magnetic material. Pd1-xFex films of 10 nm thickness and various Fe concentrations were deposited by ion beam sputtering and characterized by superconducting quantum interference device (SQUID) magnetometry, magneto-optic Kerr effect (MOKE), atomic force microscopy (AFM) and x-ray diffraction (XRD). For the nanostructuring we used films with x = 11 at% showing a Curie temperature of 230 K. This low Tc ensures that the system can be cooled from a completely paramagnetic state into the macrospin state. We have fabricated circular dots with a diameter of 150 nm on a square lattice with various inter-dot distances. The magnetization reversal of the entire system has been studied using a low-temperature MOKE setup and has been compared to model expectations of a XY system with dipolar interactions.

MA 19.17 Tue 10:45 P2

Competition of dipolar interactions and lateral exchange spring effect in NiFe elements — •Norbert Martin[1], Ingolf Mönch[2], Rudolf Schäfer[2], Ludwig Schultz[2], Jürgen Fassbender[1], and Jeffrey McCord[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden — [2]Leibniz Institut für Festkörper- und Werkstoffforschung Dresden, Helmholtzstr. 20, 01069 Dresden

Conventional exchange spring systems consist of directly exchange coupled hard and soft magnetic layers. In the presented work, lateral exchange spring structures were prepared by structured ion implantation on patterned samples to investigate the interplay between structuring and additional dipolar fields. The collective magnetization reversal of hard and soft phase is attributed to strong dipolar fields at the element edges that cause a hysteresis behaviour, which is comparable to that of a magnetic homogeneous square element. The exchange spring behaviour, occurring with increasing difference in M_s between the two phases, is related to an increase in effective shape anisotropy in the high M_s stripes. The magnetization reverses through an antiparallel alignment of magnetization of the individual stripes. The resulting lateral domain walls are stabilized by the inter-stripe flux closure. The two-step reversal is modelled by taking the demagnetization and domain wall energy terms into account. This work is funded by the German Science Foundation, project DFG: Mc 9/7

MA 19.18 Tue 10:45 P2

Localized and delocalized modes in magnonic materials of hexagonal structure — •Fabian Garbs[1], Benjamin Lenk[1], Henning Ulrichs[2], and Markus Münzenberg[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen — [2]Institut für Ange-

wandte Physik, Universität Münster

With the time resolved measurement of the magneto-optical Kerr effect (TRMOKE) the spin amplitude is detected until 1 ns after excitation. Dependence of the external magnetic field can be measured in the range of $0 \leq \mu_0 H_{\text{ext}} \leq 150\,\text{mT}$ within an angle of up to 30° out of plane. The 50 to 150 nm thin samples were nanostructured with a focused ion beam (FIB) to lattices of hexagonal or honeycomb symmetry in the micrometer range.

The existence of antidots lead to new modes in micron-sized hexagonal structured thin films of Ni or CoFeB. Due to inhomogeneities in the internal field, localized spin-wave modes in nickel and propagating surface modes in the low damping CoFeB film occur. These modes are investigated for different structural parameters and varying alignments in the external field. In both cases the structural lattice is reflected in the measurements. One finds strong changes for directions of high symmetry. To clarify the influence of the symmetry, simulations have been done to show the internal field distribution.

MA 19.19 Tue 10:45 P2

Micromagnetic analysis of spin wave propagation in nanostructured magnonic crystals — •Florin Ciubotaru, Andrii V. Chumak, Alexander A. Serga, Philipp Pirro, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Spin wave propagation in nanostructured magnonic crystals (MCs) start to be intensively studied due to its potential technological application for signal processing in spintronic devices. Here we report on micromagnetic simulations [1] of the spin wave transmission in nanosized MCs. Two kinds of Permalloy waveguides with periodically varying width were under consideration: sinusoidal and rectangular profiles [2] of the notches. The band gaps (frequency regions where spin waves are not allowed to propagate) have been clearly observed and studied in the space and frequency domain. It is shown that both the band gap frequency and its depth depend strongly on the probing position inside the MC. It is due to the geometrically induced modulation of the internal magnetization field. Furthermore, the MC transmission characteristics can be changed from multiple rejection bands state to a single-band-state by using the harmonically modulated structure. Support from DFG (grant SE 1771/1) is gratefully acknowledged.

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MA 19.20 Tue 10:45 P2

Granular CoCrPt:SiO_2 recording media on assemblies of GaSb nanocones — •David Ball[1], Stephan Günther[2], Monika Fritzsche[1], Gaspare Varvaro[4], Denys Makarov[2,3], Kilian Lenz[1], Jürgen Fassbender[1], and Manfred Albrecht[2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden — [2]Institute of Physics, TU Chemnitz, 09126 Chemnitz — [3]Institute for Integrative Nanosciences, IFW Dresden, P.O. Box 270116, 01069 Dresden — [4]ISM-CNR, Via Salaria km 29.500, C.P. 10-00016 Monterotondo Scalo, Roma, Italy

Investigation of the magnetization reversal in arrays of magnetic nanostructures is relevant for both fundamental understanding as well as application for magnetic data storage. We present a study of the magnetization reversal in granular CoCrPt:SiO_2 recording media with weakly interacting magnetic grains grown onto pre-structured templates fabricated by ion irradiation of GaSb. By tuning the irradiation conditions, assemblies of nanocones of different size and periodicity were prepared. Columnar CoCrPt grains with their c-axis normal to the surface of the cones were formed as evidenced by HR-TEM. The spread of the c-axis of these grains results in a tilted easy magnetization axis with respect to the substrate normal. Investigation of the integral magnetic properties by vector-VSM reveals a decrease of the remanence with increasing cone size. The magnetic domain patterns observed by MFM suggest that the CoCrPt behaves as a single-domain cap structure on the cones. This work is supported by DFG FA 314-7.1 and AL 618-6.

MA 19.21 Tue 10:45 P2

Magnetic microstructure of nanocrystalline Gadolinium: a small-angle neutron scattering study — •Frank Döbrich[1,4], Helmut Eckerlebe[2], Melissa Sharp[2], Joachim Kohlbrecher[3], Rainer Birringer[4], and Andreas Michels[1] — [1]University of Luxembourg, 162A Avenue de la Faïencerie, L-1511 Luxembourg — [2]GKSS Forschungszentrum, D-21502 Geesthacht, Germany — [3]Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland — [4]Universität des Saarlandes, D-66041 Saarbrücken, Germany

We report on grain-size dependent magnetic small-angle neutron scattering (SANS) experiments on nanocrystalline Gd, which was synthesized using the low-capturing isotope ^{160}Gd. The angular variation of the two-dimensional SANS cross-section at different applied magnetic fields is discussed with a special focus on the rather unusual scattering contribution of the clover-leaf-type found for nanocrystalline Gd at intermediate field values. Additionally we have calculated from experimental data the autocorrelation function of the spin misallignment. This approach allows in particular for the extraction of the field-dependent correlation length of static spin misalignment fluctuations induced by microstructural defects. The data analysis suggests that the grain boundaries constitute a major scource of spin disorder in this material, which may be attributed to local atomic site disorder and modified coupling at internal interfaces.

MA 19.22 Tue 10:45 P2

Magnetoresistance of ferromagnetic materials on self-assembled nanospheres — •Florian Strigl and Elke Scheer — Department of Physics, University of Konstanz, 78475 Konstanz, Germany

Self-assembled spherical particles provide a huge variety of applications. Here we present a study in which they are brought into a linear arrangement by deposition onto a lithographically defined mask. We evaporate ferromagnetic materials of different thickness and composition, e.g. Co/Pd multilayers, onto these chains and contact them electrically with normal or superconducting leads. Co/Pd multilayers show a high magnetic anisotropy perpendicular to their surface [Albrecht]. Due to the limited dimension and the curvature, the multilayer-caps are single-domain and magnetically decoupled, but in electrical contact with each other. It is possible to control the magnetisation of a single cap by a magnetic force microscope (MFM) or of the whole chain by applying an external field while measuring the electrical conductance. Magnetoresistance measurements on 2D arrangements [Kimling] have shown large amplitudes, where the underlying mechanism is proposed to be similar to GMR.

Currently we are investigating the magnetoresistance of pure Co layers with varying thicknesses, the influence of the contacting materials (Au, Al) and characterising the system via MFM measurements.

[Albrecht] Nature Mater. 4 (2005) 203
[Kimling] JAP 107 (2010) 09C506

MA 19.23 Tue 10:45 P2

Morphology Induced Magnetic Anisotropy of Thin Films Deposited on Nanoscale Ripple Substrates — •Michael Körner[1], Maciej Oskar Liedke[1], Kilian Lenz[1], Mukesh Ranjan[1], Monika Fritzsche[1], Stefan Facsko[1], Jürgen Fassbender[1], Ulrich von Hörsten[2], Bernhard Krumme[2], and Heiko Wende[2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P.O. Box 510119, 01314 Dresden, Germany — [2]Fakultät für Physik und CeNIDE, Universität Duisburg-Essen, 47048 Duisburg, Germany

Magnetic properties of thin films are influenced by the morphology of substrates with periodically modulated patterns on the nanometer scale [1]. These well ordered surface modulations (ripple) can be produced by low energy ion beam erosion and are tuneable over a wide range [2]. Thin magnetic films deposited on these ripple surfaces repeat the surface profiles of these patterns and thus an additional uniaxial magnetic anisotropy is induced. This is shown for thin films of Fe, Co as well as the quasi-Heusler compound Fe_3Si. The magnetic anisotropy is determined by means of angular- as well as frequency-dependent ferromagnetic resonance measurements using a vector network analyzer. We find a strong uniaxial magnetic anisotropy induced by the ripple surface, which is superimposed on the cubic anisotropy in the case of single crystalline films.

This work is supported by DFG grant FA 314/6-1.

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[2] J. Fassbender et al., New Journal of Physics 11, 125002 (2009).

MA 19.24 Tue 10:45 P2

An experimental approach to a 2-dimensional random resistor network — •Miriam Lange, Philipp Szary, Oleg Petracic, and Hartmut Zabel — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

We present an experimental approach to a 2-dimensional random resistor network using the nanosphere lithography technique. Our samples are prepared by using self-organized polystyrene micro-particles of 500 nm diameter forming a 2-dimensional array of hexagonal order on top of a Si substrate. By means of oxygen plasma etching the diameter of the spheres is reduced in a controlled fashion. In a subsequent metallization step a Permalloy (Py = $Ni_{80}Fe_{20}$) layer with a thickness of 20 nm is deposited with the particle array acting as a shadow mask. After final lift-off the Py pattern remains as an antidot array, where each bridge represents a resistor in a 2-d network. The randomness of the preliminary particle self-organization process is transferred onto the network. Variation of the etching time allows us to fabricate systems of different connection widths. Magnetic and electrical properties have been studied by means of magnetic force microscopy (MFM), magneto-optical Kerr-effect (MOKE), superconducting interference device (SQUID) and magnetoresistance (MR) measurements.

MA 19.25 Tue 10:45 P2

Temperature dependence of stochastic domain-wall depinning in permalloy nanowires — •Clemens Wuth, Peter Lendecke, and Guido Meier — Universität Hamburg, Institut für Angewandte Physik, Jungiusstraße 11, 20355 Hamburg

We investigate the temperature dependence of domain-wall depinning in permalloy nanowires by measuring depinning fields and their corresponding depinning times as a function of bias field. The domain walls are pinned at triangular notches in the nanowires and detected non-invasively by Hall micromagnetometry [1,2]. This technique allows to acquire depinning-field and -time distributions in the temperature range between 5 K and 50 K and thus to determine the stochastics of the domain-wall depinning process. The results are discussed in terms of the Néel-Brown model for thermally activated magnetization reversal [3] and aim for a better understanding of field-induced domain-wall depinning.

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MA 19.26 Tue 10:45 P2

Magnetotransport properties of iron microwires grown by local electron beam induced activation — •Fabrizio Porrati[1], Roland Sachser[1], Marie-Madeleine Walz[2], Florian Vollnhals[2], Hans-Peter Steinrück[2], Hubertus Marbach[2], and Michael Huth[1] — [1]Physik. Institut, Goethe-Univ., Frankfurt a. M. — [2]Physikalische Chemie II, Uni Erlangen-Nürnberg, Erlangen

We have grown iron microwires under UHV conditions and we have measured their magnetic and transport properties in a 4-probe geometry. The growth process takes place in two-steps: First, a SiO_2 substrate is locally activated by electron beam irradiation. Second, the molecules of a precursor gas ($Fe(CO)_5$) injected in the UHV chamber decomposes and grows autocatalytically. The growth process can be controlled by tuning the electron beam dose, the dosage of precursor flux and the deposition time. For the transport measurements, the temperature dependence of the longitudinal resistivity (ρ_{xx}) shows a typical metallic behaviour with resistivity at room temperature of about 30 mW cm, i.e. only a factor 3 larger than the bulk value. Furthermore, we have measured isothermal Hall-resistivities in the range between 4.2 K and 260 K. These measurements reveal positive ordinary and anomalous Hall coefficients, which, respectively, decrease and increase by increasing temperature. The relation between anomalous Hall resistivity (ρ_{AH}) and longitudinal resistivity is quadratic, $\rho_{AH} \sim \rho_{xx}^2$, revealing an intrinsic origin of the anomalous Hall effect. Finally, we have measured at low temperature in the transversal geometry a negative magnetoresistance in the order of 0.2%.

MA 19.27 Tue 10:45 P2

Strong enhancement of magnetic anisotropy energy in alloyed nanowires — •Nikolay Negulyaev[1], Larissa Niebergall[1], Lucila Juárez Reyes[2], Jesus Dorantes-Dávila[3], Gustavo Pastor[2], and Valeri Stepanyuk[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle, Germany — [2]Institut für Theoretische Physik, Universität Kassel, D-34132 Kassel, Germany — [3]Instituto de Física, Universidad Autónoma de San Luis Potosí, 78000 San Luis Potosí, Mexico

One-dimensional atomic structures (monatomic wires and chains) are believed to be likely candidates for creation of nanostructures with large atomic orbital moments and hence with giant magnetic anisotropy energy (MAE) per atom [1,2]. We investigate the possibility of tuning the MAE of 3d transition metal monowires alloyed with 5d elements (Ir, Pt). Our ab initio studies give clear evidence that in mixed 3d-5d atomic wires MAE is one and even two orders of magnitude more than in pure wires constructed of the corresponding 5d [2] and 3d elements, respectively. Mechanisms responsible for the formation of such a strong MAE are revealed. The interplay between the structure of a monowire and its MAE is demonstrated. The contribution of both types of species (3d and 5d) into the MAE is discussed.

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MA 19.28 Tue 10:45 P2

Characterization of TMR-based memory cells with elliptically shaped elements — •Ana Ruiz Calaforra, Andres Conca, Britta Leven, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

The optimization of TMR-based memory cells fundamentaly depends on the switching properties of the single storage elements within a cell. In particular, the understanding of the role of the dimension of the TMR-elements is of importance. To study this systematically, a 4×4 memory cell device has been developed, using standard UV-lithography techniques on Si wafers in an industrial environment. It consists of two sets of Cu current lines, which are perpendicularly oriented to each other forming a grid cross structure. On each of the 16 intersections, elliptical elements with the symmetry axis oriented parallel to the current lines are structured. An additional Cu line allows for the resetting of the magnetization of all magnetic elements. Different dimensions for the TMR-elements were tested.

We present a systematic study of the static and dynamic magnetization behavior of the memory cell device for CoFeB elements using a micro-focused time resolved MOKE setup with a spotsize of 400 nm. Experiments using different amplitude and duration (ca. 1 μs) of the applied pulses are presented.

Support by the BMBF project MultiMag (VDI-TZ 13N9913), the state Rhineland-Palatinate and Sensitec GmbH, Mainz is acknowledged.

MA 19.29 Tue 10:45 P2

Influence of the geometrical parameters on the angular dependence of H_C in elliptical microstructures — •Thomas Sebastian, Andrés Conca, Georg Wolf, Thomas Meyer, Britta Leven, and Burkard Hillebrands — FB Physik und Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Elliptical magnetic microstructures with dimensions of a few micrometers play a crucial role in the design of magnetic field sensors and in data storage applications such as MRAM cells. A systematic study of the influence of the shape anisotropy on the coercive field H_C provides important information for the ability to control the anisotropic switching properties of single elements.

Here, we present measurements on the angular dependence of H_C for elliptical elements with varying size and aspect ratio (AR). The size of the structures ranges from 6 μm to 3 μm with ARs varying from 2 to 5. The measurements were performed with a μMOKE setup equipped with a micro-focused HeNe-laser beam with a spotsize of 1 μm. The elements were structured from 5 nm thick polycrystalline films of NiFe, CoFe and CoFeB using e-beam lithography. A comparison of the influence of the shape anisotropy on the angular dependence of H_C for the three materials and for the different dimensions will be discussed.

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MA 19.30 Tue 10:45 P2

Nanocomposites as a magnetic core in torodial thin film inductors and their integration — Amit Kulkarni[1], Thomas von Hofe[2], Falk Hettstedt[3], Vladimir Zaporojtchenko[1], •Thomas Strunskus[1], Eckhard Quandt[2], Reinhard Knöchel[3], and Franz Faupel[1] — [1]Institute for Material Science, Multicomponent Materials, Faculty of Engineering, University of Kiel, Kaiserstr 2, 24143 Kiel — [2]Institute for Material Science, Inorganic Functional Materials, Faculty of Engineering, University of Kiel, Kaiserstr 2, 24143 Kiel

— [3]Institute of Electrical and Information Engineering, Microwave Group, Faculty of Engineering, University of Kiel, Kaiserstr 2, 24143 Kiel

The current advancements in many areas of modern electronics point towards the development and integration of high frequency magnetic components. Use of high permeable magnetic core in the integrated micro-inductors would lead to miniaturization of the geometry and increased inductance provided that, extra losses due to eddy currents are avoided. We have investigated the high frequency permeability of sputter co-deposited CoFe/SiO2 composite films and their integration into torodial micro inductors. High frequency permeability of the composites depends on the metal filling factor and the anisotropy field present. The later can be induced during the fabrication process. Permeabilities of the order of 100 were achieved at 1 GHz for the core material, and it was shown that the preparation technique is compatible with the inductor integration process. The integration process is presently optimized involving the electromagnetic field simulation tool HFSS.

MA 19.31 Tue 10:45 P2

Simulation of atomic deposition between MnAs-clusters — •Andreas Rühl and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

We successfully implemented a computational algorithm to calculate and simulate a classical many-body system in a given potential. The considered many-body systems consists of a fixed number of particles, which interact within the boundary conditions suiting the deposition problem at hand. To simulate the condensation of the atoms on a substrate, we included the possibility of cooling down the system by means of a renormalisation of the particles' velocities. So far, the observed results show the equilibration of the system after a certain time, meaning for example, that a random velocity distribution from the start configuration becomes a maxwellian velocity distribution. With the help of the so called radial distribution function we were also able to analyse the system after it has been cooled down to see if the particles arrange in a specific structure.

MA 19.32 Tue 10:45 P2

Néel walls in magnetic hybrid structures — Mohammed Abdul Basith[1], Stephen McVitie[1], •Thomas Strache[2], Monika Fritzsche[2], Arndt Mücklich[2], Jeffrey McCord[2], and Jürgen Fassbender[2] — [1]Department of Physics and Astronomy, University of Glasgow, G12 8QQ, United Kingdom — [2]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden - Rossendorf, PF 510119, 01314 Dresden, Germany

Néel walls in soft magnetic NiFe/NiFeGa hybrid stripe structures surrounded by a NiFe film are studied by Lorentz microscopy. Upon downscaling the stripe structure size from 1000 nm to 200 nm a transition from a discrete domain pattern to an effective magnetic medium is observed for external magnetic field reversal experiments. This transition is associated with a vanishing abilitity of hosting neighboring high angle domain walls between adjacent stripes for stripes widths smaller than 500 nm. Furthermore domain walls constricted inside the stripes are characterized concerning the connection between domain wall witdh and domain wall angle. These results are compared with unconstricted domain walls in the surrounding film, theoretical predictions and with micromagnetic simulations.

MA 19.33 Tue 10:45 P2

Magnetisation reversal of individual α-Fe nanowires embeded in carbon nanotubes studied by submicron Hall magnetometry — •Kamil Lipert[1,2], Stefan Bahr[1], Franziska Wolny[1], Paola Atkinson[1], Uhland Weissker[1], Thomas Mühl[1], Oliver G. Schmidt[1], Bernd Büchner[1], and Rüdiger Klingeler[2] — [1]Leibniz Institute for Solid State and Materials Research IFW, 01069 Dresden, Germany — [2]Kirchhoff Institute for Physics, INF 227, D-69120 Heidelberg, Germany

We present the fabrication and characterization of a submicron Hall magnetometer which is based on a n-doped GaAs/AlGaAs heterostructure forming a two dimensional electron gas (2DEG). The device is designed for investigating the magnetic properties of individual nanomagnets. Here, we have studied the magnetisation switching and its dependence on temperature (6K<T<70K) and angle between applied magnetic field and tube axis for two single crystalline Fe nanowires with different diameters $d_1 = 26$ nm and $d_2 = 17$ nm coated with carbon shells. For the thicker Fe-nanowire, the data imply a noncoherent character of the magnetisation reversal. In contrast, for the wire with $d_2 = 17$ nm the nucleation fields increase for fields parallel to the wires axis. This observation resembles the Stoner-Wohlfarth model for rotation of magnetisation in unison, even though the nanowire diameter exceeds the critical diameter of coherent rotation ($d_0 = 12$ nm). In both cases, the temperature dependence of nucleation fields implies that magnetisation switching is a localized process which in case 1 is initiated by curling.

MA 19.34 Tue 10:45 P2

Preparation of domain walls in Co/Pt multilayer wires — •Judith Kimling[1], Andreas Vogel[1], André Kobs[1], Lars Bocklage[1], Sebastian Wintz[2], Jürgen Fassbender[2], Mi-Young Im[3], Peter Fischer[3], Ulrich Merkt[1], Hans Peter Oepen[1], and Guido Meier[1] — [1]Institute of Applied Physics and Microstructure Research Center Hamburg, University of Hamburg, Germany — [2]Institute of Ion-Beam Physics and Materials Research, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — [3]Center for X-ray Optics, Lawrence Berkeley National Laboratory, Berkeley, USA

Current-induced domain wall motion for studies of spin momentum transfer requires the reliable preparation of domain walls. Since high current densities can alter or destroy the structures investigated, weak pinning potentials and reliable depinning of domain walls at low current densities are desirable. A prerequisite for the preparation of a domain wall at such pinning sites is that the domain wall nucleates at a field smaller than the field required to depin the domain wall. We suggest methods to tune the nucleation field of lithographically patterned Co/Pt multilayer wires. An up to fourfold reduction of the nucleation field could be achieved through altering the lateral shape of the wires or by depositing iron stripes on top. Furthermore we explored the applicability of geometric constrictions and ion implantation for the creation of pinning sites. The magnetization reversal in the structures was imaged by transmission X-ray microscopy.

Financial support by the DFG via SFB 668 and GrK 1286 as well as by BES Mat Sci&Eng Div at DOE is gratefully acknowledged.

MA 19.35 Tue 10:45 P2

Preparation of domain walls in cylindrical nanowires — •Judith Kimling[1], Stephan Martens[1], Kristina Pitzschel[1], Tim Böhnert[1], Michael Martens[1], Peter Lendecke[1], Lars Bocklage[1], Victor Vega[2], Florian Kronast[3], Ulrich Merkt[1], Kornelius Nielsch[1], and Guido Meier[1] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung Hamburg, Universität Hamburg, Germany — [2]Departamento de Física, Universidad de Oviedo, Asturias, Spain — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, BESSY, Germany

Electrodeposition of ferromagnetic materials in self-organized nanopores of an alumina membrane provides the unique ability to process ultrathin wires of complex shape and with reproducible properties [1]. For both fundamental research and technological applications it is of interest to understand the nucleation, propagation and pinning of domain walls in such nanostructures. We synthesized nickel and permalloy nanowires with diameters between 30 nm and 300 nm and aspect ratios up to 1000. The magnetization reversal of single wires was studied by magnetic force microscopy, magnetoresistance measurements, magneto-optical Kerr-effect and X-ray photoemission electron microscopy in straight wires, in bent wires, and in wires with diameter modulations serving as tailored pinning sites.

[1] K. Nielsch et al., Handbook of Magnetism and Adv. Magnet. Mat., Vol. 4, John Wiley and Sons, Ltd., Chichester, 2007.

Financial support by the DFG via SFB 668, GrK 1286, and SPP 1165 is gratefully acknowledged.

MA 19.36 Tue 10:45 P2

Ion-beam induced magnetic nanostructures in Fe/Cu(100) — •Sameena Shah Zaman, Hinnerk Ossmer, Jakub Jonner, Zbyněk Novotný, Andreas Buchsbaum, Ondrej Krapek, Petr Dvorak, Michael Schmid, and Peter Varga — TU Wien, Institut für Angewandte Physik, Wien, Austria.

We demonstrate fabrication of nanoscale magnetic patterns by ion irradiation. For this purpose, we have grown face-centered cubic (fcc) 8-ML and 22-ML thick Fe films on a Cu(100) single crystal; the latter ones stabilized by CO. A structural transformation of these films from the paramagnetic fcc to the ferromagnetic bcc phase can be induced by Ar^+ ion irradiation [1]. Scanning tunneling microscopy images show the nucleation of bcc crystallites, which grow with increasing Ar^+ ion dose and eventually result in complete transformation of the

film to bcc. Surface magneto-optic Kerr effect measurements confirm the transformation of the Fe film from paramagnetic to ferromagnetic with an in-plane easy axis. We also demonstrate the transformation of films coated with Au to protect them from oxidation at ambient conditions. Nano-patterning was conducted on these films via a SiN mask having 80-nm-diameter holes.

[1] S. Shah-Zaman et al., Phys. Rev. B 82, 235401 (2010).

MA 19.37 Tue 10:45 P2

Correlation between lancet domains and misorientation in FeSi sheets with Goss texture — •Jörg Fankhänel, Felix Kurth, Konrad Güth, Ludwig Schultz, and Rudolf Schäfer — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

For transformer cores, mostly Iron-Silicon-sheets with Goss texture are used. For ideal grain orientation, one of the easy <100> crystal axis is aligned along the rolling direction, while the other two are at angles of 45° with respect to the rolling direction. The magnetic performance strongly depends on the misorientation angle, i.e. the angle between the near-surface easy axis and the sheet surface. Earlier work [1] has shown that this angle correlates with the density of lancet domains, a supplement domain structure that is observed for surfaces with small misorientation and which is formed to minimize the magnetic stray-field energy. In this work we want to verify this correlation and determine the experimental conditions for a reliable determination of the misorientation angle from the lancet domain density. To achieve this we directly measured the misorientation angle by means of EBSD (electron backscatter diffraction) and cross correlate them to the lancet pattern (observed by Kerr microscopy) by application of an external magnetic field at a small angle with respect to the rolling direction. Thus the quantification of misorientation and texture degree in Goss sheets by means of Kerr microscopy is an easy to implement and fast alternative to expensive methods like EBSD or x-ray analysis.

[1] N. Bär, A. Hubert, W. Jillek , J. Magn. Magn. Mat. 6, 242 (1977)

MA 19.38 Tue 10:45 P2

Normal and anomalous Hall effect in $NbFe_2$ — •Sven Friedemann[1], Manuel Brando[2], William J Duncan[3], Andreas Neubauer[4], Christian Pfleiderer[4], and Malte Grosche[1] — [1]University of Cambridge, Cavendish Laboratory, JJ Thomson Avenue, CB3 0HE Cambridge, United Kingdom — [2]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Strasse 40, 01187 Dresden, Germany — [3]Department of Physics, Royal Holloway, University of London, Egham TW20 0EX, United Kingdom — [4]Physik Department E21, Technische Universität München, James-Franck-Strasse, D-85748 Garching, Germany

The intermetallic system $NbFe_2$ exhibits ferromagnetic and antiferromagnetic order, which can be suppressed by slight changes to the composition within the $Nb_{1-y}Fe_{2+y}$ homogeneity range, thus accessing a quantum critical point (QCP). In proximity to its QCP $NbFe_2$ exhibits non-Fermi-liquid behavior, which makes this material the first clear candidate for a three dimensional ferromagnetic QCP within the transition metals. We present Hall effect measurements on two selected samples of the $Nb_{1-y}Fe_{2+y}$ solution series. The data are analyzed in terms of anomalous and normal contributions to the Hall voltage. The normal contribution is expected to give insight into the electronic structure whereas the anomalous contributions may help to clarify the yet unresolved magnetic properties close to the QCP.

MA 19.39 Tue 10:45 P2

Scaling study on magnetic ordering transition and specific heat in the cubic helimagnet FeGe — •Andrey A. Leonov[1], Michael Baenitz[2], Walter Schnelle[2], Marcus Schmidt[2], Ulrich K. Rössler[1], and Heribert Wilhelm[3] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]MPI CPfS, Noethnitzer Str. 40, 01187 Dresden — [3]Diamond Light Source Ltd., Chilton, Didcot, OX11 0DE, United Kingdom

The magnetic phase transition of the cubic helimagnet FeGe at the ferromagnetic-paramagnetic transition have been analyzed from a scaling study on dc magnetization data by extrapolation from high applied fields. The critical properties have been calculated for a hypothetical homogeneously magnetized state, as FeGe is a helimagnet in the zero-field state. The exponents β for spontaneous magnetization, γ for the initial susceptibility above T_C, and δ for the critical magnetization isotherm at T_C have been obtained from modified Arrott plots and by the Kouvel-Fisher method. The analysis indicates a conventional magnetic phase transition with critical exponents similar to those expected for an isotropic magnet belonging to the Heisenberg universality class. Deviations from the ferromagnetic ordering are discernible at low applied fields for $T < T_C$ owing to the onset of chiral twisting and the inception of helimagnetic order. The specific heat data display only a small region near T_C where scaling applies and reliable determination of the related exponent α is not possible. The anomalous specific heat closer to T_C indicates a first-order phase transition.

MA 19.40 Tue 10:45 P2

New Resonant Inelastic X-ray Scattering and Coherent X-ray Scattering station at UE49-SGM, BESSY II — •Justine Schlappa, Peter Bischoff, Stefan Eisebitt, Frank Eggenstein, Alexander Föhlisch, Rolf Follath, Jan Geilhufe, Christian Günther, Christian Jung, Tino Noll, Bastian Pfau, Jan-Simon Schmidt, Fred Senf, Carsten Tieg, Kerstin Tietz, and Thomas Zeschke — BESSY II, Helmholtz Zentrum Berlin, Germany

Soft x-ray scattering techniques are powerful probes for the understanding of nano- and atomic-scale phenomena, including magnetism, atomic motion and electronic structure [1-3]. New beamline UE49-SGM and experimental stations are currently under construction, dedicated to the techniques of resonant inelastic x-ray scattering (RIXS) and coherent x-ray scattering (CXS). This facility will have the unique possibility to combine high-resolution spatial information studies with high-resolution chemicaly- and atomically-selective spectroscopy studies for a broad range of applications.

[1] S. Eisebitt, et al., Nature 204, 885 (2004), [2] J. Schlappa et al., Phys. Rev. Lett 103, 047401 (2009), [3] F. Hennies, et al. Phys. Rev. Lett 104, 193002 (2010).

MA 19.41 Tue 10:45 P2

Ferromagnetic resonance in Heusler thin films using broadband microwave transmission spectroscopy — •Diana Geiger[1], Marc Scheffler[1], Martin Dressel[1], and Martin Jourdan[2] — [1]1. Physikalisches Institut, Universität Stuttgart, Germany — [2]Institut für Physik, Johannes-Gutenberg-Universität Mainz, Germany

Heusler compounds with a chemical structure X_2YZ are very promising candidates for applications in spintronics because some of them are ferromagnets with a perfect spin polarization of the electrons at the Fermi level. In order to utilize these qualities it is crucial to understand the magnetic properties of these materials. $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA) is a ferromagnetic Heusler material with a Curie temperature of 700 to 800K, which makes it well suitable for magnetoelectronic devices. With ferromagnetic resonance studies, magnetization and magnetic moments of ferromagnets can be probed.

We performed broadband microwave stripline transmission measurements on CCFA Heusler samples in variable magnetic field of 0 to 160 mT at temperatures from 100K to 300K. The covered frequency range is 45 MHz to 12 GHz. We employ a stripline geometry where our CCFA thin film serves as ground plane, separated from a copper meandered inner conductor by teflon sheets. With this experimental approach we were able to detect and identify the ferromagnetic resonance in a broad frequency range. We will present both the field and temperature dependence of the ferromagnetic resonance.

MA 19.42 Tue 10:45 P2

***T*-matrix approach for electron-magnon interactions in ferromagnetic materials** — •Mathias C. Müller, Christoph Friedrich, Ersoy Sasioglu, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

First-principles calculations of the quasiparticle energies and lifetimes in real materials have been performed mainly within the GW approximation (GWA). The GWA has been shown to yield accurate quasiparticle band structures for weakly to moderately correlated systems, whereas it is expected to fail in describing short-range interactions in strongly correlated systems. The scattering between electrons and magnons that takes place in systems with localized d and f orbitals plays an important role in transport and thermodynamic properties of magnetic materials. These scattering phenomena are not accounted for in the GWA. In order to improve the theoretical description of magnetic materials we go beyond the GWA and take higher-order terms into account. We present a formalism that combines the electron-electron scattering described by GWA and the electron-magnon scattering in a unified way. The magnons are calculated with the T-matrix, which describes multiple scattering of electron-hole pairs with different

spin. Our implementation is based on the all-electron full-potential linearized augmented-plane-wave (FLAPW) method [1]. As a first step, we calculate the magnon spectra of elementary ferromagnets.
[1] E. Şaşıoğlu, A. Schindlmayr, Ch. Friedrich, F. Freimuth, and S. Blügel, Phys. Rev. B **81**, 054434 (2010).

MA 19.43 Tue 10:45 P2

Magnetic properties of $Fe_{90}Sc_{10}$ nanoglass — •Ralf Witte[1,2], Jixiang Fang[2], Mohammad Ghafari[2], Robert Kruk[2], Richard A. Brand[2], Horst Hahn[2], and Herbert Gleiter[2] — [1]Technische Universität Darmstadt, Gemeinschaftslabor Nanomaterialien, Petersenstr. 23, D-64287 Darmstadt, Germany — [2]Karlsruher Institut für Technologie, Institut für Nanotechnologie, D-76344 Eggenstein-Leopoldshafen Germany

We report on our work on magnetic properties and their correlation with local structure in Fe-Sc nanoglasses. Samples were synthesized with a nominal composition of $Fe_{90}Sc_{10}$ in an inert-gas condensation (IGC) process. X-ray diffraction, Mössbauer spectroscopy as well as magnetometric characterization methods were applied to characterize the samples. Magnetometric measurements revealed a significant change of magnetic properties in the Fe rich compound marked by an increase of the Curie point to temperatures well above 300 K, which is much higher than the transition temperature in regular metallic glasses of similar composition. The maximum magnetic hyperfine field obtained from low temperature Mössbauer spectroscopy was about 37.5 T, which is much more than observed in bcc-Fe. This newly identified ferromagnetic phase is attributed to the modified short-range-order in the interfaces of adjacent amorphous nanoparticles.

MA 19.44 Tue 10:45 P2

Finite-size effects on the magnetoelectric response of field-driven ferroelectric/ferromagnetic chains — Chenglong Jia[1], •Alexander Sukhov[1,2], Paul P. Horley[3], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06120 Halle/Saale, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle/Saale, Germany — [3]Centro de Investigation en Materiales Avanzados, S.C. (CIMAV), 31109 Chihuahua, Mexico

We study theoretically the coupled multiferroic dynamics of one-dimensional ferroelectric/ferromagnet chains with different lengths driven by harmonic magnetic and electric fields. We performed Monte-Carlo simulations and calculations based on the coupled finite-temperature Landau-Lifshitz-Gilbert and Landau-Khalatnikov equations showing that the magnetization and the polarization of thin hetero-structures can be reversed by external electric and magnetic fields, respectively.

MA 19.45 Tue 10:45 P2

Magnetoelectric response of feld-driven composite multiferroics — Chenglong Jia[1], •Alexander Sukhov[1,2], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06120 Halle/Saale, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle/Saale, Germany

We study theoretically the electric or magnetic feld-induced dynamical response of a multiferroic material and trace the footprints of the magnetoelectric (ME) coupling in this response. Several scenarios of ME couplings are considered: (*i*) strain-mediated, (*ii*) charge-mediated, (*iii*) and exchange-bias mediated multiferroic oxide composite structures. By utilizing the kinetic Monte-Carlo simulations [1], it is demonstrated that the magnetization and the polarization of the heterostructures are controllable by external electric and magnetic felds, respectively. [1] A. Sukhov, C.L. Jia, P.P. Horley and J. Berakdar, J. Phys.:Condens. Matter **22**, 352201 (2010).

MA 19.46 Tue 10:45 P2

Coupling Effects between Lattice dynamics and Magnetism in $GdMnO_3$ studied by optical spectroscopy — Sven Issing[1], Michael Schmidt[2], Franz Mayr[2], Joachim Deisenhofer[2], Alois Loidl[2], Alexander A. Mukhin[3], Andrei Pimenov[4], and •Jean Geurts[1] — [1]Experimentelle Physik III, Universität Würzburg, Germany — [2]Experimentelle Physik V, Universität Augsburg, Germany — [3]General Physics Institute of the Russian Academy of Sciences, Moscow, Russia — [4]Institut für Festkörperphysik, Technische Universität Wien, Austria

We present detailed optical reflectivity FT-IR investigations of the temperature dependence of the infrared active phonons in the multiferroic manganite $GdMnO_3$ from T = 300K down to T = 5K. $GdMnO_3$ is in the focus of interest due to its intimately coupled orbital, lattice and spin degrees of freedom and the resulting multiferroism. Our results clearly show two different coupling effects shifting the phonon frequencies at the onset of the magnetically ordered phases: Spin-Phonon Coupling (SPC) and Electromagnon-Phonon Coupling (EMPC). SPC is caused by a modulation of the magnetic exchange by a movement of the O^{2-} ions within the MnO_2 plane. Thus, it is most strongly pronounced for phonons consisting mainly of distortive modes of the MnO_6 octahedra within this plane. We observed a softening of the phonon frequencies by $\Delta\omega \approx -(1-2)\%$. EMPC on the other side manifests itself as a strong hardening of the phonon frequency ($\Delta\omega \approx +3\%$) for the $B_{3u}(1)$ mode, which is mainly a Gd^{3+} and Mn^{3+} displacement. It is clearly connected with the appearance of the Electromagnon.

MA 19.47 Tue 10:45 P2

Response of hexagonal multiferroic *R*MnO3 (*R*=Y, Yb, Ho, Er) to magnetic and electric fields — •Sebastian Manz, Tim Günter, Thomas Lottermoser, and Manfred Fiebig — HISKP, University of Bonn, Germany

Contradictory reports on the electric and magnetic properties of the multiferroic hexagonal $R\mathrm{MnO_3}$ compounds and their behavior in electric and magnetic fields are found in literature. Examples are the magnetic structure itself, critical field values for the magnetic phase transition, or the electric coercive field and saturation polarization values. These uncertainties further lead to controversial discussions of the magnetoelectric effects to be expected in the $R\mathrm{MnO_3}$ system.

Here, we report on a systematical analysis of the response of hexagonal multiferroic $R\mathrm{MnO_3}$ to magnetic and electric fields by linear and nonlinear optical techniques and pyroelectric current measurements. The response of samples grown from the flux at different dates and floating-zone samples are compared. We find that the magnetic hysteresis curve can display ferromagnetic, induced ferromagnetic, and ferrimagnetic behavior. Furthermore, we demonstrate that flux-grown samples can no longer be fully polarized at temperatures < 260 K and, due to sample leakage, not at all in the majority of floating-zone samples. We discuss the consequences for electric-field poling experiments reported in the literature.

MA 19.48 Tue 10:45 P2

Nonlinear Spectroscopy and Domain Imaging in the High-temperature Multiferroic CuO — Tim Hoffmann[1], Kenta Kimura[2], •Tsuyoshi Kimura[2], and Manfred Fiebig[1] — [1]University Bonn, HISKP, Germany — [2]Osaka University, Japan

Compounds in which the ferroelectric polarization is directly induced by the magnetic structure (joint-order parameter multiferroics) are of special interest because of their intrinsically strong magnetoelectric coupling. In the majority of these systems this effect occurs at temperatures < 50 K. However, in CuO ferroelectricity is induced by a spiral magnetic order at ≈ 230 K. This proves that joint-order-parameter multiferroicity is not limited to the low-temperature regime and renders CuO an important subject of research on the search for large magnetoelectric effects at near-ambient temperatures.

We performed a full characterization of the compound by polarization-dependent optical second harmonic generation spectroscopy. By temperature dependent measurements we could identify the SHG tensor components coupling to the multiferroic state and obtain the temperature dependence of the ferroelectric polarization and the magenetic order parameter, respectively. The gigantic efficiency of the observed SHG signal points to a substantial electronic (instead of ionic) contribution to the ferroelectric polarization. Furthermore we investigated the multiferroic domain structure by spatially resolved SHG and found that in zero-field-cooled samples the domain size is on the order of 0.1-1 μm.

MA 19.49 Tue 10:45 P2

Spin-Phonon Excitations in Multiferroics — •Safa Golrokh Bahoosh[1], Steffen Trimper[2], and Julia Wesselinowa[3] — [1]Max Planck Institute of Microstructure Physics,Halle,Germany — [2]Institute of Physics, Martin-Luther-University,Halle,Germany — [3]University of Sofia, Department of Physics,Sofia,Bulgaria

The influence of phonons on multiferroic systems are studied using a Green's function technique. The calculations are performed on the basis of considering nearest and the next nearest neighbor interaction in the Heisenberg model which favors the occurrence of helical structures in the magnetic system. The ferroelectric subsystem is characterized by the Ising model in a transverse field and is described by pseudo-

spin-operators. Taking into account anharmonic phonon couplings, spin-phonon interaction as well as pseudo-spin-phonon-interaction we calculate the temperature dependent spectrum of the coupled system. The elementary excitations determine the macroscopic properties of the system like the magnetization and the polarization. The results are compared with experimental observations.

MA 19.50 Tue 10:45 P2

Nonlinear optical spectroscopy on magnetoelectric and multiferroic pyroxenes $LiFeSi_2O_6$ and $NaFeSi_2O_6$ — •Adrian Volz[1], Naëmi Leo[1], Petra Becker[2], Ladislav Bohatý[2], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn — [2]Institut für Kristallographie, Universität zu Köln

There has been a growing interest in the class of pyroxenes $AMSi_2O_6$ (A alkali metal, M transition metal) with multifunctional properties such as multiferroicity or magnetic-field controllable electric polarization. In particular the close relation between toroidal moment and the observed cross-coupling of magnetic and electric properties are discussed for multiferroic $NaFeSi_2O_6$ and magnetoelectric $LiFeSi_2O_6$.

Here we characterize the pyroxene compounds $LiFeSi_2O_6$ and $NaFeSi_2O_6$ by optical second harmonic generation (SHG). SHG is particularly sensitive to the subtle symmetry issues distinguishing between the magnetoelectric and the multiferroic properties of the pyroxenes. We observe gigantic SHG effeciency which indicates electronic (i.e. non-ionic) contributions to the magnetically induced spontaneous polarization. By SHG spectroscopy we seperate signals of crystallographic, magnetic and electric origin which allows us to investigate the interaction between the corresponding sublattices. The influence of externally applied fields is discussed.

This work is supported by the DFG through SFB 608.

MA 19.51 Tue 10:45 P2

Magneto-electric coupling in $NdFe_3(BO_3)_4$ studied by resonant x-ray scattering — •J. E. Hamann-Borrero[1], S. Partzsch[1], S. Valencia[2], R. Feyerherm[2], C. Mazzoli[3], J. Herrero-Martin[3], C. Hess[1], A. Vasiliev[4], L. Bezmaternykh[5], B. Büchner[1], and J. Geck[1] — [1]IFW Dresden, 01171 Dresden — [2]Helmholtz Zentrum Berlin. Albert Einstein Str. 15 12489 Berlin — [3]ESRF, Boite Postale 220, 38043 Grenoble, France — [4]Faculty of Physics, Moscow State University, Russia. — [5]Kirensky Institute of Physics, Russian Academy of Sciences, Krasnoyarsk, Russia.

Resonant x-ray magnetic scattering (RXS) experiments on $NdFe_3(BO_3)_4$ were performed at the Nd $L_{2,3}$ and Fe K edges in order to determine its magnetic structure as a function of temperature (T) as well as applied magnetic (**B**) and electric (**E**) fields. Results of the T dependent measurements show that the magnetic structure changes from a commensurate collinear structure to an incommensurate spin helix structure. Moreover, the analysis of the resonant intensities shows that the T dependence of the magnetic order is different for the Nd and for the Fe sublattice. A mean field analysis implies that the magnetization of the Nd sublattice is induced by the Fe magnetization. When a **B** field is applied along the a-direction, the spin helix is destroyed and a collinear structure is formed where the moments align perpendicular to **B**. Since the critical **B** at which the spin helix is destroyed is the same at which the magnetic induced electric polarization is maximum. This shows that the spin helix is not the origin of the electric polarization in $NdFe_3(BO_3)_4$.

MA 19.52 Tue 10:45 P2

Magnetic field induced polarization in the Ba3NbFe3Si2O14 crystal with a chiral spin structure — •Matthias Hudl[1,2], Yusuke Tokunaga[3], Yasujiro Taguchi[1], Roland Mathieu[2], and Yoshinori Tokura[1,3,4] — [1]RIKEN, Adv. Sci. Inst., CERG and CMRG, Wako, Saitama, 3510198 Japan — [2]Uppsala University, Dept. Engn. Sci., SE-75121 Uppsala, Sweden — [3]ERATO JST, Multiferroics Project, Tokyo 1138656, Japan — [4]University of Tokyo, Dept. Appl. Phys., Tokyo 1138656, Japan

Single crystals of langasite Ba3NbFe3Si2O14 with a chiral magnetic structure have been synthesized by floating zone method. In this system, the magnetic ions (Fe3+) are arranged in the ab-plane forming planar triangular lattices of triangle units. Below T = 27 K, three spins within a single triangle order uniformly in a 120° spin structure in the ab-plane. This structure is helically modulated from plane to plane along the c-axis. The complex magnetic structure suggests magnetic-field-induced electrical polarization and magnetoelectric effects. We have investigated the magnetic and magnetoelectric properties of the single crystals by magnetization and electrical polarization measurements. While no polarization is induced along the c-axis of the structure for any orientation of the magnetic field, we have observed a field-induced electric polarization along the a-axis direction for applied magnetic fields in the ab-plane up to 14 T. *** M. H. and R. M. thank the Anna Maria Lundin-, Hans Werthén- and Göran Gustafsson Foundation for support. This work was in part supported by JSPS, FIRST program on "Quantum Science on Strong Correlation".

MA 19.53 Tue 10:45 P2

Magnetic Resonance and Magnetization Measurements of Multiferroic $Eu_xBa_{1-x}TiO_3$ — •Nataliya Georgieva[1], Andreas Pöppl[1], Rolf Böttcher[1], Marko Bertmer[1], Jürgen Haase[1], and Alex Sushkov[2] — [1]Faculty of Physics and Earth Sciences, University of Leipzig, Germany — [2]Department, Yale University, New Haven, Connecticut, USA

We are investigating multiferroic $Eu_xBa_{1-x}TiO_3$ with different Eu^{2+} concentrations (x = 1, 0.75, 0.5, 0.25) using magnetic resonance spectroscopy (EPR and NMR) and magnetization measurements.

The ceramics samples exhibit different magnetic and electric properties depending on their Eu^{2+} concentration. SQUID magnetization measurements have revealed Curie-Weiss behavior of all samples and magnetic ordering at low temperatures.

The X- and Q-band EPR spectra show strongly dipole-broadened and exchange-coupled Eu^{2+} signals. Temperature dependent line broadening effects are observed and differ for various Eu^{2+} concentrations.

Preliminary ^{137}Ba NMR spectra were recorded using frequency stepped Hahn Echo experiments. The line width of the central ^{137}Ba nuclear quadrupole transition shows a striking dependence on the Eu^{2+} concentration.

MA 19.54 Tue 10:45 P2

Magnetic structure of multiferroic $GdMnO_3$ explored by Resonant Soft X-ray Scattering — •Enrico Schierle[1], Victor Soltwisch[1], Detlef Schmitz[1], Andrey Malyuk[2], Fabiano Yokaichiya[2], Dimitri N. Argyriou[2], and Eugen Weschke[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Straße 15, 12489 Berlin, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin, Germany

In the orthorombic $ReMnO_3$s (Re=Gd, Dy, Tb), ferroelectric polarization is induced by complex magnetic structures resulting in a strong coupling of the two ordering phenomena [1]. While the multiferroic properties are dominated by the cycloidal structure of Mn moments as established by neutron diffraction [2], there is growing evidence for a decisive role of ordering of the Re-4f moments as well. This has been highlighted by x-ray diffraction studies as a complementary tool [3,4]. Particularly, resonant soft x-ray scattering (RSXS) is well suited to study details on the magnetic structure in an element-specific way [4]. We studied the magnetic ordering of the Gd-4f spins of $GdMnO_3$ in detail by RSXS, sheding new light on the possible mechanisms of multiferroicity. The experiment was performed using a very recently commissioned diffractometer for RSXS built at HZB.

[1] Kimura et al., Nature **426**, 55-58 (2003)
[2] Kenzelmann et al., PRL **95**, 087206 (2005)
[3] Prokhnenko et al., PRL **98**, 057206 (2007)
[4] Schierle et al., PRL **105**, 167207 (2010)

MA 19.55 Tue 10:45 P2

Resonant Soft X-ray Scattering (RSXS) Studies on Multiferroic YMn2O5 with six circle diffractometer and CCD-camera — •Sven Partzsch[1], Stuart Wilkins[2], John Hill[2], Enrico Schierle[3], Eugen Weschke[3], Dmitri Souptel[1], Bernd Büchner[1], and Jochen Geck[1] — [1]IFW Dresden — [2]BNL Upton — [3]Helmholz-Zentrum Berlin

RMn_2O_5 (R = Y, rare earth, Bi) are multiferroics there RSXS at the magnetic modulation vector $(1/2, 0, 1/4)$ provide additional information to neutrons. By tuning the energy to the Mn L- and O K-edges, respectively, the experiment becomes element selective. To see which scattering is proportional to the electric polarization the integrated intensity is important. For this we performed experiments at X1A2 (Tardis), NSLS, BNL, Upton, New York, USA. Four moving motors in six circle geometry and a CCD-camera provided the integrated intensity and all widths in three principal directions with one scan (set of images). Thus this technique is practical to study strongly correlated electron systems.

MA 19.56 Tue 10:45 P2

Multiferroics: Magnetic Structures & Excitations — •Simon Holbein[1], Max Baum[1], Thomas Finger[1], Navid Qureshi[1], Jeannis Leist[3], Götz Eckold[3], Petra Becker[2], Ladislav Bohatý[2], and Markus Braden[1] — [1]II. Physikalisches Insittut, Universität zu Köln — [2]Institut für Kristallographie, Universität zu Köln — [3]Institut für Physikalische Chemie, Georg-August-Universität Göttingen

Multiferroics possess a large application potential in data storage techniques. Quite recently, systems with a peculiar spiral magnetic order were shown to directly induce a spontaneous electric polarisation and to exhibit giant magnetoelectric and magnetocapacitance effects, among them MnWO4, TbMnO3 and the pyroxenes (Na/Li)FeSi2O6.

We already presented time resolved measurements of magnetoelectric switching in MnWO4. Stroboscopic techniques were applied in order to investigate how fast the magnetic chirality adapts to an instantaneously switched electric field. Recently we arranged a new set-up to investigate the corresponding behaviour of the electric polarisation at such electric fields.

Our results on the magnetic structure of NaFeSi2O6 reveal that the moments arrange in a helical spiral. Therefore the Dzyaloshinski-Moriya interaction is not explaining the development of electrical polarisation (a cycloidal spiral would be needed for this). We extended our investigations on electric field driven switching of magnetic chirality to NaFeSi2O6.

Furthermore we discuss the electromagnon - collective spin-phonon excitations - in DyMnO3.

MA 19.57 Tue 10:45 P2

Competing Ferri- and Antiferromagnetic Phases in Geometrical Frustrated $LuFe_2O_4$ — •Joost de Groot[1], Karin Schmalzl[1], Andrew Christianson[2], Mark Lumsden[2], Karol Marty[2], Shilpa Adiga[2], Stephen Nagler[2], Werner Schweika[1], Zahra Yamani[3], and Manuel Angst[1] — [1]IFF, JARA-FIT, Forschungszentrum Jülich GmbH, Jülich, Germany — [2]Oak Ridge National Laboratory, Oak Ridge, USA — [3]Canadian Neutron Beam Center, Chalk River, Canada

$LuFe_2O_4$ is proposed to be a multiferroic material [1], with a novel mechanism for ferroelectricity, based on Fe2+/Fe3+ charge order (CO). Frustration leads to near degeneracy between ferro- and antiferroelectric CO, with antiferroelectric long range order established below T_{CO} ∼320K [2]. Clarifying the magnetic long range order below T_N ∼240K [3] and the transition to a glassy state at T_{LT} ∼170K is as important as elucidating the origin of (anti)ferroelectricity.

We will present a detailed study of the magnetic field - temperature phase diagram, which features an antiferromagnetic and a ferrimagnetic phase and for low temperatures a phase separation. We demonstrate that nearly degenerate ferrimagnetic and antiferromagnetic instabilities at T_N are the key to the remarkably rich phase diagram. These bear a striking resemblance to nearly degenerate antiferro- and ferroelectric CO instabilities at T_{CO}[2].

[1]N. Ikeda *et al.*, Nature **436** 1136 (2005); [2]M. Angst *et al.*, Phys. Rev. Lett. **101** 227601 (2008); [3]A. D. Christianson *et al.*, Phys. Rev. Lett. **100** 107601 (2008).

MA 19.58 Tue 10:45 P2

Synthesis optimization of Possible Relaxor Ferroelectric Magnetite crystals — •Shilpa Adiga, Jörg Persson, and Manuel Angst — IFF, JARA-FIT, Forschungszentrum Jülich GmbH, Jülich, Germany

The 120 K Verwey-transition [1] in magnetite Fe_3O_4 is the classical example for charge ordering. Despite of the decades of research, the complex low-temperature structure and even the existence of $Fe^{2+/3+}$ charge order is still unresolved. Early experimental studies and recent theoretical calculations on magnetite support ferroelectricity (FE) due to charge ordering. If confirmed, FE, and thus multiferroicity from charge order in classical magnetite would be significant. Recently, Schrettle *et al* [2] observed signatures of relaxor FE in dielectric spectroscopy measurements. Specific diffuse scattering would be expected in such a case. Unambiguous proof of (relaxor) FE may be obtained by detailed scattering experiments. The sensitivity of the Verwey transition depends on sample quality (oxygen stoichiometry) [3]. The best way to obtain high-quality crystals is the direct synthesis in an appropriate CO/CO_2 flow [4]. We first investigated appropriate ratios of CO/CO_2 at high temperature on polycrystalline samples, characterized primarily by thermo-remanent magnetization and specific heat. The use of the results for the crystal growth by floating zone method and the physical properties of the grown crystals will be presented.

[1] E.J.W.Verwey, Nature **144** 327 (1939). [2] F. Schrettle *et al.*, arXive:1007.3613. [3] P. Shepherd *et al.*, Phys. Rev. B. **43** 8461 (1991). [4] R.Aragon *et al.*, J. crystal growth,. **61** 221 (1983).

MA 19.59 Tue 10:45 P2

DFT modeling of point defects in strontium titanate — •Ider Ronneberger, Matthias Zschornak, and Sibylle Gemming — Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), D-01314 Dresden, Germany

Multiferroics, which simultaneously exhibit at least 2 ferroic properties, are considered as novel materials with promising technological applications, e.g. as sensor or switching element. A possible candidate for such materials is strontium titanate, doped with magnetic point defects. In our research we studied 2 x 2 x 2 supercells of strontium titanate defect structures with DFT. As defects we considered the substitution of Ti by the transition metals Fe, Mn and V as single impurities and in combination with oxygen vacancies. From the electron density calculations we derive structural deformations, charge transfer and magnetic properties. Stability is discussed in terms of formation energies of the defects.

MA 19.60 Tue 10:45 P2

Raman spectroscopic investigations of epitaxial $BiCrO_3$ thin films on different substrates — •Andreas Talkenberger[1], Kannan Vijayanandhini[2], Christian Röder[1], David Rafaja[3], Miryam Arredondo[2], Ionela Vrejoiu[2], and Cameliu Himcinschi[1] — [1]TU Bergakademie Freiberg, Institute of Theoretical Physics, D-09596 Freiberg, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle, Germany — [3]TU Bergakademie Freiberg, Institute of Materials Science, D-09596 Freiberg, Germany

Multiferroic epitaxial thin films are of strong research interest due to their properties and potential applications for example in memory devices. In this work epitaxial $BiCrO_3$ (BCO) thin films deposited by pulsed laser deposition on $SrTiO_3$ (100), $(LaAlO_3)_{0.3}$-$(Sr_2AlTaO_6)_{0.7}$ (100) and $NdGaO_3$(110) substrates were investigated by Raman spectroscopy. The Raman spectra were measured from 87 K to room temperature using the 532 nm emission line of a Nd:YAG laser for excitation. The epitaxial relation between films and substrates was verified by analyzing high resolution transmission electron microscopy images, electron diffraction patterns, and polarization dependent Raman spectra considering that BCO crystallizes in the C2/c space group. The shift of phonon modes at room temperature indicates different strains in the BCO films grown on the three substrates. The optical phonon shift of the epitaxially strained BCO films was related to the strain determined from high resolution XRD measurements.

This work is supported by the German Research Foundation DFG HI 1534/1-1.

MA 19.61 Tue 10:45 P2

Structural and magnetic characterization of spinel films prepared by MAD — •Simon Slapka, Vasile Mosneaga, and Konrad Samwer — 1. Physikalisches Institut, Universität Göttingen

Spinels are known for a long time as magnetic materials, the oldest one (Fe3O4) used by the chinese as a compass. Spinels with multiferroic properties have been found (CoCr2O4).

In the case of manganese-doped spinel films spins are arrangend on an triangular lattice. The antiferromagnetic coupling causes magnetic frustration.

Unexpected dielectric properties have been found in thin films of Zn0.25Mn0.75Al2O4. The present study is adressed to the connection between spin frustration, magnetic properties and these unexpected dieletric properties.

MA 19.62 Tue 10:45 P2

Tuning the ferroelectric properties of $BiFeO_3$ thin films with mechanical stress — •Martin Hoffmann, Oliver Mieth, and Lukas M. Eng — Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden

In thin film physics, the crystallographic structure of the deposited film is strongly influenced by the substrate induced strain caused by the lattice mismatch between substrate and film. This leads to the fact that the properties of thin films and surfaces can differ dramatically from the corresponding bulk values.

In the present study, the ferroelectric properties of multiferroic $BiFeO_3$ thin films on $SrTiO_3$ under compressive and tensile stress were

investigated via piezoresponse force microscopy (PFM). The systematic substrate bending allows us to record the strain dependent domain distribution and the local switching behavior on the nanometer length-scale. We quantify these effects through monitoring the coercive field and the imprint as a function of applied stress; in fact, we observe that strain effects can be significantly enhanced or even fully compensated in BFO/STO thin films allowing the BFO film to become tunable in its ferroic properties.

MA 19.63 Tue 10:45 P2

Magnetic domain structure evolution in NiMnGa magnetic shape memory alloy — •Andreas Neudert and Jeffrey McCord — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Bautzner Landstr. 400, 01328 Dresden

We have investigated the magnetic domain structure evolution due to twin boundary motion in single crystalline NiMnGa (10M) magnetic shape memory samples. Due to the high mobility of the twin boundaries they can be moved by applying a magnetic field or mechanical stress. In general, the equilibrium domain width in magnetic samples depends on the interplay of demagnetization and anisotropy energy. Depending on the orientation of the easy axis within a magnetic sample different equilibrium widths can be found. We investigated the magnetic domain structure using optical polarization microscopy and magnetic indicator film technique. We found that the qualitative domain structure depends on whether the sample was subjected to magnetic fields or mechanical stresses. In both cases the twin boundary is moved and therefore the orientation of the magnetic easy axis is changing. During the field induced motion the variants are partially saturated, whereas during the stress induced motion the net magnetization in the variants is unchanged. This results in a completely different remagnetization process and magnetic domain structure. Using domain theory the equilibrium domain width can be calculated and is compared with the experimental values. We greatly acknowledge support by DFG priority program SPP 1239.

MA 19.64 Tue 10:45 P2

Local epitaxial growth of magnetic shape memory films Ni2MnGa on MgO-buffered CMOS substrates — •Yuansu Luo, Xueyuan Zhang, and Konrad Samwer — I. Phys. Institut, Universität Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

Local epitaxial films Ni2MnGa were prepared on MgO-buffered CMOS substrates for possible integration of microsensors. The MgO buffer layers were reactively sputtered at 350-700°C, exhibiting a perfect [100] orientation perpendicular to the substrate and accordingly a preference of [010] and [001] orientations parallel to the substrate. No significant difference was found of MgO buffer layers on Si and SiO2. Similar texture behaviours were measured in austenitic Ni2MnGa films and indicate the local epitaxial growth on MgO buffer. The surface of martensitic films reveals thus twin boundaries in two preferred directions perpendicular to each other. The magnetic transition at TC of about 375K was observed relatively sharp, but the martensitic phase transformation (TM ˜320K) slightly broad compared to overall epitaxial films prepared on MgO substrates. Two-dimensional (2D) grain growth and thus a smooth surface are typical characters for the local epitaxial films on the MgO buffer, rather than rough 3D grain films prepared directly on SiO2 substrates. (Supported by BMBF-project 13N10061 MSM-Sens)

MA 19.65 Tue 10:45 P2

Investigation of single-crystalline magnetic shape memory alloys: Ni-Mn-X (X = In, Ga, Sb) — •Christian Schöppner[1], Santa Pile[1], Ivan Titov[1], Detlef Spoddig[1], Ralf Meckienstock[1], Mehmet Acet[1], Michael Farle[1], Jian Liu[2], Nils Scheerbaum[2], Sandra Weiss[2], and Oliver Gutfleisch[2] — [1]Universität Duisburg-Essen, Fakultät für Physik, AG Farle, 47057 Duisburg, Germany — [2]IFW Dresden, Institue for Metallic Materials, P.O. Bos 270116, 01171 Dresden

Ni-Mn-based magnetic shape memory alloys are promising active materials for actuators and sensors, since they provide huge field-induced strains up to 10% due to magnetic field-induced structural reorientation or magnetic field-induced phase transformation. For a deeper understanding of these effects, the magnetic-structural properties of Ni-Mn-X (X= In, Sb, Ga) magnetic shape memory alloys are investigated on single-crystalline samples in the μm-range by electron-backscatter-diffraction (EBSD), magnetization analysis and ferromagnetic-resonance (FMR). Temperature and angular dependent FMR measurements on single-crystalline samples provide the possibility to determine crystalline anisotropy constants in certain crystallographic planes in austenite and martensite states and can be put into context with M(H)-data measured in the temperature range $5 \leq T \leq 400$K.

Work supported by the Deutsche Forschungsgemeinschaft (SPP1239)

MA 19.66 Tue 10:45 P2

Microstructure of free-standing Ni2MnGa films — •Richard Hausmanns, Tobias Eichhorn, and Gerhard Jakob — Institut für Physik, Johannes Gutenberg-Universität Mainz, Deutschland

One of the interesting properties of the Heusler compound Ni2MnGa is the presence of the magnetic shape memory effect with a maximum length change of 10%. Thin, single crystalline films of this material thus are interesting for miniaturized sensor and actuator applications. The here investigated samples are prepared by dc-magnetron sputter deposition on heated MgO(100) substrates with a Cr buffer layer. The films can be released from the substrate by selective chemical etching of the Cr layer. The complex crystal structure before and after releasing the film is studied by x-ray diffraction in 4-circle geometry. Thereby different orthorhombic variants and modulation (7M/14M) are identified. The crystal structure appears to be unaffected by the removal of the buffer layer.

The presence of steps in the hysteresis loops, measured on free-standing films, indicates that magnetically induced reorientation of variants can occur. To prove that the variant distribution is studied by x-ray diffraction with applied magnetic field.

MA 19.67 Tue 10:45 P2

Structural and magnetic properties of tetragonal Heusler compounds Mn2-xFe1+xGa (x=0.2-1) — •Teuta Gasi, Jürgen Winterlik, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg-University, Mainz, Germany

The subject of this brief report are the structural and magnetic properties of tetragonal Heusler compounds Mn2- xFe1+xGa (x=0.2-1). These materials play an important role because of their multifunctional application in STT-MRAM technology, STO etc. A series of samples were successfully synthesized by arc-melting and characterized. The crystal structure was determined at RT by XRD and the magnetic measurements were done using SQUID magnetometer in the temperature range 2K-800K. STT-MRAM requires high Tc, low Gilbert damping constant, low magnetic moment. The magnetic measurements show that all these materials show high Tc above 600 K and diverse magnetic hardness. We have found that a compound Fe2MnGa demonstrates the shape-memory effect.

MA 19.68 Tue 10:45 P2

Electronic structure of the austenitic and martensitic phase of Ni_2MnGa . — •Aleksej Laptev[1], Philipp Leicht[1], Mikhail Fonin[1], Martin Weser[2], Hendrik Vita[2], Yuriy Dedkov[2], S. W. D'Souza[3], and Sudipta Roy Barman[3] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz — [2]Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin — [3]UGC-DAE Consortium for Scientific Research, 452001 Indore, India

Recently Ni_2MnGa and related alloys have attracted strong scientific interest due to a reported magnetic field induced strain of up to 10 % in the low temperature martensitic phase. The occurrence of the structural martensitic phase transition is reported to be closely related to the electronic structure of this material. Especially strong Fermi-surface nesting was proposed for this material [1,2]. Here we report the investigation of the electronic structure of a $Ni_2MnGa(001)$ single crystal with angle resolved photoemission (ARPES). The sample was also studied by means of STM and revealed a well-ordered and reconstruction-free surface. ARPES measurements were performed in both austenitic and martensitic state. The obtained Fermi-surface and band structures of both phases were compared with currently existing electronic structure calculations [1,2]. At this preliminary point of our analysis good agreement between theory and experiment is found.
This work was supported by the BMBF-Project MSM-Sens 13N10062.
[1] O. I. Velikokhatnyi and I. I. Naumov, *Phys. Solid State* **41**, 617-623, (1999)
[2] C. Bungaro et al., *Phys. Rev. B* **68**, 134104 (2003)

MA 19.69 Tue 10:45 P2

Designing Heusler systems with martensitic transformations — •Ivan Titov, Mehmet Acet, and Eberhard Wassermann — Experimetalphysik, Universität Duisburg-Essen, 47048 Duisburg

The search for magnetic shape memory alloys as alternatives to the prototype Ni-Mn-Ga alloys system has provided further understanding of magnetic-field-induced effects in a variety of Ni-Mn-based martensitic Heusler alloys. Such alloys exhibit substantial antiferromagnetic exchange just below the martensitic transformation temperature, and this is thought to affect twin-boundary motion adversely since it can lead to pinning effects. We aim to find new Heusler materials that undergo martensitic transformations and, at the same time, are essentially free of antiferromagnetic exchange, or the exchange is sufficiently weak, so that twin-boundary motion is not hindered. These conditions primarily demand the alloy compositions to be Mn-free. Mn is the source of antiferromagnetic exchange, particularly at Mn-rich off-stoichiometric compositions. We present studies on the structural and magnetic properties of Co-Cr-Ga, Ni-(FeCr)-Ga, and Co-Ni-Fe-Ga and present an overview of their phase diagrams in relation to martensitic transformations.

MA 19.70 Tue 10:45 P2

Role of oxygen holes and charge-dispropotionation in transition-metal compounds,$Cs_2Au_2Cl_6$ — •Alexey Ushakov[1], Sergey Streltsov[1,2,3], and Daniil Khomskii[1] — [1]II Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln Germany — [2]Institute of Metal Physics, S. Kovalevskoy Str. 18, 620041 Ekaterinburg GSP-170, Russia — [3]Ural Federal University, Mira Str. 19, 620002 Ekaterinburg, Russia

The systems with mixed-valence (MV) state of magnetic ions and/or with spontaneous charge disproportionation attract at the moment big attention. Typical such system is perovskite gold chloride $Cs_2Au_2Cl_6$. At ambient pressure it is an insulator with tetragonal crystal structure $I4/mmm$. There appears in this phase a spontaneous charge segregation of Au into $Au^{1+}(d^{10})$ and $Au^{3+}(d^8)$, ordered in checkerboard fashion. Under the pressure this valence disproportion vanishes, and at about 11.3 GPa, this systems becomes a metal with equivalent Au (single-valent(SV) state).

In this work we perform the ab-initio band structure calculations of $Cs_2Au_2O_6$. The main aim of our research is to determine the factors, which promote the charge disproportionation in this and similar systems, and the possible role of ligand (here Cl) holes in the formation of such state and its change under pressure.

MA 19.71 Tue 10:45 P2

Electronic structure of transition metal nanoclusters — •Ingo Opahle — Institut für Theoretische Physik, Universität Frankfurt, 60438 Frankfurt/Main, Germany

The electronic structure of small to intermediate sized transition metal clusters (Au, Pt and their binary alloys with Cu and Co) is calculated within the framework of density functional theory. Global optimization of the ground state structure is performed with a recently developed genetic algorithm. Details of the implementation of the genetic algorithm and its performance will be discussed. The transition to bulk like behaviour of the clusters and their electronic and magnetic properties (including magnetic anisotropy) will be discussed.

MA 19.72 Tue 10:45 P2

About the 3ω method - the question current source or voltage source, plus application for field-dependent thermal conductivity measurements — •Johannes Kimling, Johannes Gooth, and Kornelius Nielsch — Institute of Applied Physics, University of Hamburg, Germany

The 3ω method is a standard method for thermal conductivity measurements. Researchers employ current-driven and voltage-driven setups, with or without common-mode subtraction for detecting the third harmonic component of the measurement signal. Nevertheless, there is a lack of clarity for which voltage-driven setups one has to consider a correction factor, as the formalism assumes an ideal current source at 1ω. In this work we show that for voltage-driven setups using common-mode subtraction, the application of a correction factor would be incorrect. On the other hand, for 3ω setups that use simple voltage-driven series circuits without common-mode subtraction a correction factor has to be considered. We employed the 3ω method to perform field-dependent thermal conductivity measurements on individual electrochemically synthesized nickel wires with diameters between 150 nm and 350 nm. Such structures exhibit anisotropic magnetoresistance. The field-dependent 3ω measurement allows observing the thermal analog: the anisotropic magnetothermal resistance. Measuring both effects simultaneously reveals spin-dependent changes in the Lorenz-number. Application to magnetic multilayer nanowires will allow studying the giant magnetothermal resistance in the cross-plane direction.

MA 19.73 Tue 10:45 P2

Formation and evolution of domain patterns and topological defects in antiferromagnetically coupled perpendicularly magnetized multilayers — •Nikolai Kiselev[1], Volker Neu[1], Ulrike Wolff[1], Cristina Bran[2], Olav Hellwig[3], Alex Bogdanov[1], and Ulrich Rössler[1] — [1]IFW Dresden, Germany — [2]Uppsala University, Sweden — [3]Hitachi GST, San Jose, USA

Ground states in magnetic multilayers with strong perpendicular anisotropy and antiferromagnetic (AF) interlayer exchange coupling (IEC) as [Co/Pt(Pd)]/Ru or [Co/Pt]/NiO are (i) multidomain states with ferromagnetic (FM) arrangement of magnetization through the whole multilayer and (ii) the homogeneous state with AF arrangement in adjacent layers [1]. Within the homogeneous AF state, there are different types of defects which exist as a metastable state. These defects are composed of irregular networks of isolated 180-degree domain walls in FM layers which are coupled via interlayers and stabilized by the competition between IEC and magnetostatic interaction. We distinguish sharp domain wall, ferroband and tiger tail (TT) defects [2]. Theoretical analysis using micromagnetic domain models shows that TT patterns cannot be stabilized by the interplay between magnetostatic and IEC energies only, but can be stabilized by domain wall pinning. We present a theoretical and experimental study of nucleation and evolution of these defects in magnetic fields in [Co/Pt]/Ru multilayers.

[1] N. S. Kiselev, et al., Appl. Phys. Lett. 93, 162502 (2008); [2] N. S. Kiselev, et al., J. Magn. Magn. Mater. 322, 1340-1342 (2010);

MA 19.74 Tue 10:45 P2

Micromagnetic model for exchange coupled $SmCo_5$/Fe/$SmCo_5$-trilayers — •Martin Kopte, Simon Sawatzki, Marietta Seifert, Ludwig Schultz, and Volker Neu — IFW Dresden, Germany

The enhancement of remanence and energy density in exchange coupled hard/soft magnets has reached a new record value of 300 kJ/m^3 in recently prepared epitaxial $SmCo_5$/Fe/$SmCo_5$-trilayers. A micromagnetic model has been adapted to such a trilayer system, which simulates the full hysteresis in a one-dimensional spin chain approach and the effect of the intermediate Fe-layer thickness d_{Fe} has been evaluated. The simulations have been carried out using the programs OOMMF and MicroMagus, after carefully checking the input parameters for stable solutions. Calculated hysteresis curves are in very good agreement with the experimental results, and reproduce the characteristic decay of nucleation field and coercive field with increasing d_{Fe}. A modification of the model to include gradual changes of the intrinsic magnetic parameters at the interface (mimicking the effect of a diffusion profile as a result of the deposition process) has consequences on the qualitative agreement between model and experiment.

MA 19.75 Tue 10:45 P2

Strayfield landscape supported self-assembling sub-monolayers of phthalocyanines — •Florian Ahrend[1], Ulrich Glebe[1], Tobias Weidner[2], Ulrich Siemeling[1], and Arno Ehresmann[1] — [1]University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [2]Department of Bioengineering, University of Washington, Seattle

Ion bombardment induced magnetic patterning (IBMP) modifies exchange bias layer systems into defined artificial domain patterns of different shape and size. These can be used to control the self-assembly of certain organic compounds into well ordered sub-monolayers. In this experiment topographically flat samples with a magnetic stripe pattern of a periodicity of 10 or 20 micrometer are used. A head-to-head/tail-to-tail magnetization was chosen, so that at each border of adjacent domains strong magnetic strayfields occur above the sample surface. The used organic molecules are derivatives of phthalocyanines, which possess a permanent magnetic moment and should be sensitive to external magnetic strayfields. Because of the planar shape of the phthalocyanines and their aromatic structure, they have the capacity to build self-assembled monolayers. In our case we want to inhibit a developing of a complete monolayer and want to navigate the molecules to chosen areas (i.e. on the domain walls or the domains themselves). To identify the possible alignment of the molecules along the borders of the magnetic domains several techniques were used. For example spectroscopic techniques like scanning ToF-SIMS, NEXAFS and XPEEM.

MA 19.76 Tue 10:45 P2

Investigation of the exchange coupling between Co nanoparticles and a Co/NiMn exchange bias system — •Benjamin Riedmüller, Balati Kuerbanjiang, and Ulrich Herr — Institut für Mikro- und Nanomaterialien, Universität Ulm

In this work, the exchange coupling of Co nanoparticles deposited on a layered Co/NiMn exchange bias system is studied. First the Co/NiMn stack was deposited on a 10 nm thick Ru layer by DC magnetron sputtering. All samples were covered by a 4 nm thick Ta layer to prevent oxidation. For transforming NiMn from the paramagnetic fcc phase to the antiferromagnetic fct phase the samples were annealed in vacuum conditions for 10 min at 360 °C with an external magnetic field of +3 kOe. Different thicknesses of NiMn and Co were used to optimize the interface coupling strength. For 66 nm NiMn a coupling strength of $J_{ex} = 0.3\, mJ/m^2$ was found as a maximum value. Spherical Co nanoparticles of 20 nm in diameter were prepared by Inert Gas Condensation technique. After deposition of the Co nanoparticles on top of the Co/NiMn stack a drastic reduction of the exchange bias field was observed. This effect depends on the particle coverage of the samples. Following the Meiklejohn-Bean description of the exchange bias effect this can be interpreted as a local increase of the film thickness due to exchange coupling between the the nanoparticles and the Co film.

MA 19.77 Tue 10:45 P2

Hochfeld-Magnetokraftmikroskopie und Transporteigenschaften eines epitaktischen Fe3O4/MgO-Films im hohen Magnetfeld — •Ivo Knittel[1], Uwe Hartmann[1], Gala Simon[2], Julia Orna[2] und Luis Morellon[2] — [1]Fachrichtung Experimentalphysik, Universität des Saarlandes, 66123 Saarbrücken — [2]Instituto de Nanociencia de Aragón (INA) and Instituto de Ciencia de Materiales de Aragón (ICMA), Departamento de Física de la Materia Condensada, Universidad de Zaragoza-CSIC, Zaragoza 50009, Spanien

Epitaktische Magnetitfilme unterscheiden sich in ihren magnetischen und ihren Magnetotransporteigenschaften stark vom Volumenmaterial. Selbst in Feldern von mehreren Tesla wird die Sättigungsmagnetisierung nicht erreicht, und u. a. erhöhter Magnetowiderstand und erhöhter außerordentlicher Hall-Effekt werden beobachtet. Als Ursache gilt ein Netzwerk antiferromagnetisch koppelnder Antiphasengrenzen (AF-APG). 40 nm Fe3O4 Filme auf MgO wurden durch pulsed laser deposition (PLD) mit einem 248 nm KrF Excimer Laser hergestellt. Die Struktur wurde mittels Röntgendiffraktometrie, und Transmissionselektronenmikroskopie überprüft. Ein scharfer Verweyübergang deutet auf eine reine Magnetitphase hin.

Die magnetische Struktur wird mit mittels Magnetokraftmikroskopie bis zu Feldern von 1.95 T abgebildet. Die remanente magnetische Struktur ist irregulär, im Feld reduziert sich der magnetische Kontrast gleichmäßig. Im Gegenfeld magnetisiert sich die Struktur bei Feldern um 100mT vollständig um. Modelle auf der Basis von AF-APG werden diskutiert.

MA 19.78 Tue 10:45 P2

Layer resolved magneto-optical Kerr effect magnetometry and domain studies of polycrystalline interlayer exchange coupled NiFe-Ru-Co films — •Thomas Strache and Jeffrey McCord — Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden - Rossendorf, PF 510119, 01314 Dresden, Germany

The magnetization reversal of interlayer exchange coupled NiFe-Ru-Co thin films is studied as a function of coupling strength and ratio of saturation magnetization values of both ferromagnetic layers. These quantities are changed by means of homogeneous ion irradiation, resulting in an interfacial mixing and depth selective doping in the sandwich structures. Both parameters can be varied separately by the choice of the ion species and the ion acceleration energy. In order to characterize the individual reversal mechanisms, layer resolved magnetometry and domain imaging are performed. The layer selectivity is obtained by making use of the phase differences of the Kerr signals, originating from different depths in the samples.

MA 19.79 Tue 10:45 P2

Quantitative magnetic soft X-ray spectroscopy of buried layers in reflection mode — •Patrick Audehm[1], Sebastian Macke[1], Sebastian Brück[2], Gisela Schütz[1], and Eberhard Goering[1] — [1]Max Planck Institute for Metals Research, Heisenbergstrasse 3, 70569 Stuttgart, Germany — [2]University of Würzburg, Experimental Physics, IV Am Hubland, D-97074 Würzburg, Germany

The combination of spectral information obtained with x-ray magnetic circular dichroism (XMCD) and X-ray resonant magnetic reflectometry (XRMR) gives the possibility to measure small magnetic moments and its arrangement especially at the interfaces. Utilizing well established XMCD based sum rules enables the element specific determination of absolute spin and orbital moments, even for a small amount of uncompensated magnetic moments in exchange bias (EB) systems. The measurement of the energy dependent reflection with constant momentum transfer (qz) gives XMCD like spectra. The advantage of this method is the simplified interference condition, because reflection is only affected by the energy dependent absorption and not by the momentum transfer. Using our advanced simulation tool ReMagX for analysis, i.e. fit of the data, it is possible to identify the magnetic spectroscopic nature for both, the rotatable and the pinned magnetic moments at the interface. As an example, we show const qz results of a widely studied EB-system, of polycrystalline iron (Fe)-manganese as an antiferromagnet and cobalt as a ferromagnet. The information for Fe obtained also in resonant reflection at the L3 edge at a very thin layer of uncompensated moment's right below the interface.

MA 19.80 Tue 10:45 P2

Effect of spin structure transition in IrMn on the CoPd\ IrMn perpendicular exchange biased system. — •Muhammad Bilal Janjua and Gernot Güntherodt — II. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany

The exchange bias (EB) phenomenon is studied in MBE grown Pd(10 nm)\CoPd(x=8,16,30 nm)\IrMn(15 nm)\Pd(4 nm) samples, which exhibit a perpendicular anisotropy of Co22Pd78. These samples are field cooled along the out-of-plane direction and hysteresis loops are measured along both the out-of-plane and in-plane directions. It is observed that there is a transition temperature where the out-of-plane EB becomes greater than the in-plane EB. This behavior of EB is an evidence of the change in the spin structure of the given system, which is also revealed by the magnetization versus temperature measurements of the exchange biased and of the sole IrMn samples. It is found that with increasing temperature there is a spin structure transition in Ir25Mn75 (15nm) related to the 2Q to 3Q transition in the bulk, which is responsible for the increase in out-of-plane EB. A vertical shift in the hysteresis loop is also observed in these exchange biased samples at low temperatures (T<50 K).

MA 19.81 Tue 10:45 P2

Exchange bias due to surface-stabilized spin glass in $Co_{33}Fe_{67}$-$CoFe_2O_4$ core-shell nanoparticles — •Syed Rizwan Ali[1], Ghulam Hassnain Jaffari[2], Syed Khurshid Hasanain[3], Gernot Güntherodt[1], and Syed Ismat Shah[2] — [1]Physikalisches Institut (IIA), RWTH Aachen University, Aachen 52056, Germany — [2]Department of Physics and Astronomy, University of Delaware, Newark, Delaware 19716, USA — [3]Department of Physics, Quaid-i-Azam University, Islamabad 45320, Pakistan

We investigate the magnetic and exchange bias (EB) properties of $Co_{33}Fe_{67}CoFe_2O_4$ (core-shell) nanoparticles [1]. Both dc magnetization and ac susceptibility measurements indicate the onset of a spin glass (SG) like transition at the freezing temperature of T_F=175 K. The SG transition is also supported by the field dependence of T_F following the well known Almeida-Thouless line, i.e. $T_F \tilde{} H^{2/3}$. Moreover, the particles exhibit a large EB field, H_{EB}=1357 Oe arising from the core-shell (ferromagnetic-SG) coupling. The unusually high T_F and large EB effects are attributed to several factors including the thickness of the amorphous oxide shell and large values of the exchange and anisotropy constants associated with the $CoFe_2O_4$ shell.

[1] G. H. Jaffari, S. R. Ali, S. K. Hasanain, G. Güntherodt, and S. I. Shah, J. Appl. Phys. vol. 108, pp. 063921 (2010).

MA 19.82 Tue 10:45 P2

Ultrafast all-optical switching of magnetic domains using circular polarized laser light — •Alexander Hassdenteufel, Daniel Steil, Sabine Alebrand, Mirko Cinchetti, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

Magnetic switching is typically a continuous process that can be described as a damped precession of the magnetization in an external magnetic field. This process takes typically up to 1 ns. Recently it has been shown that it is possible to achieve magnetic switching within 100 fs [1,2]. This process is induced by circularly polarized ultrashort laser pulses, where the direction of this opto-magnetic switching is determined only by the helicity of light. In this contribution, the femtosec-

ond laser-induced reversal mechanism of GdFeCo thin films is investigated by static Faraday measurements. In particular, we studied the dependence of the writing threshold by using a delayed pump-pump geometry where one of the pump pulses is linearly and the second circularly polarized. The obtained results allow to explain all optical switching as a collaborative process induced by pulse helicity and pulse fluence. The fluence dependency leads to a thermal effect. This means there is an ultrafast decrease of the sample magnetization, which is a condition for the following *pure* optical magnetic switching process induced by circularly polarized light. This work was supported by the European project UltraMagnetron (NMP3-SL-2008-214469).

[1] Kimel, A. V. et. al. Nature 435, 2005, 655-657
[2] Stanciu, PRL 99, 047601 (2007)

MA 19.83 Tue 10:45 P2

Temperature dependent propagating spin-wave spectroscopy on permalloy thin films — •Thomas Schwarze, Florian Brandl, Rupert Huber, Sebastian Neusser, Georg Dürr, and Dirk Grundler — Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, Physik Department, James-Franck-Straße 1, D-85747 Garching b. München, Germany

The study of spin wave propagation in thin films is of great interest, both, fundamentally as well as technologically [1]. In order to get a deeper understanding of the underlying physics we apply broadband all-electrical spin-wave spectroscopy [2] to a thin permalloy film and address temperatures ranging from 4 to 400 K. The external magnetic field of up to 2.5 T is applied perpendicular to the film. We present a thorough study of the temperature dependent variation of the resonance field and frequency, the resonance linewidth, the Gilbert damping α, and group velocities. For each of the relevant parameters a distinct temperature dependence is found and will be discussed. We acknowledge financial support through the European Community*s Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 228673 MAGNONICS and the excellence cluster *Nanosystems Initiative Munich*. [1] S. Neusser and D. Grundler, Adv. Materials 21, 2927 (2009) [2] S. Neusser et al., Phys. Rev. Lett. 105, 067208 (2010)

MA 19.84 Tue 10:45 P2

Spin dynamics in phase space — Yuri Kalmykov[1], •Bernard Mulligan[2], Serguey Titov[3], and William Coffey[4] — [1]Laboratoire de Mathématiques, Physique et Systèmes, Université de Perpignan, 52, Avenue de Paul Alduy, 66860 Perpignan Cedex, France. — [2]Dresden — [3]Institute of Radio Engineering and Electronics, Russian Acad. Sci., Vvedenskii Square 1, Fryazino 141190, Russia. — [4]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland.

The dynamics of a quantum spin is presented in the representation (phase) space of polar and azimuthal angles via a master equation for the quasiprobability distribution of spin orientations, allowing the averages of quantum mechanical spin operators to be calculated just as the classical case from the Weyl Symbol of the operator. The phase space master equation (see for e.g. [1,2]) has essentially the same form as the classical Fokker-Planck equation, allowing existing solution methods (matrix continued fractions, integral relaxation times, etc.) to be used. For illustration [1], the time behavior of the longitudinal component of the magnetization and its characteristic relaxation times are evaluated for a uniaxial paramagnet of arbitrary spin S in an external constant magnetic field applied along the axis of symmetry. In the large spin limit, the quantum solutions reduce to those of the Fokker-Planck equation for a classical uniaxial superparamagnet. For linear response, the results entirely agree with existing solutions.

1. Kalmykov et al., J. Stat. Phys., 141, 589 (2010).
2. Kalmykov et al., Phys. Rev. B 81, 094432 (2010).

MA 19.85 Tue 10:45 P2

Magneto-dynamic properties of CoFeB thin film elements: The role of magnetic domain walls — Claudia Patschureck[1], •Jeffrey McCord[2], Rudolf Schäfer[1], Kilian Lenz[2], Roland Mattheis[3], and Ludwig Schultz[1,4] — [1]Insitute for Solid State and Materials Research IFW Dresden, Germany — [2]Insitute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, Dresden, Germany — [3]Institute for photonic technologies (IPHT), Jena, Germany — [4]Dresden University of Technology, Dresden, Germany

Understanding the role of the magnetic domain structure on the magneto-dynamic properties of patterned thin film structures is crucial for the optimization of high frequency devices, e.g. recording heads, integrated inductors and filters. We show that a controllable domain design offers the advantage of tuning the ferromagnetic zero and low field resonance frequency.

Therefore we studied the dynamic response of closure domain structures in patterned amorphous Co40Fe40B20 stripe arrays with varying domain wall density using pulsed inductive microwave magnetometry. We show that the domain resonance frequency increases significantly the more neighboured crosstie walls interact with each other. A qualitative concept of dynamic magnetic charges is discussed as the origin of such a resonance frequency increase. The dynamic charge concept also allows the explanation of a pronounced resonance frequency increase in concertina domain structures that develop in lens shaped elements.

MA 19.86 Tue 10:45 P2

Linear and nonlinear collective modes in coupled-discs magnetic microstructures — •Henning Ulrichs[1], Vladislav E. Demidov[1], Alexey V. Ognev[2], Maxim E. Stebliy[2], Ludmila A. Chebotkevich[2], Alexander S. Samardak[2], and Sergej O. Demokritov[1] — [1]Institut für angewandte Physik, Universität Münster, Corrensstraße 2-4, 48149 Münster, Germany — [2]Laboratory of Thin Film Technologies, Far Eastern National University, Sukhanova street 8, 690950 Vladivostok, Russia

We have studied experimentally collective spin-wave modes in microscopic magnetic structures constituted by three coupled Permalloy discs, magnetized in-plane. By using phase-sensitive Brillouin light scattering spectroscopy we were able to clearly identify and investigate different types of the collective modes. In particular, we show that the studied systems support two fundamental modes characterized by in-phase and out-of-phase magnetization oscillations in neighboring discs. The in-phase mode demonstrates a maximum amplitude for the disc located in the center of the structure. Increasing the power of the excitation signal, the difference in the amplitudes in the neighboring discs tends to disappear. This behavior can be understood by assuming a nonlinear generation of higher-order spatial spin-wave harmonics. We will also discuss the role of magnetic bridges connecting individual discs. Our results show that the main characteristics of the modes are practically independent of the static field and the geometry of bridges, but are significantly affected by the nonlinearity.

MA 19.87 Tue 10:45 P2

Reliable nucleation of isolated antivortices in taylored ferromagnetic microstructures — •Matthias F.A. Pues, Michael Martens, Thomas Kamionka, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

Magnetic antivortices are topological singularities in ferromagnetic thin-film microstructures. They can be distinguished from their counterparts, the vortices, by a negative winding number. In combination, both are common in so-called cross-tie walls.

The isolation of a single antivortex is challenging [1]. We designed particularly shaped elements that facilitate a reliable nucleation and a stabilization of a single antivortex. This is shown by measurements of the anisotropic magnetoresistance (AMR) and magnetic force microscopy (MFM). The process of the nucleation can be understood by means of micromagnetic simulations.

Since antivortices behave like two-dimensional oscillators, the simultanious generation of multiple antivortices opens new opportunities for the analysis of antivortex dynamics [2], e.g. through ferromagnetic resonance measurements (FMR).

[1] K. Shigeto et al., Appl. Phys. Lett. 80, 4190 (2002)
[2] T. Kamionka et al., Phys. Rev. Lett. 105, 137204 (2010)

MA 19.88 Tue 10:45 P2

The Jülich TRACX-PEEM at BESSY II: a state-of-the-art user-facility for time-resolved magnetism research. — •Florian Nickel, Ingo Krug, Alexander Kaiser, Daniel Gottlob, Stefan Cramm, and Claus M. Schneider — Forschungszentrum Jülich, Institut für Festkörperforschung IFF-9, and JARA-FIT, 52425 Jülich, Germany

Time-resolved X-PEEM is a well-established technique for magnetisation dynamic research. To exploit the capabilities of the latest instrument generation, we built up a state-of-the-art PEEM endstation at the soft x-ray Beamline UE56/1-SGM at BESSY in 2010. This microscope, being based on a design by R. Tromp and custom-built by SPECS GmbH, is the first commercially available device incorporating a tetrode mirror corrector. Key advantages of the aberration-

correction are ultimate spatial resolution as well as dramatically improved transmission up to an order of magnitude in respect to uncorrected instruments. This makes the endstation ideally suited for signal-starved experiments such as time-resolved magnetization studies in a stroboscopic arrangement. Here we present the capabilities of our time-resolved, aberration-corrected x-PEEM (TRACX-PEEM) facility. We will present the performance of our gated MCP Detector in the BESSY hybrid-bunch filling-pattern showing that the isolated single-bunch can clearly be selected. This represents an important step for future pump-probe experiments.

MA 19.89 Tue 10:45 P2

Limitations of the macro-spin model for magnetic nanoparticles — •Mohammad Sayad, Daniel Guetersloh, and Michael Potthoff — I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg

Magnetization reversal of a magnetic nanoparticle or of a molecular magnet is often described by means of a macro-spin model assuming a strong exchange coupling between the individual spins. This model, however, is a phenomenological construct. Here we discuss the strict microscopic derivation of the macro-spin model in the limit of weak anisotropy. In addition the limitations of the model are worked out by studying linear chains as well as two- and three-dimensional clusters of ferromagnetically exchange-coupled Heisenberg quantum spins with single-site or coupling anisotropy. Magnetization profiles, correlation functions, excitation gaps and the tunneling barrier are computed by exact diagonalization and the Lanczos method for spin-S systems as a function of the system size L, the anisotropy strength and the system geometry. In the case of the classical Heisenberg model, we determine the transition between different reversal mechanisms as a function of system size, system geometry and applied external magnetic field.

MA 19.90 Tue 10:45 P2

Element-selective magneto-optics at the M absorption edge of Fe and Ni using laser generated ultrafast extreme ultraviolet light — •Dennis Lvovsky[1], Patrik Grychtol[1], Moritz Plötzing[1], Roman Adam[1], Claus M. Schneider[1], Chan La-O-Vorakiat[2], Stefan Mathias[2], Henry C. Kapteyn[2], Margaret M. Murnane[2], and Martin Aeschlimann[3] — [1]Institute of Solid State Research, IFF-9, Research Center Jülich, 52425, Jülich, Germany — [2]Department of Physics and JILA, University of Colorado, Boulder, Colorado 80309-0440, USA — [3]University of Kaiserslautern and Research Center OPTIMAS, 66606, Kaiserslautern, Germany

Extreme ultraviolet (XUV) light can be nowadays generated not only by a synchrotron but also by laser based ultrafast sources exploiting the high harmonics generation of the fundamental wavelength. Pulses in the femto-second range with photon energies up to one hundred eV enable time-resolved, element-selective measurements at the atomic absorption edges. We present transversal magneto-optical Kerr effect measurements at the M absorption edge of Ni (around 67 eV) and Fe (around 54 eV). Our results show the potential for investigating the element-selective ultrafast magnetization dynamics.

MA 19.91 Tue 10:45 P2

Spin Wave Propagation in Micron and Submicron $Ni_{80}Fe_{20}$ Stripes — •Hans Bauer, Georg Woltersdorf, and Christian Back — Universität Regensburg, 93043 Regensburg, Germany

The wavelength of propagating spin waves has often been determined in thin ferromagnetic films and more recently in structured $Ni_{80}Fe_{20}$ films [1][2]. Thin stripes are of particular interest for micron-sized spin wave devices as they serve as the building blocks for spin wave wave guides in future spin logic devices and spin wave Mach-Zender interferometers. For realization of such devices with only a few micron in size, the knowledge of the damping length of propagating spin waves within the structure is essential.
We used a TR-MOKE setup with 250 nm spatial resolution to study propagating magnetostatic spinwaves in micron and submicron wide $Ni_{80}Fe_{20}$ stripes. As the MOKE signal is proportional to the amplitude of the dynamic magnetization the wavelength and the damping length can both be directly determined at the same time. The results are compared to analytical calculations taking the excitation profile into account as well as with micromagnetic simulations.
[1] V. E. Demidov et al., Phys. Rev. B 77, 064406 (2008)
[2] S. Neusser et al., Phys. Rev. Lett. 105, 067208 (2010)

MA 19.92 Tue 10:45 P2

Scanning Kerr Microscopy - Spinwave Propagation in Ferromagnetic Nanostructures — •Kim Martens, Sebastian Mansfeld, Felix Balhorn, Jesco Topp, Wolfgang Hansen, Detlef Heitmann, and Stefan Mendach — Institute for Applied Physics, University of Hamburg, Germany

We use a scanning Kerr microscope for the time resolved mapping of spin waves in thin Permalloy films. In my poster I will introduce the concept and functionality of time resolved scanning Kerr microscopy. Additionally, I will present our recent experiments on spin-wave propagation and damping in patterned permalloy films.

We gratefully acknowledge financial support by the DFG via SFB668.

MA 19.93 Tue 10:45 P2

Magnetization dynamics described via a thermal mechanism — •Martin Lüttich[1], Jakob Walowski[1], Andreas Mann[1], Markus Münzenberg[1], Unai Atxitia[2], and Oksana Chubykalo-Fesenko[2] — [1]I. Physikalisches Institut, Universität Göttingen — [2]Instituto de Ciencia de Materiales de Madrid

Magnetization dynamics of polycrystalline nickel films with thicknesses of 2, 5, 10, 15, 20 and 40 nm is measured using the all-optical pump-probe technique. The theoretical description of the microscopic processes in these dynamics has the challenge and complexity of the parallel treatment of photons, electrons, phonons and magnetic correlation of the system. Additionally different length and time scales are involved.

We access these processes via a thermal model derived from the Landau-Lifshitz-Bloch equation. Within this approach it is assumed that the excited state is a statistical ensemble of many spin excitations. First the electron temperature is extracted via a 2 Temperature model from reflectivity measurements, and later used to model the magnetization dynamics. Because of the strong electron-spin coupling in transition metals, we find that the magnetisation dynamics is defined by the electron temperature but is slowed down with respect to the electron temperature due to the slowing down of the longitudinal relaxation defined by the exchange interactions. We discuss the effects for thinest Ni layers below 10 nm where the demagnetization deviates from the simple scaling for fluence and thickness.

MA 19.94 Tue 10:45 P2

Spin-Wave Excitations in Three-Dimensional Rolled-Up Permalloy Structures — •Felix Balhorn, Simon Jeni, Sebastian Mansfeld, Cornelius Bausch, Jesco Topp, Wolfgang Hansen, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik Hamburg, Jungiusstr. 11, 20355 Hamburg

The ability to fabricate geometrically well-defined three-dimensional nanoscrolls utilizing a self-organization process [1] gives rise to transforming any planar structure into a cylindric geometry. After rolling up permalloy (Py) structures, the spin dynamics in these systems are investigated by means of broadband microwave absorption spectroscopy.

Rolled-up Py films show several resonances which exist over a broad field range when magnetized along the rolling axis. These resonances are due to the interference of collective spin waves running in azimuthal direction [2]. In transversally magnetized samples the resonances disappear above a certain magnetic field, which is attributed to geometric anisotropy. Here, we present measurements on rolled-up Py films in transversal magnetization geometry and present a model based on the analytic spin wave dispersion relation for rectangular elements given in [3]. The model used in [2] is refined and applied on rolled-up Py stripes, i.e. small ring elements.

Financial support by the SFB668, GrK 1286, and the Cluster of Excellence Nanospintronics is acknowledged.

[1] V. Y. Prinz et al., Physica E **6**, 828 (2000); [2] F. Balhorn et al., PRL **104**, 037205 (2010); [3] K. Y. Guslienko et al., PhysRevB **68**, 024422 (2003)

MA 19.95 Tue 10:45 P2

Mechanically tunable Spin Wave Resonances in Rolled-Up Permalloy Tubes — •Cornelius Bausch, Felix Balhorn, Simon Jeni, Sebastian Mansfeld, Wolfgang Hansen, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik, Jungiusstr. 11, 20355 Hamburg

The different lattice constants of two epitaxially grown semiconductors cause strain which can be used to fabricate rolled-up mictrotubes [1]. A thin Permalloy layer can be deposited on the strained semiconductor layers before rolling up to obtain a rolled-up Permalloy tube (RUPT)[2]. Spin-wave excitations in these RUPTs have recently been

investigated using broadband microwave absorption spectroscopy [2, 3]. Several resonance modes showing different magnetic field dispersions with respect to the magnetic configuration have been observed.

We built a micromechanical squeezer consisting of a small submillimeter photo resist block on a polyethylene terephthalate/glass substrate manipulated with a piezo stack. We found that the spin-wave mode spectrum of RUPTs can be modified by mechanically deforming the RUPTs with this squeezer. The modes shift in frequency and eventually disappear. We present possible interpretations for this behavior.

We acknowledge financial support by the SFB668, Grk 1286 and the Cluster of Excellence Nanospintronics.

[1] V. Y. Prinz et al., Physica E 6, 828 (2000); [2] S. Mendach et al., Appl. Phys. Lett. 93, 262501 (2008); [3] Balhorn et al., Phys. Rev. Lett. 204, 037205 (2010)

MA 19.96 Tue 10:45 P2

Mode symmetry breaking of propagating spin waves — •Peter Clausen, Helmut Schultheiss, Björn Obry, Sebastian Schäfer, Katrin Vogt, Georg Wolf, and Burkhard Hillebrands — Fachbereich Physik and Forschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

For the realization of spin-wave logic and spintronics, the understanding of spin-wave propagation in two-dimensional waveguides is essential. We investigate the influence of a double bend on the two-dimensional spin-wave transport in a $Ni_{81}Fe_{19}$-waveguide using space-resolved Brillouin light scattering microscopy.

The observed spin-wave intensity distribution is significantly influenced by the double-bend structure and two quite different regimes can be observed. In front of the bend, the spin-wave intensity measured across the width of the waveguide is symmetric whereas it shows a clear asymmetric pattern behind the double bend. We propose a transition from interfering spin-wave width modes of first and third order, which are originally exited by the antenna, to the superposition of the first and second width mode generated by the lateral symmetry break of the spin-wave waveguide.

Financial support by the Carl-Zeiss-Stiftung, the Graduiertenkolleg 792 and Graduate School of Excellence "MAterials Science IN MainZ" is gratefully acknowledged. The authors thank the Nano+Bio Center of the Technische Universität Kaiserslautern, P. A. Beck and P. Pirro for sample preparation.

MA 19.97 Tue 10:45 P2

Determination of inertial mass of pulsed field-driven domain walls in GMR nanostripes — •Bjoern Burkhardt, Sascha Glathe, and Roland Mattheis — IPHT Jena e.V., Albert-Einstein-Str. 9, 07745 Jena

Domain walls (DW) can be described as quasiparticles with typical mechanic characteristics, e.g. an effective mass. For field driven DW motion one can assume a linear dependence between the DW velocity and field-pulse length for short pulse length (t $\approx$ 1 ns) and small fields (H $< H_w$, Walker field), which is confirmed by the 1D-Modell by Slonczewski [1]. In this regime the DW is uniformly accelerated until the equilibrium state and thus the maximum velocity for the applied field is reached. Using this regime and assuming a driving force derived from the magnetostatic potential, one can deduce an effective mass of the DW. We have measured domain wall velocities for short field pulses in thin and narrow nanostripes (w = 500nm, l = 45 μm) using the giant magnetoresistance effect between a sense layer (NiFe - 20nm thick) and a reference layer (CoFe - part of an AAF/AF-combination). The magnetic field is generated by short current pulses in a coplanar waveguide crossing the GMR nanostripe. We determined the effective mass of a DW (m $\approx 10^{-23}$kg) which is in good quantitative agreement with theory [2].

[1] A. Malozemo and J. Slonczewski, Magnetic Domain Walls in Bubble Materials (Academic Press, New York, 1979).

[2] J.-Y. Lee, S. Choi, S.-K. Kim, J. Magn., **11**, 74 (2006)

MA 19.98 Tue 10:45 P2

Spin wave resonances in ferromagnetic thin films prepared via atomic layer deposition — •Rupert Huber[1], Paul Berberich[1], Thomas Schwarze[1], Thomas Rapp[1], Julien Bachmann[2], Kornelius Nielsch[2], and Dirk Grundler[1] — [1]Lehrstuhl für Physik funktionaler Schichtsysteme, Physik Department E10, Technische Universität München,85748 Garching, Germany — [2]Institut für Angewandte Physik und Mikrostrukturzentrum, Universität Hamburg,20355 Hamburg, Germany

On the way to artificially designed three-dimensional magnetic devices atomic layer deposition (ALD) is a promising thin-film deposition technique. We have produced different ferromagnetic thin films by ALD based on the oxidation of $FeCp_2$ and $NiCp_2$ using ozone [Ref. 1] Afterwards the iron and nickel oxide, respectively, is reduced inside the ALD reactor by H_2 at 400 °C. We have studied the quasistatic and dynamic properties via the magneto-optical Kerr effect and broadband spin-wave spectroscopy, respectively. In the latter case we mount the thin film on top of a coplanar waveguide with an inner conductor exhibiting a width of 20 μm. Using a vector network analyzer we measure spin wave resonances. They depend characteristically on an applied magnetic field. We thank Sebastian Neusser for experimental help in the initial stage of the experiment. We acknowledge financial support through the European Community*s Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 228673 MAGNONICS. Ref. 1: J. Bachmann et al., JAP, 2009, 105, 07B521

MA 19.99 Tue 10:45 P2

Spin waves in antidot lattices on suspended membranes — •Florian Brandl, Rupert Huber, Sebastian Neusser, Georg Dürr, and Dirk Grundler — Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, Physik Department, James-Franck-Straße 1, D-85747 Garching b. München, Germany

We have developed a new fabrication method for antidot (AD) lattices using electron beam lithography. This method is based on a photonic crystal consisting of a periodic array of nanoholes etched into a freestanding Si membrane. The membrane is covered subsequently with thermally evaporated $Ni_{80}Fe_{20}$. Using all-electrical spin wave spectroscopy [1] we perform measurements on samples with different lattice constant and hole diameter. Applying an external magnetic field B of up to 100 mT in the plane of the AD lattices we find a series of resonant modes which depend characteristically on B. We perform micromagnetic simulations to analyze the AD modes in detail. We acknowledge financial support through the German excellence cluster "Nanosystems Initiative Munich" and the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 228673 MAGNONICS.

[1] S. Neusser et al., Phys. Rev. Lett. 105, 067208 (2010).

MA 19.100 Tue 10:45 P2

Dynamics of bubble domains in perpendicular anisotropy dots — C. Moutafis[1,2], A. Bisig[1,2], J. Rhensius[1,2,3], F. Büttner[1,6], •P. Wohlhüter[1,4], T. Thomson[5], G. Heldt[3], L. Heyderman[3], M. Weigand[6], S. Eisebitt[7], and M. Kläui[1,2] — [1]SwissFEL, PSI, CH — [2]Laboratory for Nanomagnetism & Spin Dynamics, EPFL, CH — [3]Laboratory for Micro- & Nanotechnology, PSI, CH — [4]Fachbereich Physik, Universität Konstanz — [5]University of Manchester, UK — [6]MAXYMUS, BESSY, Berlin — [7]Institut für Optik und Atomare Physik, TU Berlin

We study the dynamical response of magnetic bubbles in nanoscale dots with perpendicular anisotropy. Magnetic bubble domains in such dots have been predicted to exhibit rich dynamics dominated by their Skyrmion number N, which reflects their underlying spin structure [1,2]. Specifically, the gyrotropic motion of the symmetric, N=1, bubble (analogous to the gyrotropic mode of the magnetic vortex) was calculated recently for the first time [2]. Here, we attempt to show the bubble's response to external excitations. By using soft X-ray holography we image the magnetic states in CoPd dots of varying geometry and we also identify a bubble in certain diameter for a range of magnetic fields. Furthermore, we use Scanning X-ray Transmission Microscopy to image CoPt dots excited by various field pulses. We image the movement/shift of the bubble between different pinning sites in a dot. In addition, we calculate additional characteristic eigenmodes of the basic N=1 bubble. References: [1] Moutafis et al. Phys.Rev.B vol. 76, 104426 (2007) [2] Moutafis et al. Phys.Rev.B vol. 79, 224429 (2009)

MA 19.101 Tue 10:45 P2

Magnetizatio Dynamic In FeRh Compound — •Federico Pressacco[1] and Simon Mariager[2] — [1]Universität Regensburg, Regensburg, Deutschland — [2]Paul Scherrer Institute, Villigen, Switzerland

FeRh compounds show a first order phase transition from an Anti Ferromagnetic (AFM) to a Ferromagnetic (FM) phase after heating above room temperature. At temperature lower than 395 K the Fe ions are antiferromagnetically coupled while the Rh ions show no magnetic moment. At higher temperature Fe becomes ferromagnetically

coupled and also Rh carries a magnetic moment. This phase transition in accompanied by a lattice expansion of about 1%.This features make FeRh a suitable system for investigation of the interplay between electrons, spins and phonons (lattice). We performed laser pump-probe experiments to investigate the magnetization dynamic via Time Resolved Magneto Optical Kerr Effect (TR-MOKE). The impulsive laser heating induce the phase transition and the magnetization is probed with a delayed laser pulse. The onset of the ferromagnetic phase is still under debate. Is the phase transition driven by the lattice expansion? Laser pump-X ray probe experiment where performed to follow the lattice expansion during the onset of the ferromagnetic phase. From the comparison of the data collected in the experiments one can decouple the phonon contribution to the signal and establish if the structural change induces the phase transition.

MA 19.102 Tue 10:45 P2

Ultrafast demagnetization dynamics of thin Fe/W(110) films: comparison of time and spin-resolved photoemission with time resolved magneto-optic experiments — Alexander Weber[1,2], Federico Pressacco[1], Stefan Günther[1], •Eduardo Mancini[1], and Christian Back[1] — [1]Physics Department, Universität Regensburg, 93040 Regensburg, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

We use two complementary experimental approaches to probe ultrafast magnetization dynamics. Using a 1.55 eV pump laser pulse we demagnetize 7 monolayer (ML) thin Fe films epitaxially grown on W(110). We probe the temporal evolution of the magnetization using time-resolved magneto-optical Kerr effect (TR-MOKE) at a probe photon energy of 3.1 eV. In addition we use time- and spin- resolved photoemission (TR-SPES) to probe the evolution of the spin polarization of the film (probe photon energy 5.9 eV). With TR-MOKE for all the observed quenching the demagnetization times have the same value (within the error bars) equal to the expected cross-correlation of the pump and probe pulses (about 250 fs). However TR-SPES measurements show demagnetization times limited by the cross-correlation (about 320 fs) only for quenching below 33%. Indeed, for greater quenching we find a significant increase in the demagnetization times to about 500 fs. We explain this behavior as a clear indication of the bandstructure importance in the demagnetization process.

MA 19.103 Tue 10:45 P2

Towards an understanding of longitudinal x-ray-detected ferromagnetic resonance — •Katharina Ollefs[1], Andreas Ney[1], Ralf Meckenstock[1], Detlef Spoddig[1], Christoph Hassel[1], Christian Schöppner[1], Verena Ney[1], Fabrice Wilhelm[2], Andrei Rogalev[2], Frithjof Nolting[3], Carolin Antoniak[4], Heiko Wende[4], and Michael Farle[1] — [1]Fakultät für Physik - AG Farle, Universität Duisburg-Essen, 47057 Duisburg, Germany — [2]ESRF, 38043 Grenoble Cedex, France — [3]SLS, 5232 Villigen PSI, Switzerland — [4]Fakultät für Physik - AG Wende, Universität Duisburg-Essen, 47057 Duisburg, Germany

We present a novel experimental setup for x-ray detected ferromagnetic resonance (XDFMR), which allows the simultaneous separation of three different detection channels after x-ray and microwave absorption: A) the conventional FMR detection by microwave absorption; B) x-ray detected lattice response due to the resonant microwave absorption, C) measurement of the high frequency susceptibility based on the x-ray magnetic circular dichroism (XMCD) effect.

The mechanisms for the different absorption signals detected at resonance will be discussed.

The microwave frequency can be tuned from 4-18 GHz allowing a detailed analysis of spin relaxation mechanisms and an element-specific investigation of the dynamic magnetic properties.

Supported by ESRF, SLS, BESSY and DFG, Heisenberg Programm, SFB 491.

MA 19.104 Tue 10:45 P2

Ultrafast, Element-Specific, Demagnetization Dynamics Probed using Coherent High Harmonic Beams — •Steffen Eich[1], Stefan Mathias[1,2], Chan La-O-Vorakiat[2], Patrik Grychtol[3], Roman Adam[3], Mark Siemens[2], Justin M. Shaw[4], Hans Nembach[4], Timm Rohwer[5], Claus M. Schneider[3], Tom Silva[4], Martin Aeschlimann[1], Margaret M. Murnane[2], and Henry C. Kapteyn[2] — [1]Department of Physics and Resarch Center OPTIMAS, University of Kaiserslautern, Germany — [2]JILA, University of Colorado and NIST, Boulder, Co, USA — [3]Institute of Solid State Research, IFF-9, FZ Jülich, Germany — [4]Electromagnetics Division, NIST, Boulder, Co, USA — [5]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany

Element-specific magnetization dynamics on nanometer length and femtosecond time scales is a topic of intense interest. Ultrafast, coherent, table-top, x-ray sources based on high-harmonic upconversion of femtosecond lasers provide a new tool to study how magnets work at the shortest time and length scales, with element specificity [1]. Here, we use this new experimental capability to extract element-specific demagnetization dynamics and hysteresis loops of Fe and Ni in Permalloy.

[1] La-o-vorakiat et al., PRL 103, 257402 (2009)

MA 19.105 Tue 10:45 P2

Detection of ferromagnetic resonance by optical reflectance — •Marc Möller[1], Ralf Meckenstock[2], and Josef Pelzl[1] — [1]Institute of Experimental Physics, Ruhr-University Bochum, Bochum, Germany — [2]Experimental Physics, University Duisburg-Essen, Duisburg, Germany

The absorption of microwave radiation by ferromagnetic resonance (FMR) of a magnetic sample results in heat being dissipated inside the sample. This mechanism can be utilized to generate thermal waves by amplitude modulation of the microwave radiation. These thermal waves periodically modify the temperature dependent properties of the sample like the optical reflectance. Here we present results of the detection of FMR in the optical reflectance at the sample surface. A 10 to 100 nm thin, epitaxial Fe film is mounted inside a microwave cavity and a focused laser beam is reflected off its surface, such that the FMR spectrum can be recorded and be compared to FMR spectra measured using the magneto-optical Kerr effect (MOKE). The dependence of the reflectance changes on the frequency of the microwave amplitude modulation are used to investigate thermal properties of the film and the film/substrate interface, including the thermal contact resistance.

MA 19.106 Tue 10:45 P2

Vortex coupling in magnetic multilayer elements — •Sebastian Wintz[1], Aleksandar Puzic[2], Thomas Strache[1], Christopher Bunce[1], Michael Körner[1], Tommy Schoenherr[1], Andreas Neubert[1], Jeffrey McCord[1], Ingolf Moench[3], Roland Mattheis[4], Jörg Raabe[2], Christoph Quitmann[2], Artur Erbe[1], and Jürgen Fassbender[1] — [1]Helmholtz-Zentrum Dresden Rossendorf, 01314 Dresden, Germany — [2]Paul Scherrer Institut 5232 Villigen, Switzerland — [3]Leibniz-Institut für Werkstoff- und Festkörperforschung, 01069 Dresden, Germany — [4]Institut für Photonische Technologien, 07702 Jena, Germany

Spin vortices have attracted much attention due to their chiral nature and the variety of dynamic phenomena associated with them. In this contribution we present experimental findings on vortex coupling in trilayer elements, where two ferromagnetic layers are separated by a nonmagnetic spacer. For such systems the relative configurations of the in-plane flux senses (circulations) as well as the core orientations (polarities) of layered vortices are identified by means of scanning transmission x-ray microscopy (STXM). The dominant coupling mechanisms here are the magneto-dipolar interaction and interlayer exchange coupling (IEC). Remarkably, a modification of the IEC, which can be induced by noble gas ion irradiation, allows to specifically set the circulation configuration of a layered vortex pair to be either antiferromagnetic or ferromagnetic. In addition, time-resolved measurements of the response of interlayer coupled vortices to an excitation by sinusoidal magnetic fields will be shown.

MA 19.107 Tue 10:45 P2

Micromagnetic simulations of depinning process of the magnetic domain wall by propagating spin waves on a magnetic thin film — •June-Seo Kim[1], Luis Lopez-Diaz[2], Eduardo Martinez[2], Jungbum Yoon[3], Chun-Yeol You[3], and Mathias Kläui[1] — [1]Fachbereich Physik, Universität Konstanz, Universitätsstr. 10, D-78457 Konstanz, Germany — [2]Universidad de Salamanca, Plaza de la Merced s/n, E-37008, Salamanca, Spain — [3]Department of Physics, Inha University, Incheon 402-751, Republic of Korea

The recent discovery that a propagating spin-wave moves domain wall has created a new possibility to manipulate magnetization [1]. This is now the subject of extensive research motivated not only by its fundamental interest but also by promising applications for novel spintronic devices. First we calculate the domain wall motion by propagating spin waves (SWs) on a magnetic nanowire by using the objected oriented micromagnetic framework (OOMMF) code [2]. We calculate the depin-

ning fields of the trapped head-to-head transverse walls due to notch by propagating SWs and applied fields along the nanowire. The depinning fields depend on the frequency and amplitude of SWs. To understand the optimization frequencies to depin the DWs, we calculate the dispersion relation by using Fast Fourier Transformation (FFT) method. This work is supported by the EU-RTNs SPINSWITCH (MRTN-CT-2006-035327). [1] Dong-Soo Han et al., Appl. Rhys. Letts. 94, 112502 (2009). [2] OOMMF User's Guide, Version 1.0, M. J. Donahue and D. G. Porter, National Institute of Standard and Technology, Gaithersburg, MD, 1999, http://math.nist.gov/oommf

MA 19.108 Tue 10:45 P2

Micromagnetic simulations of depinning process of the magnetic domain wall by propagating spin waves on a magnetic thin film — •June-Seo Kim[1], Luis Lopez-Diaz[2], Eduardo Martinez[2], Jungbum Yoon[3], Chun-Yeol You[3], and Mathias Kläui[1,4] — [1]Fachbereich Physik, Universität Konstanz, Universitätsstr. 10, D-78457 Konstanz, Germany — [2]Universidad de Salamanca, Plaza de la Merced s/n, E-37008, Salamanca, Spain — [3]Department of Physics, Inha University, Incheon 402-751, Republic of Korea — [4]SwissFEL, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland & Laboratory for Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland

The recent discovery that a propagating spin-wave moves a domain wall has created a new possibility to manipulate magnetization [1]. First we calculate the domain wall motion by propagating spin waves (SWs) on a magnetic nanowire by using the objected oriented micromagnetic framework (OOMMF) code. We calculate the depinning fields of the trapped head-to-head transverse walls due to notch by propagating SWs and applied fields along the nanowire. The depinning fields depend on the frequency and amplitude of SWs. To understand the optimization frequencies to depin the DWs, we calculate the dispersion relation by using Fast Fourier Transformation (FFT) method. This work is supported by the EU-RTNs SPINSWITCH (MRTN-CT-2006-035327). [1] Dong-Soo Han et al., Appl. Phys. Letts. 94, 112502 (2009).

MA 19.109 Tue 10:45 P2

Skyrmion textures in cubic helimagnets with competing cubic and exchange anisotropies — •Filipp N. Rybakov[1,2], Andrey A. Leonov[1], Anna B. Butenko[1], Alexei N. Bogdanov[1], and Ulrich K. Rößler[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Institute of Metal Physics, UD of the RAS, 620990, Ekaterinburg, Russia

In non-centrosymmetric chiral magnets, *isotropic* Dzyaloshinskii-Moriya interactions destabilize the homogeneous magnetic structure and induce long-range 1-dimensional (spirals) and 2-dimensional (Skyrmions) chiral modulations of the magnetization with sense of rotation fixed by the sign of Dzyaloshinskii the constant D and period by the twisting length, D/A (A is the exchange stiffness) [1]. In this contribution we show that small *anisotropic* forces as cubic anisotropy and anisotropic exchange determine the propagation directions of spirals and axes of Skyrmions along certain crystal directions and stabilize Skyrmion textures in a broad range of magnetic fields. The equilibrium parameters of Skyrmions, helices, and cycloids are determined as functions of a bias magnetic field and the values of competing anisotropic interactions. The results demonstrate that a plethora of different precursor phenomena, modulated mesophases, and reorientation transitions may arise in cubic helimagnets near magnetic ordering depending on very weak magnetic couplings.

[1] U. K. Rößler et al., J. Phys., in press; arXiv:1009.4849v1 (2010); A.B. Butenko et al., Phys. Rev. B **80**, 134410 (2009).

MA 19.110 Tue 10:45 P2

Simulation of magnetic nanoparticles for hyperthermia therapy — •Christian Haase and Ulrich Nowak — University of Konstanz, 78457 Konstanz

Systems of single domain magnetic nanoparticles are investigated in view of their aplication to magnetic particle hyperthermia therapy, where under application of an ac magnetic field these particles dissipate heat and thus can be used for cancer treatment. This is done via a numerical integration of the Landau-Lifshitz-Gilbert equation including Langevin dynamics.

For an analytical description of such a system one has to consider a relaxation model based on Browns Fokker-Planck equation [1]. The heating characteristics then can be described by linear response theory for particles in the superparamagnetic size range or a Stoner Wohlfarth model type theory for bigger particles[2,3].

We compare these approaches to our numerical calculations with special emphasis on the influence of dipolar interactions which are neglected in both analytical theories. Furthermore we discuss our results in the effort to maximise the specific loss power for acceptable fields and frequencies.

[1]W. F. Brown, Jr., Phys. Rev. **130**, 1677 (1963). [2] R. Hergt et al, Nanotechnology **21**, 015706 (2010). [3] N. A. Usov and Y. B. Grebenshchikov, J. Appl. Phys. **106**, 023917 (2009).

MA 19.111 Tue 10:45 P2

Domain Structures and Hysteresis Loops in Coupled Permalloy Rectangles — •Jonas Jelli, Kristof M. Lebecki, and Ulrich Nowak — Department of Physics, University of Constance, Germany

Arrays of 2 μm x 1 μm x 20 nm Permalloy thin film elements of rectangular shape with varying interelement separation between the long edges are investigated by micromagnetic simulation. Applying one dimensional periodic boundary conditions [1], the influence of the rectangle's magnetostatic interactions on the domain structures and the shape of hysteresis loops is studied. By analyzing the angular distribution of the magnetization it is found that the coupled elements show a flux-closure Landau state whose large domains increasingly split up into two distinct domains the smaller the spacing between the rectangles is chosen. This is in good agreement with experiments in which this tendency is also observed [2]. Besides, magnetisation hysteresis loops indicate a change in the coercive field of the rectangles depending on their spacing and whether the external field is applied in the direction of periodicity or perpendicularly.

[1] K. M. Lebecki et al, J. Phys. D 41, 175005 (2008)
[2] S. Hankemeier et al, Phys. Rev. Lett. 103, 147204 (2009)

MA 20: Electron Theory of Magnetism

Time: Tuesday 11:00–12:45 Location: HSZ 103

MA 20.1 Tue 11:00 HSZ 103

Sensitivity of the calculated magnetocrystalline anisotropy of ad-atoms on the treatment of the substrate — •Ondrej Sipr[1], Sven Bornemann[2], Jan Minar[2], and Hubert Ebert[2] — [1]Institute of Physics of the ASCR v.v.i., Prague, Czech Republic — [2]Universitat Munchen, Department Chemie, Munchen, Germany

The magnetocrystalline anisotropy energy (MAE) of Fe and Co adatoms, monolayers and surface superstructures on the highly polarizable Pt(111) surface is investigated. It turns out that the finite thickness of the slab which is conventionally used to represent the substrate and interaction between the ad-atoms in neighboring surface supercells affect calculated values of the MAE much more profoundly than they affect calculated values of magnetic moments. Reliable theoretical values for the MAE thus cannot be obtained if the substrate is represented by a slab of less than 7-10 atomic layers or if the surface supercell describing the ad-atoms is so small that the relative site occupation by the ad-atoms is more than few percents.

MA 20.2 Tue 11:15 HSZ 103

Magnetic interactions of iron — •Frank Dietermann and Manfred Fähnle — Max-Planck Institut für Metallforschung, Stuttgart

We investigate the adiabatic magnetic energy landscape of iron in the bcc and fcc crystal structure by constrained spin density functional theory. We use this data, to fit the interaction coefficients of an extended Heisenberg model and of a Spin-Cluster-Expansion [1] and compare the two models. We also discuss the influence of the type of reference configurations considered - e.g. spin spirals with constant opening angle, spin spirals with various opening angles or supercells.

[1]R.Drautz and M.Fähnle, Phys.Rev. B **69**, 103303 (2004)

MA 20.3 Tue 11:30 HSZ 103

Ab-initio calculation of the Gilbert damping parameter for transition metal alloys — •Sergiy Mankovsky, Diemo Ködderitzsch, and Hubert Ebert — Dept. Chemie/Phys. Chemie, Universität München, Butenandtstr. 11, D-81377 München, Deutschland

We present a theoretical approach for the calculation of the Gilbert damping parameter α using the linear response formalism as implemented within the KKR Green's function technique. The expression for the Gilbert damping parameter was obtained in the adiabatic approximation following the ideas of Brataas et al.[1] This approach was applied to various metal alloy systems. The results for the Gilbert damping parameters are compared with corresponding theoretical results obtained recently by Starikov et al. [2] as well as available experimental data. The theoretical results agree very well among each other demonstrating the equivalence of the two different approaches used. The experimental values for α are reproduced quite well by the calculations concerning the concentration dependence, but are in general larger. This is ascribed to the influence of thermal fluctuations ignored so far in the calculations.

[1] A. Brataas, Y. Tserkovnyak, and G. E. W. Bauer, Phys. Rev. Lett. **101**, 037207 (2008).

[2] A. A. Starikov, P. J. Kelly, A. Brataas, Y. Tserkovnyak and G. E. W. Bauer, accepted to Phys. Rev. Lett. (2010)

MA 20.4 Tue 11:45 HSZ 103

Order and phase stability in CoPt: the role of magnetism. — •Sondes Karoui[1], Hakim Amara[1], Francois Ducastelle[1], and Bernard Legrand[2] — [1]LEM, ONERA-CNRS, BP72 92322 Châtillon Cedex, France — [2]SRMP, CEA, Saclay, France

Transition metal nano-alloys (FePd, CoRh, and CoPt) are innovative new materials whose size and chemical composition govern their physical and chemical properties. CoPt, the focus point of this study, had been duly studied in the bulk phase both experimentally and theoretically. There exists a large array of results that clearly hint at the importance of magnetism, and the stabilization that it brings to the system. Indeed, we strongly believe that the crystallographic order present in CoPt can be attributed to the alloy's inherent magnetic character.

To point out this effect, Density Functional Theory calculations have been performed using the ABINIT code with and without magnetism. We report on the influence of spin polarized calculations on structure stabilization in bulk Co and Pt as well as the alloy's various crystallographic phases: ordered L1o, L12, and disordered FCC. This approach corresponds to a quantitative first step towards better understanding the role of magnetism at the atomic scale.

Reference 1 (submitted): S. Karoui, H. Amara, F. Ducastelle, and B. Legrand, First principle study of order and magnetism in Co(1-x)Pt(x).

MA 20.5 Tue 12:00 HSZ 103

Magnetic properties of strongly correlated transition metal oxides studied using LSDA+U — •Gerhard Kuhn[1], Jan Minár[1], Diemo Ködderitzsch[1], Igor di Marco[2], Sergiy Mankovskyy[1], and Hubert Ebert[1] — [1]Universität München Department Chemie, Physikalische Chemie, Haus E2.033, Butenandtstr. 5-13, D-81377 München — [2]Ångströmlaboratoriet, Lägerhyddsvägen 1, 751 20 UPPSALA, SWEDEN

The magnetic properties of strongly correlated systems (MnO, FeO, CoO, NiO) in different magnetic structures (anti ferromagnetic (AF) 1, anti ferromagnetic (AF) 2, ferromagnetic (FM)) were investigated by the LSDA+U formalism implemented within the Korringa-Kohn-Rostoker (KKR) Green's function method. Calculations were performed fully relativistically as well as scalar relativistically using both, the atomic sphere approximation and a full potential formalism. Spin and orbital magnetic moments were calculated. The exchange coupling constants have been determined by a mapping of energy differences of different magnetic structures onto a Heisenberg-model. Further, the exchange coupling constants have been calculated by a relativistic generalization of Lichtenstein's formula.

MA 20.6 Tue 12:15 HSZ 103

Ab-initio description of the magnetic shape anisotropy due to the Breit interaction — •Sven Bornemann, Jan Minar, Jürgen Braun, Diemo Ködderitzsch, and Hubert Ebert — Department Chemie, Ludwig-Maximilians-Universität München, 81377 München

A quantum-mechanical description of the magnetic shape anisotropy, that is usually ascribed to the classical magnetic dipole-dipole interaction, has been developed. This is achieved by including the Breit-interaction, that can be seen as an electronic current-current interaction in addition to the conventional Coulomb interaction, within fully relativistic band structure calculations. The major sources of the magnetic anisotropy, spin-orbit coupling and the Breit-interaction, are treated coherently this way. This seems to be especially important for layered systems for which often both sources contribute with opposite sign to the magnetic anisotropy energy. Applications to layered transition metal systems are presented to demonstrate the implications of this new approach in treating the magnetic shape anisotropy.

MA 20.7 Tue 12:30 HSZ 103

Ground state properties that can be derived from total energy calculations — •Liviu Chioncel — Augsburg Center for Innovative Technologies, University of Augsburg, Germany

The temperature dependence of elastic constants for simple transition metal elements has been calculated using a combined first-principles and many-body theory. The thermal expansion has a normal linearly decreasing contribution to the elastic constant, while the electronic contribution is determined by the unique character of Coulomb correlations and may lead to anomalous temperature effects.

MA 21: Bio- and Molecular Magnetism II

Time: Tuesday 11:00–12:45 Location: HSZ 401

MA 21.1 Tue 11:00 HSZ 401

Self assembled Kondo chains: acetylacetonate on Cu(111) — •Stefan Schmaus[1,2], Toshio Miyamachi[1,2], Toyo Kazu Yamada[1,3], and Wulf Wulfhekel[1,2] — [1]Physikalisches Institut, Karlsruhe Institut für Technologie, Germany — [2]CFN-DFG Centrum für Funktionelle Nanostrukturen, Karlsruher Institut für Technologie, Germany — [3]Graduate School of Advanced Integration Science, Chiba University, Japan

Single molecular magnets (SMM) are discussed as an approach for future magnetic storage. While SMM in the bulk phases posses long term spin stability, for applications they have to be placed on a substrate and additional effects, such as molecule-substrate hybridization, play an important role.

We performed scanning tunneling microscopy (STM) studies on Chromium acetylacetonate ($Cr(acac)_3$), which posses a spin of 1/2 on the Cr ion. The molecules were sublimed in ultra high vacuum onto a clean Cu(111) surface. The individual molecules as well as ordered molecular chains could be identified in the topographic STM scans. Tunneling spectroscopy, however, showed besides the distinct molecular orbitals a strong zero bias peak, which was identified as a Kondo resonance. Spatially resolved dI/dV maps on the chains showed that the Fano resonance is not only present at the magnetic impurity but is also mediated by the surface state of Cu(111) forming quantum mirages of the Kondo state similar to previous results on single Co atoms on Cu(111) [1].

[1] H. C. Manoharan *et al.*, Nature **403**, 512 (2000)

MA 21.2 Tue 11:15 HSZ 401

Spin coherence and relaxation in Mn-dimer magnetic clusters — •Y. Krupskaya[1], R. Zaripov[2], E. Vavilova[1,2], V. Miluykov[3], I. Bezkishko[3], D. Krivolapov[3], O. Kataeva[3], O. Sinyashin[3], E. Hey-Hawkins[4], V. Voronkova[2], K. Salikhov[2], V. Kataev[1], and B. Büchner[1] — [1]IFW Dresden, Dresden, Germany — [2]Zavoisky Physical-Technical Institute of the RAS, Kazan, Russia — [3]A.E. Arbuzov Institute of Organic and Physical Chemistry of the RAS, Kazan, Russia — [4]Institute of Inorganic Chemistry, Leipzig University, Leipzig, Germany

We present a pulsed ESR study of Mn-dimer molecular complexes which show strong dependence of magnetic properties on the ligand surrounding. The complexes were studied as microcrystalline powders and, in addition, as frozen solutions (dissolved in tetrahydrofurane).

An electron spin echo in these complexes was detected and the relaxation times T_1 (spin-lattice relaxation) and T_2 (phase-coherence) were determined. We observe a simple exponential T_2 relaxation in the case of dissolved samples and two-component relaxation process in powders. Interestingly, we also observe an electron spin echo envelope modulation (ESEEM) associated with the coupling of the Mn electron spins to nearby proton moments. We discuss the nature of the observed relaxation processes and in particular the role of the intermolecular Mn-Mn relaxation.

MA 21.3 Tue 11:30 HSZ 401

Is the magnetic anisotropy barrier U fixed for a given system? — •Claudia Loose and Jens Kortus — TU-BA Freiberg, Institut für Theoretische Physik, Leipziger Str. 23, 09599 Freiberg

We studied several octahedral coordinated, $\mu_{1,1}$-bridged transition metal dimers by first-principles DFT as implemented in the all-electron NRLMOL code. We have been particulary interested in the magnetic groundstate S and the magnetic anisotropy D of the respective dimers. Our results indicate that the barrier of magnetisation U does not show the expected $U = S^2|D|$ behaviour. Instead we observe a steady state behaviour. An increase of the magnetic groundstates is coupled to a decrease of the magnetic anisotropy and hence in a resulting nearly constant barrier U.

MA 21.4 Tue 11:45 HSZ 401

Properties of highly frustrated magnetic molecules studied by the finite-temperature Lanczos method — •Jürgen Schnack and Oliver Wendland — Universität Bielefeld, Universitätsstr. 25, D-33615 Bielefeld

The very interesting magnetic properties of frustrated magnetic molecules are often hardly accessible due to the prohibitive size of the related Hilbert spaces. The finite-temperature Lanczos method is able to treat spin systems for Hilbert space sizes up to about 1 Mrd.. Here we first demonstrate for exactly solvable systems that the method is indeed accurate. Then we discuss the thermal properties of one of the biggest magnetic molecules synthesized to date, the icosidodecahedron with antiferromagnetically coupled spins of s=1/2. We show how genuine quantum features such as the magnetization plateau behave as a function of temperature.

MA 21.5 Tue 12:00 HSZ 401

Magnetization measurements of a $\{MnMn_6\}(CH_3H_5O_3)_3$ single-molecule magnet — •Klaus Gieb[1], Wolfgang Kroener[1], Carl-Georg Freiherr von Richthofen[2], Thorsten Glaser[2], and Paul Müller[1] — [1]Department of Physics and Interdisciplinary Center for Molecular Materials (ICMM), Universität Erlangen-Nürnberg, Germany — [2]Fakultät für Chemie - Lehrstuhl Anorganische Chemie I, Universität Bielefeld, Germany

We present low-temperature magnetization measurements of a novel $\{MnMn_6\}(CH_3H_5O_3)_3$ complex. The measurements at mK temperatures were carried out with a home-made micro-Hall-probe magnetometer. A commercial SQUID magnetometer was used to collect the susceptibility data. Most of the 3d-ion based single-molecule magnets, known up to now, have a low-lying spin ground state, well separated from the first excited state. In contrast to this property, the first exited state of the present complex can already be reached with moderate magnetic fields. Amazingly, loop magnetization measurements show hysteresis for both the ground state and the first exited state. This leads to a double hysteresis in the low temperature magnetization measurements. The blocking temperature was found to be $T_B \approx 1.3\,K$.

MA 21.6 Tue 12:15 HSZ 401

Optical switching of single chain magnets — •Eric Heintze[1], Fadi el Hallak[2], Angelo Rettori[3], Federico Totti[4], Martin Dressel[1], and Lapo Bogani[1] — [1]1. Physikalisches Institut, Universität Stuttgart, Stuttgart, Germany — [2]London centre for Nanotechnology, University College London, United Kingdom, London — [3]Dipartimento di Fisica, Università di Firenze, Firenze, Italy — [4]Dipartimento di Chimica, Università di Firenze, Firenze, Italy

The control of the magnetic state of materials using light is seen as an appealing ingredient for the next generation of photonic or spintronics devices for information-storage, opto-electronic systems and energy conversion. Molecular magnets show a hysteresis cycle and magnetic bistability as their relaxation time becomes exponentially long at low temperatures. Here we show, for the first time, that it is possible to switch the magnetization dynamics of molecular magnetic chains using light irradiation at low powers. We investigate the switching of the magnetization dynamics on the single chain magnet Co(hfac)2NITPhOMe. To this aim we developed photon excited torque magnetometry. Measurements of the magnetization dynamics indicate that the energy barrier can be altered by light, consistently with the creation of preferential sites of magnetic soliton nucleation. Ab-initio calculations show very good agreement between the expected energy barrier after irradiation and the experimentally extracted one. This result will allow controlling the magnetization of molecular nanowires in spintronic and photo-switchable magnetic systems.

MA 21.7 Tue 12:30 HSZ 401

Electronic structure of magnetic organic molecules on ferromagnetic surfaces — •David Klar[1], Claudia Weis[1], Barbara Brena[2], Bernhard Krumme[1], Carolin Antoniak[1], Anne Warland[1], Biplab Sanyal[2], Olle Eriksson[2], and Heiko Wende[1] — [1]Faculty of Physics and CeNIDE, University of Duisburg-Essen — [2]Department of Physics and Astronomy, Uppsala University, Sweden

Magnetic organic molecules on metal surfaces are of interest as a prototype system for molecular spintronic devices. After identifying the magnetic coupling between Fe phthalocyanine (FePc) and ferromagnetic substrates, we focus here on the electronic structure of the FePc molecule on the surface in more detail. We investigate submonolayer coverages of magnetic FePc molecules on ultrathin ferromagnetic films of Ni and Co on Cu(100) by X-Ray absorption spectroscopy (XAS) and X-Ray magnetic circular dichroism (XMCD). Angular-dependent XAS measurements at the nitrogen K-edge are compared to theoretical calculations both with the FEFF code and the StoBe code. With the help of the calculations we are able to identify the individual orbitals responsible for the fine structures in the XAS. Furthermore, we will discuss the influence of radiation damage to the molecules detected by the XA-spectra. – Supported by DFG (Sfb491) and Helmholtz-Zentrum Berlin.

MA 22: Magnetic Measurement Methods

Time: Tuesday 11:00–13:00 Location: HSZ 403

MA 22.1 Tue 11:00 HSZ 403

Cracking bits with serpent's bit - fast and easy experimental data evaluation using python — •Artur Glavic[1], Jörg Voigt[2], and Thomas Brückel[1,2] — [1]Institut für Festkörperforschung, FZ Jülich, D-52425 Jülich — [2]Jülich Centre for Neutron Science, IFF, FZ Jülich, Outstation at FRM II, Lichtenbergstrasse 1, D-85747 Garching

For many physical experiments with non commercial instruments it is necessary to program new software to evaluate the collected data. According to experience this is mostly done by small scripts developed in the experimental group using low-level languages as C or Fortran. The downside of this approach is, that these programs can't be changed very easily to adapt them to new problems and that they can't be used on different platforms.

For most of the cases the main advantage of e.g. C, namely the short execution time, is not important as the data size is small. In this contribution I will introduce the interpreter language python with some useful extension modules, which make it easy to write data evaluating script or even evaluate on-line. The resulting software doesn't have to be compiled and is platform independent. With the object oriented architecture the programs can be written very general making changes easier. I will demonstrate this on a complete evaluation of different measurement types on Multiferroic $TbMnO_3$ thin-films reaching from SQUID magnetometry, x-ray diffraction and reflectometry to magnetic neutron and x-ray scattering. All these evaluations were done with a general architecture using plug-in like parts for the different methods.

MA 22.2 Tue 11:15 HSZ 403

Noise characteristics of magnetoresistive fluxgates for weak magnetic field sensing — •Leoni Breth[1,3], Theodoros Dimopoulos[1], Rudolf Heer[1], Jörg Schotter[1], Karsten Rott[2], Dieter Süss[3], and Hubert Brückl[1] — [1]AIT Austrian Institute of Technology GmbH, Nano Systems, 1220 Vienna, Austria — [2]University of Bielefeld, Physics Department, Germany — [3]Vienna University of Technology, Solid State Physics Department, Austria

Magnetic tunnel junctions (MTJs) with MgO barriers are known for their high magnetoresistance (MR) ratio, which makes them possible candidates for measuring weak biomagnetic fields stemming from the human heart or brain activity. Today's established sensors for magneto-cardio and encephalogram employ costly SQUID systems. To make MTJ sensors competitive to SQUIDs, their detectivity, which is limited by their intrinsic noise level - especially in the low frequency range- has to reach the sub-nT regime. To this end, several designs have been proposed (e.g. integration of flux concentrators). Here, we introduce an alternative technique, inspired from fluxgate magnetometers, employing lock-in amplification. An alternating magnetic field that is produced by a current line is used to switch the free layer of the MTJ. The presence of a weak DC or low frequency magnetic field generates a second harmonic component in the MR signal of the MTJ, which is a linear measure for the magnetic field strength. We present the low frequency noise characteristics of MgO-based MTJs and discuss their influence on the magnetic field detectivity of the proposed MR fluxgate design.

MA 22.3 Tue 11:30 HSZ 403

Element-selective measurement of magnetic multilayers using a tabletop high-harmonic soft X-ray source. — •Roman Adam[1], Patrik Grychtol[1], Dennis Lvovsky[1], Chan La-O-Vorakiat[3], Stefan Mathias[2,3], Moritz Plötzing[1], Justin Shaw[4], Hans Nembach[4], Tom Silva[4], Timm Rohwer[5], Martin Aeschlimann[2], Henry Kapteyn[3], Margaret Murnane[3], and Claus Schneider[1] — [1]Institute of Solid State Research, Research Centre Jülich, Jülich, Germany — [2]TU Kaiserslautern und Forschungszentrum OPTIMAS, Kaiserslautern, Germany — [3]Department of Physics and JILA,University of Colorado, Boulder, CO, USA — [4]Electromagnetics Division, National Institute of Standards and Technology, Boulder, CO, USA — [5]Institute of Experimental and Applied Physics, University Kiel, Kiel, Germany

We performed static and time-resolved magneto-optic measurements on Ni/Ru/Fe and Ni/Cr/Fe multilayers using resonant scattering of laser-generated extreme ultraviolet (XUV) radiation tuned to the M absorption edges of Fe (53eV) and Ni (67eV). By exploiting the linear magneto dichroic effect a clear element selective magnetic contrast upon magnetization reversal can be obtained[1]. Our experiments show that the laser-generated higher harmonics can be employed for element-selective probing of magnetic multilayers with femtosecond time resolution, thus demonstrating a new experimental approach to measure ultrafast spin dynamics in heterogeneous magnetic systems. [1] C. La-O-Vorakiat et al., PRL 103, 257402 (2009.

MA 22.4 Tue 11:45 HSZ 403

Taking Ferromagnetic Resonance to Millikelvin Temperatures — •Hans Huebl, Christoph Zollitsch, Martin Radlmeier, Fredrik Hocke, Mathias Weiler, Karl Neumaier, Rudolf Gross, and Sebastian T. B. Goennenwein — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

Ferromagnetic Resonance (FMR) is a sensitive tool for the investigation of magnetic anisotropy and magnetization damping in thin magnetic films. Broadband FMR based on coplanar waveguide technology hereby is particularly attractive as it allows for the investigation of plain films as well as of single magnetic nanostructures. We here present broadband FMR data of 50 nm thick nickel and cobalt thin films, recorded at temperatures range from 4.2 K down to 50 mK. The excellent sensitivity of our setup allows for the detection of FMR with an incident microwave power of 100 fW at the base temperature of the dilution refrigerator. Our FMR measurements in Co and Ni reveal no distinct temperature dependence of the anisotropy and damping parameters in the temperature regime below 4.2 K, in agreement with the trend observed in measurements from room temperature down to 4.2 K. Our proof-of-principle experiments open the path for broadband FMR studies of magnetic anisotropy and magnetization damping at millikelvin temperatures, i.e., in a regime so far very scarcely explored.

This project is financially supported by the Deutsche Forschungsgemeinschaft via SFB 631 and the Cluster of Excellence Nanosystems Initiative Munich (NIM).

MA 22.5 Tue 12:00 HSZ 403

The new high-intensity polarized neutron reflectometer of the Jülich Centre of Neutron Science — •Stefan Mattauch[1], Denis Korolkov[1], Ulrich Rücker[2], Earl Babcock[1], Alexander Ioffe[1], and Thomas Brückel[2] — [1]JCNS,Institut für Streumethoden, Forschungszentrum Jülich GmbH — [2]Institut für Streumethoden, Forschungszentrum Jülich GmbH

The Jülich Centre of Neutron Science (JCNS) is building the new, high-intensity reflectometer MARIA in the neutron guide hall of the FRM II reactor in Garching. Unique features of MARIA include (i) vertical focussing with an elliptic guide from 170 mm down to 10 mm at the sample position, (ii) reflectometer and GISANS mode, (iii) polarization analysis over a large 2d position sensitive detector as standard, (iv) adjustable wavelength spread from 10 to 1 % by a combination of velocity selector and chopper, (v) flexible sample table using a Hexapod for magnetic field and low temperature sample environment and (vi) in-situ sample preparation facilities. Together with a 400 x 400 mm^2 position sensitive detector and a time-stable ^{3}He polarization analyzer based on Spin-Exchange Optical Pumping (SEOP), the instrument is dedicated to investigate specular reflectivity and off-specular scattering from magnetic layered structures down to the monolayer regime. In addition the GISANS option can be used to investigate lateral correlations in the nm range. This option is integrated into the reflectometer*s collimation, so it can be chosen during the measurement without any realignment.
The results of the first experiments will be presented at the conference.

MA 22.6 Tue 12:15 HSZ 403

magneto-optical dielectric tensor of Co, Fe, Ni, and of NiFe alloys under saturated magnetization conditions — •kahming mok, nan du, and heidemarie schmidt — Institute of Ion-Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Bautzner Landstrasse 400, 01328 Dresden, Germany

Magneto-optical generalized ellipsometry (MOGE) has become extensively important for characterization the magneto-optical response of single and multilayer materials. We setup a Vector-Magneto-Optical Generalized Ellipsometer (VMOGE) in the spectral range from 250 nm to 1100 nm using an octupole magnet, to perform VMOGE measurements of the Mueller matrix in a magnetic field of arbitrary orientation and magnitude up to 0.4 T at room temperature. The VMOGE features a new "field orbit" measurement that can be performed without physically moving the sample, which is useful to study magnetic multilayer or nanostructure samples. An optical model based on the 4 x 4 matrix formalism is required to evaluate and fit the experimental Mueller matrix data. Searching the best match model between experimental and calculated VMOGE data, the magneto-optical dielectric tensor ϵ^{MO} of each layer in a multilayer sample system can be determined. In this work, we investigate the magneto-optical properties of the elemental ferromagnets Co, Fe, and Ni, as well as of $Ni_{1-x}Fe_x$ alloys (x=0.20, 0.65, and 0.80). We extracted the wavelength dependence of the magneto-optical dielectric tensor under saturated magnetization conditions.

MA 22.7 Tue 12:30 HSZ 403

Vectorial magnetometry and anisotropy studies on thin $Co_{50}Fe_{50}$ films using MOKE — •Timo Kuschel[1], Jaroslav Hamrle[2], Jaromir Pistora[2], Subrojati Bosu[3], Yuya Sakuraba[3], Koki Takanashi[3] und Joachim Wollschläger[1] — [1]Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49069 Osnabrück, Germany — [2]Department of Physics, VSB - Technical University of Ostrava, 17. listopadu 15, 70833 Ostrava-Poruba, Czech Republic — [3]Institute for Materials Research (IMR), Tohoku University, Katahira 2-1-1, Aoba-ku, Sendai 980-8577, Japan

Magnetooptical Kerr effect (MOKE) is a powerful tool to determine magnetic properties of thin magnetic films. In some cases this technique is only applied to detect magnetization curves qualitatively. In order to perform a quantitative analysis we present MOKE measurements with s- and p-polarized incident light, using an external magnetic field either parallel or perpendicular to the plane of incidence of light and different orientations of the crystalline substrate. The processing of the data includes vectorial magnetometry as well as studies of the anisotropy constants and magnetic axes.
The investigated $Co_{50}Fe_{50}$ films of 50 nm thickness on MgO(001) are

prepared with different annealing temperatures (RT up to 400°C). On the one hand the films with lower annealing temperatures show typical magnetic reversal processes of samples with four-fold symmetry as expected for cubic crystal structures. On the other hand the film annealed at 400°C presents an additional strong in-plane anisotropy, which is discussed in context of a classical free energy approach.

MA 22.8 Tue 12:45 HSZ 403

Theory of Resonant Inelastic X-Ray Scattering by Collective Magnetic Excitations — •Maurits Haverkort — Max Planck Institute for Solid State Research, Heisenbergstrasse 1, 70569 Stuttgart Germany

Magnetic excitations in solids are traditionally investigated with inelastic neutron scattering. This technique has led to a better understanding of magnetism in general and shaped the thinking of physicists in terms of magnons as the magnetic quasiparticles present within a solid. It is important that the interaction of neutrons with the magnetic moment is well understood and can be approximated by a function linear in spin operators.

Resonant inelastic x-ray scattering (RIXS) is a novel tool to measure magnetic quasiparticles (magnons) and the incoherent spectral weight, as well as multiple magnons up to very high energy losses, in small samples, thin films, and multilayers, complementary to neutron scattering. I present a tractable theory for the resonant inelastic x-ray scattering of magnons. The low-energy transition operator is written as a product of local spin operators and fundamental x-ray absorption spectral functions. This leads to simple selection rules. The scattering cross section linear (quadratic) in spin operators is proportional to the fundamental magnetic circular (linear) dichroic spectral function.

MA 23: Magnetic Shape Memory Alloys I (jointly with MM)

Time: Tuesday 12:15–13:00 Location: HSZ 04

MA 23.1 Tue 12:15 HSZ 04

Relationship between orientation and strain of polycrystalline Ni50Mn29Ga21 samples — •Claudia Hürrich[1], Martin Pötschke[1], Stefan Roth[1], Bernd Rellinghaus[1], and Ludwig Schultz[2] — [1]IFW Dresden, Institute for Metallic Materials, P. O. Box 270116, 01069 Dresden, Germany — [2]Dresden University of Technology, Department of Mechanical Engineering, Institute for Materials Science, 01062 Dresden, Germany

The Ni-Mn-Ga magnetic shape memory alloy provokes plenty of interest for application because of the effect that twin variants reorient by the action of an external magnetic field. Most of the experiments were concentrated on single crystals. But, this effect can also be realised in polycrystals which can be prepared much more efficiently. Here, polycrystalline samples were prepared by directional solidification with a <100> fibre texture of the high temperature cubic phase parallel to the heat flow. A heat treatment was applied for chemical homogenisation and stress relaxation. Samples were heated up to the austenitic state and cooled down under load. The microstructure was analysed by EBSD before and after that treatment. Stress-strain curves were measured at room temperature and at 40°C. As a result of such treatment the twinning stress is reduced and the twinning strain is maximised. This work is supported by DFG within SPP 1239.

MA 23.2 Tue 12:30 HSZ 04

Microscopic origin of magnetic anisotropy in martensitic Ni_2MnGa — •Peter Klaer, Tobias Eichhorn, Gerhard Jakob, and Hans-Joachim Elmers — Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55128 Mainz, Germany

From angle-dependent x-ray magnetic circular dichroism (XMCD) transmission measurements we have derived a simple model for the magnetic anisotropy of epitaxial $Ni_2MnGa(101)/MgO(001)$ magnetic shape memory films. The magnetic shape memory film reveals an anisotropy in the Ni dichroism intensity for magnetization parallel and perpendicular to the film plane. The integrated anisotropy is related to the anisotropy of the orbital magnetic moment in agreement with the observed out-of-plane magnetocrystalline anisotropy. The spectral variation of the x-ray absorption can be traced back to changes in the spin-projected density of states when the magnetization vector is rotated from the easy to the hard magnetic axis, thus revealing the spin-orbit coupling of specific Ni $3d$ states as the microscopic origin of the magnetic anisotropy.

MA 23.3 Tue 12:45 HSZ 04

Effect of temperature and compositional changes on the vibrational properties of Ni-Mn-Ga alloys — •Semih Ener[1], Jürgen Neuhaus[1,2], Richard Mole[2], Klaudia Hradil[2], and Winfried Petry[1,2] — [1]Technische Universität München, Physik Department E13, Garching, Germany — [2]Technische Universität München, Forschungsneutronenquelle Heniz Maier-Leibnitz (FRM II), Garching, Germany

In Ni-Mn-Ga ferromagnetic shape memory alloys (FSMAs) the instability of the lattice as observed in the phonon spectra causes the structural transition by changing the temperature or by applying magnetic field in a particular direction. In this work we investigate the vibrational properties of two different FMSAs, Ni_2MnGa and $Ni_{49}Mn_{32}Ga_{19}$. The full phonon dispersions of these materials are compared with theoretical first principle phonon calculations. The inelastic neutron scattering experiments performed at the Forschungsneutronenquelle Heniz Maier-Leibnitz (FRM II) in addition to calorimetric and magnetic measurements give a detailed insight in the anomalous behavior around the structural and magnetic transition temperatures. The vibrational properties of austenite-premartensite (3M) phase and austenite-martensite (5M) phase transitions were investigated in detail to understand the differences between these two transitions. The results show same overall behavior for different compositions but the relation between the magnetic ordering and the phonon remains an open question as their particular behavior appeared at different temperatures.

MA 24: ThyssenKrupp Dissertations-Preis 2011 der AG Magnetismus

Time: Tuesday 13:30–15:15 Location: HSZ 04

Details zum Programm dieser Sitzung werden später bekannt gegeben.

MA 25: Magnetic Shape Memory Alloys II (jointly with MM)

Time: Tuesday 13:30–15:00 Location: HSZ 103

MA 25.1 Tue 13:30 HSZ 103

Polycrystalline Ni-Mn-Ga: influence of microstructure and sample shape — •Jan Romberg[1], Martin Pötschke[1], Claudia Hürrich[1], Stefan Roth[1], Bernd Rellinghaus[1], and Ludwig Schultz[1,2] — [1]IFW-Dresden — [2]TU-Dresden

Ni-Mn-Ga ferromagnetic shape memory alloys (FSMAs) show strain up to 10% in magnetic field due to the motion of twin boundaries (MIR - magnetically induced reorientation). But, the large strain is only observed for single crystals. For technical application, polycrystals are of great interest because they are easier to produce und cheaper. But in polycrystals the grain boundaries can hinder twin boundary motion. It is known that in textured polycrystals MIR is possible.

We discuss the influence of microstructure and sample shape on the

magnetically induced strain. Furthermore we worked out how to get large and yet textured grains and we developed an optimized mechanical training procedure in order to achieve large strain.

MA 25.2 Tue 13:45 HSZ 103

Cyclic fibre texture in hot extruded $Ni_{50}Mn_{29}Ga_{21}$ — •Robert Chulist[1], Werner Skrotzki[1], Carl-Georg Oertel[1], Andrea Böhm[2], Heinz-Guenter Brokmeier[3], and Thomas Lippmann[4] — [1]Institut für Strukturphysik, Technische Universitaet Dresden, D-01062 Dresden, Germany — [2]Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik, D-01187 Dresden, Germany — [3]Institut für Werkstoffforschung, GKSS Forschungszentrum Geesthacht, D-21494 Geesthacht, Germany — [4]Institut für Werkstoffforschung, GKSS Forschungszentrum Geesthacht, D-21502 Geesthacht, Germany

The cyclic texture in polycrystalline $Ni_{50}Mn_{29}Ga_{21}$ magnetic shape memory alloy fabricated by hot extrusion was investigated with high-energy synchrotron radiation, neutron diffraction and electron backscatter diffraction. Combination of these techniques reveals that the texture of the hot extruded sample is quite complex. It is composed of components related to the radial direction and rotated around the extrusion axis. Additionally, the dominant texture components change from the centre to the edge of the rod. The recrystallized grains contain a lot of twins with the trace of the twin boundaries preferentially aligned along the extrusion and radial direction showing the cyclic nature of the texture and microstructure, too. The results are discussed with respect to deformation mode, phase transformations, starting grain structure and texture.

MA 25.3 Tue 14:00 HSZ 103

Textured Ni-Mn-Ga as a material for magnetically driven actuators — •Martin Pötschke, Jan Romberg, Claudia Hürrich, Stefan Roth, and Ludwig Schultz — IFW Dresden, Institute for Metallic Materials, P. O. Box 270116, 01069 Dresden, Germany

Ni-Mn-Ga alloys are interesting because of their possible application as magnetic shape memory materials. This effect is caused by the motion of twin boundaries in a magnetic field. Up to now most of the research was concentrated on single crystals. However, the preparation of single crystals is a time consuming and cost intensive process and compositional changes along the growth axis as well as segregations may occur. This is why for technical applications there is a great interest in polycrystals, which are easier to produce. To achieve magnetic field induced twin boundary motion in polycrystals, directional solidification was applied to a 5M Ni-Mn-Ga alloy in order to prepare coarse grained, textured samples. The samples show a <100> fibre-texture. Annealing is necessary for homogenization and stress relaxation. After the annealing the samples showed chemical homogeneity along the sample axis. A two-side mechanical training was applied to decrease the stress, which is necessary to move the twinboundaries. The stress-strain curves for the two training directions show a different behaviour. Also the magnetically inducable stress is different for the two directions. This influences the magnetic-field-induced strain (MFIS). A resettable MFIS was measured in samples with a plate-like geometry.

Financial support was provided by the DFG within SPP 1239.

MA 25.4 Tue 14:15 HSZ 103

Atomically resolved surface structure of (100)-oriented thin epitaxial Ni-Mn-Ga films. — •Aleksej Laptev[1], Philipp Leicht[1], Mikhail Fonin[1], Yuansu Luo[2], and Konrad Samwer[2] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz — [2]I. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen

Epitaxial off-stoichiometric Ni-Mn-Ga films were deposited on MgO(100) substrates by dc magnetron sputtering. After appropriate cleaning steps in ultra high vacuum conditions the (100)-oriented film surface was studied at room temperature by means of scanning tunneling microscopy (STM). In the austenitic state well-ordered surface exhibiting predominantly Mn-Ga termination was observed. After a transformation of the sample to the martensitic state upon a high temperature annealing step the martensitic surface was investigated at room temperature. On a larger scale STM images show a zig-zag shaped surface topography due to the formation of twin boundaries [1]. A second corrugation feature is found on every second side of twin lamellae originating from the modulated nature of martensites. The irregularly-spaced corrugation lines and the observed atomic structure on both sides of the twin variants support the stacking approach of the modulated superstructure proposed within the model of adaptive martensites [2]. This work was supported by BMBF-Projects MSM-Sens 13N10061 and 13N10062.

[1] J. Buschbeck et al., *Acta Mater.* **57**, 2516-2526 (2009)
[2] S. Kaufmann et al., *Phys. Rev. Lett.* **104**, 145702 (2010)

MA 25.5 Tue 14:30 HSZ 103

Electronic structure, magnetic and transport properties of the Heusler shape memory alloy Mn_2NiGa. — •C. G. F. Blum[1,2], S. Ouardi[1], G.H. Fecher[1], S. Wurmehl[2], B. Buechner[2], B. Balke[1], S. Ueda[3], K. Kobayashi[3], and C. Felser[1] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, Mainz, Germany — [2]Institute of Solid State Research, IFW Dresden, D-01171 Dresden, Germany. — [3]NIMS Beamline Station at SPring-8,National Institute for Materials Science, Hyogo 679-5148, Japan.

Magnetic shape memory based on Heusler compounds have received increasing interest, due their potential use for actuator and sensor applications. The single crystals Mn_2NiGa were grown by the optical floating zone method using a image furnace with vertical setup under a purified argon atmosphere. The both cubic (austenite) and tetragonal (martensite) phases of the sample were determined using temperature dependence powder x-ray diffraction XRD. The effect of martensitic transitions on the magnetic and transport properties of the compound was investigated by measuring the saturation magnetization, electrical resistivity $\rho(T)$, the Seebeck coefficient $S(T)$ and magnetoresistance R_M. All measurements detect clear signatures of the martensitic transition around room temperature with a thermal hysteresis up to 30 K. The electronic structures of the martensitic as well the austenitic phase were investigated using bulk-sensitive hard X-ray photoelectron spectroscopy (HAXPES).

MA 25.6 Tue 14:45 HSZ 103

Phase transformations and mechanical properties of free-standing single crystalline $Fe_{70}Pd_{30}$ thin films — •Y. Ma[1,2], F. Szillat[1,2], D. Manova[1], S. Mändl[1], J. W. Gerlach[1], and S. G. Mayr[1,2] — [1]Leibniz-Institut fuer Oberflaechenmodifizierung — [2]Translationszentrum fuer Regenerative Medizin und Fakultaet fuer Physik und Geowissenschaften, Universitaet Leipzig, 04318 Leipzig

Ferromagnetic shape memory alloys have attracted significant scientific interest recently due to their high potential for actuators in microsystems. Recently, freestanding single crystalline $Fe_{70}Pd_{30}$ thin films became available, which can be transformed to the desired fct phase by annealing treatment [1]. We show, that by raising the deposition temperature to 850 °C or higher, room temperature single crystal fct Fe-Pd films are readily prepared without post-annealing treatment. Scanning electron microscopy and atom force microscopy images reflect the twin structure of martensite. The transformation temperature from fct martensite to fcc austenite at about 53 °C was confirmed independently by temperature dependent x-ray diffraction and magnetization measurements. The films were released from the substrates by chemically dissolving the MgO, while the crystal structure, phase and composition of these films are kept intact. The Young's modulus of as prepared and freestanding Fe-Pd films was determined by nanoindentation with a Berkovich tip in quasi continuous stiffness method.
This project is funded by the German BMBF, PTJ-BIO, Grant Number: 0313909.
[1] T. Edler and S. G. Mayr, Adv. Mat. (in press, 2010).

MA 26: High Frequency Magnetic Light-Matter Interaction - Invited Talk

Time: Wednesday 10:15–10:45 Location: HSZ 04

Invited Talk MA 26.1 Wed 10:15 HSZ 04

Magnetic light-matter interaction at highest frequencies — •Tobias Kampfrath[1,2,3], Alexander Sell[1], Matteo Burresi[3], Dries van Oosten[3], Manfred Fiebig[4], Susumu Noda[5], Martin Wolf[2], Alfred Leitenstorfer[1], Kobus Kuipers[3], and Rupert Huber[1] — [1]University of Konstanz, Germany — [2]Fritz Haber Institute, Berlin, Germany — [3]AMOLF, Amsterdam, The Netherlands — [4]HISKP, Bonn, Germany — [5]University of Kyoto, Japan

In light-matter interactions at terahertz or even optical frequencies, the magnetic component of light usually plays a negligible role. Here, we consider two exceptions to this rule.

First, we use intense sub-picosecond electromagnetic pulses at terahertz frequencies to launch and stop a spin precession in the antiferromagnet NiO. The Zeeman coupling between the spins and the magnetic field of the terahertz pulse is enhanced by the spin-wave resonance at 1 THz. This scheme allows for an ultrafast spin control with minimum impact on other degrees of freedom of the solid [see also T. Kampfrath *et al.*, Nature Photon., doi:10.1038/nphoton.2010.259].

Second, we consider an optical analog of electron paramagnetic resonance and study the interaction between a metal ring (diameter 300 nm) and a nano-photonic cavity at telecom frequencies of 200 THz. We observe a blue-shift of the cavity resonance when the ring is above an antinode of the magnetic field of the cavity. This shift allows us to determine the magnetic polarizability of the nano-ring. We discuss how this method could be applied to even smaller objects such as atoms [see also M. Burresi *et al.*, Phys. Rev. Lett. **105**, 123901 (2010)].

MA 27: SKM-SYTI: Topological Insulators (jointly with TT, HL)

Time: Wednesday 10:30–13:00 Location: TRE Ma

Invited Talk MA 27.1 Wed 10:30 TRE Ma

Topological insulators and topological superconductors — •Shoucheng Zhang — Stanford

Recently, a new class of topological states has been theoretically predicted and experimentally observed. The topological insulators have an insulating gap in the bulk, but have topologically protected edge or surface states due to the time reversal symmetry. Similarly, topological superconductors or superfluids have novel edge or surface states consisting of Majorana fermions. In this talk, I shall review the recent theoretical and experimental progress in the field, and focus on a number of outstanding issues, including the quantized anomalous Hall effect, quantized magneto-electric effect, the topological Mott insulators and the search for topological superconductors.

Invited Talk MA 27.2 Wed 11:00 TRE Ma

Dirac Fermions in HgTe Quantum Wells — •Laurens Molenkamp — Physikalisches Institut(EP3) der Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

HgTe quantum wells have a linear band dispersion at low energies and thus mimic the Dirac Hamiltonian. Changing the well width tunes the band gap (i.e., the Dirac mass) from positive, through zero, to negative. Wells with a negative Dirac mass are 2-dimensional topological insulators and exhibit the quantum spin Hall effect, where a pair of spin polarized helical edge channels develops when the bulk of the material is insulating. Our transport data provide very direct evidence for the existence of this third quantum Hall effect. Wells with a thickness of 6.3 nm are zero gap Dirac systems, similar to graphene. However, zero gap HgTe wells possess only a single Dirac valley, which avoids inter-valley scattering. This makes them especially suitable to study quantum interference effects under a Dirac Hamiltonian.

Invited Talk MA 27.3 Wed 11:30 TRE Ma

Interaction, disorder, and quantum criticality in Z_2 topological insulators — •Alexander Mirlin — Karlsruhe Institute of Technology, Germany

We study disorder and interaction effects in topological insulators with strong spin-orbit coupling. We find that the interplay of nontrivial topology, quantum interference, and Coulomb repulsion induces a novel critical state on the surface of a three-dimensional topological insulator. Remarkably, this interaction-induced criticality, characterized by a universal value of conductivity, emerges without any adjustable parameters. Further, we predict a direct quantum-spin-Hall transition in two dimensions that occurs via a similar critical state.

[1] P.M. Ostrovsky, I.V. Gornyi, A.D. Mirlin, Interaction-induced criticality in Z_2 topological insulators, Phys. Rev. Lett. 105, 036803 (2010)

[2] A. D. Mirlin, F. Evers, I. V. Gornyi, P. M. Ostrovsky, Anderson Transitions: Criticality, Symmetries, and Topologies, in "50 Years of Anderson Localization", ed. by E. Abrahams (World Scientific, 2010); reprinted in Int J Mod Phys B 24, 1577 (2010).

Invited Talk MA 27.4 Wed 12:00 TRE Ma

Disorder and Interactions in Topological Insulators — •Allan H. MacDonald — University of Texas, Austin TX, USA

Three-dimensional topological insulators have protected surface states that are described by massless Dirac equations. I will discuss some properties of these two-dimensional Dirac systems, emphasizing the importance of disorder and interactions. The magneto-optical properties of topological insulator thin films depend intricately on a competition between disorder and time-reversal symmetry breaking by either external magnetic fields or exchange coupling to external magnetic fields. Broken symmetry states, including notably nteraction-driven spontaneous phase coherence between top and bottom surfaces are likely to occur in the absence of a magnetic field. In addition a wide variety of unusual broken symmetry states are likely to be discovered in the presence of external magnetic fields as sample qualities improve.

Invited Talk MA 27.5 Wed 12:30 TRE Ma

Tunable multifunctional topological insulators in ternary Heusler and related compounds — •Claudia Felser[1], Stanislav Chadov[1], Lukas Müchler[1], Jürgen Kübler[2], Shou Cheng Zhang[3], Xiaoliang Qi[3], and Hai-Jun Zhang[3] — [1]University Mainz — [2]TU Darmstadt — [3]Stanford University

Recently the quantum spin Hall effect was theoretically predicted and experimentally realized in quantum wells based on the binary semiconductor HgTe. The quantum spin Hall state and topological insulators are new states of quantum matter interesting for both fundamental condensed-matter physics and material science. Many Heusler compounds with C1b structure are ternary semiconductors that are structurally and electronically related to the binary semiconductors. The diversity of Heusler materials opens wide possibilities for tuning the bandgap and setting the desired band inversion by choosing compounds with appropriate hybridization strength (by the lattice parameter) and magnitude of spinorbit coupling (by the atomic charge). Based on first-principle calculations we demonstrate that around 50 Heusler compounds show band inversion similar to that of HgTe. The topological state in these zero-gap semiconductors can be created by applying strain or by designing an appropriate quantumwell structure, similar to the case of HgTe. Many of these ternary zero-gap semiconductors (LnAuPb, LnPdBi, LnPtSb and LnPtBi) contain the rare-earth element Ln, which can realize additional properties ranging from superconductivity (for example LaPtBi) to magnetism (for example GdPtBi) and heavy fermion behaviour (for example YbPtBi).

MA 28: Spins in Organic Materials (jointly with DS) - Invited Talk

Time: Wednesday 10:15–11:00 Location: GER 37

Invited Talk MA 28.1 Wed 10:15 GER 37

Stochastic approach to electronic and spin thermal transport — •Roberto D'Agosta — Nano-bio spectroscopy group, UPV/EHU, E-20018 San Sebastian, Spain — Ikerbasque, Basque Foundation for Science, E-48011 Bilbao, Spain

The theory of open quantum systems aimed at describing the interaction of a thermal bath with a quantum mechanical system is a field of intense research activity.

In this talk, I will present some recent developments in this area used to investigate the thermal transport both in electronic and spin systems. Especially at the nanoscale, the *standard* approaches based on the Fourier law or the Landauer formalism have been put under serious scrutiny and it has been shown that they can be in contrast with both analytical and numerical results.

After a brief introduction to the field, I will discuss the differences between the two main approaches, the stochastic Schroedinger equation (SSE) and the reduced density matrix formalisms, and show how the SSE can be used to describe the dynamics of a spin chain or an electron system coupled to an external thermal bath. I will discuss how the coupling with the environment might induce correlation between the states of the system and how we can explore the dynamical approach to thermal steady states.

MA 29: Micro- and Nanostructured Magnetic Materials II

Time: Wednesday 11:00–13:15 Location: HSZ 103

MA 29.1 Wed 11:00 HSZ 103

Magnetostatic interaction of single NiFe nanostructures — •Mahmoud Reza Rahbar Azad, André Kobs, Hendrik Spahr, Björn Beyersdorff, Daniel Stickler, Robert Frömter, and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The magneto-static interaction between submicron $Ni_{80}Fe_{20}$ rectangles with aspect ratio of two has been investigated by means of magnetotransport measurements using anisotropic magneto resistance (AMR). The structures have been carved into a Cr(10nm)/$Ni_{80}Fe_{20}$(20nm)/Pt(2,5nm) trilayer utilizing a highly focused ion beam (FIB). The material surrounding the rectangles has been milled paramagnetic by applying a Ga^+-ion dose of 6000 $\mu C/cm^2$, which destroys ferromagnetism but guarantees an adequate electric conductivity. The contacting of the submicron rectangles was performed *in situ* via a tungsten tip attached to a micromanipulator [1]. Microcircuit milled by FIB enables us to measure the magnetic behavior of one single element of an array of rectangles [2]. Due to the high flexibility of our setup [1] we could systematically vary the distance between the rectangles as well as the size. Besides determining the magnetic energy of the micro-magnetic states, i.e. the Landau state of an individual rectangle [2], we can measure the strength of the magneto-static interaction between the rectangles.

[1] Daniel Stickler et al., Rev. Sci. Instr. **79**, 103901 (2008)
[2] André Kobs et al., Phy. Rev. B **80**, 134415 (2009)

MA 29.2 Wed 11:15 HSZ 103

Cobalt-based magnetic nanostructures grown by focused-elctron-beam-induced deposition. — •Evgeniya Begun, Johannes Schwenk, Fabrizio Porrati, and Michael Huth — Physikalisches Institut, Goethe-Universität, D-60438 Frankfurt am Main, Germany

The fabrication of magnetic nanostructures by means of the direct-writing technique focused-electron-beam-induced deposition (FEBID) is an alternative to more conventional lithographic methods. We have grown magnetic cobalt structures by FEBID using the precursor dicobaltoctacarbonyl $Co_2(CO)_8$. The obtained structures have a large metal content of about 85 at.% as compared to other metal-based deposits grown by the same technique, such as tungsten-based structures with 34 at.% maximum tungsten content and platin-based structures with about 24 at.% maximum platin content. We present a growth strategy for cobalt structures with tunable metal content. In particular, we show the influence of different combinations of electron-beam energy and current, the dwell time and the refresh time on the deposit composition, which was determined by energy-dispersive X-ray spectroscopy (EDX) at 5 keV.

First results of magnetotransport measurements on these cobalt-based structures are presented.

MA 29.3 Wed 11:30 HSZ 103

Magnetic behaviour of embedded antiferromagnetic elements in remanence — •Roland Neb[1], Peter Andreas Beck[1], Thomas Sebastian[1], Philipp Pirro[1], Stefan Pofahl[2], Rudolf Schäfer[2], Bernhard Reuscher[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [3]Institut für Oberflächen- und Schichtanalytik, IFOS, Trippstadter Straße 120, 67663 Kaiserslautern, Germany

We investigate small elements with ferromagnetic interlayer coupling in an antiferromagnetically coupled environment. These elements are created by focused ion beam irradiation on an antiferromagnetically coupled Fe/Cr/Fe-trilayer. We show that the behavior of these elements is dominated by rectangular edge domains of a constant size, independently of the size of the surrounding square. These domains impose a lower limit for the size of the elements, beyond which the antiferromagnetic coupling vanishes completely. A symmetry breaking is observed by finding the edge domains only on two of the four sides. Different thicknesses of the magnetic layers do not alter the properties of the domains, giving rise to the assumption that this is not an anisotropy effect, but only due to exchange coupling.

MA 29.4 Wed 11:45 HSZ 103

Magnetic pinning in self-assembled sub-200nm antidot arrays — •Felix Häring, Ulf Wiedwald, Karsten Küpper, and Paul Ziemann — Universität Ulm, Institut für Festkörperphysik

Self-assembled and isotropically etched Polystyrene (PS) nanoparticles serve as template for the subsequent deposition of magnetic thin films. In this way, films with ordered arrays of antidots are obtained, which can be fine-tuned with respect to their diameters and distances. Both of these parameters are kept within the sub-200nm range. Applying SQUID-magnetometry and magnetotransport measurements, a strong dependence of the magnetic film properties is found on these structural parameters and the film-thickness. For example, an antidot array with a periodicity of 200 nm, antidot diameter of 150 nm within a permalloy film of 20 nm thickness shows a coercive field of 250 Oe, which is an enhancement by a factor of 80 as compared to continuous reference films (3 Oe). This increase is due to domain wall pinning at antidot sites caused by local variations of shape anisotropy. Scanning Transmission X-Ray-Microscopy (STXM) and micromagnetic simulations give further insight into this type of pinning.

MA 29.5 Wed 12:00 HSZ 103

Extremely high coercivity of Co Islands on Ir(111) probed by spin-resolved scanning tunneling microscopy — •Jessica Bickel, Focko Meier, Jens Brede, Kirsten von Bergmann, and Roland Wiesendanger — Insitute of Applied Physics, University of Hamburg, Hamburg, Germany

As length scales continue to decrease, surfaces and small atomic clusters and islands play an increasingly large role in determining material properties. Thus it is imperative to study and understand the properties of small islands in order to further our fundamental understanding of reduced dimension properties and to exploit these properties for device applications.

Co islands on Ir(111) were examined by spin-resolved scanning tunneling microscopy (SPSTM) and spectroscopy. The Co islands grow pseudomorpically on the Ir substrate, forming triangular shaped is-

lands with no regular dislocation structure and are magnetized perpendicular to the Ir surface. The islands have a high coercivity and require a field of B=5T to fully align all the islands in a magnetic field applied along the easy magnetization axis. Effects of the stray field of the SPSTM tip on island switching will be discussed.

MA 29.6 Wed 12:15 HSZ 103

Electric field as a switching tool for magnetic states in atomic-scale nanostructures — •Nikolay Negulyaev[1], Valeri Stepanyuk[1], Wolfram Hergert[2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle, Germany — [2]Fachbereich Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

One of the most promising candidates for the construction of ultra-high-density storage media are low-dimensional magnetic nanostructures exhibiting magnetic bi- or multi-stability. This property is peculiar to magnets that have two or more stable magnetic states characterized by a relatively small energy difference between them (of the order of tens of meV) [1]. In this work we propose a novel route of locally controlling and switching magnetism in such structures: our ab initio studies give clear evidence that applying an external electric field it is possible to switch a nanostructure between its different magnetic states. We first examine a system exhibiting magnetic bi-stability, a Mn dimer on a non-magnetic Ag(001) substrate, and then generalize our statements by extending the reasoning onto the case of a multi-stable system, a Mn dimer on a magnetic Ni(001) surface. We also reveal that by applying an external electric field one can rotate the direction of atomic spins for a certain magnetic state of a nanostructure.

[1] R. Sessoli et al., Nature 365, 141 (1993); L. Thomas et al., Nature 383, 145 (1996).

MA 29.7 Wed 12:30 HSZ 103

Magnetic reversal in a laterally structured spin valve system with one tunable magnetic layer — •Frank Brüssing, Melanie Ewerlin, Radu Abrudan, and Hartmut Zabel — Department of Physics, Ruhr-University Bochum, 44780 Bochum, Germany

We investigated the magnetization reversal of interacting Co islands and how their behavior is altered after switching on the interlayer exchange interaction to a second magnetic layer with different magnetic domain structure and different coercivity values. As a test system we grew via MBE an epitaxial magnetic heterostructure comprising two ferromagnetic layers, one with a high Curie temperature (T_C) (Co) and one with a T_C below room temperature (RT) ($Fe_{1-x}Cr_x$), and a mediating Cr layer in between. This heterostructure was patterned via e-beam lithography and ion beam etching in the lateral direction. We have investigated the magnetization reversal of Co at RT and of the combined system at low temperature, using x-ray resonant magnetic scattering (XRMS), which allows element selective investigations of the magnetic behavior by tuning the x-ray energy to the respective L-edges of Co and Fe. As reference we also investigated the same heterostructure before patterning. The lateral periodic pattern gives raise to new in-plane Bragg reflections, revealing the structural and magnetic correlation between the islands. We have used a CCD camera for investigating the magnetic Bragg peaks and magnetic diffuse scattering as a function of temperature above and below the T_C of $Fe_{1-x}Cr_x$. Furthermore, by varying the field we followed the domain formation during the magnetization reversal for the respective layers.

MA 29.8 Wed 12:45 HSZ 103

Investigation of magnetic nanostructures by means of neutron-polarisation analysis — •Dirk Honecker[1], Frank Döbrich[1], Charles Dewhurst[2], Albrecht Wiedenmann[2], Cristina Gómez Polo[3], Kiyonori Suzuki[4], and Andreas Michels[1] — [1]Laboratory for the Physics of Advanced Materials, University of Luxembourg, Luxembourg — [2]Institut Laue-Langevin, Grenoble, France — [3]Departamento de Física, Universidad Pública de Navarra, Pamplona, Spain — [4]Department of Materials Engineering, Monash University, Clayton, Australia

Small-angle neutron scattering (SANS) is a very powerful technique for the investigation of magnetic nanostructures since it provides information from within the bulk of the material and on a length scale of a few to some hundred nanometres. SANS is commonly utilised with an unpolarised or a polarised incident neutron beam, where an analysis of the spin state of the neutron after the scattering process is not performed. Due to the recent development of efficient ^{3}He spin filters, it becomes possible now to perform routinely longitudinal neutron-polarisation analysis (POLARIS) in a SANS experiment. In this contribution, we discuss the equations of the non-spin-flip and spin-flip cross sections for bulk ferromagnets along with typical angular anisotropies and asymmetries. In order to demonstrate the potential of the POLARIS technique, we present results on nanocrystalline cobalt and on Fe based soft magnetic nanocomposites.

MA 29.9 Wed 13:00 HSZ 103

Preparation and Analysis of Ni Nanowires on Si Gratings — •Wolfgang Kreuzpaintner[1], Boris P. Toperverg[3], Dieter Lott[2], Michael Störmer[2], Volker Neu[4], Christine Bran[4], Birgit Wiedemann[1], Andreas Schreyer[2], and Peter Böni[1] — [1]Technische Universität München, Physik-Department E21, James-Franck-Straße, 85748 Garching — [2]Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH, Max-Planck-Straße 1, 21502 Geesthacht, Germany — [3]Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [4]IFW Dresden, Institute for Metallic Materials, Dpt. Magnetic Microstructures, Helmholtzstraße 20, 01069 Dresden, Germany

Ni nanowires with a nominal cross-section of approx. 10 nm × 10 nm, a wire spacing of 750 nm and a length of several cm were deposited homogeneously on a prestructured Si-surface area of approx. 4 cm^2. The structural and magnetic properties of this sample as obtained from SEM imaging and AFM and MFM micrographs will be shown. Emphasis will be given on the lateral periodicity over a macroscopic distance and the buried sample structures, which were probed by off-specular x-ray scattering and analysed using Distorted-Wave Born Approximation (DWBA). An excellent agreement between the measured and simulated off-specular intensity distribution could be achieved. Furthermore, polarised off-specular neutron scattering on this sample was also carried out to probe the magnetic nature of the sample using the NERO reflectometer at the GENF facility in Geesthacht and will briefly be presented.

MA 30: Magnetic Semiconductors I

Time: Wednesday 11:00–13:15 Location: HSZ 401

MA 30.1 Wed 11:00 HSZ 401

Coherent magnetization precession in ferromagnetic (Ga,Mn)As induced by picosecond acoustic pulses — •Michael Bombeck[1], Alexey Scherbakov[2], Alexey Salasyuk[1,2], Dmitri Yakovlev[1,2], Andrey Akimov[2,3], Xinyu Liu[4], Christian Brüggemann[1], Victor Sapega[2], Jacek Furdyna[4], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, Dortmund, D-44227, Germany — [2]Ioffe Physical Technical Institute of the Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom — [4]Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, USA

In this work we investigate the influence of picosecond strain pulses on the magnetic properties of a thin film of a ferromagnetic semiconductor. By a pump-probe technique we measure the transient magneto-optical Kerr effect in a 200nm $Ga_{0.95}Mn_{0.05}As$ film. Pump pulses of an amplified Ti:Sa-laser, applied to a 100nm Al-film serving as a optoelastic transducer, generate a strain pulse in the studied structure. Kerr rotation of a linearly polarized probe beam reflects the time evolution of magnetization. The effect of the strain pulses on the magnetic domains of the (Ga,Mn)As film is mediated by the strain-induced changes of the magneto-crystalline anisotropy. We observe the tilt of the magnetization vector M on a picoseconds time scale caused by the strain pulse and followed by the coherent precession of M with a frequency of 10 GHz around its equilibrium orientation.

MA 30.2 Wed 11:15 HSZ 401

Tailoring the magnetism of GaMnAs films by ion irradia-

tion — •Lin Li[1,2], Shengqiang Zhou[1,2], Danilo Bürger[2], Jürgen Fassbender[2], Manfred Helm[2], Bryan Gallagher[3], Carsten Timm[4], and Heidemarie Schmidt[2] — [1]State Key Laboratory of Nuclear Physics and Technology, Peking University, China — [2]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany — [3]School of Physics and Astronomy, University of Nottingham, United Kingdom — [4]Institute for Theoretical Physics, Technische Universität Dresden, Germany

Ion irradiation of semiconductors is a well understood method to tune the carrier concentration in a controlled manner. The ability to tune the magnetic properties of magnetic semiconductors, e.g. GaMnAs, is an important issue in future spintronics devices. In this contribution, we show the possibility of fine tailoring the magnetism of GaMnAs films by He+ ion irradiation. With increasing the displacement per atom (ion fluence), the GaMnAs films become more insulating step by step and only paramagnetic at the end. The coercivity can be increased by three times from 50 to 165 Oe. At the same time, the irradiated GaMnAs films become magnetically more isotropic. The electrical and structural characterization of the irradiated GaMnAs films indicates that the controlled tailoring of magnetism results from a compensation of holes by irradiation-induced donors [1]. [1] L. Li, et al., J. Phys. D (2011), in press

MA 30.3 Wed 11:30 HSZ 401

Stacking faults in (Ga,Mn)As and uniaxial magnetocrystalline anisotropy — •Frantisek Maca, Jan Masek, Milos Kopecky, Jiri Kub, and Tomas Jungwirth — Institute of Physics ASCR, Praha, Czech Republic

The high resolution X-ray difraction measurements of (Ga,Mn)As and (Ga,Mn)(As,P) epilayers showed a structural anisotropy in the form of stacking faults which are present in the (-1-11) and (111) planes and absent in the (-111) and (1-11) planes. Our full-potential density functional calculations explain the energetic preference of substitutional Mn to decorate the stacking faults. This preference energy is comparable with the formation energy of the faults in a pure GaAs. We surmise that the enhanced Mn density along the common [1-10] direction of the stacking fault planes represents the micro-structural origin of the in-plane uniaxial magnetocrystalline anisotropy of these semiconductors.

MA 30.4 Wed 11:45 HSZ 401

Reliable calculations of generalized RKKY-couplings for dilute magnetic semiconductors — •Stefan Barthel[1], Georges Bouzerar[2], and Gerd Czycholl[1] — [1]Institute for Theoretical Physics, University of Bremen, Germany — [2]School of Engineering and Science, Jacobs University Bremen, Germany

A multiband empirical tight-binding model for magnetically doped group-III-V-semiconductors with zincblende structure (e.g. $Ga_{1-x}Mn_xAs$, etc.) for the valence bands is applied to the calculation of generalized RKKY-couplings J_{ij} between magnetic impurities (e.g. Mn^{2+}). Our approach does treat disorder exactly and enables a direct mapping on a disordered Heisenberg model to allow further studies. We will present analytic expressions of the double- and superexchange terms in the limit of large splitting JS and show numerical results in the dilute regime for realistic parameters of doping concentration, hole density and impurity potential. Finally a comparison to results obtained by more sophisticated methods (Monte-Carlo simulations) is made and we will comment on the discrepancies, which will lead to different Curie temperatures.

MA 30.5 Wed 12:00 HSZ 401

Magnetic properties of Fe/(Ga,Mn)As interface: thickness and atomic composition dependence — •Svitlana Polesya[1], Sergiy Mankovsky[1], Jan Minár[1], Sven Bornemann[1], Hubert Ebert[1], Matthias Sperl[2], and Christian Back[2] — [1]LMU München, Dept. Physikalische Chemie, München, Germany — [2]Institut für Experimentelle Physik, Univ. Regensburg, Germany

The dependence of the magnetic properties of the heterogeneous interface system nFe/m($Ga_{0.95}Mn_{0.05}As$)/GaAs on the thickness m of $Ga_{0.95}Mn_{0.05}As$ film as well as the different atomic (Ga or As) termination has been studied within ab initio electronic structure calculations using the SPR-KKR Green's function method in its tight-binding (TB) version. The m value was varied from 4 to 12 structure units. For all film thicknesses it was found that the ground state magnetic properties at the interface do hardly depend on the $Ga_{0.95}Mn_{0.05}As$ film thickness. The influence of Mn interstitials as well as different surface termination (Ga or As) on the magnetic properties at the interface were also examined. The largest modification of magnetic properties for the interface region occurs for the As terminated case in comparison to the Ga terminated one. The finite temperature behavior of magnetic properties was studied by Monte Carlo simulation using calculated exchange coupling parameters. The influence of Mn concentration x as well as various capping layers on the magnetic anisotropy of $Ga_{1-x}Mn_xAs$ films was also studied. The results are compared with recent experimental data.

MA 30.6 Wed 12:15 HSZ 401

Spin-polarized hole transport in pulsed laser annealed Ge:Mn up to 30 K — •Danilo Bürger, Shengqiang Zhou, Manfred Helm, and Heidemarie Schmidt — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden

The incorporation of transition metals dopants in semiconductors over their solubility limit is the main challenge for the fabrication of diluted ferromagnetic semiconductors. Low temperature molecular beam epitaxy (LT-MBE) is the standard technique for the fabrication of GaAs:Mn. Nevertheless, for Ge:Mn [1] the LT-MBE approach seems to be not successful to reach hole concentrations necessary for hole mediated ferromagnetism. On the other hand, pulsed laser annealing is a successful nonequilibrium annealing method and a promising technique for the fabrication of diluted Ge:Mn [2] and for III-V semiconductors, e.g. GaAs:Mn [3]. Recently we fabricated a ca. 100 nm thick Ge:Mn film by low temperature Mn-implantation followed by pulsed laser annealing and observed hole-mediated ferromagnetism up to 30 K via SQUID magnetization as well as magnetotransport measurements. The anisotropy of ferromagnetic Ge:Mn films will be discussed. Moreover, the Ge:Mn films show a remanent magnetization up to 220 K which is lower than the Curie temperature of typical Mn_xGe_y clusters [1]. The confirmation of spin-polarized hole transport up to 220 K becomes difficult because at elevated temperatures the conductivity is mainly determined by the Ge substrate. [1] M. Jamet *et al.*, Nature. Mat. **5**, 653 (2006) [2] Shengqiang Zhou *et al.*, PRB **81**, 165204 (2010) [3] Danilo Bürger *et al.*, PRB **81**, 115202 (2010)

MA 30.7 Wed 12:30 HSZ 401

Optical studies of magnetic field induced phenomena in MBE grown MnS layer — •Manuel Demper[1], Christine Bradford[2], Kevin A. Prior[2], and Wolfram Heimbrodt[1] — [1]Department of Physics and Material Science Center, Philipps University, Marburg, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, UK

Recently, a considerable amount of attention has been paid to the theoretical investigation of two-dimensional spin systems. Experimentally it is still a challenge to approach the two dimensional limit, as in reality one is always faced with quasi 2D magnetic structure. To reach the 2D limit antiferromagnetic zinc blende MnS films with various thicknesses have been prepared by MBE. To avoid any interplane interactions these single layers were grown in between diamagnetic ZnSe cladding layers on a GaAs substrate. Since the small number of spins in these single layers makes conventional techniques like SQUID-measurements rather difficult, we developed an optical spectroscopy method using the internal $^4T_1$-$^6A_1$ emission of the Mn 3d-states as a probe. Thus, the MnS films have been studied by temperature dependent photoluminescence measurements in external magnetic fields up to 7 T. The detailed studies of the data reveal a phase diagram for the thinnest sample, which is known from antiferromagnetic materials with a weak uniaxial anisotropy. However, for a thick MnS layer no effect on the antiferromagnetic phase was observed. We will present a detailed explanation of this unique magnetic behavior.

MA 30.8 Wed 12:45 HSZ 401

Voigt effect measurements on PLD grown nickel oxide thin films — •Scarlat Camelia[1], Mok Kah Ming[1], Zhou Shengqiang[1], Lorenz Michael[2], Grundmann Marius[2], Helm Manfred[1], Schubert Mathias[3], and Schmidt Heidemarie[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]University Leipzig, Linnéstrasse 5, 04103 Leipzig, Germany — [3]University of Nebraska-Lincoln, 209N WSEC, Lincoln, Nebraska 68588-0511, USA

NiO has great potential applications in spin valves, magnetooptical sensors, optical fibers, solar thermal absorbers, or in non-volatile resistive random memories. In our study NiO, NiMnO, and NiMnLiO thin films have been grown on double-side polished r-plane sapphire substrates by pulsed laser deposition. We measured the complex Voigt

angle [1] which is a second-order magneto-optic effect. The polarization state of light after transmission through a sample consisting of ca. 1 μm thick, weak ferromagnetic and diamagnetic NiO thin films on purely diamagnetic r-plane sapphire substrates has been modelled using the 4×4 matrix formalism in dependence of an external magnetic field applied in-plane, i.e. in Voigt configuration. The modelling results revealed that for the bare diamagnetic substrate the Voigt angle depends parabolically on the external magnetic field and that the weak ferromagnetic and diamagnetic NiO thin films changed the parabolic dependence of the Voigt angle in the range of ±0.3 T to a flat-top shape in agreement with the experimentally determined Voigt angle. [1] C. Scarlat et al., Phys. Stat. Sol. (C) 7 (2010) 334-337.

MA 30.9 Wed 13:00 HSZ 401

An ab initio study of the magnetic properties of CoO — •Adam Jakobsson[1,2], Stefan Blügel[1], Marjana Ležaić[1], and Biplab Sanyal[2] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics and Astronomy, Uppsala University, Box-516, 75120, Uppsala, Sweden

The magnetic structure of cobalt monoxide has been investigated in several theoretical and experimental works, but no conclusive answer has been found to the direction of the easy axis. We address this question with the APW+lo+SOC code ELK [1]. As the transition metal monoxides are strongly correlated systems, we use the LSDA+U functional in Hubbard formalism in its most general formulation by Liechtenstein et al. [2] Recently it was been shown [3] that the choice of the magnitude of Hund's J might play a crucial role in the calculation of the easy axis for non-collinear magnetic systems through the off-diagonal terms in the LSDA+U potential. This stresses the need for a general formulation of LSDA+U and the possibility of including intra atomic non-collinearity in these cases. We discuss the relevance of these issues for the magnetic structure of CoO.

We gratefully acknowledge the support from HGF Nachwuchsgruppe Programme VH-NG-409

[1] http://elk.sourceforge.net/ [2] A. Liechtenstein, V. Anisimov and J. Zaanen. Phys. Rev. B 52, R5467 (1995). [3] E, Bousque and N. Spaldin arXiv:1011.0939v1 [cond-mat.str-el]

MA 31: Magnetization Dynamics III

Time: Wednesday 11:00–12:45 Location: HSZ 403

MA 31.1 Wed 11:00 HSZ 403

Atomistic Simulations of the Dynamaics of Antiferromagnets and Ferrimagnets — •Sönke Wienholdt[1], Frank Schlickeiser[1], Oksana Chubykalo-Fesenko[2], and Ulrich Nowak[1] — [1]Universität Konstanz, Germany — [2]Instituto de Ciencia de Materiales de Madrid, Spain

So far, ultrafast all-optical magnetization switching has been demonstrated experimentally only in ferrimagnetic materials like GdFeCo[1]. A reason for this restriction seems to be the antiferromagnetic coupling of the two sub-lattices in these materials, which may lead to completely different dynamics as compared to a ferromagnet, combined with a strong, ultrashort magnetic field pulse induced by the inverse Faraday effect [2]. Also the heating by the laser pulse is assumed to play a crucial role in this process and it was speculated that the special properties of the ferrimagnet close to the compensation point could be relevant [3].

To understand the dynamics in these materials, we perform atomistic simulations of antiferromagnets as well as ferrimagnets, driven either by extern magnetic field pulses or variation of the spin temperature. We calculate the effective frequencies and damping parameters, compare them with experimental findings[4] and analytical results and investigate possible switching mechanisms as well as their typical timescales. [1] C.D. Stanciu et al., Phys. Rev. Lett., 99 (047601), 2007 [2] A.V. Kimel et al., Nature Physics, 5 (727 - 731), 2009 [3] K. Vahaplar et al., Phys. Rev. Lett. 103 (117201), 2009 [4] C.D. Stanciu et al., Phys. Rev. B, 73 (220402), 2006

MA 31.2 Wed 11:15 HSZ 403

Time-resolved magnetization dynamics of tetragonally distorted antidot lattices — •Benjamin Lenk, Fabian Garbs, and Markus Münzenberg — I. Physikalisches Institut, Universität Göttingen

Femtosecond laser pulses can be used to optically excite (pump) and subsequently measure (probe) magnetization dynamics on timescales as long as nanoseconds. Two-dimensional arrays of antidots in a ferromagnetic film provide a periodic "potential" to the excited spin waves and induce drastic changes in the magnetization dynamics.

Magnonic modes with Bloch-like character can be observed as well as non-dispersive localized modes situated at the edges of the individual antidots. The understanding of these rivaling effects is only possible via the locally varying internal magnetic field. In the presented work a tetragonal distortion of the initially square lattice is used to address this issue. In combination with the applied external field the resulting asymmetry leads to differently large overlaps of the regions of strong field inhomogeneity.

We focus on the influence of the in-plane angle between external field and distorted antidot lattice. In particular, by applying the field along the long or short axis the overlap of regions of inhomogenious internal magnetic field can be varied. Thus, a tuning of the degree of localization is possible.

MA 31.3 Wed 11:30 HSZ 403

Nonlinear magnon scattering in nano-sized Permalloy elements — •Henning Ulrichs[1], Vladislav E. Demidov[1], Sergej O. Demokritov[1], and Sergei Urazhdin[2] — [1]Institut für angewandte Physik, Universität Münster, Correnstraße 2-4, 48149 Münster, Germany — [2]Department of Physics, West Virginia University, Morgantown, WV 26506, USA

In this talk we will report about nonlinear magnetization dynamics in sub-micron-sized elliptical Permalloy dots. The dynamics was excited using intense microwave pulses and studied by means of micro-focus Brillouin light scattering spectroscopy. In the linear regime, one predominantly observes excitation of the fundamental eigenmode of the dot, which resembles the FMR mode in such a confined geometry. At higher pulse powers a secondary, low-frequency mode is excited in addition to the fundamental mode. This process nucleates at the center of the dot, where the amplitude of the fundamental mode shows a maximum. Our explanation assumes a scattering of magnons of the fundamental mode into the lowest frequency state. This process is reminiscent of the initial phase in the formation of magnon Bose-Einstein condensate observed in low-loss garnet films.

MA 31.4 Wed 11:45 HSZ 403

Angular momentum conservation in ultrafast spin manipulation processes on magnetic nanoclusters — •Georg Lefkidis and Wolfgang Hübner — Kaiserslautern University of Technology and Research Center OPTIMAS, Germany

Ultrafast optical Λ processes have been shown to lead to coherent spin manipulation on magnetic nanostructures with a few magnetic centers [1-3]. Thus multicenter magnetic clusters allow exploiting spin dynamics for full-fledged logic functionalization [2]. To explain the angular momentum conservation during the spin-flip processes we propagate in time the intragap levels of a NiO cluster under the influence of a linearly polarized laser pulse [3]. Subsequently we calculate the induced time-dependent electric polarization in the material and Fourier-transform into the frequency regime while convoluting with a time-weighting function. This way we calculate the frequency- and time-dependent Stokes vector. Using quantum optics analysis we show how the coherently induced material polarization leads to angular-momentum exchange between the light and the irradiated NiO surface. We also predict a dynamic Kerr-effect, which provides a signature for monitoring spin-dynamics, by simply measuring the transient rotation and ellipticity of the reflected pump beam [1].

[1] G. Lefkidis, G. P. Zhang, and W. Hübner, Phys. Rev. Lett. **103**, 217401 (2009).
[2] W. Hübner, S. Kersten and G. Lefkidis, Phys. Rev. B **79**, 184431 (2009).
[3] G. Lefkidis and W. Hübner, Phys. Rev. B **76**, 014418 (2007).

MA 31.5 Wed 12:00 HSZ 403

Evolution from superparamagnetism to ferromagnetism in

nanostructures studied by first-principles magnetization dynamics — •Danny Böttcher[1,2], Arthur Ernst[1], and Jürgen Henk[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

With respect to the ongoing miniaturization of spintronic devices, the magnetic stability of nanostructures becomes increasingly important. These systems have, thus, to be described theoretically on the atomic length-scale and on the femtosecond time-scale.

We report on an investigation of atomistic magnetization dynamics by means of the stochastic Landau-Lifshitz-Gilbert equation. The exchange and anisotropy parameters of the spin Hamiltonian are computed from first principles. For the paradigmatic Co nanoislands on Cu(111), we focus on the evolution from superparamagnetic (non-collinear) states to a ferromagnetic (collinear) state in dependence on temperature, island size, and external magnetic field. It turns out that corners and edges of the triangular islands act as nucleation centers of magnetic nanodomains.

MA 31.6 Wed 12:15 HSZ 403

Lateral spin-valve devices operated by spin pumping — •Nils Kuhlmann, Andreas Vogel, Toru Matsuyama, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

In the last years, all-metal lateral spin-valve devices have been studied intensively since they provide fundamental understanding of spintronics [1], as well as new concepts for logic devices [2]. Recently, high frequency properties of nanostructures became of great interest because of potential technological applications. The aim of our work is to build an all-metal lateral spin-valve device, where the injected spin current arises from a ferromagnet driven at ferromagnetic resonance (FMR) with an rf-field, pumping spins into the adjacent normal metal [3]. The detection of a spin current created by spin pumping with a spin-valve structure in non-local geometry provides the possibility to quantify the pumping efficiency but has not yet been accomplished. We present the basic concept of a FMR pumped spin-valve device, and show first results. The cone angle of the magnetization precession of a single electrode driven in FMR was determined via the anisotropic magnetoresistance (AMR) to be up to 14°, which is to the best of our knowledge the highest value reportet in the literature so far. Also, the dependence of the interaction between the electrodes on the distance between them was investigated and optimized.

[1] A. Vogel et al., APL 94, 122510 (2009); [2] T. Kimura et al., APL 97, 182501 (2010); [3] M. V. Costache et al., PRL 97, 216603 (2006)

MA 31.7 Wed 12:30 HSZ 403

Nonlinear hybridization of the fundamental eigenmodes of microscopic ferromagnetic ellipses — •Matthias Buchmeier[1], Vladislav E. Demidov[1], Karsten Rott[2], Patryk Krzysteczko[2], Jana Münchenberger[2], Günter Reiss[2], and Sergej O. Demokritov[1] — [1]Institute for Applied Physics, University of Münster, Germany — [2]Department of Physics, Bielefeld University, Germany

We present an experimental study of nonlinear eigenmodes of microscopic Permalloy elliptical elements using micro-focus Brillouin light scattering spectroscopy, a technique providing sub-micrometer spatial resolution. We find that two fundamental eigenmodes of such ferromagnetic elements, the edge and the center mode, show an essentially different nonlinear behavior [1]. With increasing amplitude, the frequency of the edge mode exhibits a continuous positive nonlinear shift. On the other hand the frequency of the center mode stays unchanged until it is approached by the edge mode. Subsequently the modes hybridize which influences both the frequencies and the spatial distributions of the dynamic magnetization. As a consequence of this nonlinear hybridization the distributions lose the shape well known for the linear regime and take a hybrid form. Our findings contribute to the deep understanding of the essentially nonlinear large-amplitude magnetization dynamics in microscopic magnetic-film structures, which is of special importance for the understanding of spin-transfer-torque and microwave-assisted magnetization-switching phenomena.

[1] V. E. Demidov et al., *Phys. Rev. Lett.* **104**, 217203 (2010).

MA 32: Magnetic Thin Films I

Time: Wednesday 11:00–13:00 Location: HSZ 04

MA 32.1 Wed 11:00 HSZ 04

Remanence enhanced high-energy density in epitaxial exchange-coupled $SmCo_5$/Fe/$SmCo_5$-trilayers — •Simon Sawatzki[1], Rene Heller[2], Christine Mickel[1], Marietta Seifert[1], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, Institute for Metallic Materials, PO Box 270116, D-01171 Germany — [2]Helmholtz-Zentrum Dresden Rossendorf, Germany

In order to enhance the energy density $(BH)_{max}$, as a key property for permanent magnet applications, exchanged-coupled trilayers of $SmCo_5$/Fe/$SmCo_5$ with fixed $SmCo_5$ layer thicknesses (25 nm) and varying soft magnetic Fe film thickness have been epitaxially grown by pulsed laser deposition on Cr buffered MgO(110) substrates. The realization of one single in-plane easy axis of the highly anisotropic $SmCo_5$ phase through the whole layer stack as well as phase formation and texture could be confirmed by Bragg-Brentano X-ray diffraction and pole figure measurements. The effect of the increasing soft layer thickness on the reversal mechanism and improved remanence due to the higher Fe-volume fraction was investigated by vibrating sample magnetometer measurements with external fields up to 9 T. As the energy density strongly depends on the volume of the samples, emphasize is put on multilayer architecture investigation and reliable thickness determination. Concerning the latter all applied analysis methods as energy dispersive X-ray analysis, Rutherford backscattering spectroscopy and transmission electron microscopy confirm energy densities with maximum values of 312 kJ/m^3 (39 MGOe).

MA 32.2 Wed 11:15 HSZ 04

Growth, structure, and magnetic properties of epitaxial Ni_xMn_{100-x} single layers and Co/Ni_xMn_{100-x} bilayers on $Cu_3Au(100)$ — •Muhammad Yaqoob Khan[1], W. A. A. Macedo[2], P. L. Gastelois[2], J. Miguel[1], M. D. Martins[2], and W. Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, 14195 Berlin, Germany — [2]Centro de Desenvolvimento da Tecnologia Nuclear, 31270-901 Belo Horizonte, MG, Brazil

In contrast to Cu(100), on which NiMn grows with its c axis in the film plane, the larger lattice constant of $Cu_3Au(100)$ should enable growth of ordered antiferromagnetic $L1_0$ NiMn epitaxial thin films with the c axis perpendicular to the plane. The growth and structure of single-crystalline ultrathin Ni_xMn_{100-x} films on $Cu_3Au(100)$, and also the magnetic properties of Co/Ni_xMn_{100-x} bilayers have been investigated by low-energy electron diffraction (LEED), reflection high-energy electron diffraction (RHEED), and magneto-optical Kerr effect (MOKE). For the concentration range $10 \leq x \leq 77$, our results reveal good epitaxial layer-by-layer growth at a substrate temperature of 300 K. From LEED-IV and RHEED measurements, the equiatomic NiMn films were found to be in a face-centered tetragonal (fct) structure as expected for the $L1_0$ NiMn phase, with the c axis along the film normal. For Co/NiMn bilayers with $23 \leq x \leq 55$, MOKE hysteresis loops show a thickness-independent coercivity, suggesting no magnetic coupling at the interface and hence no indication of antiferromagnetism in the NiMn in contrast to earlier observations on Co/$Ni_{50}Mn_{50}$/Cu(100).

MA 32.3 Wed 11:30 HSZ 04

FIB induced structural modifications in thin magnetic films — •Olga Roshchupkina, Jörg Grenzer, Thomas Strache, Monika Fritzsche, Arndt Mücklich, and Jürgen Fassbender — Helmholtz-Zentrum Dresden-Rossendorf

Focused ion beam irradiation is a versatile tool that can be used for magnetic nanostructuring. In this work we compare both FIB irradiation and a standard implantation taking into account their distinctive irradiation features. A 50nm thick permalloy layer ($Ni_{80}Fe_{20}$) irradiated with different Ga^+ ion fluences was used for the investigations. The structure was studied via XRD and EXAFS measurements carried out on the ESRF ROBL and ID01 facilities. Additionally TEM and magneto-optic Kerr effect magnetometry were performed. Both types of irradiation demonstrate a similar behaviour: increasing the

ion fluence causes a further material crystallization and a decrease of the magnetic moment. However FIB irradiation leads to a stronger crystallite growth due to the high current densities used.

MA 32.4 Wed 11:45 HSZ 04

Magnetic anisotropy investigations in single crystalline Fe films on ripple MgO templates — •Maciej Oskar Liedke, Michael Körner, Kilian Lenz, Thomas Strache, Jeffrey McCord, Mukesh Ranjan, Stefan Facsko, and Jürgen Fassbender — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Institute of Ion Beam Physics and Materials Research, P.O. Box 510119, 01314 Dresden, Germany

Ion erosion of MgO substrates produces highly ordered surface patterns. The so-called ripples are not only induced along any arbitrary in-plane orientation but outstandingly, they stay crystalline upon ion irradiation. Due to the low lattice mismatch single crystalline Fe films can be grown onto these periodically modulated MgO(100) templates. Despite the intrinsic magnetic property of *bcc* Fe, i.e. cubic anisotropy, an additional ripple morphology driven uniaxial magnetic anisotropy is introduced. Thus an ensemble of twofold and fourfold symmetry is created, which is confirmed by ferromagnetic resonance and magneto-optic Kerr effect measurements. The orientation and strength of the uniaxial anisotropy, which mainly originates from shape and step-edge contributions, depends on the angle of the ripple ridges elongation with regard to the [100] direction of MgO and on the Fe film thickness, respectively. Theoretical analysis reveals anisotropy fields and orientations of both anisotropy contributions that are in agreement with the experiment.

MA 32.5 Wed 12:00 HSZ 04

Magnetic properties of Permalloy elements fabricated by focused-ion-beam-based methods — •Saleh Getlawi, Nikolas Becker, Haibin Gao, Michael Koblischka, and Uwe Hartmann — Inst. of Experimental Physics, Saarland University, P.O. Box 151150, 66041 Saarbrücken

Focused-ion-beam (FIB) irradiation and milling are very versatile and rapid laboratory techniques for structuring small elements from thin films. The purpose of this work is a systematic comparison of the magnetic properties of Permalloy(Py,Ni81FE19) thin elements prepared by conventional electron beam lithography (EBL) and by FIB-based methods. In particular effects of Ga+ ion irradiation on structural and magnetic properties were investigated. A variety of Py nanowires of 20nm thickness and 200nm width were prepared. The wires have notches for domain wall pinning and pads of different geometry for domain wall nucleation. Atomic and magnetic force microscopy were used for structural and magnetic characterization. The influence of Ga+ irradiation was found to be significant.

MA 32.6 Wed 12:15 HSZ 04

Different Methods for the Investigation of a Substrate Induced Uniaxial Anisotropy — •Stefan Rössler, Sebastian Hankemeier, Robert Frömter, and Hans Peter Oepen — Institute of Applied Physics, Hamburg, Germany

As a result of the polishing process polishing lines remain on the surface of a diamond substrate. The lateral distance of these lines is about 100-200 nm and the height about 1-2 nm, respectively. We have investigated the impact of these lines on the magnetic properties of a 20 nm Permalloy film. The surface texture of the substrate is replicated in the thin film. The magnetic properties have been investigated by means of magneto optical Kerr effect (MOKE) measurements. These measurements reveal a morphology induced anisotropy with an easy axis of magnetization parallel to the polishing lines. A model has been developed to evaluate the strength of this anisotropy from the surface configuration. From Atomic Force Microscopy (AFM) analysis we obtain the surface morphology, which is used for the calculation of the uniaxial anisotropy constant. The effect of the anisotropy on the domain pattern in 5 μm × 5 μm × 10 nm Permalloy squares has been investigated by means of SEMPA. From the size of the four domains of a Landau state the local anisotropy in the nanostructure can be calculated utilizing OOMMF simulations. Magnetotransport measurements have been performed with Permalloy squares as a function of the direction of an externally applied magnetic field. The transport results can also be used to determine the strength of the local anisotropy.

This work is supported by DFG via SFB 668.

MA 32.7 Wed 12:30 HSZ 04

Nanoengineered iron oxide — •Mehrdad Baghaie Yazdi[1], David Bierwagen[1], Marie-Laure Goyallon[1], Heinz Wanzenböck[2], Wolfgang Donner[1], and Lambert Alff[1] — [1]Institute of Materials Science, Technische Universität Darmstadt — [2]Institute for Solid State Electronics, Technische Universität Wien

Fe_3O_4 is clearly an interesting candidate as material for spintronics. Here we show that Fe_3O_4 can perform as transparent magnetic oxides (TMO) and that Fe nanoclusters can be used to tune the resistivity of magnetite layers. We have successfully grown multilayer thin films of magntite/aluminum doped zinc oxide (ZAO) on glass, by a combination of rf and dc-sputtering, yielding average transmittance in the visible spectrum (400-800 nm) ranging from 40 to above 80% , while maintaining a magnetic moment per area of 0.05 A. Further multilayers of $\alpha-$Fe and Fe_3O_4 have been grown in one single step using a kinetically controlled process of reactive rf-sputtering. These films show a decrease in resistivity by one order of magnitude compared to single layer magnetite. The Fe_3O_4 in both, TMO and the iron-iron oxide composite, shows a sharp Verwey transitions around 120 K, confirming the high quality of the magnetite layers.

MA 32.8 Wed 12:45 HSZ 04

Magnetic Properties of $(CoFe)_x(MgO)_{100-x}$ nanogranular thin films investigated by FMR spectroscopic tool — •Olga Meshcheriakova[1], Yuri Kudryavtsev[2], Volodymyr Yermolenko[2], Benjamin Balke[1], Gerhard Fecher[1], and Claudia Felser[1] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg-University Mainz, D-55099 Mainz, Germany — [2]Institute of Metal Physics, National Academy of Sciences of Ukraine, 252680 Kiev-142, Ukraine

The ferromagnetic and magneto-transport properties of $(CoFe)_x(MgO)_{100-x}$ nanogranular films were investigated. Tunneling magnetoresistance (TMR) of magnetic nanogranular films has been measured by four-probe DC conductivity measurements depending on the concentration of $(CoFe)_x$ ferromagnetic granules and the thermal treatment. The maximum TMR effect of 1.5% at H=6500 Oe occurs at x=50 in the as-deposited films. Annealing process leads to drastic reduction of TMR due to the ferromagnetic granules coalescent into magnetic clusters, thus the conductance changes from tunneling to metal type. FMR spectra are experimentally obtained for the samples in the initial and annealed states in a range of concentrations x=90, 73, 60, 50, 35, and 23. The annealing of $(CoFe)_x(MgO)_{100-x}$ nanogranular films at 350°C during 1 hour causes significant changes of magnetic properties of the films: effective and saturation magnetizations significantly increase and initially paramagnetic films become ferromagnetic due to the slight size increasing of ferromagnetic clusters. Further research requires more detailed structural analysis.

MA 33: Focus Session "Spins in Organic Materials I" (jointly with DS)

Time: Wednesday 11:00–13:00 Location: GER 37

Topical Talk MA 33.1 Wed 11:00 GER 37

Selective spin-blockade in interacting molecular interferometers — •Milena Grifoni, Andrea Donarini, and Georg Begemann — Institut für Theoretische Physik, Universität Regensburg, Regensburg, Germany

We consider molecular junctions in the single-electron tunneling regime which, due to a high degree of spatial symmetry, have a degenerate many-body spectrum. As a consequence, interference phenomena which cause a current blocking can occur at specific values of the bias and gate voltage. We present here necessary and sufficient conditions for interference blockade also in the presence of spin-polarized leads. As an example we analyze a benzene single-electron transistor. For a setup with parallel polarized leads, we show how to exploit the current blocking to selectively prepare the system in a defined spin state without application of any external magnetic field.

References:

A. Donarini, G. Begemann and M. Grifoni, Nano Lett. 9, 2897

(2009)
A. Donarini, G. Begemann and M. Grifoni, Phys. Rev. B 82, 125451 (2010)

Topical Talk MA 33.2 Wed 11:30 GER 37

Charge and Spin Transport through Single-Atom and Single-Molecule Junctions — •Jörg Kröger — Institut für Physik, Technische Universität Ilmenau, D-98693 Ilmenau, Germany

The tip of a scanning tunnelling microscope is used to controllably contact single atoms and molecules adsorbed to surfaces. Owing to atomically precise imaging, the conductance dependence of a single-C_{60} junction on the C_{60} orientation has been unambiguously demonstrated. Time-resolved measurements of these junctions show two-level variations of the conductance and indicate an enhanced coupling of electrons to molecular vibrations. Orders-of-magnitude modifications of single-molecule contact conductances have been achieved by dehydrogenating tin-phthalocyanine molecules on Ag(111). Concomitant calculations visualize the current flow through the molecule and highlight the importance of chemical bonds to the electrodes. Spin valve effects have been observed at the ultimate size for magnetic single-atom contacts, which exhibit spin-dependent conductance in the ballistic electron transport regime.

Topical Talk MA 33.3 Wed 12:00 GER 37

The strange life of a molecular spin observed under a microscope — •Germar Hoffmann — University of Hamburg, Germany — Academia Sinica, Taiwan

The 90ies saw the emerging of a new and fascinating class of magnetic materials based on molecules [1]. Although, the spin density is low, spin information can be efficiently stored in and transmitted by spatially and energetically well defined molecular orbitals. These orbitals can be experimentally precisely addressed. The internal and external spin interaction through molecular orbitals can be engineered by the molecular design. This opens also new concepts for spintronic devices through the combination of the molecular spin with additional functionality - on a length scale not accessible by classical systems. Though, the further development lacks of precise experimental access to understand the behavior of the individual molecular spin in a given environment and to guide toward an improved design of molecular spin-systems.

Here, I will present and discuss recent results on molecular magnetism. By means of spin-polarized scanning tunneling microscopy, scanning tunneling spectroscopy, and local manipulation, single magnetic molecules are locally and energetically investigated in different environments. Thereby, molecular systems cover commercially available [2], specially synthesized, and on-surface synthesized systems.

[1] R. Sessoli et al., JACS 115, 1804 (1993); M. Tamura et al., Chem. Phys. Lett. 186, 401 (1991). [2] J. Brede et al., Phys. Rev. Lett. 105, 047204 (2010); N. Atodiresei et al., Phys. Rev. Lett. 105, 066601 (2010).

MA 33.4 Wed 12:30 GER 37

Design of the Local Spin-Polarization at Hybrid Organic-Ferromagnetic Interfaces — •Nicolae Atodiresei[1], Predrag Lazić[2], Vasile Caciuc[1], and Stefan Blügel[1] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425-Jülich, Germany — [2]Massachusetts Institute of Technology, Cambridge, 02139-Massachusetts, USA

Combining molecular electronics with spintronics represents one of the most exciting avenues in building future nanoelectronic devices. In this context, a clear understanding of the physics at magnetic electrode-molecule interfaces is highly desirable and, in particular, first principles simulations are used to elucidate and design the functionality of specific molecules in a given organic-metal surface environment. We will present a conceptual study to understand the manipulation of the local spin-polarization present at the interface for several single organic molecules adsorbed on a ferromagnetic surface. The generality of the concept predicted by the theoretical calculations on model systems is further strengthened by the spin-polarized scanning tunneling microscopy (SP-STM)experiments. In this study it is demonstrated that, by an appropriate selection of the adsorbed molecules, the electrons of different spin [i.e. up and down] can selectively be injected from the same ferromagnetic surface by locally controlling the spin-polarization. [1] N. Atodiresei *et al.* Phys. Rev. Lett. 102, 136809 (2009); [2] J. Brede *et al.* Phys. Rev. Lett. 105, 047204 (2010); [3] N. Atodiresei *et al.* Phys. Rev. Lett. 105, 066601 (2010).

MA 33.5 Wed 12:45 GER 37

Structural and magnetic properties of trinuclear-Cu(II)-complexes — •Torsten Hahn[1], Tobias Rueffer[2], and Vladislav Kataev[3] — [1]Institute for Theoretical Physics, TU Bergakademie Freiberg, Germany — [2]Department of Chemistry, Chemnitz University of Technology, Germany — [3]Leibniz Institute for Solid State and Materials Research Dresden, Germany

The magnetic super-exchange interactions in Cu(II) bis(oxamato) and bis(oxamidato) complexes [1] are shown to be highly sensitive to structural modifications coordinating close to the central copper. This work presents a detailed theoretical investigation of the influence of such modifications of the molecular structure on the magnetic coupling by means of DFT using the broken symmetry approach. The relation between structural parameters, the local spin density and the corresponding magnetic exchange parameters is discussed and compared to experimental results from EPR studies and magnetic measurements. Special attention was paid to the relationship between the spin population of the monomeric building blocks and the trends of the exchange interaction in case of the corresponding trinuclear complexes. Furthermore, the use of a simplified transport model based on the Non-Equilibrium-Green-Functions formalism delivers first insights into transport properties of these complexes for possible spintronic applications.

Funding by the DFG via the research unit 1154 "Towards Molecular Spintronics" is gratefully acknowledged.

[1] B. Braeuer, et. al., Inorg. Chem. 47, 6633 (2008)

MA 34: Surface magnetism I (jointly with O)

Time: Wednesday 11:15–13:30 Location: CHE 184

MA 34.1 Wed 11:15 CHE 184

Structural and magnetic investigations of Fe_3Si/GaAs(001) — •Sani Noor, M. Samet Özkan, and Ulrich Köhler — Experimentalphysik IV, AG Oberflächen, Ruhr-Universität Bochum

Fe_3Si has got magnetic and electric properties that make it a possible candidate as a spin aligning material in spintronic devices. Thus, it is of great interest to investigate its growth behaviour on semiconductor substrates.

In this contribution we present growth studies of the system Fe_3Si/GaAs(001) as measured by STM. Atomic resolution reveals long range ordering alongside a lattice structure that is to be compared with theory. The influence of varying growth temperatures and post annealing on the surface morphology has been investigated. We find that under the appropriate parameters layer-by-layer growth can be achieved. Magnetic analysis was performed by angular dependent in situ MOKE. While the uniaxial anisotropy remains unaffected by the growth temperature the coercive field scales with it. In order to determine the magnetic moment the samples were measured with SQUID magnetometry. It appears that the magnetic moment shows a dependence on the layer thickness.

MA 34.2 Wed 11:30 CHE 184

Scattering behaviour of single non-magnetic and magnetic impurities buried under a Cu(100) surface — •Henning Prüser[1], Martin Wenderoth[1], Piet E. Dargel[2], Alexander Weismann[1], Robert Peters[2], Thomas Pruschke[2], and Rainer G. Ulbrich[1] — [1]IV. Physikalische Institut, Georg-August Universität Göttingen, Germany — [2]Institut für Theoretische Physik, Georg-August Universität Göttingen, Germany

It has been recently shown [1] that the anisotropy of the copper Fermi surface leads to a strongly directional propagation of quasi particles called electron focusing. This effect gives access to individual bulk impurities in a metal that were previously assumed to be "invisible" due to charge screening. Following this idea we have investigated the energy-dependent scattering characteristics for single isolated atoms of Ag, Co and Fe buried under a Cu(100) surface using low temperature scan-

ning tunnelling spectroscopy (STS). For the case of a non-magnetic Ag impurity a Friedel oscillation in the local density of states is observed. For a magnetic Fe or Co impurity the Kondo effect influences strongly the energy-dependent scattering behaviour. We present a theoretical interpretation of the measured signatures using a combined approach of band structure and many-body numerical renormalization group calculations. The obtained results are in excellent agreement with the rich spatially and spectroscopically resolved experimental data. This work was supported by DFG SFB 602 Project A3.

[1] A. Weismann et al., Science 323, 1190 (2009)

MA 34.3 Wed 11:45 CHE 184

First-principles study of the magnetic interaction in single atom contacts — •Cesar Lazo, Paolo Ferriani, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, University of Kiel, Germany

The miniaturization of spintronic devices towards the limit of single atoms calls for an understanding of the interaction and electron transport in atomic-scale contacts. Such structures are extreme cases, where the typical dimensions are comparable to the Fermi wavelength and a fully quantum mechanical description is required. Based on density functional theory calculations, we investigate single atom contacts formed by an antiferromagnetic Cr-tip of a scanning tunneling microscope (STM) and a magnetic atom adsorbed on a metallic surface. We analyze the exchange interaction between tip and adatom from the tunneling to the contact regime and explain a spin-valve effect observed with an STM [1]. Furthermore, we characterize the geometric properties of the contact as the tip approaches the sample, and show that the relaxations in the system can be related to the measured spin-polarization [1].

[1] M. Ziegler et al. in preparation

MA 34.4 Wed 12:00 CHE 184

Spin-Resolved Investigations of the Exchange Split Gd Surface and Image-Potential State — •Beatrice Andres[1,2], Kristian Döbrich[1], Marko Wietstruk[1], Anke B. Schmidt[3], Markus Donath[3], and Martin Weinelt[1,2] — [1]Max-Born-Institut, 12489 Berlin — [2]Fachbereich Physik, Freie Universität Berlin, 14195 Berlin — [3]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster

The study of image-potential states (IPS) in front of ferromagnetic surfaces provides information about the magnetic properties of surfaces and thin films. Recent investigations on IPS revealed exchange splittings ΔE_{ex} in Fe, which persist even above the Curie temperature T_{C} [1].

Gd(0001) exhibits a d-derived surface state (SS) with $\Delta E_{\mathrm{ex}} > 0$ above T_{C} [2]. We used the occupied majority spin component of this state to populate the first ($n = 1$) image potential state on a 100-Å-thick Gd film on W(110) with the second harmonic of our Ti:Sa laser ($h\nu = 3.30$ eV). By probing with the fundamental IR pulse ($h\nu = 1.65$ eV), we investigated the binding energy and exchange splitting of the IPS as a function of the temperature.

[1] M. Pickel *et. al.*, *Phys. Rev. Lett.* **104**, 237204 (2010).
[2] M. Getzlaff *et al.*, *J. Magn. Magn. Mater.* **184**, 155 (1998).

MA 34.5 Wed 12:15 CHE 184

Magnetic signature of surface defects at nanodiamonds — •Nora Jenny Vollmers, Uwe Gerstmann, and Wolf Gero Schmidt — Theoretische Physik, Universität Paderborn

The n-type doping of diamond has been a long-standing issue, which recently gained attention in the context of nanodiamonds. Attempts of doping with nitrogen failed to result in the Electron paramagnetic Resonance (EPR) fingerprints expected from bulk material. Instead, the nanodiamond signals show a much larger deviation from the free-electron g-value and are believed to be related to intrinsic, carbon inherited defects. However, the absence of the bulk-like EPR spectra does not mean that nitrogen is not incorporated at all. The N atoms could be built in predominantly at or at least close to the surfaces yielding EPR spectra, very different from those measured in the bulk.

In this work, we elucidate the situation by investigating the magnetic signature of paramagnetic defects in the nanodiamonds. We use the gauge-including projector augmented plane wave (GI-PAW) approach [1, 2] to calculate the hyperfine splittings and the elements of the electronic g-tensor. Taking the C(100) surface as a first model system, a possible contribution of nitrogen is discussed by comparing EPR parameters for different N incorporation depths: Incorporated directly at the surface, N gives rise to surface states similar to intrinsic carbon dangling bond-like states. Otherwise N is able to introduce surface conductivity as demonstrated by calculated effective mass tensors.

[1] Ch.J. Pickard, F. Mauri, Phys. Rev. Lett. 88, 086403 (2002).
[2] U. Gerstmann et al., phys. stat. sol. (c) 7, 157 (2010).

MA 34.6 Wed 12:30 CHE 184

Realizing Spin Logic Atom by Atom — •Alexander Khajetoorians, Bruno Chilian, Jens Wiebe, and Roland Wiesendanger — Institute of Applied Physics, Hamburg University, Jungiusstrasse 11, 20355 Hamburg, Germany

Scanning tunneling microscopy (STM) has emerged as a leading technique which can address single atom magnetism with high energy and spatial resolution. With the development of sub-Kelvin high-magnetic field STM, two complementary methods, namely spin-polarized scanning tunneling spectroscopy (SP-STS) and inelastic STS (ISTS), can address the fundamental properties of individual magnetic impurities at surfaces [1-2]. We use a map of the distance-dependent RKKY interaction between Fe atoms on Cu(111) obtained by SP-STS to engineer complex magnetic nanostructures with tailored magnetic properties with atomic manipulation. By combining constructed antiferromagnetic structures with spin frustration, we realize an atomic-scale logic device which functions solely on the spin-degrees of freedom of its magnetic constituents.

[1] A. A. Khajetoorians, B. Chilian, J. Wiebe, S. Schuwalow, F. Lechermann, and R. Wiesendanger, Nature 467, 1084 (2010).

[2] A. A. Khajetoorians, S. Lounis, B. Chilian, A. T. Costa, L. Zhou, D. Mills, J. Wiebe, and R. Wiesendanger, arXiv:1010.1284v2 (2010).

MA 34.7 Wed 12:45 CHE 184

Magnetic anisotropy of Co and Ni adlayers on diamond and GaAs surfaces: an ab-initio study — •Bernd Stärk, Peter Krüger, and Johannes Pollmann — Westfälische Wilhelms-Universität, Münster, Germany

We present ab-initio investigations of magnetic transition-metal multilayers on semiconductors. In our work, we focus on the description of noncollinear magnetic systems and their magnetic anisotropy. To this end, we employ density functional theory in the framework of both LDA and GGA using a basis set of Gaussian orbitals.

Adsorption of Co/Ni adlayers on C(111)/C(001)-(1x1) surfaces is distinguished by a very small lattice mismatch. For one adlayer we find the metal adatoms to be localized in positions saturating all surface dangling bonds. They form strong covalent bonds with the substrate atoms that markedly reduce the magnetic moment at the interface and can even change the direction of the easy axis of magnetization as compared to the free standing monolayer. Furthermore, we find a strong dependance of anisotropy energies on the number of adlayers.

Secondly, we also discuss Ni on GaAs surfaces. Recent experiments suggest [1] that Ni grows epitaxially in bcc structure on GaAs(001) and that its magnetic properties strongly deviate from the bulk fcc case. We present a thorough investigation of possible atomic structures for this system and their magnetic properties.

[1] C. S. Dian *et al.*, PRL 94, 137210 (2005).

MA 34.8 Wed 13:00 CHE 184

A spin polarizing electron mirror for spin-resolved photoelectron microscopy — •Christian Tusche, Martin Ellguth, A. Akin Ünal, Aimo Winkelmann, Alexander Krasyuk, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik Halle, D-06120 Halle, Germany

We report on a novel imaging spin-filter for electrons, that allows the parallel detection of the electron spin-polarization over a two-dimensional field of view. The spin-filter is installed in our momentum microscope, consisting of a photoelectron emission microscope (PEEM) optics and a double hemispherical imaging energy analyzer. After the energy analyzer, a reciprocal image is 90 degrees reflected at a tungsten (100) surface. Spin contrast is obtained due to the spin-dependent reflection probability of low energy electrons, while the angle of incidence is conserved in the outgoing elastic (00) diffraction spot [1]. This geometry transfers the full PEEM image, whereas the spatial information is encoded by small deviations of the angel of incidence.

We demonstrate that the magnetic domain structure of cobalt films grown on Cu(100) can be imaged with a resolution better than 500 nm, limited by the natural domain wall width (≈ 400 nm [2]) of the film. The intensity asymmetry, defined by $A = [M^+ - M^-]/[M^+ + M^-]$, shows sharp maxima and minima as a function of the scattering energy

in the range between 15 eV and 90 eV, whereas a maximum scattering asymmetry of up to A=45% is found.

[1] German Patent DE102005045622B4 (2009)
[2] A. Berger and H. P. Oepen, Phys. Rev. B **45**, 12596 (1991)

MA 34.9 Wed 13:15 CHE 184

(SP)VLEED: Experimental access to the spin-dependent surface barrier — •Kathrin Wulff, Anke B. Schmidt, and Markus Donath — Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster

We present the first spin-polarized very-low-energy electron-diffraction (SPVLEED) measurements on a ferromagnetic system.

The fine structures, which appear in intensity vs. energy *I(V)* profiles of elastically reflected electrons [1], are sensitive to the shape of the surface-barrier potential. On the vacuum side far from the surface, the potential resembles the well-known Coulomb-like shape, while, on the crystal side, it merges the inner potential. In theoretical calculations the transition region, i.e. the surface barrier, is usually described by a parameterized phenomenological model. Our experiment gives access to exactly this transition region.

On Co/Cu(001) we found a significant spin dependence of the reflected intensities that varies strongly with incidence and azimuth angles. It should be noticed that the spin-dependent reflectivity of very-low-energy electrons from ferromagnetic surfaces has recently been utilized in electron spin polarimeters [2,3].

[1] R.O. Jones, P.J. Jennings, Surf. Sci. Reports **9**, 165 (1988) ; [2] A. Kakizaki *et al.*, Rev. Sci. Instrum. **79** (2008) 123117 ; [3] A. Winkelmann *et al.*, Rev. Sci. Instrum. **79** (2008) 083303

MA 35: Spin Structures/ Skyrmions (jointly with TT) - Invited Talks

Time: Wednesday 14:00–16:30 Location: HSZ 04

Invited Talk MA 35.1 Wed 14:00 HSZ 04

Skyrmion crystals and topological transport phenomena — •Yoshinori Tokura — Department of Applied Physics, University of Tokyo, Tokyo, Japan

A class of helimagnet is derived from the Dzyaloshinskii-Moriya(DM) interaction on a non-centrosymmetric crystal; prototypical examples are the B20 type (FeSi type) transition-metal silicide and germanide families. Recently, the Skrymion lattice was confirmed to form in a narrow temperature(T) -magnetic field(B) region near the hlimagnetic to paramagnetic transition boundary. By contrast, thin films of B20 type MSi (M=Mn or Fe1-xCox) or MGe (M=Mn, Fe), whose thickness is smaller than the helical spin modulation period (=10-100nm), ubiquitously form the two-dimensional (2D) Skyrmion crystal with magnetic fields (B) applied normal to the film plane over a wide T-B region. The implication of such a 2D Skyrmion crystal in the magneto-transport properties is discussed, such as the spin-chirality- induced topological Hall effect.

This work was done in collaboration with X.Z. Yu, N. Kanazawa, Y. Onose, Y. Shiomi, Y. Matsui, N. Nagaosa, J.H. Park, J.H. Han, K. Kimoto, W.Z. Zhang, T. Arima, S. Wakimoto, K. Ohoyama, and K. Kakurai

Invited Talk MA 35.2 Wed 14:30 HSZ 04

Discovery of an atomic-scale skyrmion lattice in an ultrathin magnet: Fe/Ir(111) — •S. Heinze[1], K. von Bergmann[2], M. Menzel[2], J. Brede[2], A. Kubetzka[2], R. Wiesendanger[2], G. Bihlmayer[3], and S. Blügel[3] — [1]Institute of Theoretical Physics and Astrophysics, University of Kiel — [2]Institute of Applied Physics, University of Hamburg — [3]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA

Skyrmions are topologically protected field configurations with particle-like properties that play an important role in various fields of science. They have been predicted to exist also in bulk magnets and in recent experiments it was shown that they can be induced by a magnetic field. A key ingredient for their occurrence is the Dzyaloshinskii-Moriya interaction (DMI) which was found to be strong also in ultrathin magnetic films on substrates with large spin-orbit coupling [1]. In these systems the DMI stabilizes spin-spirals with a unique rotational sense propagating along one direction of the surface [1,2]. Here, we go a step beyond and present an atomic-scale skyrmion lattice as the magnetic ground state of a hexagonal Fe monolayer on Ir(111). We develop a spin-model based on density functional theory that explains the interplay of Heisenberg exchange, DMI and the four-spin exchange as the microscopic origin of this intriguing magnetic state. Experiments using spin-polarized scanning tunneling microscopy confirm the skyrmion lattice which is incommensurate with the underlying atomic lattice. [1] M. Bode et al., Nature 447, 190 (2007). [2] P. Ferriani et al., Phys. Rev. Lett. 101, 027201 (2008).

Invited Talk MA 35.3 Wed 15:00 HSZ 04

Skyrmion states in noncentrosymmetric magnets — •Alexei N. Bogdanov, Andrei A. Leonov, and Ulrich K. Rössler — IFW Dresden

Axisymmetric magnetic strings with a fixed sense of rotation and nanometer sizes (chiral magnetic vortices or Skyrmions) have been predicted to exist in a large group of noncentrosymmetric crystals more than two decades ago [1]. Recently these extraordinary magnetic states have been directly observed in thin layers of cubic helimagnet (Fe,Co)Si [2]. In this report we apply our earlier theoretical findings and recent results [3] to review main properties of chiral Skyrmions, to elucidate their physical nature, and to analyse these recent experimental results on magnetic-field-driven evolution of Skyrmions and helicoids in chiral helimagnets. Concentrating on the physical side of the problem rather than on mathematical details we give an elementary introduction into the properties of chiral Skyrmions in magnetism. [1] A. N. Bogdanov, A. D. Yablonsky Sov. Phys. JETP 68 (1989) 101. [2] X. Z. Yu et al. Nature 465 (2010) 901. [3] U. K. Rößler et al., Nature 442 (2006) 797; arXiv:1009.4849; A. A. Leonov et al., arXiv:1001.1992v2.

Invited Talk MA 35.4 Wed 15:30 HSZ 04

Complex Magnetic Phase Diagram of the cubic Helimagnet FeGe — •Heribert Wilhelm — Diamond Light Source Ltd., Chilton, Didcot, OX11 0DE, United Kingdom

Cubic FeGe (B20 structure type) shows helical order below T_c = 278.3 K. Depending on temperature and magnetic field a complex sequence of cross-overs and phase transitions in the vicinity of T_c has been observed in magnetization and ac-susceptibility measurements in fields parallel to the [100] direction. In a narrow temperature range below T_c several magnetic phases have been found before the field-polarized state occurs. Of particular interest is the so-called A-phase. It splits in at least two distinct areas, A_1 and A_2. This has been confirmed by small-angle neutron scattering data. These data also yield a hexagonal scattering pattern, the fingerprint of a Skyrmion lattice, within the A_1 and A_2 regions. Precursor phenomena found above T_c display a complex succession of temperature-driven cross-overs and phase transitions before the paramagnetic phase is reached at T_0. The low-field state for $T_c < T < T_0$ is probably characterized by some kind of magnetic correlations concluded from nuclear forward scattering data. They revealed that this phase exists up to about 27 GPa, although the helical order is already suppressed at 19 GPa. No signatures of magnetic order have been observed above 30 GPa. Within a phenomenological model for chiral ferromagnets, which includes magnetic anisotropy, Skyrmionic phases and 'confined' chiral modulations were obtained. The observed precursor phenomena are then a general effect related to the confinement of localized Skyrmionic excitations.

Invited Talk MA 35.5 Wed 16:00 HSZ 04

Magnetoelectric effects in non-collinear magnets — •Maxim Mostovoy — Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

The coupling of the electric field to the spin degrees of freedom in Mott insulators leads to a variety of spectacular phenomena in multiferroic materials, such as the magnetic field control of electric polarization in spiral magnets, the clamping between the ferroelectric and (anti)ferromagnetic domain walls in orthorhombic and hexagonal manganites and the excitation of magnons by the electric component of light (electromagnon peaks). The microscopic mechanisms of magnetoelectric coupling also allow for the electric field control of non-collinear spin structures in conventional magnets, which may find applications in spintronics. I will discuss the relevance of unusual magnetic multipoles, such as the monopole and toroidal moments, for the linear

magnetoelectric effect and electromagnon excitation. I will also discuss the new dynamic magnetoelectric interaction, which can be used to move non-collinear spin textures in ferromagnets with an applied electric field. The effect of this coupling is dramatically enhanced for non-coplanar topological magnetic defects, such as magnetic vortices and Skyrmions.

MA 36: Micro- and Nanostructured Magnetic Materials III

Time: Wednesday 14:45–16:45 Location: HSZ 103

MA 36.1 Wed 14:45 HSZ 103

Magnetic correlations in laterally patterned antiferromagnetically coupled Fe/Cr multilayers — •Markus Schmitz, Alexander Weber, Elisabeth Josten, Ulrich Rücker, and Thomas Brückel — IFF-Streumethoden, Forschungszentrum Jülich, 52425 Jülich

Patterned magnetic structures are the basic elements of spintronic devices. The ongoing miniaturization makes the influence of neighboring structures more and more important. Fe/Cr multilayers have been grown epitaxially on GaAs (100) single crystals by Molecular Beam Epitaxy. The Cr interlayers induce an antiferromagnetic coupling between adjacent Fe layers. Thus, the magnetic dipole moment is reduced and a magnetic superstructure is created, which is, due to the contrast of Cr to Fe, easily observable by polarized neutron reflectometry. The lateral structuring was performed by UV-nanoimprint lithography and Reactive Ion Etching. The structural characterization was carried out by Scanning Electron Microscopy, Atomic Force Microscopy and X-ray scattering under grazing incidence. The macroscopic magnetic properties were determined by MOKE and SQUID magnetometry. Polarized neutron reflectometry and off-specular scattering was used to determine the magnetic domain formation within the individual layers. The work presented gives insight into the interplay of shape and crystal anisotropy within the individual layers and patterns.

MA 36.2 Wed 15:00 HSZ 103

Reversible tuning of the magnetic moment of nanocrystalline maghemite/platinum composites by electrochemical charging — •Thomas Traussnig[1], Stefan Topolovec[1], Kashif Nadeem[2], Dorothée Vinga Szabo[3], Heinz Krenn[2], and Roland Würschum[1] — [1]Inst. f. Materialphys., TU Graz, Petersgasse 16, 8010 Graz, Austria — [2]Inst. f. Physik, Univ. Graz, Graz, Austria — [3]Inst. f. Materialforschung III, KIT, Karlsruhe, Germany

Recent studies on nanocrystalline metals demonstrated that their physical properties, such as magnetic moment or conductivity, can be reversibly tuned by electrochemical charging owing to the high interfacial charge carrier densities and the high surface-to-volume ratio. In the present work this concept of charge-induced property tuning is extended to nanocrystalline metal oxides. Reversible variations of the magnetic moment of up to 10.4% could be achieved by making use of a γ-Fe_2O_3/Pt nanocomposite. The maghemite nanocrystallites with a small crystallite size and a narrow size distribution were prepared by microwave plasma synthesis. Intermixing the ferrimagnetic maghemite nanocrystallites with paramagnetic Pt nanocrystallites results in a conductive porous network which can be charged electrochemically upon immersing in 1-M KOH electrolyte. Magnetic measurements were performed in-situ by SQUID magnetometry. The reversible variations of the magnetic moment in the 10%-regime are considered to arise from surface modifications of the maghemite nanoparticles due to reversible oxygen adsorption/desorption processes. Financial support by the FWF Austrian Science Fund is appreciated (project S10405-N16).

MA 36.3 Wed 15:15 HSZ 103

Self assembled Iron Oxide Nanoparticles - Variation of the growth process analysed by GISAXS — •Elisabeth Josten[1], Ulrich Rücker[1], Denis Korolkov[3], Erik Wetterskog[2], Artur Glavic[1], Sabrina Disch[1], Raphael Hermann[1], Florian Menau[4], Lennard Bergström[2], and Thomas Brückel[1,3] — [1]IFF-4, Forschungszentrum Jülich, 52425 Jülich — [2]Stockholm Universitet, Department of Materials and Environmental Chemistry, Stockholm, Sweden — [3]JCNS, Forschungszentrum Jülich, Garching, Germany — [4]Synchrotron Soleil, L'Orme des Merisiers, Saint-Aubin, BP 48, 91192 Gif-sur-Yvette, France

Fundamental research on magnetic nanostructures is an important part of todays science in the field of information technology. Highly ordered 3 dimensional structures of nanoparticles are model systems to study the magnetic inter-particle interactions. In this investigation we studied the influence of growth parameters on the ordering of the superstructures. Monodisperse Fe_2O_3 nanoparticles have been deposited on a substrate to form highly ordered superstructures (mesocrystals) using drop casting. The type of order in these superstructures has shown dependency on the nanoparticle shape and deposition conditions. Structural surface characterization was carried out by SEM and AFM. The 3D order has been investigated by GISAXS. We found that mesocrystalline order of the nanoparticles in the μm-range appears under appropiate conditions.Additionally a simulation of the GISAXS pattern was developed, which describes well the observed intensity.

MA 36.4 Wed 15:30 HSZ 103

Influence of crystallite size and temperature on the antiferromagnetic helices of terbium and holmium metal — •Jens-Peter Bick[1,2], Andreas Michels[1,2], Adrian Ferdinand[1], Rainer Birringer[1], Jörg Baller[2], Roland Sanctuary[2], Stefan Philippi[3], Dieter Lott[4], Sandor Balog[5], Eli Rotenberg[6], Günter Kaindl[7], and Kristian M. Döbrich[7,8] — [1]Universität des Saarlandes, D-66041 Saarbrücken — [2]University of Luxembourg, L-1511 Luxembourg — [3]Leibniz Institute for Solid State and Materials Research, D-01069 Dresden — [4]GKSS Research Center, D-21502 Geesthacht — [5]Paul Scherrer Institute, CH-5232 Villigen — [6]Lawrence Berkeley National Laboratory, California 94720, USA — [7]Freie Universität Berlin, D-14195 Berlin-Dahlem — [8]Max-Born-Institut, D-12489 Berlin

We report on the results of grain-size and temperature-dependent magnetization, specific-heat, neutron-scattering, and angle-resolved photoelectron spectroscopy (ARPES) experiments on the heavy rare-earth metals terbium and holmium, with particular emphasis on the temperature regions where the helical antiferromagnetic phases exist. In contrast to Ho, we find that the helical structure in Tb is relative strongly affected by microstructural disorder, specifically, it can no longer be detected for the smallest studied grain size of $D = 18\,\mathrm{nm}$. Moreover, in coarse-grained Tb a helical structure persists even in the ferromagnetic regime, down to about $T = 215\,\mathrm{K}$, in agreement with the ARPES data, which reveal a nesting feature of the Fermi surface at the L point of the Brillouin zone at $T = 210\,\mathrm{K}$.

MA 36.5 Wed 15:45 HSZ 103

Influence of MnAs nanoclusters on the angle-dependent transport behaviour in GaAs:Mn/MnAs hybrid structures — •Matthias T. Elm[1], Shingo Ito[2], Shinjiro Hara[2], Hans-Albrecht Krug von Nidda[3], and Peter J. Klar[1] — [1]1. Physikalisches Institut, Justus-Liebig University, Heinrich-Buff-Ring 16, 35392 Gießen — [2]Research Center for Integrated Quantum Electronics, Hokkaido University, Sapporo, Japan — [3]Experimentalphysik V, University of Augsburg

Using selective-area MOVPE on pre-patterned substrates different arrangements of ferromagnetic MnAs nanoclusters and cluster chains were prepared. The single nanoclusters have a length of 730 nm and a width of 300 nm. FMR and MFM measurements confirm an orientation of the cluster magnetization along the clusters' main axes of elongation. Magneto-transport measurements were performed in the temperature range from 15 to 280 K in external magnetic fields up to 10 T. A strong dependence of the magnetoresistance effects on cluster arrangement can be observed. At low temperatures also angle-dependent measurements of the transport through the paramagnetic matrix were investigated. In-plane as well as in out-of-plane geometry the magnetoresistance behaviour shows deviations from an expected sine-dependence of the matrix. This behaviour can be described qualitatively by a simple model taking an average behaviour of the nanoclusters' magnetizations into account.

MA 36.6 Wed 16:00 HSZ 103

FePtCu films on SiO_2 spherical particle arrays — •Fabian Ganss, Christoph Brombacher, Beate Mainz, Michael Hietschold, and Manfred Albrecht — Chemnitz University of Tech-

nology, Institute of Physics, Germany

Following the concept of bit patterned media for data storage application [1], FePt/Cu bilayers were sputter deposited at room temperature onto hexagonal close packed arrays of spherical silica particles with a diameter of 100 nm. Rapid thermal annealing at various temperatures was performed to transform the bilayers into an $(Fe_{52}Pt_{48})_{86}Cu_{14}$ alloy with perpendicular magnetic anisotropy [2, 3] and to achieve decoupled film caps on top of the particles by dewetting, thus forming hard magnetic nanostructures. The dewetting behaviour of the film in dependence on the annealing temperature was studied by SEM and cross-section TEM. Hysteresis loops measured by SQUID magnetometry reveal an increasing perpendicular anisotropy at higher annealing temperatures and a coercivity of almost 2 T. The magnetic characterization was complemented by MFM at different remanent states, showing the magnetic decoupling between the caps. Points of a remanence curve were extracted from the MFM images and are compared to SQUID measurements.

[1] B. D. Terris, J. Magn. Magn. Mater. 321, 512 (2009)
[2] M. L. Yan et al., J. Appl. Phys. 99, 08G903 (2006)
[3] D. Makarov et al., Appl. Phys. Lett. 96, 062501 (2010)

MA 36.7 Wed 16:15 HSZ 103

Magnetoimpedance of Permalloy nanowires — •Saleh Getlawi, Haibin Gao, Michael Koblischka, and Uwe Hartmann — Inst. of Experimental Physics, Saarland University, P.O. Box 151150, 66041 Saarbrücken

The magneto-impedance (MI) effect was studied extensively on amorphous wires, ribbons, and on multilayer thin films. This effect involves huge changes of the complex impedance of soft magnetic materials upon applying an external magnetic field. In this contribution we explore the MI effect on Permalloy nanowires. Nanowires of lengths of 40-60 mu and widths of 200-400 nm were prepared by electron beam lithography (EBL) and a lift-off process. Electrodes for the transport measurements and platinum contacts were fabricated by focused-ion-beam(FIB)-based methods. Magnetic force microscopy (MFM) was employed to observe the magnetic domain structures of the nanowires. For high frequency measurement, the sample was placed on a microwave transmission line consisting of two gold microstrip lines. MI measurements were performed in the range from 10 MHz to 3 GHz.

MA 36.8 Wed 16:30 HSZ 103

Magnetic Films on Nanoperforated Templates for Percolated Perpendicular Media — •Carsten Schulze[1], Marco Faustini[2], Herbert Schletter[1], Matthias U. Lutz[3], Michael Hietschold[1], Denys Makarov[1,3], and Manfred Albrecht[1] — [1]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [2]Laboratoire de Chimie de la Matière Condensée de Paris, Université Pierre et Marie Curie-Paris 6, CNRS, 75252 Paris cedex 05, France — [3]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany

A study on the magnetization reversal in Co/Pt multilayers with perpendicular magnetic anisotropy deposited onto membranes with densely distributed perforations is presented. It was shown that the magnetic domain walls are pinned at the inhomogeneities provided by perforations with sizes down to 17 nm [1, 2], suggesting a possible application of such a system for magnetic data storage as a recording scheme called percolated perpendicular medium (PPM) [3]. However, for the application as a recording medium the size of the perforations has to be further reduced. In this regard, the influence of the perforation size with respect to the domain wall width on the pinning strength will be discussed.

[1] D. Makarov *et al.*, IEEE Trans. Magn. **45** (2009) 3515.
[2] C. Schulze *et al.*, Nanotechnology **21** (2010) 495701.
[3] D. Suess *et al.*, J. Appl. Phys. **99** (2006) 08G905.

MA 37: Magnetic Semiconductors II

Time: Wednesday 14:45–16:45 Location: HSZ 401

MA 37.1 Wed 14:45 HSZ 401

Magnetic ordering in manganese stabilized zirconia — •Jan Zippel, Michael Lorenz, Jörg Lenzner, Anette Setzer, Pablo Esquinazi, and Marius Grundmann — Universität Leipzig, Institut für Experimentalphysik II, Linnéstraße 5, 04103 Leipzig

The selective control of the spin of electrons as a new degree of freedom in a conventional charge-based electronic offers the possibility to combine the advantages of non-volatility and fast data processing with the properties of conventional semiconductor devices. Recently, ferromagnetism has been observed in nominally undoped oxides like ZnO, HfO_2 or TiO_2 [1]. The origin of the observed ferromagnetism is still a controversy [2].

We present the growth of manganese doped zirconia (MnSZ) with pulsed-laser deposition (PLD). For Mn contents x>15 at%, we were able to stabilize MnSZ in its cubic crystalline phase being predicted to show ferromagnetic properties [3]. A weak, doping independent ferromagnetism in undoped as well as in manganese stabilized zirconia is observed. Hysteresis loops at $T = 5$K and at room temperature independent of x are shown. The lack of Mn induced magnetic ordering indicates, that the observed magnetic properties are defect related. The saturation magnetization at $T = 5$K depends on the strain as well as on the defect density of the films supporting the assumption of a defect related origin of the ferromagnetism.

[1] M. Khalid et al., Phys.Rev.B (2009), **80**, 035331 [2] M. Khalid et al., Phys.Rev.B (2010) **81**, 214414 [3] S. Ostanin et al., Phys. Rev. Lett. (2007) **98**, 016101

MA 37.2 Wed 15:00 HSZ 401

Magneto-optical studies on doped and undoped ZnO nanostructures — •Stephanie Jankowski[1], Limei Chen[1], Sebastian Geburt[2], Carsten Ronning[2], and Wolfram Heimbrodt[1] — [1]Department of Physics and Material Science Center, Philipps-University Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Physikalisch-Astronomische Fakultät, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany

High quality ZnO nanowires doped with different content of Manganese and Cobalt as well as ZnO quantum wells embedded between ZnMgO barriers are investigated by magneto photoluminescence and magnetic circular dichroism (MCD) in a split-coil superconducting magnet system. The measurements have been performed in magnetic fields up to 7 Tesla in a temperature range 1.6-300 K. MCD and Zeeman-spectroscopy in the excitonic region have been used to determine the g-factors of the samples. Even in case of transition metal doped ZnO surprisingly small Zeeman-splitting has been found. The reason for the rather small values as well as the change of sign of the g-value will be discussed. The transition metal doped ZnO shows also an interesting difference concerning the optical 3d intra-ionic transitions. Whereas in the Co-doped samples the 3d transitions are observable in case of the Mn-doped samples the Mn-PL is rather vanishing. The physical reasons for the odd behaviour will be discussed.

MA 37.3 Wed 15:15 HSZ 401

Magnetic properties of ZnO based diluted magnetic semiconductors using hybrid functional DFT — •Sanjeev K. Nayak, Heike C. Herper, Markus E. Gruner, and Peter Entel — Faculty of Physics, University of Duisburg-Essen, 47057 Duisburg

We study the magnetic properties of diluted magnetic semiconductor based on ZnO with transition metal dopants (Cr, Fe, Mn, Co and Ni) using the hybrid functional treatment in density functional theory (PBE0 [1], HSE [2]). At first the electronic structure using a semiconductor supercell is studied with the hybrid functional. Thereafter the dopants are substituted in the cation lattice sites, structurally relaxed and their magnetic properties are investigated. We mostly focus on the nearest neighbor interactions of the dopant atoms. Our preliminary results show that out of the two similar nearest neighbors (nn) in ZnO, the one lying along the c-axis favors a ferromagnetic alignment of Co spins and the other nn along the hexagonal plane favors antiferromagnetic interaction in GGA. However, both the nn separations stabilize antiferromagnetic interaction in hybrid functional calculations. This is similar to what is obtained when the Hubbard correlation U is added to the system. We compare the GGA+U and the hybrid functional results. All our studies are done with the Vienna ab-initio simulation package (VASP [3]).

[1] Paier *et al.*, J. Chem. Phys. **122**, 234102 (2005), [2] Paier *et al.*,

J. Chem. Phys. **124**, 154709 (2006), [3] Kresse *et al.*, Phys. Rev. **B 54**, 11169 (1996)

MA 37.4 Wed 15:30 HSZ 401

muSR proof of magnetism in undoped ZnO thin films — •Thomas Tietze[1], Patrick Audehm[1], Boris Straumal[1,2], Peter Straumal[2], Zaher Salman[3], Hubertus Lütkens[3], Thomas Prokscha[3], and Eberhard Goering[1] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart — [2]Moscow Institute of Steel and Alloys, Technological University, Leninsky Prospect 4, 119991 Moscow, Russia — [3]Paul Scherrer Institut, Labor für Myon-Spin Spektroskopie, CH-5232 Villigen PSI, Switzerland

Over the last decade tremendous efforts have been taken to reveal the origin of room temperature (RT) ferromagnetism (FM) in transition metal (TM) doped ZnO. SQUID measurements mostly showed ferromagnetic behavior whereas element specific methods like x-ray magnetic circular dichroism (XMCD) could not address the FM to any of the containing elements. FM occurred even in undoped ZnO, if the specific grain boundary area exceeds a threshold value. We suggest vacancy like states located at the grain boundaries as a possible source of the origin of RT FM of undoped ZnO. In order to proof intrinsic magnetism of nanostructured pure ZnO, we performed low energy muon spin rotation (LE-muSR) experiments at the Swiss Muon Source (SmuS). SQUID hysteresis loops revealed enhanced FM according to higher specific grain boundary area, in perfect agreement with our muSR measurements. The maximum muSR related magnetic volume fraction for nano grained samples was about 35%, while the pure ZnO single crystal sample was solely diamagnetic. Therefore, we present intrinsic evidence for a new type of RT-FM.

MA 37.5 Wed 15:45 HSZ 401

Defect induced ferromagnetic and metallic character of ZnO single crystals — •Khalid Muhammad[1], Pablo Esquinazi[1], Daniel Spemann[2], Wolfgang Anwand[3], and Gerhard Brauer[3] — [1]Division of Superconductivity and Magnetism, University of Leipzig, Germany — [2]Division of Nuclear Solid State Physics, University of Leipzig, Germany — [3]Institut für Strahlenphysik, Forschungzentrum Dresden-Rossendorf, Dresden, Germany

We investigated the magnetic and electrical properties of H-plasma treated ZnO single crystals. Hysteresis loops taken by SQUID magnetometry at 300 K showed a ferromagnetic behavior with a magnetization at saturation ~ 4 emu/g. A successive chemical etching process showed that the major ferromagnetic contribution comes from the first 10 nm layer. A clear semiconductor-metallic transition is observed in H-ZnO single crystals. The saturation magnetization as well as semiconductor-metallic transition temperature depend on the concentration of defects which is closely related to the exposed time of the sample to H-plasma. We observed a negative and positive magnetoresistance behavior. We attribute the ferromagnetic and metallic behavior of H-ZnO single crystals to hydrogen related defects.

MA 37.6 Wed 16:00 HSZ 401

Magnetic Properties of Polar ZnO Surfaces from *Ab-Initio* Calculations — •Guntram Fischer[1], Arthur Ernst[2], Waheed Adeagbo[1], Nadia Sanchez[3], Zdzislawa Szotek[4], Walter Temmerman[4], Wolfram Hergert[1], and Carmen Muñoz[3] — [1]University of Halle, Halle, Germany — [2]Max-Planck-Institute for Microstructure Physics, Halle, Germany — [3]Instituto de Ciencia de Materiales de Madrid, Madrid, Spain — [4]Daresbury Laboratory, Warrington, United Kingdom

We have investigated a magnetic moment formation of three oxygen-terminated polar ZnO surfaces. Specifically, these are the (000-1) surface, the (0001) surface with an oxygen atom on top of the Zn atom [(0001)-t], and the (0001) surface with an oxygen atom in a threefold hollow site [(0001)-h].

In this study we have used a multi-code approach allowing us to relax the surface structure and calculate the Heisenberg exchange parameters via a magnetic force theorem. Also, the influence of applying self-interaction corrections (SIC) to the oxygen p orbitals has been investigated.

Our calculations show that all three surfaces are magnetic. In addition, we find that applying SIC is necessary to correctly describe the top oxygen atom of the (0001)-h and (0001)-t surfaces, for both of which we find Curie temperatures to be larger than room temperature. The latter have been derived from Monte Carlo simulations based on the calculated exchange parameters.

MA 37.7 Wed 16:15 HSZ 401

F-centres and ferromagnetism in oxides — •Aurab Chakabarty and Charles Patterson — School of Physics, Trinity College Dublin, Dublin 2, Ireland

We present Hybrid and LDA calculations to explain the ferromagnetism (FM) observed in oxide thin films[1]. A model is proposed where FM can occur in oxides with F-centre defects when defect levels are partially filled and can be described by a single band Hubbard model. The model predicts room-temperature FM in large Hubbard-U limit[2]. We show that positively charged oxygen vacancy is metastable[3], but in oxygen poor and n-type conditions, oxygen and zinc vacancies are strongly bound together to form a ZnO divacancy, which is an F-centre with a Hubbard-U large enough to support ferromagnetism at room temperature. The Hubbard-U value is estimated from defect transition levels and from total energy calculations on divacancy pairs with parallel and anti-parallel magnetic moments. This model may also explain ferromagnetism in other nonmagnetic oxides such as MgO, as the MgO divacancy is an F-centre [4] with a large U.

References:
1. J.M.D. Coey et al, nat. mater. 4, 173 (2005)
2. J. A. Henderson et al, Phys. Rev. B. 46, 6328 (1992)
3. C. H. Patterson, Phys Rev. B, 74, 144432 (2006)
4. D. Ricci et al, J. Chem. Phys, 117, 2844 (2002)

MA 37.8 Wed 16:30 HSZ 401

Magnetism and correlation effects in "d^0" magnetic oxides — •Ivetta Slipukhina, Phivos Mavropoulos, Stefan Blügel, and Marjana Ležaić — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

In the past few years there is a growing interest in engineering a ferromagnetic state in otherwise nonmagnetic insulators by doping with *sp* elements instead of transition metals that is traditionally used in diluted magnetic semiconductors. This novel magnetic materials design was stimulated by several unexpected experimental observations of room-temperature ferromagnetism in highly defective wide-gap semiconductors and insulators and is particularly interesting, both from fundamental and practical point of view. In this presentation we discuss possible d^0-magnetism in some otherwise non-magnetic oxides, using first-principles calculations within GGA and GGA+U approaches. Starting from Nitrogen doped MgO as a model system, we show that strong on-site electron interactions could lead to relative spin and orbital ordering of the Nitrogen induced hole states and significantly reduce the ferromagnetic exchange interaction. We discuss the mechanism behind the ferro- or antiferromagnetic state stabilization at different orbitally ordered configurations and analyze the influence of structural distortions on the magnetic interactions. The importance of structural distortions and strong electron correlations in Nitrogen doped $SrTiO_3$ perovskite is also examined. We gratefully acknowledge the support from HGF Nachwuchsgruppe Programme VH-NG-409.

MA 38: Magnetization Dynamics IV

Time: Wednesday 14:45–17:15 Location: HSZ 403

MA 38.1 Wed 14:45 HSZ 403

Monitoring Vortex Dynamics and Vortex Core Polarization with Magnetic Tunnel Junctions — •Hermann Stoll[1], Matthias Noske[1], Karsten Rott[2], Markus Sproll[1], Matthias Kammerer[2], Michael Curcic[1], Bartel Van Waeyenberge[3], Günter Reiss[2], and Gisela Schütz[1] — [1]MPI für Metallforschung, Stuttgart — [2]Universität Bielefeld — [3]Ghent University, Belgium

Nakano et al. [1] have shown, that a magnetic tunnel junction (MTJ) placed on a micron-sized vortex element is capable of detecting gyrotropic motion and vortex core polarization when the vortex is excited by an ac current. However, problems occurred by crosstalk between

the excitation current and the MTJ output. We have virtually eliminated this drawback by taking advantage of a sophisticated lock-in technique. In that way we would like to demonstrate a 1 bit vortex V(ortex)MRAM - with electric write and read-out - where data is stored in the out-of-plane magnetization of the vortex core, showing up or down - in a Permalloy vortex structure, 0.5 microns in diameter. In addition, our technique allows us to perform table-top experiments on vortex dynamics and vortex core reversal and can replace microscopic techniques (e.g., X-ray or MFM microscopy) in many cases. We will proof this in a second example where we have measured the frequency and amplitude dependence of the gyrotropic eigenmode of a vortex structure in an external static magnetic field. We will compare our findings with similar results [2] achieved by Magnetic Resonance Force Microscopy (MRFM). [1] K. Nakano et al., Applied Physics Express 3 (2010) 053001 [2] P. Pigeau et al., APL 96, 132506 (2010)

MA 38.2 Wed 15:00 HSZ 403

Controlled Vortex Core Reversal by Excitation of Spin Wave Modes — •Matthias Kammerer[1], Markus Weigand[1], Michael Curcic[1], Matthias Noske[1], Markus Sproll[1], Hermann Stoll[1], Bartel Van Waeyenberge[2], Georg Woltersdorf[3], Christian H. Back[1], and Gisela Schütz[3] — [1]MPI für Metallforschung, Stuttgart — [2]Ghen University, Belgium — [3]Universität Regensburg

It is well known, that magnetic vortex core reversal can be achieved by excitation of the (sub-GHz) vortex gyromode [1,2]. Surprisingly our experiments and micromagnetic simulations show an unidirectional vortex core switching by excitation of magneto static spin waves at frequencies more than an order of magnitude higher. These results were obtained with time-resolved magnetic imaging at the scanning X-ray microscope MAXYMUS at BESSY II, Berlin. Circular Permalloy platelets have been excited with in-plane rotating magnetic field bursts at GHz frequencies. Imaging could be performed with 30 ps time resolution. Vortex state structures possess spin wave eigenmodes arising from the magneto-static interaction. The interaction between these modes and the gyrotropic mode breaks the cylindrical symmetry of the micromagnetic objects, leading to a frequency splitting of the spin wave modes with opposite rotation senses. We could demonstrate [3] that the unidirectional vortex core reversal process is not limited to the gyrotropic mode but is a general mechanism when azimuthal modes (with m = +/- 1) are excited. [1] B. Van Waeyenberg et al., Nature 444, 461 (2006) [2] M. Curcic et al., PRL 101, 197204 (2008) [3] M. Kammerer et al., http://arxiv.org/abs/1008.4719

MA 38.3 Wed 15:15 HSZ 403

Fast and Selective Switching of the Vortex Core with Orthogonal Magnetic Pulses — •Matthias Noske[1], Markus Weigand[1], Bartel Van Waeyenberge[2], Hermann Stoll[1], Arne Vansteenkiste[2], Matthias Kammerer[1], Michael Curcic[1], Markus Sproll[1], Georg Woltersdorf[3], and Gisela Schütz[1] — [1]MPI for Metals Research, Stuttgart — [2]Department of Solid State Science, Ghent University, Belgium — [3]Department of Physics, Regensburg University

Reliable, low-power and selective switching of the magnetic vortex core using rotating magnetic fields has been demonstrated by [1] and has potential application in vortex random access memory as discussed in [2]. However, when rotating RF magnetic fields are applied, the vortex will gyrate a few times before the core polarity switches and a few times after until it reaches the equilibrium position again. In contrast, orthogonal pulses can cause switching after less than one gyration period. Our micromagnetic simulations and experiments prove that the vortex core in sub-micron sized permalloy structures can be unequivocally and unidirectionally reversed by two carefully designed orthogonal magnetic in-plane pulses. Additionally, by tuning the length of the second pulse, the vortex displacement after switching can be minimized, effectively quenching the residual vortex motion. The time-resolved experiments were conducted at the newly installed scanning X-ray microscope MAXYMUS at BESSY II, Berlin.

[1] M. Curcic et al., Phys. Rev. Lett. 101, 197204 (2008)
[2] S.-K. Kim et al., Appl. Phys. Lett. 92, 022509 (2008)

MA 38.4 Wed 15:30 HSZ 403

Pump-Probe SAXS experiments on ultrafast demagnetization of magnetic multilayers — B. Pfau[1], •S. Schaffert[1], J. Mohanty[1], J. Geilhufe[1], F. Büttner[1,2], S. Flewett[1], L. Müller[3], C. Gutt[3], A. Al-Shemmary[3], S. Düsterer[3], H. Redlin[3], G. Grübel[3], B. Vodungbo[4], J. Lüning[5], D. Stickler[6], R. Frömter[6], H.P. Oepen[6], W.F. Schlotter[7], and S. Eisebitt[1] — [1]IOAP, Technische Universität Berlin, Germany — [2]Paul Scherrer Institut, Villigen, Switzerland — [3]HASYLAB at DESY, Hamburg, Germany — [4]ENSTA ParisTech - Ecole polytechnique, Palaiseau, France — [5]Université Pierre et Marie Curie, Paris, France — [6]Universität Hamburg, Germany — [7]LCLS at SLAC, Menlo Park, USA

We have investigated the ultrafast optical demagnetization of domain patterns in magnetic multilayers with perpendicular magnetic anisotropy in an infrared-pump x-ray-probe experiment. As a probe we used small angle x-ray scattering which, via x-ray magnetic circular dichroism at the Co M-edge, allows us to simultaneously obtain information on the magnitude of the local magnetization and the characteristic length scale of the magnetic domains. The free-electron laser source FLASH at Hamburg was tuned to deliver $\lambda = 20.9$nm x-ray pulses of approx. 25 fs duration which were synchronized to an infrared fs laser for pump-probe experiments with sub-ps time resolution. In addition to ultrafast demagnetization, we observe sub-ps structural changes of the magnetic domain configuration. Models to explain this ultrafast structural change will be discussed.

MA 38.5 Wed 15:45 HSZ 403

Ultrafast Element-Specific Decoupling of Magnetization Dynamics in Permalloy — •Patrik Grychtol[1,3], Chan La-O-Vorakiat[1], Stefan Mathias[1,2], Justin Shaw[4], Roman Adam[3], Hans Nembach[4], Mark Siemens[1], Steffen Eich[2], Henry Kapteyn[1], Margaret Murnane[1], Claus M. Schneider[3], Tom Silva[4], and Martin Aeschlimann[2] — [1]Department of Physics and JILA, University of Colorado, Boulder, Colorado 80309-0440, USA — [2]University of Kaiserslautern and Research Center OPTIMAS, 67663, Kaiserslautern, Germany — [3]Institute of Solid State Research, IFF-9, Research Center Juelich, 52425, Juelich, Germany — [4]Electromagnetics Division, National Institute of Standards and Technology, Boulder, Colorado 80305-3328, USA

Elucidating the dynamic behavior of complex magnetic systems far from their thermal equilibrium is a topic of utmost scientific interest. In our work, we employ soft x-ray pulses from high-harmonic-generation to probe the dynamic response of thin permalloy films during an ultrafast optically driven demagnetization process [1]. We find that the demagnetization times for the elements Fe and Ni differ significantly, despite their strong exchange coupling in the thermodynamic equilibrium. We ascribe this difference to a breakdown of exchange interaction on the femtosecond timescale, a process that we further enhance by alloying permalloy with Cu. Our data shows that, in general, a site-specific spin environment must be considered to correctly describe ultrafast magnetization processes in compounds.

[1] La-O-Vorakiat *et al.*, Phys. Rev. Lett. **103**, 257402 (2009)

MA 38.6 Wed 16:00 HSZ 403

The Driving Force of Ultrafast Demagnetization Dynamics — •Benedikt Müller, Mirko Cinchetti, Tobias Roth, Martin Aeschlimann, and Bärbel Rethfeld — University of Kaiserslautern, Germany

Irradiating a ferromagnetic material with an ultrashort laser pulse leads to a demagnetization process on a femtosecond timescale. Elliott-Yafet type scattering is one of the most invoked spin-flip mechanisms to give a microscopic description of such behavior. In particular, electron-electron (el-el) [1] and electron-phonon (el-ph) [2] spin-flip scattering have been considered. We combined the basic ingredients of those two models. In the framework of a spin-resolved Boltzmann equation [3] this allows us to evaluate the relative importance of Elliott-Yafet-type spin-flip scattering and to identify the driving force for ultrafast demagnetization: The equilibration of temperatures and chemical potentials of the introduced spin-up and spin-down electronic systems.

[1] M. Krauss et al., Phys. Ref. B **80**, 180407 (2009)
[2] B. Koopmans et al., Nature Materials **9**, 3 (2010)
[3] B. Rethfeld et al., Phys. Ref. B **65**, 214303 (2002)

MA 38.7 Wed 16:15 HSZ 403

Distinct Demagnetization Dynamics of Ni and Fe Magnetic Moments in a NiFe Alloy — •Andrea Eschenlohr[1], Ilie Radu[1,2], Christian Stamm[1], Niko Pontius[1], Torsten Kachel[1], Florin Radu[1], Theo Rasing[2], and Alexey V. Kimel[2] — [1]Helmholtz Zentrum Berlin für Materialien und Energie, Elektronenspeicherring BESSY II, Albert-Einstein-Str. 15, 12489 Berlin — [2]Radboud University Nijmegen, Heijendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

Ultrafast demagnetization has been approached from a variety of experimental and theoretical angles since the first observation of a subpicosecond quenching of magnetization in Ni [1]. Time constants of demagnetization have been established for elementary transition metals and rare earths. Their compounds and alloys, which are highly relevant for technological applications and for research into the microscopic origins of ultrafast demagnetization, are increasingly investigated with methods like TR-MOKE. Yet experimental methods which combine femtosecond time resolution with an element-sensitive measurement of the magnetization have so far been sparse. We bridge this gap by probing magnetization dynamics in ferromagnetic NiFe alloys in an element-resolved way with 100 fs x-ray pulses generated by the Femtoslicing facility at BESSY II via XMCD. We find different demagnetization time constants for Ni (80 +/- 30 fs) and Fe (240 +/- 30 fs) in Ni50Fe50, evidence of a decoupling of the Ni and Fe dynamics on ultrafast timescales despite the exchange interaction between the two elements. [1] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250 (1996).

MA 38.8 Wed 16:30 HSZ 403

Relating Gilbert damping and ultrafast laser-induced demagnetization — •Christian Illg, Jonas Seib, and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart

Two regimes of short-time magnetization dynamics are usually distinguished: First, the dynamics on a time scale of nanoseconds to several picoseconds driven by external magnetic fields or by spin-polarized electrical currents. Second, the dynamics on a time scale of few picoseconds to subpicoseconds when exposing a thin film of Ni, Fe, or Co, e.g., to an optical femtosecond laser pulse. The first regime can be modelled by the Gilbert equation and the second by the Elliott-Yafet relation. There is a great interest to relate these two regimes.

In this talk a relation is established between the conductivity-like contribution to the Gilbert damping α at low temperatures and the demagnetization time τ_M for the ultrafast laser-induced demagnetization at low laser fluences [1]. It is assumed that the same types of spin-dependent electron-scattering processes are relevant for α and τ_M. The relation contains information on the properties of single-electron states which are calculated by the *ab initio* electron theory. The predicted value for α/τ_M is in good agreement with the experimental value.

[1] M. Fähnle, J. Seib, and C. Illg, Phys. Rev. B **82**, 144405 (2010)

MA 38.9 Wed 16:45 HSZ 403

Ultrafast Demagnetization Dynamics in $Ni_{1-x}Pd_x$ alloys — •Moritz Plötzing[1], Patrik Grychtol[1], Dennis Lvovsky[1], Roman Adam[1], Claus M. Schneider[1], Hans Nembach[2], Justin Shaw[2], Tom Silva[2], Daniel Steil[3], Mirko Cinchetti[3], and Martin Aeschlimann[3] — [1]Institute of Solid State Research, IFF-9, Research Center Jülich, 52425, Jülich, Germany — [2]Electromagnetics Division, National Institute of Standards and Technology, Boulder, Colorado 80305-3328, USA — [3]University of Kaiserslautern and Research Center OPTIMAS, 67663, Kaiserslautern, Germany

In our study we systematically investigate the ultrafast demagnetization process of alloys based on Ni and Pd induced by intense laser pulses in the femtosecond range. To this end, we fabricated samples by thermal co-evaporation of the respective elements over a wide range of $Ni_{1-x}Pd_x$ stoichiometries. We characterized all samples by measurements of the ferromagnetic resonance to determine the Gilbert damping parameter α as well as by measurements of the critical temperature T_c in a vibrating sample magnetometer. In time-resolved pump-probe experiments, exploiting the magneto-optical Kerr effect, we measured the demagnetization time τ_M for different $Ni_{1-x}Pd_x$ samples. Our contribution presents detailed experimental analysis of the relation of τ_M to α and T_c compared to the theoretical predictions as presented in [1].

[1] Koopmans et al., Phys. Rev. Lett. 95, 267207 (2005)

MA 38.10 Wed 17:00 HSZ 403

Understanding demagnetization dynamics in the Heusler alloy $Co_2Mn_{1-x}Fe_xSi$ — •Daniel Steil[1], Sabine Alebrand[1], Tobias Roth[1], Michael Krauss[1], Takahide Kubota[2], Mikihiko Oogane[2], Yasuo Ando[2], Hans Christian Schneider[1], Martin Aeschlimann[1], and Mirko Cinchetti[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67653 Kaiserslautern, Germany — [2]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Sendai 980-8579, Japan

We have investigated ultrafast demagnetization in the half-metallic Heusler alloy system $Co_2Mn_{1-x}Fe_xSi$ (CMFS). The two investigated compounds CMS and CFS are predicted to be half metallic [1], with a different lineup of the minority band gap and the Fermi level. In CMS, the Fermi energy is lined up to the top of the valence band, while in CFS to the bottom. Despite such differences, both alloys show remarkably similar magnetization dynamics, as measured by the time-resolved magneto optical Kerr effect. Based on the experimental observations and our recent dynamical model that includes momentum- and spin-dependent carrier scattering [2], we show that magnetization dynamics are dominated by hole spin flips below the Fermi energy, which are not influenced by the band gap [3].

[1] B. Balke *et al.*, Phys. Rev. B **74**, 104405 (2006)
[2] M. Krauß *et al.*, Phys. Rev. B **80**, 180407 (2009)
[3] D. Steil *et al.*, Phys. Rev. Lett. **105**, 217202 (2010)

MA 39: Spins in Organic Materials (jointly with DS) - Invited Talk

Time: Wednesday 15:00–15:45 Location: GER 37

Invited Talk MA 39.1 Wed 15:00 GER 37

Electrical spin injection in a hybrid organic/inorganic spin-polarized light emitting diode (spin-LED) — •Ezekiel Johnston-Halperin — Department of Physics, The Ohio State University, USA

The development of organic-based magnets with room temperature magnetic ordering and semiconducting functionality promises a route to all-organic spintronic devices and hybrid organic/inorganic structures capable of exploiting both the multifunctionality of organic systems as well as the established spintronic functionality of inorganic materials. Here we report the successful extraction of spin polarized current from a thin film of the organic-based room-temperature ferrimagnetic semiconductor V[TCNE]x (x~2; TCNE: tetracyanoethylene) and its subsequent injection into a GaAs/AlGaAs light-emitting diode (LED). The orientation of this spin current is determined by polarization analysis of the electroluminescence from the LED and is found to be parallel to the magnetization of the V[TCNE] layer, in agreement with theoretical predictions. Detailed analysis of the optical selection rules in the LED, coupled with control measurements of magnetic circular dichroism in the V[TCNE] layer, reveals the magnitude of the electron spin polarization to be largely insensitive to both electrical bias and temperature. This successful demonstration of spin injection in a hybrid organic/inorganic structure opens the door to a new class of active, hybrid spintronic devices with the potential for multifunctional behavior defined by the optical, electronic and chemical sensitivity of the organic layer.

MA 40: Surface magnetism II (jointly with O)

Time: Wednesday 15:00–16:45 Location: CHE 184

MA 40.1 Wed 15:00 CHE 184

Hyrogen-induced Kondo effect for Co/Pt(111) — •Quentin Dubout, Fabian Calleja Mitja, Markus Etzkorn, Anne Lehnert, Laurent Claude, Pietro Gambardella, and Harald Brune — Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

We present 0.4 K Scanning Tunneling Spectroscopy (STS) results on hydrogenated Co adatoms on Pt(111). Molecular H dosage creates two Co-H adsorption complexes with comparable abundance. Type I displays very large (˜40 %) inelastic conductance steps that originate from vibrations, as evidenced by their shift when substituting H by D. Type II displays smaller (˜5 %) conductance steps at higher energies, again due to H vibrations, together with a large conductance peak at the Fermi level. This feature is attributed to the Kondo effect. Its splitting in magnetic fields up to 8 Tesla identifies the Co-H complex as a S = 1/2 system, whereas clean Co/Pt(111) has a spin of 1 and shows no Kondo effect. H-adsorption has been reported to quench the Kondo effect, here we show that it can produce it.

MA 40.2 Wed 15:15 CHE 184

Magnetic and structural investigations of thin ferromagnetic CrSb layers on GaAs(110)/GaAs(001) — •Carsten Godde and Ulrich Köhler — Institut für Experimentalphysik IV / AG Oberflächen, Ruhr-Universität Bochum, Germany

In this contribution we present structural and magnetic measurements of thin CrSb layers on GaAs(110) and GaAs(001) surfaces. These systems are of great interest because of their possible use as spin aligner for spin injection in semiconductors. Thin CrSb layers up to 4 ML thickness grow in the metastable zinc blende structure on GaAs and keep ferromagnetic properties and structural stability up to high annealing temperatures which is interesting for enabling better crystalline quality. We investigate the growth of CrSb on the GaAs surfaces at different coverages and annealing temperatures by STM, LEED and SQUID magnetometry. The CrSb films are co-deposited on the GaAs substrate by MBE at a deposition temperature of 250°C with a co-deposition ratio of Cr and Sb: 1:6. On the GaAs(110) surface STM shows for a 3ML CrSb deposition a closed film of rectangular and rooflike islands elongated in $[1\bar{1}0]$-direction of substrate with increasing tendency towards a flat continuous morphology with height variations in the monolayer range after thermal processing at 300°C for 45min. These flat areas are characterized by a atomic fishbone row structure in $[1\bar{1}0]$-direction. SQUID magnetometry measurements show ferromagnetic characteristics of the thin CrSb layers with a magnetic moment per atom of $\approx 3\ \mu_B$.

MA 40.3 Wed 15:30 CHE 184

Fe/GaAs(001) and MgO/Fe/GaAs(001) epitaxial systems: A spin- and angle-resolved photoemission study — •Daniel Gottlob[1,2], Lukasz Plucinski[1], Carsten Westphal[2], and Claus M. Schneider[1] — [1]Forschungszentrum Jülich GmbH — [2]Technische Universität Dortmund

Spintronics is an inportant field of current Solid State Research and memory units based on Magnetic Tunnel Junctions (MTJs) are now within reach. In MTJ's the nature of the electronic structure at the interface determines the spin-selectivity of the tunneling process, and thereby the magnetorestive potential of the MTJ.

Electronic interface states can influence the tunneling process in epitaxial MTJs especially for thinner tunnel barriers. The research that has been done at Beamline 5, DELTA, Dortmund in the context of a Diploma thesis focussed on the electronic structure of Fe/GaAs(001) and MgO/Fe/GaAs(001) and a surface/interface state of these systems. The samples have been prepared *in situ* by molecular beam epitaxy and characterized by LEED and Auger spectroscopy.

The electronic structure was probed in two different regions of the Brillouin zone, which have been chosen for reference (normal emission, Γ point) and the expectation of the surface state (21° off normal) that has been seen on Fe/W(001) in a previous study [1]. Measurements on the MgO capped iron sample have been conducted to confirm whether the surface state does transform into an interface state.

[1] L. Plucinski, Y. Zhao, C.M. Schneider, B. Sinkovic, and E. Vescovo; Phys. Rev. B 80, 184430 (2009)

MA 40.4 Wed 15:45 CHE 184

Itinerant Nature of Atom-Magnetization Excitation by Inelastic Scanning Tunneling Spectroscopy — Alexander Khajetoorians[1], Samir Lounis[2], Bruno Chilian[1], Antonio Costa[3], Lihui Zhou[1], Douglas Mills[2], Sergej Schuwalow[4], Frank Lechermann[4], •Jens Wiebe[1], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, Hamburg University, Germany — [2]Department of Physics and Astronomy, University of California Irvine, USA — [3]Instituto de Física, Universidade Fedeal Fluminense, Niterói, Brazil — [4]I. Institute for Theoretical Physics, Hamburg University, Germany

We have performed single-atom magnetization curve (SAMC) measurements [1] and inelastic scanning tunneling spectroscopy (ISTS) on Fe atoms adsorbed on a semiconducting [2] and a metallic substrate [3]. ISTS reveals magnetization excitations whose lifetime strongly depends on the type of substrate. In the semiconducter case the lifetime is relatively long. In the metallic case the lifetime decreases upon application of a magnetic field and the SAMCs show a broad distribution of magnetic moments. The experimental observations are quantitatively explained by the decay of the magnetization excitation into Stoner modes of the itinerant electron system as shown by newly developed theoretical modeling [3].

[1] F. Meier *et al.*, Science **320**, 82 (2008).
[2] A. A. Khajetoorians *et al.*, Nature **467**, 1084 (2010).
[3] A. A. Khajetoorians *et al.*, arXiv:1010.1284v2.

MA 40.5 Wed 16:00 CHE 184

Magnetism of ultrathin Fe layers on $BaTiO_3$(001) — •Remya Kunjuveettil Govind[1], Vasili Hari Babu[2], Federica Bondino[3], Marco Malvestuto[3], Martin Trautmann[1], Karl-Michael Schindler[1], and Reinhard Denecke[2] — [1]Institut fur Physik, Martin-Luther-Universität Halle-Wittenberg — [2]Wilhelm-Ostwald-Institut fur Physikalische und Theoretische Chemie, Universität Leipzig — [3]IOM CNR, Laboratorio Nazionale TASC, Area Science Park, Basovizza, Italy

Multiferroic systems are promising candidates for switching magnetization using voltages. Layered systems from ultrathin magnetic films on ferroelectric substrates are model systems. In this study ultrathin layers of Fe are deposited on a $BaTiO_3$(001) substrate and characterized by XPS, AES, NEAXFS and LEED. X-ray circular dichroism (XMCD) measurements in remanent magnetization show no magnetization for thicknesses up to 6 Å, in contrast to theoretical predictions [1]. From 8 to 28 Å, the XMCD spectra clearly show in-plane magnetization and the XMCD spectra look like bulk Fe. However, the dichroism is smaller and values for orbital and spin magnetic moments derived from a sum rule analysis are significantly smaller than bulk values. Possible reasons for this behavior, like partial oxidation of the Fe layer or non-uniform layer growth will be discussed.

[1] M. Fechner et al., Phys. Rev. B 78 (2008) 212406; M. Fechner et al., Phys. Stat. Sol. B 1 (2010) 8.

MA 40.6 Wed 16:15 CHE 184

Quantum-well-states in a copper/cobalt/copper hetero-structure — •Philipp Kloth[1], Martin Wenderoth[1], Henning Prüser[1], Alexander Weismann[2], and Rainer G. Ulbrich[1] — [1]IV. physikalisches Institut, Georg-August Universität Göttingen, 37077 Göttingen — [2]IEAP, Christian-Albrechts-Universität zu Kiel, 24098 Kiel

The morphological and electronic properties of a copper/cobalt/copper hetero-structure have been investigated by LEED, AES and STM/STS. We focus on the structural dependent electronic features, that could be observed for different preparation methods.

The samples are prepared and analyzed under UHV-conditions. Cobalt and copper films are deposited onto a (100)-copper single crystal by electron beam evaporation. The growth of both materials at room and LN2 temperature with a subsequent annealing step reveals different surface morphology. Furthermore a considerable diffusion between the interfaces takes place during the deposition process - even at low temperatures.

Due to the finite thickness of just a few monolayers the copper film on top of the sample exhibits the formation of quantum-well-states which can be identified by STS. The crossover to smoother hetero-structures

by growing at low temperatures leads to a change in the energetic behaviour of those states. This is explained by the anisotropic electron propagation of copper [1]. This work is supported by the SFB 602 TP A3.

[1] A. Weismann et al., Science 323, 1190 (2009)

MA 40.7 Wed 16:30 CHE 184

Observing the Spin of an Individual Mn_{12} Molecule — •Steffen Kahle[1], Zhitao Deng[1], Charlène Tonnoir[1], Nicha Thontasen[1], Gordon Rinke[1], Nikola Malinowski[1], Alicia Forment Aliaga[1], Stephan Rauschenbach[1], Markus Ternes[1], and Klaus Kern[1,2] — [1]MPI for Solid State Research, Stuttgart — [2]EPFL, Lausanne, Switzerland

The Mn_{12}-acetate$_{16}$ molecule (Mn_{12}) is considered a prototypical single molecular magnet (SMM) because its high spin measured in bulk is commonly attributed as spin of the individual molecules [1]. To confirm this we want to measure the spin of an individual Mn_{12} molecule.

We are able to gently deposit Mn_{12} molecules on different metal substrates by electrospray ion beam deposition [2]. STM images show intact and individual addressable molecules, which can be resolved with submolecular resolution.

Low temperature (1K) scanning tunneling spectroscopy on top of the molecule adsorbed on bare metal is featureless near E_F. This changes when we decouple the molecule from the metal adding a BN layer on the substrate before deposition. We now observe symmetric inelastic tunneling features around E_F in the range of a few mV, which is ascribed to spin flip excitations. The excitation is delocalized evenly over the whole molecule supporting the giant-spin model.

This proofs the existence of a molecular spin, thus confirming the SMM nature of individual Mn_{12} molecules on the surface.

[1] R. Sessoli *et. al.*, **Nature** 365, 141, (1993).
[2] N. Thontasen *et. al.*, **J. Phys. Chem. C** 114, 17768, (2010).

MA 41: Focus Session "Spins in Organic Materials II" (jointly with DS)

Time: Wednesday 15:45–16:45 Location: GER 37

Topical Talk MA 41.1 Wed 15:45 GER 37

Organic spintronics and the great potential of ferromagnetic metal-organic interfaces — •Martin Aeschlimann — Department of Physics, University of Kaiserslautern

The study of the spin properties of organic semiconductors (OSC) is recently receiving great attention. One of the most promising routes to employ them for spintronics applications is to exploit the high spin injection achievable across ferromagnetic metal-organic interfaces [1]. Combined with the extreme flexibility and tunability of OSC, it is expected that such hybrid interfaces will constitute a fundamental building block for advanced spintronics devices, where spin-injection is controlled by fine-tuning of the interface physical and chemical properties. An example has been recently presented in [2], where doping of the OSC copper phthalocyanine (CuPc) has been successfully used to tune the spin functionality of a cobalt-CuPc interface. In particular, the presence of a spin-polarized hybrid interface state, acting as a spin-filter at the interface, has been used to enhance the efficiency of spin injection to values above 100%. Besides the cobalt-CuPc interface, we have studied the iron-CuPc, cobalt-Tris(8-hydroxyquinolinato)aluminium (Alq3) and iron-Alq3 interfaces. The studies have been conducted by means of spin polarized scanning tunnelling microscopy and spectroscopy, spin-resolved ultraviolet photoemission spectroscopy and spin- and time-resolved two-photon photoemission.

[1] M. Cinchetti et al., Nature Materials 8, 115-119 (2009)
[2] M. Cinchetti et al., Phys. Rev. Lett. 104, 217602 (2010)

MA 41.2 Wed 16:15 GER 37

Investigation of the chemical and electronic structure of CoPc from monolayer to thick films by photoemission spectroscopy — •Uwe Treske, Mandy Grobosch, Feng Zhu, and Martin Knupfer — IFW - Dresden

In this work monolayers and multilayers of cobalt(II)phthalocyanine (CoPc) were analysed with respect to their chemical and electronical properties. The organic material was deposited under ultra high vacuum conditions on single crystalline Au(100) (5×20 reconstruction) and Ag(111) surfaces that were cleaned by Ar^+ bombardment and annealing cycles. The molecular ordering has been studied by low energy electron diffraction (LEED) and the morphology of thick films by scanning probe microscopy (AFM) that indicates a polycristalline growth.

The results of combined X-ray and ultraviolet photoemission spectroscopy (XPS, UPS) indicate clear differences in the valence band and Co2*p* core level spectra for mono- and multilayer due to charge transfer to the monolayer cobalt ion and a possible influence of image charge screening effects enhanced by the metal substrates. An additional interface state in the vicinity of the Fermi level was observed in the monolayer spectra.

MA 41.3 Wed 16:30 GER 37

Cobalt-Meq$_3$ (Me=Al, In, Ga) interface formation studied by spin- and time-resolved photoemission spectroscopy — •Nicolas Grossmann, Sabine Steil, Martin Laux, Andreas Ruffing, Indranil Sarkar, Mirko Cinchetti, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany

We have studied the formation of the interface between an epitaxially grown Co(001) thin film and the organic semiconductors tris(8-hydroxyquinoline)aluminium(III) (Alq$_3$), tris(8-hydroxyquinoline)gallium(III)(Gaq$_3$) and tris(8-hydroxyquinoline) indium(III)(Inq$_3$). The organic semiconductors were progressively grown on the cobalt substrate up to a coverage of 5 monolayers. The grown interfaces have been characterized by means of spin-resolved ultraviolet photoemission spectroscopy and spin- and time-resolved two-photon photoemission spectroscopy. For every growth step we have monitored the changes in the work function, the energetic position of the occupied and unoccupied molecular orbitals and interface states, and the changes in the cobalt spin polarization induced by interface formation. In addition, we have measured the spin-resolved lifetime of unoccupied hybrid interface states. The results will be discussed with focus on the relevance of spin-polarized hybrid interface states on the sign of the magnetoresistance observed in organic spin valves based on Alq$_3$ [1].

[1] V. A. Dediu, et al., Nature Mater. 8, 707 (2009);

MA 42: Topological Insulators (jointly with TT, HL)

Time: Wednesday 16:45–19:15 Location: HSZ 04

MA 42.1 Wed 16:45 HSZ 04

Complex spin structure of the topological insulator Bi_2Te_3(0001) — •Jürgen Henk[1], Arthur Ernst[1], Sergey V. Eremeev[2], and Evgueni V. Chulkov[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Donostia International Physics Center, San Sebastian, Spain

Topological insulators — like Bi_2Te_3(0001) — show a unique surface electronic structure. A model Hamiltonian [1] describes well the anisotropic dispersion of the Dirac state, as is evident from agreement with photoemission experiments (e. g. [2]). The spin of the Dirac state shows a circular arrangement in the momentum distribution, even in the presence of warping.

We prove by relativistic first-principles calculations that the spin structure of the Dirac state in Bi_2Te_3(0001) is much more complicated than that derived from model calculations. First, all three spin components at the top Te layer are reversed with respect to those in the subsurface layers, and, second, the circular spin structure is de-

stroyed at the cusps of warped momentum distributions, showing a vortex-like structure. Our findings are explained by hybridization of p orbitals in the topmost quintuple layer and may have implications for spintronic applications.

[1] L. Fu, Phys. Rev. Lett. **103** (2009) 266801.
[2] D. Hsieh et al, Phys. Rev. Lett. **103** (2009) 146401.

MA 42.2 Wed 17:00 HSZ 04

Thermal and structural stability of the topological state on Bi_2Se_3 — •Dandan Guan[1,2], M. Bianchi[1], R. C. Hatch[1], S. Bao[2], J. Mi[3], B. B. Iversen[3], and Ph. Hofmann[1] — [1]Department of Physics and Astronomy, Aarhus University, Denmark — [2]Department of Physics, Zhejiang University, Hangzhou, China — [3]Department of Chemistry, Aarhus University, Denmark

Topological insulator surfaces have recently attracted considerable attention, not least because they are predicted to play host to many novel physical phenomena. The topological states are also thought to have possible applications in (spin) transport, since they are not only protected from back-scattering, their very existence can be viewed as a bulk property. This implies that minor surface modifications can change the detailed dispersion of the topological state, but not remove it altogether.

We investigate the thermal and structural stability of the topological state on Bi_2Se_3 using angle resolved photoemission spectroscopy. The electron-phonon coupling strength is obtained through measurements of the temperature-dependent self-energy and the resulting λ value is compared to the bulk and to other surface-localized states. The structural stability is tested by surface modifications through noble gas ion bombardment.

MA 42.3 Wed 17:15 HSZ 04

Does magnetism destroy the Dirac state in a topological insulator? — Arthur Ernst[1], •Jürgen Henk[1], Evgueni V. Chulkov[2], Igor V. Maznichenko[3], and Ingrid Mertig[3] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Donostia International Physics Center, San Sebastian, Spain — [3]Martin Luther University Halle-Wittenberg, Halle, Germany

A striking feature of topological insulators is that the Dirac states are protected by topology. However, how robust are these surface states against perturbations really? Given the prescribed spin structure of the Dirac state, one may ask whether magnetism destroys this state or — at least — modifies its spin-resolved dispersion.

To answer the above question we have investigated theoretically the topological insulator $Bi_2Te_3(0001)$ by means of relativistic *ab initio* calculations. The Bi atoms in the topmost quintuple layer form a substitutional alloy with Mn (i. e. $Bi_{1-c}Mn_c$) that is described within the coherent potential approximation. We find significant modificiations of the Dirac state in dependence of the Mn concentraction c and on the orientation of the Mn magnetic moments.

MA 42.4 Wed 17:30 HSZ 04

Surface electronic structure and surface state topology of Sb(110). — •Marco Bianchi[1], D. Guan[1,2], A. Strozecka[3], C.H. Voetmann[1], J. I. Pasqual[3], S. Bao[2], and Ph. Hofmann[1] — [1]Inst. Fysik og Astronomi Aarhus Universitet, Aarhus, Denmark — [2]Dep. of Physics, Zheijang University, Hangzhou, China — [3]Fachbereich Physik, Freie Universität Berlin, Berlin, Germany

Topological insulators are a recently discovered class of materials where the bulk is insulating while fundamental topological considerations require the surfaces to be metallic. The first experimentally confirmed topological insulator was the intermetallic alloy $Bi_{1-x}Sb_x$ ($0.09 < x < 0.18$). This topological insulator phase owes its existence to important changes in the band structure as the two semimetals are alloyed. Theoretical predictions based on the topological character of the bulk electronic structure agree with measurements on the alloy and also predict pure Sb to be a strong topological insulator. On the other hand, the electronic structure of the Bi surfaces, while being very similar to that of the alloy, appears to be consistent with that of a topologically trivial material.

We report on an experimental investigation of the Sb(110) electronic structure combining scanning tunnelling microscopy with angle-resolved photoemission. The topological character of the surface states can be inferred from the number of Fermi level crossings between time-reversal invariant momenta in the surface Brillouin zone. This surface topology is compared to that of Bi(110), Sb(111) and the theoretical predictions.

MA 42.5 Wed 17:45 HSZ 04

Topological insulators in ternary compounds with a honeycomb lattice — •Stanislav Chadov[1], Jürgen Kübler[2], and Claudia Felser[1] — [1]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg Universtität, 55099 Mainz — [2]Institut für Festkörperphysik, Technische Universität Darmstadt, 64289 Darmstadt

Based on electronic structure calculations we propose the certain extension to the class of the topological insulators which provide the convenient material base to realize the phenomenon of quantum spin Hall effect intensively studied nowadays. These new candidates (e. g. LiAuSe, KHgSb) are ternary semiconductors with a weakly coupled honeycomb layers (e. g. Au-Se, Hg-Sb) analogical to a weakly graphite sheets. It makes them very similar to graphene which is a single layer of graphite: their band structures exhibit the so-called linearly dispersive Dirac cone centered at the Fermi energy. However, in contrast to graphene with two Dirac cones at K and K' points, these materials exhibit the surface states formed by only a single Dirac cone at the Γ point, allowing for the non-vanishing quantum spin Hall effect. The additional stuffing" elements (Li, K, etc.) extend the material multifunctionality, i. e. give more possibilities for tuning and coupling of their properties. In contrast to other topologically non-trivial systems, as e. g. recently proposed half-Heuslers, the honeycomb compounds possess the non-zero band gap in the bulk, i. e. provide the "natural" 3D topological materials.

MA 42.6 Wed 18:00 HSZ 04

Thallium-based topological insulators from first principles — •Gustav Bihlmayer[1], Sergey V. Eremeev[2], Stefan Blügel[1], and Eugene V. Chulkov[3] — [1]Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, Jülich, Germany — [2]Institute of Strength Physics and Materials Science, Tomsk, Russia — [3]Donostia International Physics Center (DIPC), San Sebastián, Spain

Currently, there is a substantial interest in topological insulators, which show protected edge-states carrying dissipationless spin currents. Among the new classes of these materials the Tl-based compounds $TlAB_2$ (A=Bi,Sb; B=Se,Te) have attracted considerable interest both on the experimental and theoretical side. We present density functional theory calculations of the bulk materials and their (111) surfaces, displaying protected Dirac-cone shaped surface states together with "trivial" surface states. In contrast to layered materials like Bi_2Te_3, these compounds are of more three-dimensional character. From the bulk calculations we observe a strong sensitivity of the topological properties on the structural details, that have to be described very accurately. In the surface calculations deeply penetrating Dirac-cone states are observed, calling for careful convergence of the calculations with respect to the film thickness. Similar materials, e.g. the sulfides and $InAB_2$ compounds will be discussed for comparison.

MA 42.7 Wed 18:15 HSZ 04

Electronic structure of the topological semiconductors PtYSb, PtLaBi, and PtGdBi explored by hard X-ray photoelectron spectroscopy. — •Siham Ouardi[1], Shekar Shandra[1], Gerhard H. Fecher[1], S. Chadov[1], X. Kozina[1], G. Stryganyuk[1], C. Felser[1], S. Ueda[2], and K. Kobayashi[2] — [1]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg Universtität, 55099 Mainz — [2]National Institute for Materials Science, SPring-8, Hyogo, Japan

One of the recent topics in spintronics is the realization of the so-called topological insulators, that are insulators in the bulk and gapless semiconductors at the surface. Besides the well-known wide range of properties of the Heusler family it was recently shown that many of the heavy Heusler semiconductors with 1:1:1 composition and $C1_b$ structure are zero band-gap insulators and exhibit a inverted band structure. The density of states of several compounds was investigated by bulk sensitive hard X-ray photoelectron spectroscopy. First experimental results on PtYSb, PtLaBi, and PtGdBi give clear evidence for the zero band-gap state. Their structural, spectral and transport characteristics will be compared to calculations.

MA 42.8 Wed 18:30 HSZ 04

Tolerance of topological surface state towards adsorbed magnetic moments: Fe on Bi_2Te_3 — •Markus Scholz[1], Dmitry Marchenko[1], Jaime Sanchez-Barriga[1], Andrei Varykhalov[1], Andrei Volykhov[2], Lada Yashina[2], and Oliver Rader[1] — [1]Helmholtz-Zentrum für Materialien und Energie, Berlin, Deutschland

— [2]Moscow State University, Moskau, Russland

Topological surface states on Bi_2Se_3 and Bi_2Te_3 are protected by time reversal symmetry [1]. Magnetic fields break time-reversal symmetry, and they have been used in two-dimensional spin quantum-Hall systems to destroy the topological edge states [2]. Another possibility is to introduce magnetic moments. This has been done by substitution of Mn and Fe into the bulk [3][4]. For Fe a small gap of 44meV was created, however, at very large amounts (12%). In this work, we deposit Fe directly onto the surface where the topological surface state is localized. We show for coverages of 0.25 and 1 ML Fe that the Dirac point remains intact and no gap appears. Core level spectroscopy of Bi and Te states gives insight into the interaction between substrate and adatoms. In addition, extra surface states appear at the Fermi energy which show a large Rashba-type spin-orbit splitting. The orientation of the spin of both, the topological as well as the Rashba-type split surface states is analysed. [1] Kane and Mele, Phy. Rev. Lett 95, 146802 (2005); Liang Fu et al., Phys. Rev. Lett. 98, 106803 (2007) [2] König et al.,Science 318, 5851 (2007) [3] Hsieh et al., Phys. Rev. Lett. 103, 146401 (2009) [4] Chen et al., Science 329, 5992 (2010)

MA 42.9 Wed 18:45 HSZ 04

Rashba-type surface emission observed on W(110) — •Juergen Braun[1], Jan Minar[1], Akio Kimura[2], Koji Miyamoto[2], Markus Donath[3], and Hubert Ebert[1] — [1]Department Chemie, LMU München, Germany — [2]Graduate School of Science, Hiroshima University, Higashi-Hiroshima, Japan — [3]Physikalisches Institut, Universität Münster, Germany

In this contribution we discuss surface related spectral features of bcc W(110) by means of angle- and spin-resolved photoemission. For more than thirty years Tungsten serves as a prototypical material for studying spin-orbit effects in simple metals. Also, it is used for a quite long time in electron polarimeters [1]. Nevertheless, there still remain some pecularities in its electronic structure concerning surface emission. It is known that a surface resonance exists on W(110) dispersing around $\overline{\Gamma}$ in the vicinity of the Fermi level [2]. But not much is understood concerning surface emission for higher binding energies. From our investigation we found that surface emission dominates the $E(\mathbf{k}_\parallel)$ intensity distribution measured along $\overline{\Gamma N}$. The spin analysis reveals a Rashba-like behavior for features related to the spin-orbit induced symmetry gap existing at $\overline{\Gamma}$. The theoretical analysis has been performed in the framework of the fully relativistic version of the one-step model of photoemission [3].

1. J. Kirschner, Polarized electrons at surfaces, Springer, Berlin (1985). 2. R. H. Gaylord et al., PRL 62, 2036 (1989). 3. H. Ebert et al., The Munich SPR-KKR package, version 5.4, http://olymp.cup.uni-muenchen.de/ak/ebert/SPRKKR (2010).

MA 42.10 Wed 19:00 HSZ 04

Wave-packet transport in HgTe — •Viktor Krueckl and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

Recent experiments have shown the Quantum Spin Hall State in mercury telluride quantum wells and the associated edge channel transport at zero external magnetic field [1]. We employ a four band model to investigate the propagation of such topological edge state wave-packets in the gap, as well as bulk states in the conducting region. Our recently developed algorithm is able to solve the time-dependent scattering problem for arbitrary scattering potentials and gives revealing insight into the occurring edge phenomena. The obtained time evolution of the wavefunction is used to calculate the complete energy dependent scattering matrix for a time-independent Hamiltonian. With this we investigate the transport in different mesoscopic setups and are particularly interested in the scattering of edge states at constrictions.

[1] A. Roth, C. Brüne, H. Buhmann, L. W. Molenkamp, J. Maciejko, X.-L. Qi and S.-C. Zhang, Science **325**, 294 (2009)

MA 43: Micro- and Nanostructured Magnetic Materials IV

Time: Wednesday 17:00–19:00 Location: HSZ 103

MA 43.1 Wed 17:00 HSZ 103

Domain wall resistance between artificial domains created in exchange coupled bilayers by keV He ion bombardment induced magnetic patterning — •Christoph Schmidt, Dieter Engel, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Ion bombardment induced lateral magnetic patterning (IBMP) has been used to generate different magnetic patterns (artificial domains) in an exchange bias bilayer system without changes in the surface topography. This technique enables to create adjacent areas with designed magnetization directions stable in remanence. Within the same layer system it is possible to create Bloch or Néel walls. Corresponding magnetical stripe patterns were analyzed by magnetic force microscopy and Kerr microscopy. Magnetoresistance measurements were performed to investigate the domain wall resistance (DWR) at room temperature and low temperatures.

MA 43.2 Wed 17:15 HSZ 103

Domain wall movement assisted transport of superparamagnetic particles on magnetically patterned samples — •Daniel Lengemann, Florian Göllner, Dieter Engel, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

By 10 keV He-ion bombardment IrMn/CoFe exchange biased layers were patterned magnetically into stripes with alternating anisotropy directions. In remanence superparamagnetic particles were deposited onto the Bloch domain walls. The domains of the sample have different magnetization reversal mechanisms in an external magnetic field for each hysteresis loop branch: In the branch towards saturation the reversal is dominated by domain wall movement, in the branch towards remanence domain nucleation and coherent rotation are dominant.

With these mechanisms the particles move due to domain wall movement while no movement is seen for the domain nucleation and rotation. With controlling the x- and the z-direction of the pulsed external field, the direction of the particle movement can be defined.

MA 43.3 Wed 17:30 HSZ 103

Beyond a compact magnetic domain wall — •Philipp Eib, Carl Zinoni, Antoine Vanhaverbeke, Gian Salis, Andreas Bischof, and Rolf Allenspach — IBM Research - Zurich, Säumerstrasse 4, 8803 Rüschlikon, Switzerland

The generally accepted concept that limits magnetic domain wall velocity is the Walker breakdown: It determines the magnetic field at which the wall motion becomes turbulent [1]. This sets an upper limit on the performance of domain wall-based spintronic devices.

To understand the limiting mechanisms, we study domain wall dynamics in $Ni_{80}Fe_{20}$ wires with widths between 300 and 900 nm. A time-resolved magneto-optical Kerr effect setup with pump-probe technique is used to detect the moving walls. The wires are fabricated by electron-beam lithography and our nanostencil tool [2].

We find the dynamics of vortex walls to depart significantly from the current description of a compact entity evolving along the wire; instead, the wall is composed of several substructures, each one propagating and evolving in a different dynamic regime with very different velocities. Extensive, parallelized micromagnetic simulations reveal the unusual wall structure and complement the experimental findings. From the insight gained into this complex dynamics we discuss possibilities how to overcome the limits imposed by the Walker breakdown.

[1] R. Cowburn and D. Petit, *Nature Mater.* **4**, 721 (2005)

[2] L. Gross, R. R. Schlittler, G. Meyer, and R. Allenspach, *Nanotechnology* **21**, 325301 (2010)

MA 43.4 Wed 17:45 HSZ 103

Magnetoresistance and thermopower measurements of an individual ferromagnetic metallic nanowire — •Corinna Steinweg[1,2], Harald Austenfeld[1], Saskia F. Fischer[2], William Töllner[3], and Kornelius Nielsch[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Novel Materials, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [3]Multifunctional Nanostructures, Universität Hamburg, 20355 Hamburg, Germany

We investigate individual Au-Ni/NiO-Au nanowires to determine magnetotransport properties and the thermopower. The electrochemically deposited Ni nanowire has in situ deposited Au endings to enable low-ohmic contacts. The nanowire is placed on a Si/SiO2 substrate, and the contacts are structured by optical lithography, metal evaporation and a lift off process. The measured resistivity of 7.46 $\mu\Omega$cm of the nanowire is significantly lower than that measured for nanowires with contacts made by electro thermal annealing [1]. The temperature-dependence of the anisotropic magnetoresistance yields switching fields which are in agreement with predictions by the curling mode magnetization reversal of an infinite cylinder [2]. With an additional heating wire we achieve a temperature difference of 1.2 K at 300 K along the ends of the wire. We measure a voltage drop at the ends of the wire as a function of the heating power, e.g., 2.84 μV at 12 mW.

[1] E. Shapira, et al., Nanotechnology 18, 485703 (2007). [2] W. Wenrsdorfer, et al., Phys. Rev. Lett. 77, 9 (1996).

MA 43.5 Wed 18:00 HSZ 103

Fabrication and investigation of regular arrays of Fe, Ni and Co nanowires using template synthesizing technique — •Nina Winkler, Yong Lei, and Gerhard Wilde — Institute of Materials Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany

Regular arrays of magnetic nanowires with a high aspect ratio have possible applications in high density magnetic recording media. Basic knowledge about magnetism may be obtained from these nanowire arrays as transition of multi-domain to single-domain wires occurs at the nanoscale. Modified Porous Alumina Membranes (PAMs) with pore diameters from 20 to 80 nm are well suited as templates for electrodeposition due to their high pore regularity. The pores of the PAM were filled with nickel, iron, cobalt, and multilayer structures of these metals, resulting in different metallic nanowire arrays. The deposition conditions for growing metallic nanowires are investigated in detail. The homogeneous structure and morphology of the template-prepared nanowire arrays is observed by SEM and TEM. The TEM and X-ray measurements indicate that the crystalline structure is either polycrystalline or amorphous depending on the deposition conditions. The magnetic properties of the nanowire arrays are investigated with vibrating sample magnetometry , which shows a preferential direction of magnetization along the wire axis due to the high aspect ratio of the nanowires. The wire interaction in the array is observed qualitatively with magnetic force microscopy.

MA 43.6 Wed 18:15 HSZ 103

An individual iron nanowire-filled carbon nanotube probed by micro-Hall magnetometry — •Stefan Bahr[1], Kamil Lipert[1,2], Franziska Wolny[1], Paola Atkinson[1], Uhland Weissker[1], Thomas Mühl[1], Oliver G. Schmidt[1], Bernd Büchner[1], and Rüdiger Klingeler[2] — [1]Leibniz Institute for Solid State and Materials Research IFW, 01069 Dresden, Germany — [2]Kirchhoff Institute for Physics, INF 227, D-69120 Heidelberg, Germany

We report on the magnetic properties of an individual, high-quality single-crystalline iron nanowire with diameter d=26 nm. The nanowire is embedded in a carbon nanotube which provides complete shielding against oxidation.

The magnetic properties are investigated by micro-Hall magnetometry which has a potential sensitivity of up to $10^4\mu_B$. We use a two-dimensional electron gas confined in an n-type GaAs/AlGaAs modulation doped heterostructure 90 nm below the surface to measure the magnetic stray fields of our individual iron nanowire.

Magnetization reversal of the individual iron nanowire is associated with domain wall formation where domain nucleation is initiated by curling. The observed nucleation fields of up to 900 mT at low temperatures are much higher than reported previously and nearly reach the shape anisotropy field of iron nanowires.

MA 43.7 Wed 18:30 HSZ 103

Quantum oscillations and ferromagnetic hysteresis observed in iron filled multiwall carbon nanotubes — •Jose Barzola-Quiquia[1], Niko Klingner[1], Axel Molle[1], and Albrecht Leonhardt[2] — [1]Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig, Germany — [2]Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany

Carbon-based materials as multiwall carbon nanotubes (MWCNT) are attractive for spintronics because spin is only weakly coupled to the lattice, leading to large spin-flip scattering length and long spin relaxation times. In this contribution we have investigated the electrical transport properties of iron filled MWCNT (outer diameter 150 nm, inner diameter 25 nm and length 2000 nm) as a function of temperature and magnetic field. We observed quantum interference effects, i.e. universal conductance fluctuations, and weak localization effects. The in-plane magnetoresistance shows typical butterfly structure revealing the ferromagnetic properties of the Fe-filled MWCNT. The ferromagnetic hysteresis was observed up to 40K.

MA 43.8 Wed 18:45 HSZ 103

Examination of the Switching Field Distribution (SFD) and the shape anisotropy constant of nickel nanorods — •Florian Krämer, Philipp Bender, Andreas Tschöpe, and Rainer Birringer — Universität des Saarlandes, Saarbrücken

Nickel nanorods with diameters $D < 64$nm and aspect ratios $n > 3$ are expected to be uniaxial ferromagnetic single domain particles. The most simple approach to estimate their magnetic behavior is the Stoner-Wohlfarth-Modell (SWM), where magnetic reversal of ellipsoidal particles is assumed to occur by delocalized coherent rotation. However measurements of Ni nanorods show that their coercivity is significantly smaller than predicted by the SWM. There are two possible explanations for this discrepancy: first, a reduced shape anisotropy constant, and second, deviations from the proposed delocalized coherent rotation.The objective of this work was to study the magnetism of Ni nanorods with varying geometry ($D = 12 - 22$ nm, $n > 5$), in terms of their switching field distribution and shape anisotropy constant.The Ni nanorods were synthesized by current-pulsed electrodeposition of Ni into hexagonally ordered porous alumina templates. The nanorods were released from the templates by dissolution of the alumina in aqueous NaOH and dispersed in gelatine solutions (10 wt% gelatine) at 60 °C. Applying an external homogenous magnetic field during gelation enables the preparation of magnetically textured ferrogels with negligible dipolar interaction between the rods.The shape anisotropy constant and SFD's of the nanorods were determined from static magnetization measurements of the uniaxial ferrogels.

MA 44: Magnetic Half-metals and Oxides I

Time: Wednesday 17:00–19:15 Location: HSZ 401

MA 44.1 Wed 17:00 HSZ 401

Giant Nonlinear Faraday Effect in the Ferromagnetic Semiconductor EuO — •Masakazu Matsubara[1], Andreas Schmehl[2], Jochen Mannhart[2], Darrell Schlom[3], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn, Germany — [2]Institut für Physik, Universität Augsburg, Germany — [3]Department of Materials Science and Engineering, Cornell University, USA

Faraday's discovery in 1846 of magnetically induced optical activity has constituted the first conclusive demonstration of the intimate connection between magnetism and light. Since then this so-called Faraday effect and other magneto-optical effects have been playing a vital role in modern technology. It became important to find new materials or novel mechanisms with magneto-optical effects as large as possible.

Here we report the experimental observation of nonlinear Faraday effect (NFE) in optical third-harmonic generation (THG) process and a demonstration of the giant enhancement of the NFE in epitaxial film of the ferromagnetic semiconductor EuO. The NFE in THG process is caused by the magnetization-induced term of the third-order optical polarization. We investigated the NFE by the temperature-, magnetic field-, and spectral-dependent measurements and show that the large NFE occurs at $4f^7 \rightarrow 4f^6 5d^1(t_{2g})$ transitions of Eu^{2+}. It is shown that the NFE can be much larger than linear Faraday effect and its polarization rotation ability exceeds 10^7 deg/cm in EuO.

This work was supported by the Alexander von Humboldt Foundation.

MA 44.2 Wed 17:15 HSZ 401

Magnetic Oxides EuO and $NiFe_2O_4$ for Spintronics. — •Christian Caspers[1], M. Müller[1], A. Gray[2], S. Döring[3], A. Kaiser[2], R. Dittmann[4], C. Westphal[3], C. S. Fadley[2], and C. M. Schneider[1] — [1]Inst. für elektronische Eigenschaften (IFF-9), FZ Jülich — [2]Dept. of Physics, UC Davis, USA — [3]Exp. Physik I, TU Dortmund — [4]Inst. für elektronische Materialien (IFF-6), FZ Jülich

Magnetic oxides provide the rare combination of electrical insulation and ferromagnetism and—prepared as thin films—are well-suited as tunnel barriers in efficient spinfilters. We optimize thin films of EuO and $NiFe_2O_4$ in crystal structure, magnetic and electronic properties. EuO thin films were prepared using an oxide MBE system. EuO single-crystalline thin films can be grown epitaxially on MgO and lattice-matched YSZ substrates, where on the latter a sustained layer-by-layer growth was achieved. A meticulous regulation of the oxygen supply renders EuO thin films possible ($t_{\mathrm{EuO}} \geq 20\,\mathrm{nm}$) with bulk-like magnetization $m_{\mathrm{sat}} = 7\mu_{\mathrm{B}}$ and $T_{\mathrm{C}} = 69\,\mathrm{K}$. The chemical states of EuO on silicon were studied in detail by HAXPES which clearly confirmed the high stoichiometric quality of EuO. The room temperature ferromagnetic spinel $NiFe_2O_4$ (NFO) was prepared by pulsed laser deposition (PLD). The chemical oxidation states and site occupancy (octahedral vs. tetrahedral) of the metal cations (Ni, Fe), investigated by Core-level XPS experiments, determine the magnetic behavior of NFO. In our $NiFe_2O_4$ samples exhibit $m_{\mathrm{sat}} = 1.2\mu_{\mathrm{B}}$. Magnetic oxides EuO and $NiFe_2O_4$ with high-quality magnetic, structural and chemical properties were prepared to be exerted as tunnel barriers in spinfilters.

MA 44.3 Wed 17:30 HSZ 401

Cation energetics in epitaxially strained inverse spinel ferrites $CoFe_2O_4$ and $NiFe_2O_4$ — •Daniel Fritsch and Claude Ederer — School of Physics, Trinity College Dublin, Ireland

Inverse spinel ferrites $CoFe_2O_4$ (CFO) and $NiFe_2O_4$ (NFO) are both insulating ferrimagnetic oxide materials with high magnetic ordering temperature and large saturation magnetisation which make them very attractive for a variety of applications. Many of these applications require the corresponding materials to be grown on lattice-mismatched substrates which can incorporate significant amounts of strain in the thin films. It has been shown that density functional theory (DFT) calculations together with the Hubbard "+U" approach provide reliable insight in strain-induced changes of the structural and magnetic properties of these materials [1].

The degree of inversion λ in spinel materials describes the concentration of divalent cations (Co^{2+}, Ni^{2+}) on the octahedrally coordinated B-sites. While for bulk NFO the inversion is essentially complete, i.e., $\lambda = 1$, for CFO the degree of inversion can depend strongly on the specific preparation conditions and is typically around 0.7 .. 0.8. We present DFT total energy calculations for CFO and NFO with different degrees of inversion and different amounts of epitaxial strain. We address the question of whether epitaxial strain can influence the degree of cation inversion in these materials, and compare our results with available experimental data.

[1] D. Fritsch and C. Ederer, Phys. Rev. B **82**, 104117 (2010).

MA 44.4 Wed 17:45 HSZ 401

Spin-states in the single-layered cobaltates — •Dirk Fuchs[1], Michael Merz[1], Levin Dieterle[3], Stefan Uebe[1,2], Markus Wissinger[1,2], Andrea Assmann[1,2], Peter Nagel[1], Rudolf Schneider[1], Stefan Schuppler[1], Dagmar Gerthsen[3], and Hilbert v. Löhneysen[4] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, Karlsruhe, Germany — [2]Karlsruher Institut für Technologie, Fakultät für Physik, Karlsruhe, Germany — [3]Karlsruher Institut für Technologie, Laboratorium für Elektronenmikroskopie, Karlsruhe, Germany — [4]Karlsruher Institut für Technologie, Physikalisches Institut, Karlsruhe, Germany

The delicate balance between the crystal-field (CF) splitting and Hund's rule coupling results in different possible spin-states - high-spin, low-spin (LS) and intermediate-spin state - of the Co ion and thus in an additional degree of freedom in the cobaltates. Since the CF splitting is very sensitive to hydrostatic, chemical or epitaxial pressure the cobaltates provide large playground for artificial spin-state manipulation. For example, epitaxial tensile strain is able to suppress a low-temperature spin-state transition to a LS-state in $LaCoO_3$ films [1]. Therefore, it is very likely that the spin blockade in the layered cobaltates can be suppressed by tensile strain of the CoO_2 layers too. With respect to this, the influence of chemical and epitaxial pressure on the spin-state of $La_{2-x}A_xCoO_4$ (A = Ca, Sr or Ba) cobaltates was investigated. Bulk samples as well as thin films were prepared and the structural and magnetic properties were characterized in detail.

[1] D. Fuchs et al. Phys. Rev B 75, 144402 (2007).

MA 44.5 Wed 18:00 HSZ 401

Structural distortions and the nature of metal-insulator transition in ferromagnetic hollandite $K_2Cr_8O_{16}$ — •Alexey Ushakov[1], Sergey Streltsov[2], Toriwaki Toriyama[3], Toshiki Konishi[4], Yukinori Ohta[3], Akiko Nakao[5], Hironori Nakao[5], Masahiko Isobe[6], Yutaka Ueda[6], and Daniil Khomskii[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Strae 77, D-50937 Köln, Germany — [2]Institute of Metal Physics, S.Kovalevskoy St. 18, 620041 Ekaterinburg GSP-170, Russia — [3]Department of Physics, Chiba University, Chiba 263-8522, Japan — [4]Graduate School of Advanced Integration Science, Chiba University, Chiba 263-8522, Japan — [5]Inst. Mat. Struct. Science, Photon Factory, Tsukuba, Ibaraki 305-0801, Japan — [6]Materials Design and Characterization Laboratory, Institute for Solid State Physics, University of Tokyo, Kashiwa 277-8581, Japan

It was recently discovered (K.Hasegawa et al. Phys.Rev.Lett.103, 146403 (2009)) that the ferromagnetic chromium hollandite $K_2Cr_8O_{16}$ experiences metal-insulator transition (IMT) at $T_{IMT} = 90\ K$, with the retention of ferromagnetism. The nature of this transition remained unclear. Detailed structural investigation demonstrated that there occurs at this transition a structural transition from the tetragonal $I4/m$ to monoclinic $P21/a$ phase, with the appearance of dimerization – inequivalent Cr-Cr distances, but without any charge ordering. By ab-initio band structure calculations, using different methods, we propose that IMT in $K_2Cr_8O_{16}$ is caused by a Peierls-like dimerization in one-dimensional "columns" made of four coupled Cr chains.

MA 44.6 Wed 18:15 HSZ 401

XMCD study of Ir based double perovskite $La_{2-x}Sr_xCoIrO_6$ — •Anastasiya Kolchyns'ka[1], Philipp Komissinskiy[1], Daria Mikhailova[1,2], Naren Narayanan[1,2], Helmut Ehrenberg[2], Fabrice Wilhelm[3], and Lambert Alff[1] — [1]Institute of Materials Science, Technische Universität Darmstadt, Germany — [2]Institute of Complex Materials, IFW Dresden, Germany — [3]ESRF, ID-12, Grenoble, France

Double perovskites $La_{2-x}Sr_xCoIrO_6$ with $0 \leq x \leq 2$ were studied by X-ray Magnetic Circular Dichroism (XMCD). Neutron scattering has revealed a canted antiferromagnetic order of the Co ions [1]. Only by XMCD the magnetic moments within the Ir sublattice could be determined: For $x = 0$ we observe a magnetization on the Ir site of about $0.2\,\mu_{\mathrm{B}}$ which is coupled antiferromagnetically to the residual Co magnetization. This indicates a kinetically driven induced magnetism at the Ir site similar as in compounds such as Sr_2CrOsO_6 [2]. With increasing Sr content x, the induced magnetic moment decreases and finally vanishes for $x = 2$.

[1] N. Narayanan *et al.*, Phys. Rev. B **82**, 024403 (2010). [2] Y. Krockenberger *et al.*, Phys. Rev. B **75**, 020404(R) (2007).

MA 44.7 Wed 18:30 HSZ 401

Resistive switching in nanocolumnar manganite thin films — •Christin Kalkert, Jon-Olaf Krisponeit, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I. Phys. Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The phenomenon of resistive switching, observed in a number of perovskite materials, has the potential of creating new resistive random access memory devices. Here we report the resistive switching effect in the $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) manganite.

We prepared LSMO thin films by using the metalorganic aerosol deposition technique on sapphire substrates. On these substrates the manganite films show a columnar growth as determined by x-ray diffraction and TEM analysis. The films were characterized by electric and magnetic measurements and structured by means of electron beam lithography and argon etching. The structures consist of μm-sized LSMO-bridges with LSMO contact areas on both sides of the bridge. On these contact areas we deposited Cr/Au contact pads via a lift-off process. The obtained structures show a bipolar resistive switching effect, which we discuss in terms of a local structural transformation at the grain boundaries between the individual nanocolumns.

Financial support by DFG via SFB 602, TPA2 and the Leibniz Program is acknowledged.

MA 44.8 Wed 18:45 HSZ 401

Resistive switching on $La_{0.8}Ca_{0.2}MnO_3$ films: nanoscale and time evolution studies of conductively switched domains — •Jon-Olaf Krisponeit, Christin Kalkert, Bernd Damaschke, Vasily Moshnyaga, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The resistance behavior of perovskite manganites comprises a variety of interesting phenomena, reflecting the complexity of their microscopic constituents and the strong correlations among them. In addition to the temperature- and magnetic-field-induced metal-insulator transition (colossal magnetoresistance), manganites also exhibit a resistance switching driven by electric fields.

We have performed scanning force microscopy measurements (AFM) with conductively coated probes on a $La_{0.8}Ca_{0.2}MnO_3$ thin film and observed a bipolar switching behavior with a sharp threshold voltage. Current maps reveal nanoscale conducting domains which evolve in time and space under applied electric field.

We present a phenomenological model to describe the effect in terms of a local structural transition. An analysis of the growth behavior of the metallic regions during the voltage pulse further supports this scenario.

Acknowledgement: The work is supported by DFG via SFB 602, TP A2 and the Leibniz program.

MA 44.9 Wed 19:00 HSZ 401

YBCO/LCMO bilayers: Interface coupling and electric transport properties — •Christoph Raisch[1], Robert Werner[2], Adele Ruosi[3], Bruce Davidson[4], Mathias Glaser[1], Reinhold Kleiner[2], Dieter Koelle[2], and Thomas Chassé[1] — [1]Institut für Physikalische Chemie, Uni Tübingen, Germany — [2]Physikalisches Institut, Experimentalphysik II, Uni Tübingen, Germany — [3]CNR-SPIN and Dept. of Physics, University of Naples Federico II, Italy — [4]CNR-IOM TASC National Laboratory, Basovizza, Trieste, Italy

We studied bilayers of $La_{0.7}Ca_{0.3}MnO_3$ (LCMO) and $YBa_2Cu_3O_7$ (YBCO) [1]. We investigated the unoccupied electronic structure by X-ray Absorption Spectroscopy (XAS), the magnetization of Mn and Cu species by X-ray Magnetic Circular Dichroism (XMCD) and the orbital occupation of the transition metal atoms by Linear Dichroism (LD) measurements. While we could reproduce earlier XMCD data and their temperature dependence [2], we could not find any evidence for charge transfer across the interface or orbital reconstruction on copper [3]. The results of our transport measurements indicate a suppression of the superconducting transition temperature only below a YBCO film thickness of 5nm. This hints to an electronically less transparent interface, probably due to a stronger hybridization between Mn and Cu via O at the interface. From the analysis of our data, we conclude that covalent bonding and the resulting orbital reconstruction are not necessary for the spin canting of Cu moments in proximity to Mn spins. [1] Werner, PRB, accepted, [2] Chakhalian, Nature Physics 2, [3] Chakhalian, Science 318

MA 45: Micromagnetism/ Computational Magnetics

Time: Wednesday 17:30–19:00 Location: HSZ 403

MA 45.1 Wed 17:30 HSZ 403

Pinning of domain walls in exchange-spring composite media — •Dagmar Goll[1] and Helmut Kronmüller[2] — [1]Aalen University, Materials Research Institute, Beethovenstr. 1, 73430 Aalen — [2]Max Planck Institute for Metals Research, Heisenbergstr. 3, 70569 Stuttgart

High-density magnetic recording in the Tbit/in^2 range is based on single bit particles in the nm-range. The prerequisites for high-density recording are the following ones: Texture axis in perpendicular direction, thermal stability up to 100 °C, reversal fields between 1 - 2 T, and switching times in the ps-range. Composite nanoparticles composed of a soft and a hard magnetic layer are suitable to fulfill the above conditions. The magnetic ground states of bi- and trilayers are determined as a function of the thickness of the soft magnetic layer. It is shown that there exist critical fields for the ground state defining homogeneous and inclined magnetic states as well as reversal fields depending on the exchange length of the hard magnetic layer. The coercive field has a lower bound for film thicknesses larger than the exchange length of the magnetization determined by the depinning field of a Néel wall at the phase boundary. An upper limit exists for film thicknesses of the soft magnetic film of the order of the exchange length of the crystalline anisotropy of the hard magnetic phase and is given approximately by 1/4 of the nucleation field of the hard phase.

MA 45.2 Wed 17:45 HSZ 403

Depinning fields of domain-walls at defects and notches in magnetic nanowires with perpendicular magnetic anisotropy determined by micromagnetic simulations — •Theo Gerhardt[1], André Drews[1,2], and Guido Meier[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Germany — [2]Arbeitsbereich Technische Informatik Systeme, Department Informatik, Universität Hamburg, Germany

Magnetic multilayers with perpendicular magnetic anisotropy are a well known material system with potential application e.g. in storage concepts based on current-driven domain-wall motion [1,2]. For the feasibility of this concept the domain-walls need to get pinned at predefined positions which can be created by artificial defects or notches. Artificial defects are local reductions of the anisotropy constant K_1. We present a systematic investigation of the influence of the shape, size, and strength of the reduction of the anisotropy constant K_1 on the depinning field of domain-walls at defects. The depinning fields strongly depend on the shape of the defect and increase with a larger defect size and a stronger reduction of the anisotropy constant K_1. Furthermore the depinning fields at notches are systematically investigated in dependence on the shape and size of the notch. The shape of the notch has a significant influence on the maximal depinning field. Deeper notches cause an increase of the depinning field. Comparison between simulated and theoretical depinning fields of defects and notches reveal a good agreement. [1] S. S. P. Parkin et al., Science **320**, 190 (2008), [2] Hironobu Tanigawa et al., Appl. Phys. Express **2** , 053002 (2009)

MA 45.3 Wed 18:00 HSZ 403

Transmission of spin waves at pinned domain walls in exchange-spring composite media — •Sebastian Macke[1] and Dagmar Goll[2] — [1]Max Planck Institute for Metals Research, Heisenbergstr. 3, 70569 Stuttgart — [2]Aalen University, Materials Research Institute, Beethovenstr. 1, 73430 Aalen

Exchange-coupled composite (ECC) elements which seem to be most straightforward for realizing ultrahigh recording densities (>1 Tbit/in^2) are composed of a hard magnetic part and a soft magnetic part which are coupled by exchange interaction through the common interface. Recently investigations of the spin wave behavior at hard-soft interfaces started to become a matter of interest in order to determine the magnetic properties at the interfaces. With a pinned magnetic domain wall at such interfaces these properties can be influenced by an external magnetic field [1] which can be used in spin wave valve applications. We investigated the injection of spin waves from one material into the other by analyzing the frequency dependent transmission and reflection coefficients of the propagating spin waves. The topic is handled within the framework of the continuum theory of micromagnetism by numerical simulations. Pinned by an external magnetic field at the interface charged Néel walls in stripes as well as Néel walls in thin films are analyzed for different material combinations. Dependent on the spin wave frequency the transmission rate of the spin waves can change by one order of magnitude when the strength of the applied magnetic field is close to the depinning field.

[1] Livesey et. al., Phys. Rev. B. 73, 184432 (2006)

MA 45.4 Wed 18:15 HSZ 403

New methodology for micromagnetic simulations of nanocomposites — •Sergey Erokhin, Dmitry Berkov, and Nataliya Gorn — INNOVENT e.V., Pruessingstr. 27B, D-07745 Jena, Germany

A new micromagnetic methodology for numerical simulations of magnetic nanocomposites is presented. It enables to calculate the magnetization distribution and corresponding small-angle neutron scattering (SANS) cross section of a 3D nanocrystalline system.

In our contribution we consider a nanocomposite of the Nanoperm

type, which consists of the iron based crystallites with size of around 10 nm (hard magnetic phase) embedded in an amorphous soft magnetic matrix. The basic constituents of our methodology are as follows: (1) The spatial arrangement of the finite elements is random to avoid artifacts caused by the regular element placement. To generate a corresponding mesh, we employ the modified algorithm suggested earlier for the random close packing of spheres. (2) The magnetodipolar interaction between finite elements is computed in the spherical dipoles approximation. Being exact for spherical particles, this approximation results in some computational errors for the polyhedra used in our method. However, these errors are small, because the shape of our finite elements is close to spherical (due to their spatial distribution). (3) The exchange interaction energy is computed using the standard Heisenberg exchange form. The exchange constant is proportional to the volumes of neighbouring finite elements and depends on the spacing between them as in a standard finite-difference approach.

MA 45.5 Wed 18:30 HSZ 403

Master equation in phase space for a spin in an arbitrarily directed uniform external field — Yuri Kalmykov[1], •Bernard Mulligan[2], Serguey Titov[3], and William Coffey[4] — [1]Laboratoire de Mathématiques, Physique et Systèmes, Université de Perpignan, 52, Avenue de Paul Alduy, 66860 Perpignan Cedex, France. — [2]Dresden — [3]Institute of Radio Engineering and Electronics, Russian Acad. Sci., Vvedenskii Square 1,Fryazino 141190, Russia. — [4]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland.

The time evolution equation for the probability density function of spin orientations in the phase space representation of the polar and azimuthal angles is derived [1] for the nonaxially symmetric problem of a quantum paramagnet subjected to a uniform magnetic field of arbitrary direction. This is accomplished by first rotating the coordinate system into one in which the polar axis is collinear with the field vector, then writing the reduced density matrix equation in the new coordinate system as an explicit inverse Wigner-Stratonovich transformation so that the phase space master equation may be derived just as in the axially symmetric case [2]. The properties of this equation, resembling the corresponding Fokker-Planck equation, are investigated. In particular, in the large spin limit, the master equation becomes the classical Fokker-Planck equation describing the magnetization dynamics of a classical paramagnet in an arbitrarily directed uniform external field.

1. Yu.P. Kalmykov et al., J. Stat. Phys., 141, 589 (2010).
2. Yu. P. Kalmykov et al., J. Stat. Phys. 131, 969 (2008).

MA 45.6 Wed 18:45 HSZ 403

Dynamical simulation of integrable and non-integrable models in the Heisenberg picture — •Dominik Muth, Razmik Unanyan, and Michael Fleischhauer — Fachbereich Physik und Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern

The numerical simulation of quantum many-body dynamics is typically limited by the linear growth of entanglement with time. Recently numerical studies have shown, however, that for 1D Bethe-integrable models the simulation of local operators in the Heisenberg picture can be efficient as the corresponding operator-space entanglement grows only logarithmically. Using the spin-1/2 XX chain as generic example of an integrabel model that can be mapped to free particles, we here provide a simple explanation for this. We show furthermore that the same reduction of complexity applies to operators that have a high-temperature auto correlation function which decays slower than exponential, i.e., with a power law. This is amongst others the case for models where the Blombergen-De Gennes conjecture of high-temperature diffusive dynamics holds. Thus efficient simulability may already be implied by a single conservation law (like that of total magnetization), as we will illustrate numerically for the spin-1 XXZ model. Finally we discuss the advantage of incorporating the conservation law into the algorithm, which can be essential for applications and is frequently implemented in the Schrödinger picture.

Dominik Muth, Razmik G. Unanyann, and Michael Fleischhauer, arXiv:1009.4646

MA 46: Magnetic Thin Films II

Time: Wednesday 17:00–19:15 Location: CHE 184

MA 46.1 Wed 17:00 CHE 184

Flash-lamp annealing of Fe_xPt_{100-x} films — •Christoph Brombacher[1], Marcus Daniel[1], Thomas Schumann[2], Sven Häberlein[3], Jörn Donges[4], Andreas Liebig[1], Gunter Beddies[1], Wolfgang Skorupa[2], and Manfred Albrecht[1] — [1]Chemnitz University of Technology, Institute of Physics, Chemnitz, Germany — [2]Institute of Ion Beam Physics and Materials Research, FZD, Dresden, Germany — [3]FHR Anlagenbau GmbH, Dresden, Germany — [4]HASYLAB, DESY, Hamburg, Germany

Flash-lamp annealing with annealing times in the millisecond time regime was used to transform sputter deposited Fe_xPt_{100-x} films ($42 \leq x \leq 60$) from the chemically disordered A1 phase into the chemically ordered $L1_0$ phase which exhibits a large uniaxial magnetocrystalline anisotropy. The evolution of the magnetic and structural properties upon flash-lamp annealing was investigated with respect to the chemical composition and the annealing temperature. It could be demonstrated that an annealing time of 20 ms is sufficient to induce the A1 to $L1_0$ phase transformation. The fabricated polycrystalline $Fe_{52}Pt_{48}$ films exhibit a high degree of $L1_0$ order which leads to an isotropic magnetic behavior with coercivities up to (10.4 ± 0.5) kOe. A variation of the Fe content x from $42 \leq x \leq 60$ revealed that the largest volume fraction of chemically ordered grains is formed for slightly Fe enriched Fe_xPt_{100-x} films, whereas the grain growth was observed to be independent on the chemical composition.

This work was financially supported by the EU project TERAMAGSTOR (No. FP7-224001) and by HASYLAB (No. I-20100067).

MA 46.2 Wed 17:15 CHE 184

Charge-induced reversible change of magnetic properties in ultrathin FePt films — •Karin Leistner, Norman Lange, Steffen Oswald, Sebastian Fähler, and Ludwig Schultz — IFW Dresden, PF 270116, 01171 Dresden

FePt has attracted a lot of interest as hard magnetic material due its high magnetocrystalline anisotropy. For various applications fast and reversible changes of magnetic properties induced by an electric field would be ideal. Weisheit et al. [Science 315 (2007) 349] showed that the coercivity of ultrathin FePt films can be changed by 4 % by electronic charging. Larger E-field induced effects are expected at critical points. We study continuous 2 nm thin FePt(001) films where perpendicular magnetocrystalline anisotropy competes with shape anisotropy. The films are charged in an electrolyte by applying an electric voltage of 2 to 3 V vs. Li/Li+. We observe a large reversible change of anisotropy (up to 20 %). At the same time, the magnitude of the anomalous Hall effect as a measure for the moment changes up to 4 %. XPS studies showed that the effect is strongly enhanced in films with a surface iron oxide layer, but smaller in films with low oxygen content. This implies that the moment increase at lower potentials results from electrochemical reduction of surface iron oxide species to metallic iron. The corresponding decrease of perpendicular anisotropy can be attributed to soft magnetic Fe being exchange coupled to FePt. We conclude that electrical charging of exchange coupled composite films allows tuning the magnetic properties reversibly over a broad range.

MA 46.3 Wed 17:30 CHE 184

Magnetic circular dichroism in near-threshold photoemission from an ultrathin Co/Pt(111) film at variable work function — •Kerstin Hild[1], Gerd Schönhense[1], Hans-Joachim Elmers[1], Takeshi Nakagawa[2], Toshihiko Yokoyama[2], Kartick Tarafder[3], and Peter Oppeneer[3] — [1]Institute of Physics, Johannes Gutenberg University Mainz, Germany — [2]Institute for Molecular Science, The Graduate University for Advanced Studies Okazaki, Japan — [3]Department of Physics and Materials Science, Uppsala University, Sweden

In order to disentangle the magnetic dichroism effect [1], [2] of the two excitation steps in a two-photon photoemission process (2PPE) we compare measurements at different work function for the same Co/Pt(111) sample. The work function Φ is adjusted by Cs adsorption and the photon energy $h\nu$ by a tunable Ti:Sa femtosecond laser. For one-photon photoemission (1PPE) at $h\nu = 3$ eV we measure an asym-

metry of 6.2 %. A 2PPE process at the same photon energy yields a value of 8.3 %. This suggests the first step to be the major asymmetry creating process. A considerably larger asymmetry (17 %) is observed for 2PPE at hν = 1.5 eV. The results are explained by interband transitions deviating from the direction of observation Γ-L. These MCD experiments suggest a paradigm shift from the classical model of photoemission that exclusively considers k|| conserving emission processes.

Funded by Carl-Zeiss-Stiftung and the Graduate School of Excellence MAINZ (Kerstin Hild) [1] T. Nakagawa and T. Yokoyama, PRL 96, 237402 (2006). [2] K. Hild et al., PRL 102, 057207 (2009).

MA 46.4 Wed 17:45 CHE 184

Anisotropic Paramagnetic Response Of $CePt_5$ Surface Alloys Studied With XMCD — •Christian Praetorius, Annemarie Köhl, Sebastian Götz, and Kai Fauth — Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg

We have investigated the magnetic response of structurally ordered $CePt_5$ surface alloys with X-ray Magnetic Circular Dichroism. Ultrathin CePt films were prepared on Pt(111) by evaporation of Cerium onto the clean surface and subsequent annealing. Depending on the initial Ce coverage these systems order in a variety of hexagonal phases which can be monitored by LEED, as shown in previous studies. Using Ce $M_{4,5}$-XMCD at normal and grazing incidence, respectively, we observe a strong anisotropy in the paramagnetic response which can be rationalized by consideration of the hexagonal crystal field. Likewise, the temperature dependence of the paramagnetic susceptibility is strongly influenced by the crystal field splitting of the Ce $4f^1$ configuration. Our measurements provide access to the relevant energy scales in these surface alloys, which prove to deviate from those known from bulk $CePt_5$. The observed behavior at the lowest accessible temperatures (12 K) is indicative of a ferromagnetic instability around 7 K. Again, this finding contrasts the behavior of bulk $CePt_5$, known to order antiferromagnetically at low temperature.

MA 46.5 Wed 18:00 CHE 184

Structure and magnetic anisotropy of Co/Pt thin films — •Gerrit Winkler[1], André Kobs[1], Wolfgang Kreuzpaintner[2], Simon Hesse[1], Dieter Lott[2], Andreas Schreyer[2], and Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]Helmholtz-Zentrum Geesthacht, Zentrum für Material- und Küstenforschung GmbH Max-Planck-Straße 1, 21502 Geesthacht, Germany

The crystallographic properties of Co/Pt multilayer films were studied using x-ray reflectometry and x-ray diffraction in order to understand the magnetic anisotropy. The texture of the multilayers depends on substrate. For multilayers on natural oxidized Si the strongest texture is found. The interface quality is almost the same for all substrates. We find a small interface roughness of about one atomic layer while intermixing of Co and Pt appears to a certain amount. The magnetic anisotropy has been investigated by means of the magneto-optic Kerr effect. From the variation of the magnetic anisotropies on Co thickness we determine the volume and interface anisotropy contribution. For multilayers grown on natural oxidized Si we find the highest interface anisotropy while the volume anisotropy is strongest for systems on SiN. The behavior of the magnetic anisotropy is discussed in the framework of the structural results.

MA 46.6 Wed 18:15 CHE 184

Anisotropic interface magnetoresistance in Co/Pt — •André Kobs[1], Simon Hesse[1], Wolfgang Kreuzpaintner[2], Gerrit Winkler[1], Dieter Lott[2], Andreas Schreyer[2], and Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]Helmholtz-Zentrum Geesthacht, Zentrum für Material- und Küstenforschung GmbH Max-Planck-Straße 1, 21502 Geesthacht, Germany

We report on a magnetoresistance (MR) effect which was detected in sputter-deposited and electron-beam evaporated Co/Pt films in the temperature range from 4.2 to 300 K. In contradiction to the anisotropic MR (AMR) in bulk materials, different values of the resistivity for magnetization in-plane (ρ_t: transverse resistivity) and perpendicular to the film plane (ρ_p: polar resistivity) - while perpendicular to the current - are found with $\rho_p > \rho_t$. To investigate the physical origin of the magnetoresistance anisotropy we systematically varied the Co layer thickness of sputter-deposited Pt/Co/Pt sandwiches from 0.8 to 50 nm. The results reveal an enhancement of the absolute diffusive scattering probability at the interface of 4% when the magnetization is rotated from the transverse to the polar geometry. In the thin film regime this *anisotropic interface magnetoresistance* (AIMR) is as large as the AMR. This result has a drastic implication on the interpretation of measurements of the *intrinsic* domain wall resistance in Co/Pt. To confirm the transport investigation the structural properties of the films are determined by x-ray reflectivity and diffraction.

MA 46.7 Wed 18:30 CHE 184

Metamagnetism in epitaxial $BaFe_{1.8}Cr_{0.2}As_2$ thin films — •Jan Engelmann, Silvia Haindl, Karl-Hartmut Mueller, Kazumasa Iida, Konstantin Nenkov, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden

The itinerant magnetic behaviour has attracted wide interest within the newly discovered Fe-based superconductors. To study the influence of Cr doping on $BaFe_2As_2$ we prepared epitaxial thin films of $BaFe_{1.8}Cr_{0.2}As_2$ on single crystalline (La,Sr)x(Al,Ta)O_3 (LSAT) substrates under ultra high vacuum conditions by pulsed laser deposition. Magnetic measurements were performed using a vibrating sample magnetometer. A metamagnetic transition was observed at low temperatures and fields above 4 T.

MA 46.8 Wed 18:45 CHE 184

Sabilization of Skyrmion textures in thin layers of cubic helimagnets — •Anna B. Butenko, Andrei A. Leonov, Ulrich K. Rössler, and Alexei N. Bogdanov — IFW Dresden

In cubic noncentrosymmetric ferromagnets, uniaxial distortions effectively suppress one-dimensional modulations (helical states) and stabilize Skyrmion lattices in a broad range of thermodynamical parameters [1]. Recently the first direct observations of Skyrmion states have been reported in $Fe_{0.5}Co_{0.5}Si$ nanolayers [2]. In this contribution we develop a phenomenological theory of chiral modulations in thin layers of cubic helimagnets and demonstrate that hexagonal Skyrmion lattices in (Fe,Co)Si layers [2] are stabilized due to a combined effect of surface induced unaxial anisotropy and an applied magnetic field. We derive the equilibrium parameters of the Skyrmion and helical states as functions of the applied magnetic field and induced uniaxial anisotropy and construct the magnetic phase diagram which allows to formulate practical recommendations how to stabilize Skyrmion states at low temperatures in MnSi, FeGe, (Fe,Co)Si and similar intermetallic compounds with B20 structure.

[1] A.B. Butenko et al., Phys. Rev. B **82** (2010) 052403; U. K. Rößler et al. arXiv:1009.4849.

[2] X.Z. Yu et al., Nature **465** (2010) 901.

MA 46.9 Wed 19:00 CHE 184

Effect of anisotropic lattice changes on ferromagnetic order in $Sr_{1-x}Ca_xRuO_3$ — •Markus Wissinger[1], Dirk Fuchs[1], Levin Dieterle[2], Harald Leiste[3], Rudolf Schneider[1], Dagmar Gerthsen[2], and Hilbert v. Löhneysen[1,4] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, 76021 Karlsruhe, Germany — [2]Karlsruher Institut für Technologie, Laboratorium für Elektronenmikroskopie, 76131 Karlsruhe, Germany — [3]Karlsruher Institut für Technologie, Institut für Materialforschung, 76131 Karlsruhe, Germany — [4]Karlsruher Institut für Technologie, Physikalisches Institut, 76131 Karlsruhe, Germany

Thin films of $Sr_{1-x}Ca_xRuO_3$ were prepared on (001) oriented $SrTiO_3$ and $(La_{0.3}Sr_{0.7})(Al_{0.65}Ta_{0.35})O_3$ single crystal substrates via pulsed laser deposition. The films experience epitaxial strain ranging from compressive to tensile. Increasing compressive strain leads, independently of the Ca content x, to a shrinking unit cell volume. For constant x, compressive (tensile) strained films showed a decrease (increase) of the ferromagnetic Curie temperature, T_C, compared to the bulk value. The strain induced reduction of T_C was found to be strongly correlated to the decrease of the unit-cell volume V_{UC}, i. e., $\partial T_C/\partial V_{UC} \approx 26.2\,K\text{Å}^{-3}$, nearly independent of x. Surprisingly, the anisotropic biaxial strain in our films leads to almost the same value of $\partial T_C/\partial V_{UC}$ that has been deduced for bulk $SrRuO_3$ under isotropic hydrostatic pressure.

MA 47: Spintronics I/ Spin-dependent Transport/ Spin Torque - Invited Talk

Time: Thursday 10:15–10:45 Location: HSZ 04

Invited Talk MA 47.1 Thu 10:15 HSZ 04

Perpendicular 40 nm MgO-CoFeB Magnetic Tunnel Junction — •Hideo Ohno — Center for Spintronics Integrated Systems, Tohoku University, Sendai, Japan — Res. Inst. Elec. Commun., Tohoku University, Sendai, Japan

Magnetic tunnel junction (MTJ), a spintronic device, can lead not only to fast, non-volatile, high density stand-alone/embedded RAMs but also to a possibility of constructing compact, nonvolatile, low-power CMOS VLSI processors employing logic-in-memory architecture [1]. To this end, an MTJ has to meet the following conditions at the same time: (1) thermal stability factor E/kBT greater than 40 at a reduced footprint, (2) resistance area product below 20 Ohm micrometer2 to allow current-induced switching, (3) intrinsic switching current IC0 of F micro A or below in a device having a feature size of F nm, (4) high tunnel magnetoresistance over 100%, and (5) BEOL compatibility capable of going through 350 oC annealing required for standard semiconductor processing without losing its high TMR ratio. Utilizing the perpendicular interface anisotropy at MgO-CoFeB, we show that these five conditions can nearly be met in a device having a 40 nm diameter [2]. I conclude my talk with prospects along with the remaining challenges.

[1] S. Ikeda, et al., IEEE Trans. ED, 54, 991, 2007. [2] S. Ikeda, et al., Nature Materials, 9, 721, 2010.

Work carried out at CSIS of Tohoku University (http://www.csis.tohoku.ac.jp) and supported by the FIRST program from JSPS.

MA 48: SKM-SYDT: Diffusionless Transformations in Magnetic and Ferroelectric Bulk and Thin Films (jointly with MM, DS, DF)

Time: Thursday 10:30–13:00 Location: TRE Ma

Invited Talk MA 48.1 Thu 10:30 TRE Ma

Domain boundaries as active elements in multiferroics and martensites: steps towards Domain Boundary Engineering — •Ekhard K.H. Salje — University of Cambridge, Cambridge CB2 3EQ, UK

Domain boundaries can contain properties, which are absent in the bulk of the material. Typical examples which can be used for applications in Domain Boundary Engineering are ferroelectric boundaries in ferroelastic matrices. A similar example is piezoelectricity in boundaries where the matrix remains non-piezolelectric and materials with reversed contrast. In addition, electronic and ionic transport are often greatly enhanced in boundaries. An extreme case are superconducting twin walls in a ferroelectric matrix. Increased ionic transport is common in twin boundaries of most materials with perovskite-type structures. While much progress has been made in ceramics, we also find indications for specific domain boundary effects in shape memory metals. The mobility of matensitic twins depends greatly on their internal structure, e.g. their ability to anchor dislocations. All materials have in common that strain interactions are strong and hence long correlations prevail. This make the system amenable to Landau theory including appropriate coupling terms which modify the bulk and the domain walls differently. The general concept and some examples will be discussed.

Ref.: E.K.H. Salje (2010) Multiferroic domain boundaries as active memory devices: trajectories towards domain boundary engineering, Chemphyschem 11, 940.

Invited Talk MA 48.2 Thu 11:00 TRE Ma

Intermediate Phases in Perovskite Solid Solutions — •Ian Reaney[1], Clive Randall[2], and David Woodward[3] — [1]Department of Materials Science and Engineering, University of Sheffield, Sheffield, S1 3JD, UK — [2]Department of Physics, University of Warwick, Gibbet Hill Road,Coventry CV4 7AL, UK — [3]144 MRL Bldg., Penn State University,University Park, PA 16802, USA

The intermediate monoclinic (M) phase in Pb(ZrxTi1-x)O3 (PZT) in-between rhombohedral (R) and tetragonal (T) displacive variants is considered as a high profile example of a more general phenomenon in which low symmetry intermediate phases are stabilised between higher symmetry displacive variants. In the case of the M phase, the order parameter is dominated by polarisation but similar situations are reported where the order parameter is dominated by strain, amplitude of octahedral rotation or combinations thereof. This article presents examples of intermediate phases and discusses their structures and functional properties.

Invited Talk MA 48.3 Thu 11:30 TRE Ma

Adaptive martensite and giant strain effects in multiferroics — •Ulrich K. Rössler — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Ferroelastic behavior in martensitic microstructures relies on the reorientation of twin variants under applied external fields. Giant strains driven by multiferroic couplings, as in ferromagnetic shape-memory alloys (FSMA) and in ferroelectric perovskites, have been achieved in modulated lattice structures only. The concept of adaptive martensite introduced by Khachaturyan and co-workers explains these lattice structures by twinning at the unit cell level. The formation of such nanoscale microstructures is determined by lattice geometry and the compatibility at the habit plane. The martensite transformation creates metastable states with a maximum density of twin boundaries. For FSMAs as Ni_2MnGa or Co_2NbSn the modulated low symmetry phases can be identified as nanotwinned structures of a tetragonal lattice in accordance with results on the ground state from ab initio calculations. The adaptive nature of modulated structures and microstructure in the Heusler Ni_2MnGa alloys has been demonstrated in experiments. In epitaxial films the modulated structure at the habit plane is found to be rigidly connected to the coexisting tetragonal martensite by branching. In these constrained films, the habit plane acquires a fractal geometry which fixes the lengths in the microstructure from the lattice cells up to the coarsened twins. Metastability and hierarchical organization of adaptive martensites are suggested as essentials for the easy variant re-arrangement in mesoscale twinned microstructures.

Invited Talk MA 48.4 Thu 12:00 TRE Ma

Nature of magnetic coupling in Ni-Mn-based martensitic Heusler alloys — •Mehmet Acet[1], Seda Aksoy[1], Eberhard F. Wassermann[1], Lluis Manosa[2], and Antoni Planes[2] — [1]Experimetalphysik, Universität Duisburg-Essen, 47048 Duisburg — [2]Departament d*Estructura i Constituents de la Matèria, Facultat de Física, Universitat de Barcelona, Diagonal 647, E-08028 Barcelona, Catalonia, Spain

To understand the cause of magnetic field induced effects in shape memory alloys, it is necessary to understand the nature of the magnetic coupling in the temperature-vicinity of the martensitic transition. Neutron diffraction, and neutron polarization analysis experiments on Ni-Mn-based martensitic Heusler systems show that at temperatures just below the martensitic transformation, the magnetic short-range correlations are antiferromagnetic in a spin-liquid type state. The correlations are mixed ferromagnetic and antiferromagnetic at temperatures above the martensitic transition; and well beyond the Curie temperature of the austenite state. The results of further ferromagnetic resonance studies show that antiferromagnetic exchange in the martensite state persists down to the lowest temperatures and coexists with the long-range ferromagnetism below the austenite Curie temperature. These results are also in line with the presence of a spin liquid state just below the martensitic transition.

Invited Talk MA 48.5 Thu 12:30 TRE Ma

Orthorhombic to tetragonal transition of $SrRuO_3$ layers in $Pr_{0.7}Ca_{0.3}MnO_3/SrRuO_3$ superlattices — •Michael Ziese[1], Francis Bern[1], Ionela Vrejoiu[2], Eckhard Pippel[2], and Eliza-

veta Nikulina[2] — [1]Div. of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig, Germany — [2]Max Planck Institute of Microstructure Physics, D-06120 Halle, Germany

In perovskite superlattices (SLs) the intimate interplay between structural, magnetic and electronic properties can be modified by geometrical constraints. This is explored in this work by the study of the crystallographic, magnetic and magnetotransport properties of ultrathin $SrRuO_3$ (SRO) layers embedded in SLs. $Pr_{0.7}Ca_{0.3}MnO_3/SrRuO_3$ (PCMO/SRO) SLs were grown by pulsed laser deposition on vicinal $SrTiO_3$ substrates with a miscut angle of about 0.1°, uniform TiO_2-termination and an atomically flat terrace morphology. The SRO layer thickness was kept constant at 4 nm, whereas the PCMO layer thickness was varied between 1.5 and 4 nm. High resolution TEM investigations of the PCMO/SRO SLs showed that the PCMO layers were orthorhombic throughout, whereas the SRO layers were orthorhombic when adjacent to 1.5 nm thick PCMO layers and transformed to tetragonal when adjacent to 4 nm thick PCMO layers. This structural transformation profoundly changed the form of the angular dependent magnetoresistance (MR) as well as the direction of the magnetic easy axes. Further the antiferromagnetic interlayer exchange coupling between PCMO and SRO layers was stronger in the orthorhombic than in the tetragonal phase.

MA 49: Spin-dependent Transport/ Spin Torque

Time: Thursday 10:45–13:00 Location: HSZ 04

MA 49.1 Thu 10:45 HSZ 04

Correlating transmission and local electronic structure in planar junctions: An analysis tool for spin-dependent transport calculations — •Peter Bose[1], Peter Zahn[2], Ingrid Mertig[1,2], and Jürgen Henk[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

Calculations of spin-dependent transport in planar tunnel junctions are typically analyzed by means of transmission and spectral-density maps that display the transmittance or spectral densities in the two-dimensional Brillouin zone at a fixed energy. A visual inspection of these maps in order to reveal, e. g., which layers or which orbitals determine the conductance is not only tedious but also ambiguous.

We propose to analyze spin-dependent transport calculations quantitatively and without ambiguity by correlating transmission and spectral-density maps. Since spectral-density maps can be resolved with respect to atom, angular momentum, and spin, the resulting correlation coefficients reveal unequivocally detailed features of the conductances. Salient properties of our method are discussed for selected planar junctions.

MA 49.2 Thu 11:00 HSZ 04

EuS Spin Filter Tunnel Contacts to Silicon with various doping concentrations — •H. Doganay, M. Müller, R. Schreiber, and C. M. Schneider — IFF-9, FZ Jülich

Utilizing spin filter (SF) materials as tunnel barrier is a unique method to generate highly spin-polarized currents. We studied electrical and magnetic properties of EuS SF tunnel contacts to silicon with the emphasis of different Si doping concentrations. First, we explored the magnetic properties of EuS on Si(100) in thickness regime of tunnel barriers. Our studies indicated that thin EuS/Si films exhibit bulk-like magnetic properties above $d \geq 3\,nm$ [1]. Furthermore, we studied the morphology of Si/EuS($d = 1{-}6$nm)/Au sample surfaces by AFM and found that magnetization M correlates with roughness. We investigated the electrical transport properties across EuS/Si(100) interfaces for different n-Si doping concentrations. Transport experiments on Si(100)/Au junctions revealed the respective Schottky barrier profile. We analyzed both spin injection and -detection conditions of R(T) and I(V) characteristics of EuS/Si(100) contacts. By fitting the temperature-dependent I(V) characteristics we determined the exchange splitting of a 4 nm thick EuS SF barrier as 0.30eV, which is comparable to the bulk value ($\Delta E_{xc}(EuS_{bulk})$=0.36eV). Moreover, we found that SF in EuS/Si is bias-dependent, with the maximum tunneling SP occurring at medium bias voltages ($0.40 < V < 0.70$). In summary, our experiments demonstrate a successful integration EuS as a tunnel barrier to n-Si(100) for different n-Si doping concentrations.[1] M. Müller *et al.*, submitted to JAP

MA 49.3 Thu 11:15 HSZ 04

Ab initio theory of tunneling anisotropic magnetoresistance in Fe/GaAs/Ag(001) system — Rudolf Sykora and •Ilja Turek — Charles University, Faculty of Mathematics and Physics, DCMP, Prague, Czech Republic

The electronic structure and transport properties of epitaxial magnetic tunnel junctions Fe/GaAs/Ag(001) are studied theoretically by means of a first-principles tight-binding linear muffin-tin orbital (TB-LMTO) method. The effect of the spin-orbit interaction is treated as an on-site perturbation to a scalar-relativistic TB-LMTO Hamiltonian and the ballistic conductance of the system is calculated within the Kubo-Landauer formalism. Particular attention is paid to the dependence of the conductance on the orientation of magnetization direction of the Fe electrode and on the thickness of the GaAs barrier. The calculated tunneling anisotropy magnetoresistance (TAMR) ratio exhibits a non-monotonic thickness-dependence with a maximum around 8 nm of GaAs, in rough agreement with the barrier thickness used in recent experiments on TAMR in similar systems. This behavior as well as hot spots found in the $k_{\|}$-resolved conductances are explained in terms of a hybridization of interface resonances formed on both sides of the junction.

MA 49.4 Thu 11:30 HSZ 04

Quantum conductance between the STM tip and magnetic clusters on metal surfaces: ab initio studies — •Kun Tao[1], Ivan Rungger[2], Stefano Sanvito[2], and Valeri.S Stepanyuk[1] — [1]Max-Planck-Institute of Microstructure Physics, Halle, Germany — [2]School of Physics and CRANN, Trinity College, Dublin, Ireland

We perform ab inito calculations to investigate the quantum conductance between the STM tip and magnetic clusters adsorbed on metal surfaces. Based on the nonequilibrium Green's function method, we perform spin polarized transport calculations. Our results give clear evidence that the conductance of a single atomic junction in the contact regime is close to G0/2 (G0 is the quantum of conductance) for ferromagnetic electrodes and to G0 for nonmagnetic ones[1]. Our results demonstrate that a conductance of G0/2 originates from a combination of partially open majority and minority channels. We also studied the tunneling magnetoresistance (TMR) effect between the spin-polarized STM tip and magnetic clusters on metal surfaces. It is found that the TMR effect in the junction strongly depends on the tip-substrate distance.

[1] Kun Tao, I. Rungger, S. Sanvito, V.S. Stepanyuk, Phys. Rev. B. 82, 085412 (2010)

MA 49.5 Thu 11:45 HSZ 04

Thermal activated domain wall depinning: Extraction of the non-adiabatic contribution — •Jan Heinen[1], Mathias Kläui[1,2], Olivier Boulle[3], Gregory Malinowsky[4], Christian Ulysse[5], and Giancarlo Faini[5] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]SwissFEL, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland and Laboratory for Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [3]INAC, CEA, 38054 Grenoble, France — [4]Laboratoire de physique des solides, Université Paris-sud, 91405 Orsay, France — [5]Phynano Team, Laboratoire de Photonique et de Nanostructures, CNRS, 91460 Marcoussis, France

We report time resolved measurements of the extraordinary hall effect (EHE) on perpendicularly magnetized nanowires with narrow domain wall (DW) structures. Using Co/Pt multilayer nanowires, we have previously shown that despite Joule heating effects it is possible to deduce the non-adiabacity factor β [1] and determined the contribution of spin torque and Oersted field effects from DW depinning experiments [2]. Time resolved experiments to measure the extraordinary hall voltage of a Hall cross show the existance of multiple metastable pinning sites, which can be used to study thermally activated depinning. The variation of an applied external field and the variation of current allows us to extract of the non-adiabaticity factor β.

References: [1] O. Boulle et al., Phys. Rev. Lett. 101, 216601

(2008). [2] J. Heinen et al., Appl. Phys. Lett. 96, 202510 (2010).

MA 49.6 Thu 12:00 HSZ 04

A direct approach to measure the nonadiabatic spin transfer torque parameter — •Ming Yan[1] and Riccardo Hertel[1,2] — [1]Institut für Festkörperforschung, Elektronische Eigenschaften, Forschungszentrum Jülich GmbH — [2]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg, CNRS UMR 7504

The nonadiabatic spin transfer torque parameter β plays an important role in spin dynamics driven by electric current. Measuring β is however usually difficult due to the entanglement of β with the spin polarization rate P. Although various methods to extract the value of β have been suggested, a direct measurement which does not require a model-dependent comparison with numerical simulations is to date elusive. The recently reported dynamic properties of transverse domain-walls in thin cylindrical nanowires [1] provide an approach to measure P and β directly and independently. Driven by a magnetic field or/and an electric current, this type of domain wall precesses around the wire while propagating along the wire. Measuring the linear velocity of the domain wall driven by an electric current allows a direct determination of P. The precessional frequency of the domain wall is proportional to β. The value of β can be unambiguously determined by measuring the frequency shifts caused by electric currents from the Larmor precession of the domain wall. An excellent agreement is achieved between analytical calculations and micromagnetic simulations.
[1] M. Yan, A. Kákay, S. Gliga, and R. Hertel, Phys. Rev. Lett. 104, 057201 (2010).

MA 49.7 Thu 12:15 HSZ 04

Probing the Nonadiabaticity of the Spin-Torque via direct Imaging of Current induced Vortex Domain Wall Excitations — •M. Stärk[1,2], A. Bisig[1,3], J. Rhensius[2,4], C. Moutafis[1], J. Heidler[1], G. Kiliani[2], M. Kläui[1,2], H. Stoll[3], L.J. Heyderman[4], B. Van Waeyenberge[5], and T. Tyliszczak[6] — [1]SwissFEL, PSI, 5232 Villigen and Laboratory of Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland — [2]Universität Konstanz, 78457 Konstanz, Germany — [3]Max-Planck-Institut für Metallforschung, 70569 Stuttgart, Germany — [4]Labor für Mikro- und Nanotechnologie, PSI 5232 Villigen, Switzerland — [5]Ghent University, 9000 Ghent, Belgium — [6]Advanced Light Source, 94720 Berkeley LBNL, USA

Magnetic vortex domain walls, where the magnetization curls in the plane of the wire around a central vortex core, are candidates for novel memory devices based on current induced domain wall motion or vortex core switching. Here we report on the investigation of the interaction between vortex domain walls and microwave spin polarized currents, employing time-resolved scanning transmission x-ray microscopy (STXM). Beyond the one dimensional quasi particle treatment of magnetic domain walls we describe the wall as a composite object consisting of a vortex and two half-vortices. From the phase-shift of the response of the different topological defects, we measure the adiabatic and non-adiabatic spin torque terms to test predictions of the correlations between the different spin torque terms and the local magnetization gradients.

MA 49.8 Thu 12:30 HSZ 04

Low spin current-driven dynamic excitations and metastability in spin-valve nanocontacts with unpinned artificial antiferromagnet — •Moritz Eggeling[1], Theodoros Dimopoulos[1], Thomas Uhrmann[1], Ole Bethge[2], Rudolf Heer[1], Volker Hoeink[1], and Hubert Brueckl[1] — [1]Austrian Institute of Technologie GmbH - Devision Nano Systems, Donau-City-Str. 1, 1220 Vienna, Austria — [2]Institute for Solid State Electronics, Vienna University of Technology, Floragasse 7, 1040 Vienna, Austria

This work concerns the dynamic excitation of non-uniform, vortex-like magnetic states due to spin-transfer torque in spin-valve nanocontacts, employing an unpinned artificial antiferromagnet of CoFe/Ru/CoFe as polarizer and amorphous CoFeB as free layer. The frequency spectra are in the sub-gigahertz regime for circular contacts of 150 to 200 nm in diameter. The critical current density, marking the onset of the dynamic excitation, attains considerably low values, while the dynamic spectra show reversibility with respect to the DC current. The oscillation power strongly depends on the in-plane magnetic field, assuming maximum values in the vicinity of the free layer's magnetization switching. The maximum in power is accompanied by a minimum in the oscillation linewidth. We also show that for specific current and magnetic field windows metastable dynamic states are excited, believed to induce linewidth broadening.

MA 49.9 Thu 12:45 HSZ 04

Domain Wall Manipulation With a Magnetic Tip — •Thim Stapelfeldt, Robert Wieser, Elena Y. Vedmedenko, and Roland Wiesendanger — Institute of Applied Physics and Microstructure Advanced Research Center, University of Hamburg

A theoretical concept of local manipulation of magnetic domain walls is introduced. In the proposed procedure a domain wall is moved by a magnetic tip, as used in a scanning tunneling microscope, placed above a magnetic nanostripe and than moved along it's long axis with a current flowing through the vacuum barrier. The angular momentum from the spin polarized current exerts a torque on the magnetic moments underneath the tip and leads to a displacement of the domain wall, when the tip approaches the wall. Particularly, the manipulation of a ferromagnetic 180° transverse domain wall has been studied by means of Landau-Lifshitz-Gilbert dynamics and Monte-Carlo simulations. Several operation modes corresponding to different relative orientations of the tip and the sample magnetization have been considered. The position dependent magnetic conductivity G corresponding to experimentally derived I/U curves have been obtained for each geometry.

MA 50: Surface magnetism III

Time: Thursday 11:00–13:00 Location: HSZ 103

MA 50.1 Thu 11:00 HSZ 103

Spin reorientation related changes of the electronic structure in ultrathin Fe/Mo(110) films — •Torsten Methfessel and Hans-Joachim Elmers — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudingerweg 7, D-55099 Mainz

The magnetic easy axis in ultrathin Fe/Mo(110) films changes from a perpendicular easy axis at low temperatures to an in-plane easy axis at hight temperatures at the transition point around 13 K. We investigated this spin reorientation (SRT) using spin-resolved scanning tunneling microscopy (STM) and spectroscopy (STS). Magnetic domain patterns remain stable near the SRT. We measured domain wall widths versus temperature resulting in a measurement for the temperature dependent anisotropy. The electronic structure of the mono (ML) and double layer (DL) Fe/Mo(110) shows a variation with the reorientation of the magnetic easy axis. The spin averaged tunneling conductivity of the DL Fe shows a distinct increase with rising temperature clearly below the transition temperature which can be attributed to a magnetization along a magnetic hard axis. The SRT of Fe/Mo(110) can be identified as a discontinuous reorientation transition, revealing two simultaneous minima of the free energy in a certain temperature range.

MA 50.2 Thu 11:15 HSZ 103

Uniaxial anisotropy in Fe/GaAs(001): oriented bonds versus magneto-elastic interaction. — •Günther Bayreuther[1,2], Jörg Premper[1], Matthias Sperl[2], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Inst. für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, Germany

Ultrathin Fe films epitaxially grown on GaAs(001), in addition to their thickness-dependent cubic anisotropy, show a pronounced in-plane uniaxial magnetic anisotropy with the easy axis along [110], controversially attributed either to oriented interface bonds or to a magneto-elastic interaction. In order to check the relevance of magneto-elastic contributions we performed MOKE and magneto-elastic stress measurements on MBE-grown Fe(001) and $Fe_{32}Co_{68}$(001) films on GaAs(001). The uniaxial anisotropy constant K_U has the same sign

for Fe and $Fe_{32}Co_{68}$. The magneto-elastic coupling coefficients B_2 of the films were measured using a cantilever method [1] and resulted to be of opposite sign for Fe and $Fe_{32}Co_{68}$ films, respectively. As all the films are under compressive strain with a lattice misfit of -1.16 % for Fe and -0.41 % for $Fe_{32}Co_{68}$ the magneto-elastic anisotropy contribution to K_U is expected to be of opposite sign for both materials, based on the respective values of B_2. The observed identical sign of K_U in both cases means that a magneto-elastic interaction is not the main origin of the uniaxial magnetic anisotropy in ultrathin Fe(001) films on GaAs(001).

[1] D. Sander, Rep. Prog. Phys. 62, 809 (1999)

MA 50.3 Thu 11:30 HSZ 103

Influence of the growth temperature on the electronic structure of ultrathin cobalt films studied by spin-resolved photoemission — •Cheng-Tien Chiang, Aimo Winkelmann, Martin Ellguth, Ahmet Akin Ünal, Christian Tusche, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120, Halle (Saale), Germany

We investigate the electronic structure of ultrathin cobalt films grown on Cu(001) by spin-resolved one- and two-photon photoemission (1PPE and 2PPE). A majority quantum well state located at 2.1 eV above the Fermi level and a minority surface resonance state at 0.4 eV below the Fermi level are identified in 6 monolayer thick cobalt films. The photoemission features of the quantum well state and the surface resonance state are strongly suppressed for cobalt films grown at 170 K as compared to films grown at 330 K. 2PPE through the quantum well state increases the photoelectron spin-polarization by about 10%, and in 1PPE a sign reversal of the spin-polarization is observed from the surface resonance state. These observations are applied for electronic state sensitive imaging of magnetic domains in energy- and spin-resolved photoelectron emission microscopy (PEEM).

MA 50.4 Thu 11:45 HSZ 103

NiO thickness and temperature dependent coercivity of Fe layers grown on NiO/Ag (100) — •Anita Dhaka, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 061120 Halle (Germany)

We have performed temperature dependent magneto-optical kerr effect (MOKE) measurements in the longitudinal geometry to investigate the coercivity of 6 monolayers (ML) Fe on NiO deposited on Ag (100). MOKE indicates that the coercivity of Fe on NiO strongly depends on the thickness of NiO, and this effect is temperature dependent. We find that the coercivity of 6 ML films deposited on 20 ML NiO of H_c=142 mT at 300 K,which increases to 172 mT at 150 K. For 40 ML NiO, the coercivity is 148 mT at 300 K, and 284 mT at 150 K. 6 ML Fe on Ag (100) show a constant H_c of 9±3 mT from 150 K to 470 K. The change of coercivity with temperature is reversible up to T=470 K. At higher temperature intermixing is found by Auger elctron dpectroscopy, and the magnetic behavior is no longer reversible upon cooling. No increase of coercivity is observed for Fe films on 20 ML and 40 ML NiO at 470 K. Temperature dependence of the coercivity is ascribed to presence of antiferromagnetic NiO, and our data indicate a Neel temperature of 20 ML NiO of approximately 470 K [1]. Financial support by SFB 762 is gratefully acknowledged. [1] D. Alders, L. H. Tjeng, F. C. Voogt, T. Hibma, G. A. Sawatzky, C. T. Chen, J. Vogel, M. Sacchi, S. Iacobucci, Phys. Rev. B **57**, 11623, (1998).

MA 50.5 Thu 12:00 HSZ 103

Antiferromagnetic Mn chains on Ni(110) — •Simon Holzberger, Tobias Schuh, and Wulf Wulfhekel — Physikalisches Institut, Karlsruher Institut für Technologie, Germany

A novel even-odd effect has recently been predicted for atomic manganese chains supported by a ferromagnetic substrate [1]. While odd chains possess a net spin that aligns according to the coupling to the substrate resulting in a collinear spin state, even chains display a non-collinear state. To investigate atomic chains experimentally, low-temperature spin-polarized scanning tunneling microscopy (Sp-STM) was used. To favor the growth of linear chains, a ferromagnetic Ni(110) surface was chosen as substrate. While self assembly of chains by thermal diffusion always led to intermixing with the substrate, pure manganese chains could be created by atomic manipulation. The electronic structure of the chains was investigated by scanning tunneling spectroscopy revealing a strong dependence on the length of the chain. This is explained within the model of an unoccupied quasi atomic state in single manganese adatoms. Sp-STM confirmed the predicted collinear antiferromagnetic ground state for linear trimers. In contrast to the calculations, however, there was no indication of an antiferromagnetic or non-collinear spin structure for even-numbered chains. This observation is explained by the degeneracy of the antiferromagnetic ground state highlighting the quantum nature of the magnetic state.

[1] S. Lounis *et al.*, Phys. Rev. Lett. **101**, 107204 (2008)

MA 50.6 Thu 12:15 HSZ 103

Spinresolved UPS: Study of the O p(1x1) phase on Fe(100) Using a Novel Multichannel Spinpolarimeter — •Michaela Hahn, Bernd Petereit, Martin Jourdan, Hans-Joachim Elmers, and Gerd Schönhense — Institut für Physik, Staudinger Weg 7, 55128 Mainz

A novel type of multichannel spindetector has been implemented recently, with strongly improved efficiency as compared to modern state-of-the-art single channel spin analysers. By the usage of parallel multichannel detection, it is possible to reduce the measuring time by orders of magnitude [1]. The sample systems Fe/MgO and O/Fe/MgO have been studied as a first application exploiting the detector's efficiency. Epitaxial iron layers were evaporated onto MgO(100) single crystals, oxygen was dosed in small steps.

The O p(1x1) phase on Fe(100) is of particular interest, as for example described in [2]. It is formed at a dosage of 6L oxygen on the clean Fe(100) surface. Due to additional FeO-bands in the surface layer, the spin asymmetry close to the Fermi edge is expected to exhibit new features as compared to clean iron. Our spectra show a strong quenching of the minority peak very close to E_F with increasing oxygen dosage. Furthermore, new features occur in the majority bandstructure.

Funded by Stiftung Rheinland-Pfalz für Innovation (project 886) and DFG (Scho 341/9-1)

[1] M. Hahn et al., this conference

[2] A. Tange et al., Phys. Rev. B 81, 195410 (2010)

MA 50.7 Thu 12:30 HSZ 103

Magnetic Properties of Fe-Co alloy films on Ir(001) — •Rantej Bali, Marek Przybylski, and Jürgen Kirschner — Max Planck Institut für Mikrostruktur Physik, Halle, Germany 06120

We report on the magnetic behavior of $Fe_{1-x}Co_x$ alloy films grown on the Ir(001) surface. A variety of properties are observed depending on the Co content and film thickness. The first 4 monolayers (ML) of Fe (x = 0) do not exhibit magnetic hysteresis hinting to the existence of an antiferromagnetic phase, since thicker films are ferromagnetic. Ferromagnetism in the first 4 ML begins to be observed above x = 0.25 and further increase in Co content causes the easy axis to be perpendicular to the film plane [1]. For 10 ML thickness, this perpendicular anisotropy remains larger than the shape anisotropy at least up to the x = 0.6 composition. The increase and decay of the perpendicular anisotropy are observed through spin reorientation transitions that occur between the out-of-plane and in-plane magnetization directions of the film.

The differences in magnetic ordering such as the occurrence of antiferromagnetic and ferromagnetic phases and in-plane and perpendicular easy axes can be caused by the combination of strain induced modification of the electronic structure and the composition dependent adjustment of the Fermi energy.

[1] F. Yildiz *et al.*, J. Appl. Phys. 105, 07E129 (2009).

MA 50.8 Thu 12:45 HSZ 103

Qualitative extraction of spin polarization on a single magnetic nanostructure — •Hirofumi Oka, Pavel Ignatiev, Sebastian Wedekind, Guillemin Rodary, Larissa Niebergall, Valeri Stepanyuk, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institute of Microstructure Physics, Weinberg 2, D-06120, Halle, Germany

We present a qualitative extraction of spin polarization on single Co nanoislands using SP-STM. We use low-temperature STM in magnetic fields to manipulate parallel (P) and anti-parallel (AP) states of the magnetization orientation between a Co island on Cu(111) and a magnetic tip [1]. We measure the differential conductance (dI/dV) on the same island in both states as a function of energy, and obtain the asymmetry of the dI/dV, $(dI/dV_{AP} - dI/dV_P)/(dI/dV_{AP} + dI/dV_P)$, which is related to the spin polarization of a sample [2]. We find that the sign and magnitude of the dI/dV asymmetry strongly depend on energy. In conjunction with ab initio calculations, we demonstrate that the dI/dV asymmetry obtained by our method is proportional to the spin-polarization of the sample [3]. We find in the theoretical results a minimum and a maximum spin-polarizations on a Co film at energies of -0.25 and $+0.15$ eV, respectively, which agrees with the

energy dependence of the dI/dV asymmetry.

[1] G. Rodary *et al.*, JJAP 47, 9013 (2008). [2] D. Wortmann *et al.*, PRL 86, 4132 (2001). [3] H. Oka *et al.*, Science 327, 843 (2010).

*Present address (G.R.): Laboratoire de Photonique et Nanostructures, CNRS UPR20, 91460 Marcoussis, France.

MA 51: Magnetic Half-metals and Oxides II

Time: Thursday 11:00–13:15 Location: HSZ 401

MA 51.1 Thu 11:00 HSZ 401

Spin polarized surface states at the free Co_2MnSi(100) surface — •Roman Fetzer[1], Jan-Peter Wüstenberg[1], Jan Minàr[2], Jürgen Braun[2], Hubert Ebert[2], Takayuki Ishikawa[3], Masafumi Yamamoto[3], Martin Aeschlimann[1], and Mirko Cinchetti[1] — [1]Department of Physis and Research Center OPTIMAS, TU Kaiserslautern, Erwin Schrödingerstr. 46, D-67663 Kaiserslautern — [2]Department Chemie und Biochemie, Ludwig-Maximilians-Universität München, Butenandtstr. 11, 81377 München — [3]Graduate School of Information Science and Technology, Hokkaido University, Kita 14 Nishi 9, Sapporo 060-0814, Japan

Interface states are believed to play a crucial role for the performance of Heusler-based magnetic tunnelling junctions [1]. As a first step towards the investigation of real interfaces, we present a comprehensive study of the free (001) surface of the Heusler alloy Co_2MnSi. We show the presence of minority electron surface states with predominant Δ_1 symmetry at the Fermi energy. Using a combined approach consisting of low energy electron diffraction, Auger analysis and spin-resolved photoelectron spectroscopy, the link between the spin-resolved electronic structure and the surface termination is drawn and substantiated by LSDA+DMFT photoemission calculations using different surface terminations.

[1] T. Ishikawa, N. Itabashi, T. Taira, K. Matsuda, T. Uemura, and M. Yamamoto. J. Appl. Phys. **105**, 07B110 (2009).

MA 51.2 Thu 11:15 HSZ 401

Quadratic MOKE on Co-based Heusler compounds — •Georg Wolf[1], Jaroslav Hamrle[2], Britta Leven[1], Daniel Ebke[3], Andy Thomas[3], Günter Reiss[3], and Burkard Hillebrands[1] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute of Physics, VSB - Technical University of Ostrava, Czech Republic — [3]Thin Films and Physics of Nanostructures, Physics Department, Bielefeld University, Germany

The intensive research on Co-based Heusler compounds revealed that some of these materials show a large quadratic magneto-optical Kerr effect (QMOKE) [1,2]. The presence of QMOKE strongly depends on the electronic band structure. In the case of Heusler compounds the electronic bands can be modified by changing the composition or improving the crystalline structure. This work presents a systematic study on several Heusler compounds (Co_2FeSi, $Co_2Fe_{0.5}Mn_{0.5}Si$, Co_2MnSi and $Co_2FeAl_{0.5}Si_{0.5}$). The amplitude of the QMOKE is investigated as a function of the post deposition annealing temperature, which is known to improve the crystal ordering. We find that the QMOKE is increasing with the annealing temperature. From this we conclude that there is a strong correlation between the presence of QMOKE and the high crystalline ordering in Heusler compounds.

The DFG Research Unit 559, New Materials with High Spin Polarization, and the BMBF project Heuspin are gratefully acknowledged for financial support.

[1] J. Hamrle et al. J.Phys.D **40**, 1563 (2007).
[2] S. Trudel et al. J.Appl.Phys. **107**, 43912 (2010).

MA 51.3 Thu 11:30 HSZ 401

The influence of the disorder on the electronic states of the Heusler compound $Co_2FeAl_{0.3}Si_{0.7}$ studied by ARUPS and tunnelling spectroscopy. — •Elena Arbelo Jorge, Christian Herbort, Michaela Hahn, Gerd Schönhense, and Martin Jourdan — Institute of Physics, Johannes-Gutenberg University, Staudinger Weg 7, 55099 Mainz, Germany

Heusler compounds have attracted much interest based on their half metallic properties predicted by band structure calculations. However, a direct comparison of the theoretical predictions with experiments remains difficult, even if the spin degree of freedom is averaged. Additionally, the influence of atomic disorder on the band structure is of major interest and is in general expected to result in a broadening of the electronic states. We present in-situ spin averaged angular resolved UV-photoemission spectroscopy (ARUPS) of rf-sputtered Heusler thin films. Additionally, tunnelling spectroscopy on planar junctions of Heusler thin films with AlO_x barrier is performed. Samples of the compound $Co_2FeAl_{0.3}Si_{0.7}$ with different degrees of disorder (B2 and $L2_1$) are studied. The ARUPS results at energies close to the Fermi edge are compared to measurements of the bias voltage dependent tunnelling conductivity of $Co_2FeAl_{0.3}Si_{0.7}/AlO_x/Ag$ and $Co_2FeAl_{0.3}Si_{0.7}/AlO_x/CoFe$ junctions. Whereas the ARUPS shows clear correlations with the degree of disorder of the Heusler compound, the interpretation of the tunnelling spectroscopy results in terms of the density of states is challenging.

MA 51.4 Thu 11:45 HSZ 401

Spectroscopy of the electronic states of the Heusler compounds Co_2FeAl and $Co_2Cr_{0.6}Fe_{0.4}Al$ and the influence of oxidation — •Martin Jourdan, Fabian Grosse-Schulte, Michaela Hahn, and Gerd Schönhense — Institut für Physik, Johannes Gutenberg Universität, Staudingerweg 7, 55128 Mainz

Band structure calculations, which predict half metallic properties for several Heusler compounds, initiated great experimental efforts concerning this class of materials. The validation of the calculated electronic properties remains difficult, though. The band structures of the Heusler compounds $Co_2Cr_{0.6}Fe_{0.4}Al$ and Co_2FeAl were investigated in-situ by angle resolved ultraviolet photoemission spectroscopy (ARUPS). The samples were prepared by a sputtering process optimized for tunneling junction preparation, the photoemission process in normal direction of the (001)-oriented thin films was excited by a Helium gas discharge lamp (excitation energies 21.2eV and 40.8eV). The spectra of clean samples are compared with calculations of the total and partial bulk density of states and are evaluated within the three-step model of photoemission. Basic agreement with theoretical predictions of the bulk band structure is concluded. At oxygen exposures of only 1 Langmuir a chemisorption phase with significant changes of the valence-band spectrum near the Fermi-energy is observed. At 10L oxygen the spectra are indicative of beginnig oxide formation within the UPS probing depth.

MA 51.5 Thu 12:00 HSZ 401

Magnetoresistrance and anomalous Hall Effect measurements of Co_2MnGe and Cu_2MnAl Heusler alloy thin film microstructures — •Mohamed Obaida[1,2], Denise Erb[1], Kurt Westerholt[1], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44797 Bochum. — [2]National Research Center (NRC), Tahrir Street - Dokki., 12311 Cairo., Egypt.

We study the magnetoresistance and Hall Effect of thin films of the ferromagnetic Heusler compounds Co_2MnGe and Cu_2MnAl prepared by UHV magnetron sputtering at room temperature. In the as-prepared state the Heusler alloy films are non-ferromagnetic (Cu_2MnAl) or weakly ferromagnetic (Co_2MnGe)[1] and the resistivity shows a negative temperature coefficient, indicative of strong disorder renormalization of the electronic density of states. The magnetoresistance and the anomalous Hall coefficient in the as-prepared state are small. The magnetoresistance strongly increases when the ferromagnetism gradually develops after step by step thermal annealing at high temperatures and decreases again when the magnetic moment approaches its saturation value.

[1] D. Erb et al. J. Phys. D: Appl. Phys. 43 (2010).

MA 51.6 Thu 12:15 HSZ 401

Calculation of the Fermi surface of NiMnSb — •Liviu Chioncel — Augsburg Center for Innovative Technologies, University of Augsburg, Germany

Using a combined electronic structure and many-body calculations we revisit the electronic properties of the prototype half-metallic NiMnSb. In particular we discuss changes in the topology of the Fermi surface determined by the presence of electronic correlations beyond the mean-

field approach.

MA 51.7 Thu 12:30 HSZ 401

Half-metallic antiferromagnets and their possible device applications — •Nguyen Hoang Long[1,2], Masako Ogura[2], and Hisazumi Akai[2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics, Graduate School of Science, Osaka University, Osaka 560-0043, Japan

Half-metallic antiferromagnetism is a special case of half-metallic ferrimagnetism where the total magnetization is completely canceled out (fully spin-compensated). Such materials exhibit half-metallicity with 100% spin-polarized Fermi surface and vanishing magnetization simultaneously. They are especially useful for spintronics devices since they are insensitive to external field and in many cases have a high magnetic transition temperature.

In this work, a new type of half-metallic antiferromagnets are designed by use of the first-principles KKR Green's functions method. The materials consist of transition metals A and B, with the total *d*-valence electron number of 10, and chalcogens/pnictogens X (with chemical formula ABX_2) or halogens Y (with chemical formula ABY_4). We have found that they are chemically stable and the calculated magnetic transition temperatures are relatively high. The transport properties of the systems are also calculated by the KKR-CPA method combined with the Kubo-Greenwood formula. The results show that those systems can function as spintronics materials if used as components of GMR/TMR and magnetic random access memory cells.

We acknowledge funding from DFG project MO 1731/3-1.

MA 51.8 Thu 12:45 HSZ 401

Systematic studies of ferromagnetic ordering in EuB_6 — •Adham Amyan[1], Pintu Das[1], Mariano de Souza[1], Michael Lang[1], Peng Xiong[2], Stephan von Molnár[2], Zachary Fisk[3], and Jens Müller[1] — [1]Physikalisches Institut, Goethe Universität, D-60438 Frankfurt (M). — [2]Department of Physics MARTECH, Florida State University, Tallahassee, USA. — [3]Department of Physics, University of California, Irvine, USA.

The ferromagnetic semimetal EuB_6 recently has attracted renewed interest due to its rich transport and magnetic properties. In transport and thermodynamic measurements, two consecutive phase transitions at $\sim$ 12.6 K and 15.3 K are observed, where upon lowering the temperature a charge-localization transition via the overlap of magnetic polarons precede the ferromagnetic ordering. This behavior is discussed in terms of electronic phase separation and a percolative phase transition [1].

In this work, we performed fluctuation (noise) spectroscopy measurements of high-quality single crystals of EuB_6 in order to investigate the dynamics of the charge carriers close to the above-mentioned transitions. In addition, higher-harmonics transport measurements reveal clear signatures of non-linear effects going along with the lower ferromagnetic transition. Furthermore, ultra high-resolution thermal expansion measurements reveal that lattice degrees of freedom are strongly coupled to both low-temperature transitions.

[1] X. Zhang, L. Yu, S. von Molnár, Z. Fisk and P. Xiong, PRL 103,106602 (2009)

MA 51.9 Thu 13:00 HSZ 401

A study of the Verwey transition in epitaxial magnetite thin films by Raman spectroscopy and SQUID-magnetometry — •Mehrdad Baghaie Yazdi[1], Dirk Wulferding[2], Choi Kwang Yong[2,3], Peter Lemmens[2], and Lambert Alff[1] — [1]Technische Universität Darmstadt — [2]Technische Universität Braunschweig — [3]Chung-Ang University, Seoul, Korea

The origin of the Verwey transition, despite decades of research, remains a heavily debated fundamental property of magnetite. Its understanding involves concepts such as charge ordering which are essential in transition metal oxides. For this work, epitaxial thin films of magnetite (Fe_3O_4) have been grown, using reactive rf-magnetron sputtering, on single crystal (100) MgO (magnesium oxide) and *c*-cut Al_2O_3 (sapphire) substrates. The phase purity and orientation was analyzed using high resolution X-ray diffraction. The Verwey transition was studied by both Raman spectroscopy and SQUID-magnetometry. The Raman spectra of the magnetite grown on Al_2O_3 show an earlier onset of the transition at around 150 K with a definite change at T_V = 130 K, which corresponds to the data obtained by SQUID. As for the films grown on MgO, the transition is close to the literature value of 120 K.

MA 52: Magnetic Thin Films III

Time: Thursday 11:00–13:15 Location: HSZ 403

MA 52.1 Thu 11:00 HSZ 403

Electronic structure of fully epitaxial Co2TiSn thin films — •Markus Meinert[1], Jan-Michael Schmalhorst[1], Hendrik Wulfmeier[1], Günter Reiss[1], Elke Arenholz[2], Tanja Graf[3], and Claudia Felser[3] — [1]Dünne Schichten und Physik der Nanostrukturen, Fakultät für Physik, Universität Bielefeld, 33501 Bielefeld, Deutschland — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, CA 94720, USA — [3]Institut für Anorganische Chemie und Analytische Chemie, Johannes-Gutenberg-Universität, 55128 Mainz, Deutschland

We report on the properties of thin films of the full Heusler compound Co2TiSn prepared by DC magnetron co-sputtering. Fully epitaxial, stoichiometric films were obtained by deposition on MgO (001) substrates at substrate temperatures above 600°C. The films are well ordered in the $L2_1$ structure, and the Curie temperature exceeds slightly the bulk value. They show a significant, isotropic magnetoresistance and the resistivity becomes strongly anomalous in the paramagnetic state. The films are weakly ferrimagnetic, with nearly 1 μ_B on the Co atoms, and a small antiparallel Ti moment, in agreement with theoretical expectations. X-ray absorption spectra on the Co $L_{3,2}$ edges, including circular and linear magnetic dichroism are compared with ab initio calculations of the x-ray absorption and circular dichroism spectra. We infer that the electronic structure of Co2TiSn has essentially non-localized character. Spectral features that have not been explained in detail before, are explained here in terms of the final state band structure.

MA 52.2 Thu 11:15 HSZ 403

First principles investigation of the influence of excess Fe and Si(Al) on the magnetic properties of Co_2FeZ (Z = Si,Al)/MgO(001) — •Heike Herper and Peter Entel — Faculty of Physics, University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

Ferromagnet/semiconductor spintronic devices make high demands on the magnetic material, i.e., high spin polarization and Curie temperature are prerequisites. Heusler alloys such as Co_2FeSi fulfill the requirements in their $L2_1$ bulk phase. However, in thin films the spin-polarization (P) is often smaller which seems to be related to structural disorder and formation of off-stoichiometric alloys. Furthermore, the Heusler alloys experience lattice strain if grown on MgO(001) which can also change the magnetic properties.

We investigate the influence of off-stoichiometry, disorder, and strain on the magnetic properties in bulk-like Fe-Co-Si(Al) systems and thin films on MgO(001) within density functional theory using VASP [1]. Exchange parameters and magnetic transition temperatures are obtained from KKR[2] calculations.

Our investigations show that the polarization depends on the interplay between composition, e.g., Fe excess can reduce P, and strain which increases P in case of excess Fe. Additional Co on the Fe sublattice improves the magnetic properties of the system.

[1] G. Kresse and J. Furthmueller, Comput. Mater. Sci. 6, 15 (1996).
[2] The Munich SPR-KKR package, version 3.6, H. Ebert et al.

MA 52.3 Thu 11:30 HSZ 403

X-ray diffraction studies of $Mn_{3-x}Ga$ Heusler thin films — •Patrick Thomas, Daniel Ebke, Manuel Glas, and Günter Reiss — Thin Films and Physics of Nanostructures, Physics Department, Bielefeld University, Germany

Perpendicular magnetized thin films have attracted a lot of attention, because of the possible higher storage densities in comparison to common magnetic memory devices. In contrast to multilayered thin films

like Co/Pd for inducing a perpendicular anisotropy, we have investigated the crystal structure of the tetragonal distorted Heusler lattice $Mn_{3-x}Ga$. In this work we will discuss the crystal growth properties of the Heusler thin films for different substrates and buffer layers as a function of deposition temperature and film thickness.

MA 52.4 Thu 11:45 HSZ 403

Structural and magnetic ordering of Cu_2MnAl on MgO(001) studied by XAS and XMCD — •Bernhard Krumme[1], Heike Herper[1], Denise Erb[2], Claudia Weis[1], Anne Warland[1], Carolin Antoniak[1], Kurt Westerholt[2], Peter Entel[1], and Heiko Wende[1] — [1]Faculty of Physics and CeNIDE, University of Duisburg-Essen, D-47048 Duisburg, Germany — [2]Faculty of Physics IV, Ruhr-University Bochum, D-44801 Bochum, Germany

Since many Heusler compounds are predicted to be halfmetallic ferromagnets, these materials are very promising candidates for ferromagnetic electrodes in spintronic devices. However, in ferromagnet/insulator hybrid structures used for these devices, the magnetic properties of the Heusler compounds strongly depend on the structural quality of the films and their interfaces. Therefore, we investigate the influence of chemical order on the electronic structure as well as the magnetic properties element-specifically by means of X-ray absorption and X-ray magnetic circular dichroism (XMCD) spectroscopy at the $L_{2,3}$ absorption edges of Cu and Mn, respectively. Due to the element-specificity of these techniques, we are able to monitor the disorder-order transition at both the Cu and Mn sites and to identify a small, induced magnetic moment of 0.045 μ_B per Cu atom, which is in reasonable agreement with our SPR-KKR calculations [1].

– Supported by DFG (SFB 491) and Helmholtz-Zentrum Berlin.

[1] The Munich SPR-KKR package, version 3.6, H. Ebert et al.

MA 52.5 Thu 12:00 HSZ 403

Anisotropic magnetorestistance and magnetic anisotropy of Heusler compound thin films — •Matthias Althammer[1], Alexander T. Krupp[1], Franz D. Czeschka[1], Matthias Opel[1], Inga-Mareen Imort[2], Günter Reiss[2], Andy Thomas[2], Rudolf Gross[1], and Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Fakultät für Physik, Universität Bielefeld, Bielefeld, Germany

Magnetic anisotropy is of fundamental importance in ferromagnets, as it strongly influences their properties. Using anisotropic magnetoresistance (AMR) measurements, we investigate the magnetic anisotropy of the ferromagnetic Heusler compound Co_2FeAl. Thin Co_2FeAl films grown on (001)-oriented MgO substrate were patterned into Hall-bar mesa structures via optical lithography and etching. To quantify the magnetic anisotropy, we recorded the angle dependent magnetoresistance (ADMR), i.e., the AMR as a function of magnetic field *orientation* for different magnetic field magnitudes $|H|$. From the ADMR data taken at high $|H|$, the resistivity coefficients are obtained. The magnetic anisotropy is then extracted from ADMR taken at lower $|H|$. We will quantitatively compare the resistivity coefficients and the magnetic anisotropy in Co_2FeAl thin films with thicknesses of 20 nm, 50 nm, 80 nm, 100 nm, as a function of temperature from 5 K to 350 K.

Financial support by the Deutsche Forschungsgemeinschaft via project GO 944/3-1 and the NRW MIWF is gratefully acknowledged.

MA 52.6 Thu 12:15 HSZ 403

Magnetic domain patterns in Co2MnGe-Heusler nanostripes — •Katherine Gross, Philipp Szary, Oleg Petracic, Kurt Westerholt, and Harmut Zabel — Festkörperphysik, Ruhr Universität Bochum, D-44780 Bochum, Germany

We have investigated the magnetic domain patterns of Co2MnGe-Heusler microstructures resulting from the interplay between the magneto-crystalline, growth induced uniaxial, and shape anisotropies. Before patterning, thin films of ferromagnetic Co2MnGe Heusler alloys grown on Al2O3 a-plane substrates exhibit, besides a small cubic anisotropy, a dominant in-plane uniaxial anisotropy parallel to the Al2O3 -c-axis. On submicron wide slabs prepared by electron beam lithography we analyzed the influence of the slab geometry (width,length and thickness) on the magnetic domain configurations by magnetic force microscopy (MFM) and SQUID Magnetometry. In the remanent state with the uniaxial anisotropy axis perpendicular to the long axis of the slabs we observed perfectly regular multidomain patterns with the magnetization direction perpendicular to the slab axis and the domain width varying approximately as the square root of the slab width. For an oblique orientation between the slab axis and the uniaxial anisotropy axis ($0°<\alpha<90°$) the magnetization switches from a multidomain configuration to a single domain dipole state below a critical angle αC, which depends on the width of the stripes. The essential features of the domain patterns that we have imaged by MFM could well be reproduced by OOMMF micromagnetic simulations.

MA 52.7 Thu 12:30 HSZ 403

Co_2FeGa Heusler nanoparticles at the interface of physics, chemistry and materials science. — •Changhai Wang, Frederick Casper, Benjamin Balke, Gerhard H. Fecher, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

This work reports on the chemical synthesis and characterizations of the ternary Heusler Co_2FeGa nanoparticles. Specifically, the role of particle size in affecting the long and short range order and magnetic properties of the Heusler nanoparticles is investigated. The formation of the $L2_1$ Co_2FeGa phase is confirmed by anomalous X-ray diffraction (AXRD), extended X-ray absorption fine structure (EXAFS), Mössbauer spectroscopy, and magnetic measurements. The degrees of long and short range order of Co_2FeGa nanoparticles decrease for smaller particles. The population of superparamagnetic particles increases with decreasing particle size. The correlation of the TEM-derived particle size and Mössbauer spectroscopy specifies the critical size of Co_2FeGa nanoparticles bridging superparamagnetism and ferromagnetism. It is found that stoichiometric Co_2FeGa phases can be obtained under nonstoichiometric conditions. Pure Co_2FeGa phases are formed at precursor compositions of low Co/Fe ratio, nominal Co and excess Fe. A microscopic study reveals that the size of Co_2FeGa nanoparticles is dependent on the size and morphology of silica supports.

The authors gratefully acknowledge financial support by the DFG (Research Unit FOR 1464 “ASPIMATT”).

MA 52.8 Thu 12:45 HSZ 403

Tuning the magnetic anisotropy in $Mn_{3-x}Co_xGa$ Heusler compounds for spintronic applications — •Vajiheh Alijani, Jürgen Winterlik, Benjamin Balke, Gerhard H. Fecher, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

Heusler compounds such as tetragonal phase of $Mn_{3-x}Ga$ are currently receiving increased interest due to their benefits for applications, especially in the research field of spintronics. Our current research is particularly focused on Mn_2-based Heusler compounds. These compounds are of exceptional importance due to their large diversity of adaptive magnetic properties and their tunability by variation of several physical parameters such as temperature, magnetic field, or electron-doping. The materials $Mn_{3-x}Co_xGa$, i. e. substitution of Mn atoms by Co, exhibit very interesting features. While the Mn-rich alloys are very similar to Mn_3Ga as they crystallize in the identical tetragonal structure and show comparable hard-magnetic properties, the Co-rich samples show the cubic Heusler structure, soft-magnetic hysteresis loops, and perfect Slater Pauling behavior. This facilitates the tuneability of the magnetic anisotropy by varying the Co concentration. This work is supported by the Deutsche Forschungsgemeinschaft through the ASPIMATT projects TP 1.2-A (CH 952/1-1) and TP 2.3-A (FE 633/11-1).

MA 52.9 Thu 13:00 HSZ 403

Towards stretchable magnetoelectronics — •Michael Melzer, Denys Makarov, and Oliver G. Schmidt — Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstraße 20, 01069 Dresden

Magnetic multilayer stacks revealing giant magnetoresistance (GMR) are crucial components of magnetic sensor devices. Currently, GMR sensors are fabricated on rigid substrates. In this respect, successful operation of GMR devices on stretchable and flexible substrates can open up a variety of new applications for magnetic sensors due to arbitrary surface geometries possible after fabrication.

Here, we present a study of the magnetic and structural properties of GMR elements fabricated on free-standing elastic Poly(dimethylsiloxane) (PDMS) membranes. 40 μm thick PDMS films were spin-coated onto silicon wafers comprising an anti-stick layer, which allows for easily pealing the PDMS film off. GMR stacks consisting of 50 bilayers of Co/Cu as well as $Ni_{81}Fe_{19}$/Cu were grown on the elastic PDMS surfaces using magnetron sputter deposition. The GMR ratio measured on the multilayers grown on the elastic PDMS is found to be comparable to values obtained on rigid substrates. The optimization of the sensitivity of the resulting GMR elements with respect to sensing of low magnetic fields was performed by tuning the

coupling between the magnetic layers. Furthermore, the performance of these magnetic sensor elements upon stretching will be in the scope of the presentation.

The work was supported in part via BMBF project Nanett (FKZ: 03IS2011).

MA 53: Magnetic Storage Media, Applications - Invited Talks

Time: Thursday 14:00–15:00 Location: HSZ 04

Invited Talk MA 53.1 Thu 14:00 HSZ 04

From nanolithography to energy assisted writing - what is the limit to magnetic recording? — •Bruce Terris — Hitachi GST, San Jose, CA USA

As magnetic recording technology extends to ever higher areal density, it is possible that the often predicted, and constantly increasing, density limit for conventional magnetic recording will be reached. This limit will likely be in the range of 1 to 1.5 Tb/in2. However, new technologies are being explored which may extend this limit toward 10 Tb/in2 or beyond. These new technologies still have substantial unresolved questions on the underlying fundamental physics, will present manufacturing challenges, and will require significant changes to the hard disk drive. In this talk we will discuss the physical underpinnings and technology challenges of the technologies which are being pursued to push the density limit at least another factor of 10. These technologies include lithographically patterned single domain nm-scale islands, novel forms of energy assisted recording including near-field optical sources and spin torque oscillator microwave sources, and novel data encoding and architecture schemes.

Invited Talk MA 53.2 Thu 14:30 HSZ 04

29.5 Gb/in^2 Recording Areal Density on Barium Ferrite Tape — •Mark Lantz — IBM Research-Zurich, 8803 Rüschlikon, Switzerland

We investigated the performance of a barium ferrite tape medium in linear tape recording, using a giant-magnetoresistive read head with a 200 nm reader width. A linear density of 518 kbpi with an error rate of < 10^-4 was demonstrated based on measured recording data and a simulated channel that used an advanced data dependent noise predictive maximum likelihood detection scheme. Three advances in media technology relative to previous generations of BaFe were key to this achievement: (i) a reduction in particle volume to 1800 nm^3; (ii) an increase in the perpendicular squareness ratio to 0.7; and (iii) a reduction in surface roughness to 0.8 nm.

In order to facilitate the aggressive scaling of track density, we have made several advances in the area of track follow performance. First, we have developed a new timing-based servo format that enables the generation of high-bandwidth nm-scale position information. Second, we developed a new method for detecting the position information that reduces the noise floor of the position error signal (PES). Combining these technologies with a track follow servo controller based on advanced state-space-based control concepts and an ultra quite tape transport, we achieved a PES with a 1-sigma standard deviation of less than 24nm. This magnitude of PES allows the writing and reading of 446 nm tracks at 518 kbpi, for an equivalent areal density of 29.5 Gb/in^2.

MA 54: Spin Excitations I

Time: Thursday 15:00–17:00 Location: HSZ 04

MA 54.1 Thu 15:00 HSZ 04

An X-ray View on Ultrafast Magnetization Switching of GdFeCo — •Ilie Radu[1,2], Kadir Vahaplar[1], Christian Stamm[2], Torsten Kachel[2], Niko Pontius[2], Hermann Dürr[2,5], Thomas Ostler[3], Joe Barker[3], Richard Evans[3], Roy Chantrell[3], Arata Tsukamoto[4], Akiyoshi Itoh[4], Andrei Kirilyuk[1], Theo Rasing[1], and Alexey Kimel[1] — [1]IMM/SSI Radboud University Nijemegen, The Netherlands — [2]Helmholtz-Zentrum Berlin, BESSY II, Germany — [3]Department of Physics, University of York, United Kingdom — [4]College of Science and Technology, Nihon University, Japan — [5]SLAC National Accelerator Laboratory, USA

Exchange interaction is the strongest force in magnetism, being ultimately responsible for ferromagnetic or antiferromagnetic spin order. How do spins react after being optically perturbed on a timescale faster than the exchange interaction? Here, we demonstrate that femtosecond measurements of ferrimagnetic GdFeCo alloy using X-ray magnetic circular dichroism provide revolutionary new insights into the problem of magnetism on timescales pertinent to the exchange interaction. In particular, we show that upon fs optical excitation the ultrafast spin reversal of GdFeCo - a material with antiferromagnetic coupling of spins - occurs via a transient ferromagnetic state. The latter one emerges due to different dynamics of Gd and Fe magnetic moments: Gd switches within 1.5 ps while it takes 300 fs for Fe. These observations, supported by atomistic simulations, present a novel concept of manipulating magnetic order on timescales of the exchange interaction. Funding from EU through UltraMagnetron programme is acknowledged.

MA 54.2 Thu 15:15 HSZ 04

Magnetization reversal process in Permalloy nanostructures — Markus König, Saleh Getlawi, •Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P.O.Box 151150, D-66041 Saarbrücken, Germany

The understanding and control of the displacement and motion of magnetic domain walls (DW) induced by a magnetic field or a spin-polarized current is of great interest due to potential applications such as magnetic memory devices. Permalloy (Ni81Fe19) nanowires with various pad geometries for DW propagation and optimized geometries for DW nucleation and annihilation were fabricated by electron beam lithography (EBL) and focused-ion-beam (FIB) methods. The actual dimensions of the structures were determined by SEM and AFM. The DW was imaged using MFM before, during and after applying an in-plane one- or two-dimensional magnetic field. Results show that switching fields strongly depend on the nanowire widths and the pad geometries. Micromagnetic simulations by OOMMF were performed for comparison to determine the primary domain structure as well as the DW displacement and the switching field. Theoretical and experimental results are in fairly good agreement.

MA 54.3 Thu 15:30 HSZ 04

Magnetic excitations of atomic systems by femtosecond laser pulses — •Daria Popova, Andreas Bringer, and Stefan Blügel — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Ultrafast optical control of the magnetic state of a medium attracts much scientific interest. It opens vistas for the development of novel concepts for high-speed magnetic recording and information processing. Furthermore, it uncovers magnetization dynamics in a strongly out-of-equilibrium regime. A set of experiments has revealed the direct optical control on magnetization via the inverse Faraday effect [1]. In these experiments circularly polarized high-intensity laser pulses at femtosecond time scale are used to excite the magnetic system of the sample. The fundamental mechanisms of the generation of magnetic field by light are still not understood.

In order to get insight into the magnetization dynamics at femtosecond time scales we study theoretically the influence of a subpicosecond laser pulse on the magnetic states of atomic systems. We consider isolated atoms, which are constituents of materials used in experiments, and the ones in a crystal field. We discuss the stimulated Raman-like scattering process, which was suggested to be responsible for the magnetization reversal by light [2].

We are thankful for the support by the FANTOMAS project.

[1] A. Kimel *et al.*, Nature **435**, 655 (2005).
[2] F. Hansteen *et al.*, Phys. Rev. B **73**, 014421 (2006).

MA 54.4 Thu 15:45 HSZ 04

Structural Effects on Magnon Excitations in Ultrathin Fe Films — •Tzu-Hung Chuang, Yu Zhang, Khalil Zakeri, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

We report the experimental results of high wave-vector magnon excitations in a 2 monolayer (ML) Fe film grown on 2ML Au/W(110) obtained by spin-polarized electron energy loss spectroscopy. It is found that the magnon energies in 2ML Fe on 2ML Au/W(110) are lower than the ones in 2ML Fe directly grown on W(110) [1]. This observation is correlated to the structure of the films, studied by means of low-energy electron diffraction (LEED) experiments. The LEED intensity-voltage analyses combined with the diffraction patterns revealed that the first two atomic-layers of Fe films grow on 2ML Au/W(110) are most likely the starting slabs of fcc Fe(111) surface.

The strength of the exchange coupling, estimated by using a classical Heisenberg model, is found to be weaker than the one of the bcc Fe(110) films directly grown on W(110). The experimental results are consistent with the earlier theoretical calculation of bulk fcc Fe [2].

[1] W.X. Tang,*et al.*, Phys. Rev. Lett., **99**, 087202 (2007).

[2] R.F. Sabiryanov and S.S. Jaswal, Phys. Rev. Lett. **83**, 2062 (1999).

MA 54.5 Thu 16:00 HSZ 04

Interface electron complexes and Landau spin-wave damping in ultrathin magnets — Pawel Buczek, Arthur Ernst, and •Leonid Sandratskii — Max Plank Institute of Microstructure Physics, Halle, Germany

The Landau damping of spin-waves in ultrathin magnets caused by the presence of non-magnetic metallic substrate is studied by means of *ab initio* linear response time dependent density functional theory. By contrasting two systems: 1ML Fe/Cu(100) and 1ML Fe/W(110), we show how the strength and the details of the hybridization of electronic states of the magnetic monolayer and the substrate influence the Landau damping, allowing to tune the latter from moderate to strong. We introduce the concept of *Landau map* to distinguish the contributions of different groups of electronic states to the spin-wave attenuation. We demonstrate that the contribution coming from the continuum of substrate states is rather weak and uniformly distributed on the Landau map. We explore a novel mechanism leading to a strongly enhanced Landau attenuation in thin magnets. This mechanism is related to the formation of electronic complexes localized at the film-substrate interface and leads to *Landau hot spots* in the Landau maps. It is demonstrated that the life-time of the magnons in ultrathin films can be longer than in the bulk phases. This paves the way to the design of metallic nanostructures with desired strength of the damping of high frequency magnetization dynamics by means of the engineering of substrate properties.

MA 54.6 Thu 16:15 HSZ 04

Scaling behavior of the spin pumping effect in conductive ferromagnet/platinum bilayers — Franz D. Czeschka[1], Lukas Dreher[2], Martin S. Brandt[2], Matthias Althammer[1], Inga-Mareen Imort[3], Günter Reiss[3], Andy Thomas[3], Wladimir Schoch[4], Wolfgang Limmer[4], Hans Huebl[1], Rudolf Gross[1], and •Sebastian T.B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany — [3]Fakultät für Physik, Universität Bielefeld, Germany — [4]Abteilung Halbleiterphysik, Universität Ulm, Germany

Spin pumping experiments allow to measure spin currents or the spin Hall angle. We have systematically studied the spin pumping DC voltage occurring in conjunction with ferromagnetic resonance in a series of conductive ferromagnet/platinum bilayers, made from elemental 3d transition metals, Heusler compounds, ferrite spinel oxides, and magnetic semiconductors. In all bilayers, we invariably observe the same DC voltage polarity. Moreover, we find that the voltage magnitude scales with the magnetization precession cone angle with a universal prefactor, irrespective of the magnetic properties, the charge carrier transport mechanism, and the charge carrier type in a given ferromagnet. These findings quantitatively corroborate the present theoretical understanding of spin pumping in combination with the inverse spin Hall effect, and establish spin pumping as a generic phenomenon.

Financial support by the Excellence Cluster Nanosystems Initiative Munich (NIM) and the NRW MIWF is gratefully acknowledged.

MA 54.7 Thu 16:30 HSZ 04

Theory of ac driven resonant spin amplification and depletion in FNF spin valves: prediction of negative GMR — •Denis Kochan, Martin Gmitra, and Jaroslav Fabian — University of Regensburg

Parallel (P) and antiparallel (AP) configurations of FNF junctions have, in a dc regime, different resistivities (AP>P), giving rise to the giant magnetoresistance (GMR) effect. This can be explained within the spin diffusion model.

We extend the model to include ac phenomena and predict resonant amplification and depletion of spin accumulation in the P and AP configurations, respectively. As a result, the spin valve impedance shows oscillations as a function of the driving ac frequency, with periods of negative GMR.

From the spin-valve oscillation periods, which are experimentally accessible, the time-dependent spin diffusion model allows to extract, all electronically, the spin relaxation times without additional input.

This work is supported by the DFP SFB 689.

MA 54.8 Thu 16:45 HSZ 04

Non-Collinear Ferromagnetic Luttinger Liquids — •Nicholas Sedlmayr, Sebastian Eggert, and Jesko Sirker — Technische Universität Kaiserslautern, Germany

In the now classic Tomonaga-Luttinger model the presence of the electron-electron interaction in one dimension is shown to profoundly change the properties of the system. We consider here the magnetic and electronic properties of a *ferromagnetic* Luttinger liquid when it has a region of non-collinearity present, i.e. a domain wall. Spin-charge separation does not survive in this system, and the absence of both spin-charge separation and coherent spin-charge excitations has consequences for the spin-transfer-torque effects which cause domain wall motion. Furthermore the presence of the domain wall introduces a spin dependent scatterer into the problem, which will alter both the transport, and the static electronic, properties of the system. Finally we show how the magnetization dynamics of the domain wall will be modified for a Luttinger liquid.

MA 55: Surface Magnetism IV

Time: Thursday 15:15–17:15 Location: HSZ 103

MA 55.1 Thu 15:15 HSZ 103

SP-STM study on bulk nickel (111) surface — •Liudmila Dzemiantsova, André Kubetzka, Kirsten von Bergmann, and Roland Wiesendanger — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

It has been recently reported that ferromagnetic materials, in particular nickel, can be used as ideal substrates for a high quality graphene formation [1, 2]. Despite the fact that nickel is a good source of spin-polarized electrons, there remains a lack of information about spinpolarized scanning tunneling microscopy (SP-STM) investigations of its surfaces [3, 4].

In our study we used SP-STM to explore the domain structure of a bulk nickel crystal (111) surface on a large scale. We showed that domains can easily be shifted at low magnetic fields or by the stray field of the magnetically coated tip. The strongest magnetic signal was achieved at energies below the Fermi level. This result is in contrast to previous theoretical expectations [3].

[1] A. Varykhalov et al., Phys. Rev. B., 80, 035437 (2009)

[2] Yu.S. Dedkov et al., App. Phys. Lett., 92, 052506 (2008)

[3] K-F. Braun et al., Phys. Rev. B, 77, 245429 (2008)

[4] Y. Nishimura et al., Phys. Rev. B, 79, 245402 (2009)

MA 55.2 Thu 15:30 HSZ 103

Orientation-dependent Kondo resonance of the $Ni_2(hfaa)_4(bpm)$ and $Mn_2(hfaa)_4(bpm)$ single molecular magnets — •Lei Zhang[1], Michael Schackert[1], Toshio

Miyamachi[1], Toyokazu Yamada[1], Frank Schramm[2], Mario Ruben[2], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Karlsruhe Institut of Technology, Germany — [2]Institut of Nanotechnology, Karlsruhe Institut of Technology, Germany

Single molecular magnets (SMM) attract much interest due to their potential applications in spintronics. We investigated metal organic molecules based on $(hfaa)_4(bpm)$ containing two $3d$ ions (Ni or Mn) using low temperature scanning tunneling microscopy (STM) at 1 K in ultra-high vacuum. In the bulk, the two metallic ions couple antiferromagnetically leading to an $S = 0$ ground state [1,2].

The Ni_2 and Mn_2 molecules were sublimed onto atomically clean Cu(100) surfaces resulting in two different absorptions configurations. Scanning tunneling spectroscopy (STS) with a high energy resolution of 0.3 meV showed a strong Kondo resonance on the position of the metal ions inside the molecules indicating that the hybridization of the local spins with the substrate is more efficient than their antiferromagnetic coupling. The Fano resonance showed a pronounced dependence on the adsorption geometry indicating different Kondo temperatures and q-parameters. This is explained by a adsorption dependent hybridization between SMM and the substrate.

[1] G. Brewer *et al.*, Inorg. Chem. **24**, 4580-4584 (1985)
[2] M. Barquín *et al.*, Transition Metal Chemistry **24**, 546-552 (1999)

MA 55.3 Thu 15:45 HSZ 103

Search for homochiral magnetic structures along the step edge of Pt(664) — •Benedikt Schweflinghaus, Bernd Zimmermann, Gustav Bihlmayer, and Stefan Blügel — Peter Grünberg Institut (PGI-1) & Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Co chains at the step edge of Pt(997) is historically the prime example of a one-dimensional metallic magnet. A series of experimental and theoretical studies uncovered and explained the magnetic properties of this novel magnet. We re-investigate this type of system in the light of the recently discovered Dzyaloshinskii-Moriya interaction (DMI) of ultrathin films causing spin-orbit driven homochiral magnetic structures. The question arises whether the DMI in the Co chain at the Pt edge is strong enough to drive a spin-spiral state of one handedness.

In this contribution we investigate this point applying the material specific density functional theory by means of the Full-Potential Linearized Augmented Plane-Wave (FLAPW) method as implemented in the FLEUR code [1] to a variety of transition-metal (TM) chains on Pt(664). We compare TM chains to the previous analysis of the magnetic anisotropy energy (MAE) for Co chains on Pt(664) [2]. Via a micromagnetic model that includes the MAE, as well as the spin stiffness and the Dzyaloshinskii vector we investigate the possible magnetic phases. While in the Co chain it appears that the ground state is collinear, yet in other TM chains non-collinear states may be possible.

[1] http://www.flapw.de
[2] S. Baud *et al.*, Physical Review B **73**, 104427 (2006)

MA 55.4 Thu 16:00 HSZ 103

Magnetism of Cobalt-coordination nodes in 2D supramolecular networks — •Uta Schlickum[1], Willi Auwärter[2], Markus Etzkorn[1], Stefano Rusponi[1], Pardeep Thakur[3], Knud Seufert[2], Svetlana Klyatskaya[4], Mario Ruben[4], Johannes V. Barth[2], and Harald Brune[1] — [1]Institute of Condensed Matter Physics, Ecole Polytechnique Fédérale de Lausanne, Switzerland — [2]Physik Department E20, Technische Universität München, Germany — [3]European Synchrotron Radiation Facility, Grenoble, France — [4]Institut für Nanotechnologie, Karlsruher Institut für Technologie, Germany

Supramocular engineering on crystalline surfaces offers the possibility to fabricate networks with embedded metal centers having specific physicochemical properties. Here we report on the magnetic nature of individual Co atoms in 2D architectures providing different coordination environments probed with X-ray magnetic circular dichroism. Changing the coordination symmetry using related functional organic ligands strongly influences the magnetic characteristics of the metal center. While Co atoms with threefold coordination to carbonitriles show large magnetic moments, these vanish in the case of fourfold coordination to pyrrole ligands in a Co-porphyrin. Further modification of the magnetic properties by site-selective decoration of the individual Co centers by small Fe clusters will be discussed.

MA 55.5 Thu 16:15 HSZ 103

Charge-transfer correlation effects on the spin state of magnetic molecules at a metal interface — •Sebastian Stepanow[1], Piter Miedema[2], Aitor Mugarza[1], Gustavo Ceballos[1], Paolo Moras[3], Julio Cezar[4], Carlo Carbone[3], Frank de Groot[2], and Pietro Gambardella[1] — [1]ICN Barcelona — [2]U Utrecht — [3]CNR Trieste — [4]ESRF Grenoble

We investigate the hierarchy of local correlation and hybridization effects in metal-organic molecules adsorbed on metals. Using x-ray magnetic circular dichroism and ligand field multiplet calculations, we demonstrate that the $3d$ electronic ground state of monolayer metal-phthalocyanine (CoPc, FePc) on Au(111) is given by the coherent superposition of two charge states, $d^nE + d^{n+1}$, where E represents a substrate electron bound to the central metal ion and d^n the many-body ionic orbital configuration of the unperturbed molecule. These results differ from previous models of hybrid metal-organic systems, and provide a consistent description of their magnetic properties in terms of spin and orbital multiplicity.

MA 55.6 Thu 16:30 HSZ 103

Adsorbate-Dependent Changes in the Surface Magnetization of TiO_2 terminated $SrTiO_3$ Surface from *Ab-Initio* Calculations — •Waheed A. Adeagbo, Guntram Fischer, and Wolfram Hergert — University of Halle, Halle, Germany

Motivated by a recent experiment by Khalid *et al.* [1], in which the surface magnetization of STO was increased (weakened) after ultrasonic cleaning in ethanol (acetone), we have studied the magnetic moment formation of the TiO_2 terminated STO surface.

For this we have considered the perfect surface as well as one containing an O vacancy or a Ti vacancy. Both of the latter are found to be magnetic, whereas the perfect surface is non-magnetic. Furthermore, we have investigated how the adsorption of the ethanol or acetone influences the results calculated above. We find that the two adsorbates affect the magnetization of the Ti vacancy differently.

Our results are compared to the experimental ones. The calculated observed effects are robust with respect to LDA+U correlation corrections applied to the Ti $3d$ orbitals.

[1] M. Khalid et al., *Phys. Rev. B* **81**, 214414 (2010)

MA 55.7 Thu 16:45 HSZ 103

Chiral spin-structure of biatomic Fe chains on Ir(001) — •Yuriy Mokrousov[1], Matthias Menzel[2], Robert Wieser[2], Kirsten von Bergmann[2], Elena Vedmedenko[2], André Kubetzka[2], Roland Wiesendanger[2], Stefan Blügel[1], and Stefan Heinze[3] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany — [3]Institut für Theoretische Physik und Astrophysik, Universität zu Kiel, 24098 Kiel, Germany

We investigate from *ab initio* the magnetism of biatomic Fe chains, which form due to self-organization on the (5×1)-reconstructed Ir(001) surface [1]. Using the `FLEUR` code [2], we calculate the magnetic anisotropy and exchange energies with different exchange-correlation functionals, and find very small Heisenberg exchange interactions along the chain of the order of 10 meV/Fe-atom. Upon including spin-orbit coupling we obtain the contribution from the Dzyaloshinskii-Moriya interaction and find that it leads to a 120° spin-spiral ground state of the Fe chains with a unique rotational sense. The results of the Monte-Carlo simulations based on the parameters from *ab initio* are in a very good agreement to STM experiments on the system. We acknowledge funding under HGF-YIG Programme VH-NG-513.

[1] L. Hammer *et al.*, Phys. Rev. B **67**, 125422 (2003).
[2] www.flapw.de

MA 55.8 Thu 17:00 HSZ 103

Dzyaloshinskii-Moriya interaction in $3d$-$5d$ zig-zag biatomic chains — V. Kashid[1], •B. Zimmermann[2], T. Schena[2], Ph. Mavropoulos[2], H. G. Salunke[3], V. Shah[4], Y. Mokrousov[2], and S. Blügel[2] — [1]Department of Physics, University of Pune, Pune 411 007, India — [2]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [3]Technical Physics Division, Bhabha Atomic Research Centre, Mumbai 400 085, India — [4]Interdisciplinary School of Scientific Computing, University of Pune, Pune 411 007, India

We investigate from first principles the influence of the antisymmetric Dzyaloshinskii-Moriya interaction (DMI) on the magnetic properties of free-standing zig-zag biatomic chains consisting of $3d$ (Fe, Co) and $5d$ (Ir, Pt, Au) transition-metal atoms. Using the `FLEUR` code [1],

we perform self-consistent spin-spiral calculations while treating the spin-orbit interaction within first-order perturbation theory [2]. In this way we can extract the strength of DMI and analyze it in terms of the electronic structure of the chains. Moreover, within a simple tight-binding model we are able to grasp main features of the DMI in these systems and characterize them in terms of symmetry, band-filling and spin-spiral vector.

We acknowledge funding under HGF-YIG Programme VH-NG-513.

[1] www.flapw.de
[2] M. Heide, G. Bihlmayer, S. Blügel, Physica B **404**, 2678 (2009)

MA 56: Graphene (jointly with DY, DS, HL, O, TT)

Time: Thursday 15:15–17:00 Location: HSZ 401

MA 56.1 Thu 15:15 HSZ 401

Tunable edge magnetism in graphene — •Manuel J. Schmidt[1], Daniel Loss[1], David J. Luitz[2], and Fakher F. Assaad[2] — [1]Universität Basel, Switzerland — [2]Universität Würzburg, Germany

Edge states with nearly zero energy that are exponentially localized at zigzag edges of graphene ribbons, in combination with electron-electron interactions give rise to edge magnetism. We show how the characteristic momentum-dependence of the transverse wave function of the edge states may be exploited in order to manipulate the edge state bandwidth [1]. This allows to tune graphene edges from the usual edge magnetism regime, over a regime of itinerant one-dimensional ferromagnetism, down to the non-magnetic Luttinger liquid regime. As an example we discuss graphene/graphane interfaces for which we propose an experimental setting in which the bandwidth may be tuned in situ by means of electrostatic gates [2]. We introduce an effective one-dimensional model for the edge states, on the basis of which we investigate the tunability of edge magnetism. Our analysis uses essentially three techniques: by a mean-field treatment of the effective interaction, the phase diagram is established. Quantum fluctuations, which may not be neglected in one dimension, are taken into account on the basis of a bosonization technique. Finally, these analytical calculations are complemented by an exact diagonalization analysis of the effective edge state model.

[1] M.J. Schmidt and D. Loss, Phys. Rev. B 81, 165439 (2010).
[2] M.J. Schmidt and D. Loss, Phys. Rev. B 82, 085422 (2010).

MA 56.2 Thu 15:30 HSZ 401

Ballistic transport at room temperature in micrometer size multigraphene — •Srujana Dusari[1], José Luis Barzola Quiquia[1], Pablo Esquinazi[1], and Nicolas Garcia[2] — [1]Division of Superconductivity and Magnetism, Universität Leipzig, Faculty of Physics and Earth Sciences, Institute for Experimental Physics II, Linnéstr. 5, 04103 Leipzig, Germany — [2]Laboratorio de Física de Sistemas Pequeños y Nanotecnología, Consejo Superior de Investigaciones Científicas, Serrano 144, E-28006 Madrid, Spain

As an emergent material for electronic applications, graphite and graphene and their electrical transport properties have become a subject of intense focus. By performing transport measurements through micro and submicro constrictions in ~10 nm thick graphite samples, we observe drastic increase in the resistance decreasing the constriction width. Our experimental observations indicate that electrons behave ballistically even at room temperature and with mean free path of the order of microns. The values obtained for the mobility (~10^7 cm^2 v^-1 s^-1) and density of the electrons (~10^8 cm^-2) indicates that the graphene layers inside graphite are of higher quality than single ones. The decrease of magneto resistance with decreasing constriction width also indicates that the carrier mean free path is larger than few microns at room temperature.

MA 56.3 Thu 15:45 HSZ 401

Long spin relaxation times in bilayer graphene — •Frank Volmer[1,2], Tsung-Yeh Yang[1,2], Jayakumar Balakrishnan[3], Ahmet Avsar[3], Manu Jaiswal[3], Julia Samm[1,2], Syed Rizwan Ali[1,2], Alexandre Felix Pachoud[3,4], Ming-Gang Zeng[3,5], Mihaita Popinciuc[1,2], Barbaros Özyilmaz[3,4,5], Gernot Güntherodt[1,2], and Bernd Beschoten[1,2] — [1]II. Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — [2]JARA: Fundamentals of Future Information Technology, 52074 Aachen, Germany — [3]Department of Physics, National University of Singapore, 117542 Singapore — [4]NUS Graduate School for Integrative Sciences and Engineering (NGS), Centre for Life Sciences (CeLS), 117456 Singapore — [5]Nanocore, National University of Singapore, 117576 Singapore

The demonstration of micrometer long spin relaxation lengths in graphene at room temperature has made this material a promising candidate for spintronic applications. We investigated the spin transport in the non-local spin valve geometry in bilayer graphene using MgO barriers for spin injection. We demonstrate that the dominant spin relaxation mechanism in bilayer graphene is of the D'yakonov-Perel' type. In this case the spin dephasing time scales inversely with the charge carrier mobility. At room temperature spin dephasing times of up to 2 ns are measured in samples with the lowest mobility.

This work has been supported by DFG through FOR 912.

MA 56.4 Thu 16:00 HSZ 401

The graphene Landau quartet unveiled — •Sander Otte[1,2,3], Young Jae Song[2,3], and Joseph Stroscio[2] — [1]Delft University of Technology, The Netherlands — [2]National Institute of Standards and Technology (NIST), USA — [3]Maryland NanoCenter, University of Maryland, USA

Some of the unique properties of graphene come to expression when its electrons are locked into Landau levels in an external magnetic field. Due to spin-degeneracy in combination with the two-atom unit cell of the hexagonal lattice (valley degeneracy), each Landau level is expected to host four electrons. We use a newly completed dilution refrigerator cooled STM system to study epitaxial graphene at 10 mK in magnetic fields up to 15 T. The unparalleled energy resolution of this instrument enables us to break the predicted fourfold Landau level degeneracy and to measure the sublevel splittings as a function of the magnetic field. Surprisingly large splittings are found for the valley states, which are not magnetic by nature. In addition, intriguing partial filling of the sublevels is observed, yielding access to promising electron correlation effects.

MA 56.5 Thu 16:15 HSZ 401

Emergent magnetism of *5d* transition-metal adatoms on Graphene — •Hongbin Zhang[1], Cesar Lazo[2], Stefan Blügel[1], Stefan Heinze[2], and Yuriy Mokrousov[1] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Theoretical Physics and Astrophysics, University of Kiel, 24098 Kiel, Germany

Owing to its peculiar electronic structure, graphene serves as a playground for many interesting physical properties and has drawn a lot of attention recently [1]. In this work, using the first principles FLAPW methods, we investigate the magnetism of 5*d* transition metal (TM) atoms from Hf to Pt deposited on graphene in different supercell geometries. By taking into account the effect of atomic relaxations, we find that most of the 5*d* TMs exhibit strong local magnetism when deposited on graphene. A combination of large spin moments with strong spin-orbit coupling in considered adatoms leads to gigantic values of the magnetic anisotropy energies, reaching values as large as 30 meV/atom. We also investigate the influence of external electric fields on the magnetic properties of 5*d* TM adatoms and discuss possible transport applications. We acknowledge funding under HGF-YIG Programme VH-NG-513.

[1] A. H. C. Neto, *et al.*, Rev. Mod. Phys. **81**, 109 (2009).

MA 56.6 Thu 16:30 HSZ 401

Anisotropic magnetoresistance observed in graphite flakes — •Jose Barzola-Quiquia, Andreas Schadewitz, Winfried Böhlmann, and Pablo Esquinazi — Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig, Germany

The possibility to have magnetic order at room temperature in a system without 3d metallic magnetic elements attracts the interest of the solid state physics community. Experimental evidence for the existence of ferromagnetism in virgin and proton-irradiated graphite samples was published based on SQUID [1] and XMCD [2] measurements. An alternative method to detect magnetic order is to measure the

magnetoresistance (MR). The MR develops a characteristic butterfly loop when measured vs. magnetic field. In this work we have studied the magnetotransport properties of micrometer-size and ˜10 nm thick graphite flakes as a function of temperature, magnetic field applied in- and out-plane configurations. We investigated especially the MR as a function of the angle between current and applied field in order to study the anisotropic magnetoresistance (AMR). Virgin graphite flakes show a small AMR and flakes treated with H_2SO_4 show an increase in the AMR signal. The observed behavior provides evidence for intrinsic and induced ferromagnetism at the surface of graphite samples. This investigation also was complemented using SQUID magnetometry on graphite powder in virgin state and after treatment with H_2SO_4 resulting in a clear ferromagnetic signal. [1] P. Esquinazi et al., Phys. Rev. B 66, 024429 (2002), Phys. Rev Lett. 91, 227201 (2003). [2] H. Ohldag et al., Phys. Rev. Lett. 98, 187204 (2007).

MA 56.7 Thu 16:45 HSZ 401

Magnetic clusters on graphene flakes — •Wolfgang Landgraf, Sam Shallcross, and Oleg Pankratov — Lehrstuhl fur Theoretische Festkorperphysik, Staudstr. 7-B2, 91058 Erlangen, Germany.

We present an investigation of the properties of magnetic ad-atoms and clusters on graphene flakes. We consider clusters of 1-7 atoms of metals from the 3d series assembled on graphene flakes composed of the order of 100 carbon atoms. All calculations are performed within the spin density functional theory formalism in the local density approximation. We elucidate the range of the magnetic interaction for pairs of magnetic ad-atoms on graphene flakes, as well as the equilibrium magnetic structure for various cluster types. By a comparison of such clusters on flakes with their counterparts on extended sheets, we are able to elucidate the role of the flake shape upon the magnetic interaction. In this way we determine the role of confinement on the magnetic interaction, and comment on the possibility of using flake shape as a design parameter of magnetic nanostructures on graphene flakes.

MA 57: Focus Session "X-ray absorption spectra - state of the art of theory and experiment" (jointly with DS, HL, MM, O), Organization: Andreas Ney (Universität Duisburg-Essen)

Time: Thursday 15:15–19:00 Location: HSZ 403

Invited Talk MA 57.1 Thu 15:15 HSZ 403
Simulations of X-ray Spectra using FEFF9 and OCEAN — •John Rehr — University of Washington, Seattle, WA, USA

There has been dramatic recent progress in the theory of x-ray spectra. This spectra probes excited state properties of a system, and thus requires theoretical treatments beyond the independent particle approximation. Here we discuss two complementary approaches based on the GW/BSE method. First is a real-space Green*s function approach, as implemented in the FEFF9 code [1]. FEFF9 has improved treatments of many-body effects and can also include LDA+U corrections. Second, is a new k-space approach implemented in the GW/BSE code OCEAN (Obtaining Core Excitation using ABINIT and NBSE)[2]. OCEAN also includes intra-atomic coulomb interactions and can also treat multiplet effects. FEFF9 and OCEAN have complementary spectral ranges. However, the combination is applicable from the UV-VIS to x-ray energies. These two approaches are illustrated with applications to several core-level specra including XAS and RIXS. This work is supported by US DOE Grant DE-FG03-97ER45623 and the CMCSN. [1]J. J. Rehr et al.,Comptes Rendus Physique 10,548 (2009). [2]J. Vinson et al., arXiv:1010.0025

Topical Talk MA 57.2 Thu 15:45 HSZ 403
Polarisation dependent X-ray spectroscopy — •Andrei Rogalev, Fabrice Wilhelm, and Jose Goulon — European Synchrotron Radiation Facility (E.S.R.F.), 6 rue Jules Horowitz, 38000 Grenoble, France

In these recent years X-ray spectroscopies have been undergoing a continuous expansion, as illustrated by the discovery of a variety of new experimental techniques associated with the exploitation of the polarisation properties of synchrotron radiation. The detection of X-ray magnetic linear and circular dichroism in ferro-, ferri- and paramagnetic systems, the discovery of X-ray natural circular dichroism in gyrotropic single crystals as well as the observation of non-reciprocal X-ray linear dichroism and X-ray magneto-chiral dichroism in magnetoelectric systems are particularly interesting. In combination with sum rules these element and orbital selective spectroscopies have proved to be remarkable tools to study fundamental properties of magnetic matter via various order parameters, e.g., spin and orbital moments, electric dipole moment, orbital anapole etc. In this talk we report on advanced instrumentation developed at the ESRF beam line ID12 which is dedicated to polarization dependent x-ray spectroscopy at photon energies above 2keV. Several examples have been selected to illustrate the present performances of the beam line and to show the recent advances in the field.

Topical Talk MA 57.3 Thu 16:15 HSZ 403
Theoretical description of X-ray absorption in correlated transition metal systems — •Hubert Ebert[1], Jan Minar[1], and Ondrej Sipr[2] — [1]Ludwig-Maximilians-Universität München, Department Chemie und Biochemie, Physikalische Chemie, Butenandtstraße 11, D-81377 München, Germany — [2]Institute of Physics AS CR, Prague, Czech Republic

During the last years, great progress has been made in dealing with correlation effects in solids. Among the various theoretical approaches available now, the LSDA+DMFT (local spin density approximation + dynamical mean field theory) plays a prominent role, as it accounts for dynamical correlations when dealing with the ground state. We present a description of x-ray absorption spectra based on combining the LSDA+DMFT and the multiple scattering formalism. Working with a fully relativistic formulation, this approach gives access to a corresponding treatment of x-ray magnetic circular dichroism (XMCD). By applying the XMCD sum rules, we can demonstrate that the enhancement of orbital magnetism in ferromagnetic 3d-transition metals, which results from using the LSDA+DMFT formalism instead of plain LSDA, is indeed reflected by the XMCD spectra. Comparing the LSDA+DMFT-based XAS and XMCD spectra with experiment, however, some discrepancies remain that are ascribed to dynamical effects connected with the absorption process itself. To account for these effects we extended the sketched approach by including the presence of a core hole within the XAS and XMCD calculations using various schemes.

15 min. break

Topical Talk MA 57.4 Thu 17:00 HSZ 403
Paramagnetic molecules on metal surfaces: prototypes for spin-hybrid systems — •Heiko Wende — Faculty of Physics and CeNIDE, University of Duisburg-Essen, 47048 Duisburg, Germany

The fundamental understanding of the interaction of paramagnetic molecules with metal surfaces is crucial for the possible application of these spin-hybrid systems in molecular spintronics. We study the magnetic properties of Fe-porphyrin and Fe-phthalocyanine molecules with sub-monolayer coverages on Ni and Co films on Cu(100) with and without an intermediate layer of atomic oxygen. Dichroism in X-ray absorption spectra (XNLD and XMCD) at the respective absorption edges (Fe, Co and Ni $L_{2,3}$-edges, N and C K-edges) is investigated to identify the coupling of the molecules to the ferromagnetic layers, the orientation on the surfaces and the electronic structure. To determine the magnetic anisotropy of Fe- and Co-porphyrin molecules, the molecules were adsorbed on a non-magnetic substrate (Cu(100)). Therefore, angular-dependent XAS and XMCD spectra were measured at 5T and 8K. Calculated XAS spectra obtained from DFT and multiplet calculations using ligand field theory enable a solid interpretation of the experimental data. This work is done in collaboration with C. Weis, D. Klar, D. Bovenschen, M. Kaya, H.C. Herper, B. Krumme, A. Warland, C. Antoniak (Univ. Duisburg-Essen), M. Bernien, J. Miguel, M. Piantek, K. Baberschke, W. Kuch (FU Berlin), P. Srivastava (IIT Delhi), and B. Brena, Md. E. Ali, P.M. Panchmatia, P.M. Oppeneer, B. Sanyal, O. Eriksson (Uppsala Univ.). Supported by BMBF (05 ES3XBA/5), DFG (SFB 491 and SFB 658), STINT and ESRF(HE2700).

Invited Talk MA 57.5 Thu 17:30 HSZ 403

Can Carbon Be Ferromagnetic? — •Hendrik Ohldag[1], Elke Arenholz[2], Pablo Esquinazi[3], Daniel Spemann[3], Annette Setzer[3], Martin Rothermel[3], and Tilman Butz[3] — [1]SLAC National Accelerator Center — [2]Lawrence Berkeley National Laboratory — [3]University Leipzig

The existence of long range magnetic order at room temperature in carbon based structures without magnetic elements is very unexpected. Theoretical results from different groups suggest that the existence of long range magnetic order in a graphite structure is possible, if one takes the effects of defects and/or the incorporation of hydrogen atoms into account. SQUID results provided first systematic hints for the existence of magnetic order at room temperature in virgin as well as irradiated graphite samples. We present a x-ray dichroism study of graphite surfaces [1] that addresses the origin and magnitude of ferromagnetism in metal-free carbon. Using element specific x-ray microscopy we can show that metallic impurities do not play a role in the ferromagnetism of carbon and that carbon can be ferromagnetic without ferromagnetic impurities. A detailed spectroscopic study shows that in addition to carbon pi-states, also hydrogen-mediated electronic states exhibit a net magnetization with magnetic remanence at room temperature. The observed magnetism is restricted to the top ˜10 nm of the sample where the actual magnetization reaches a value similar to that of Nickel. [1] H. Ohldag et al., Phys. Rev. Lett. 98, 187204 (2007) and to appear in New. Jour. Phys. (2011).

MA 57.6 Thu 18:00 HSZ 403

Investigation of strain and doping induced ferromagnetism in $LaCoO_3$ by x-ray absorption and magnetic circular dichroism — Michael Merz[1], Peter Nagel[1], Andrea Assmann[1,2], Stephan Uebe[1,2], Markus Wissinger[1,2], Hilbert von Löhneysen[1,3], Dirk Fuchs[1], and •Stefan Schuppler[1] — [1]Institut für Festkörperphysik, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [2]Fakultät für Physik, Karlsruhe Institute of Technology — [3]Physikalisches Institut, Karlsruhe Institute of Technology, 76031 Karlsruhe, Germany

Undoped bulk $LaCoO_3$ remains paramagnetic down to liquid He temperatures; it has been shown that upon cooling, the Co^{3+} ions undergo a spin-state transition to the $S = 0$ low-spin (LS) state. We explore two avenues for inducing ferromagnetism in this compound: (i) strain, applied by the lattice mismatch between a $LaCoO_3$ thin film and the substrate, and (ii) doping, both with electrons and holes. The spin-state structure of these systems can be studied in detail by near-edge x-ray absorption fine structure and by soft x-ray magnetic circular dichroism at the Co $L_{2,3}$ and the O K edges. It turns out that the mechanism responsible for ferromagnetism in each of the systems – strained undoped, electron doped, hole doped – is unique and distinctly different from the others, explaining the vastly differing transition temperatures. In all cases, a mix of Co spin states is realized, and thus their actual microscopic arrangement is a co-determining factor for magnetic parameters like the spin and orbital moments.

MA 57.7 Thu 18:20 HSZ 403

Ab initio study of surface and interface effects on XANES and XMCD of Fe/BaTiO3 systems — •Stephan Borek[1], Angelika Chassé[1], Remya Kunjuveettil Govind[1], Vasili Hari Babu[2], Federica Bondino[3], Martin Trautmann[1], Marco Malvestuto[3], Karl-Michael Schindler[1], Reinhard Denecke[2], Igor Maznichenko[1], and Arthur Ernst[4] — [1]Institute of Physics, Martin-Luther-University Halle-Wittenberg, Germany — [2]Wilhelm-Ostwald Institute for Physical and Theoretical Chemistry, University Leipzig, Germany — [3]IOM CNR, Laboratorio Nazionale TASC, Area Science Park, Basovizza, Italy — [4]Max-Planck-Institut für Mikrostrukturphysik Halle

The aim of our work is the spectroscopic characterization of multiferroic heterostructures by means of x-ray absorption spectroscopy (XAS). Starting form first-principles calculations of bulk $BaTiO_3$ (BTO) the influence of surface and surface termination of BTO on x-ray absorption near edge structure (XANES) and x-ray magnetic circular dichroism (XMCD) is studied for different edges in BTO. In the case of iron layers on BTO, effects at the interface and of layer thickness on XANES and XMCD are considered by means of layer-resolved contributions within a multi-code approach. Calculations are shown in dependence on the direction of polarization of ferroelectric BTO (tetragonal phase). The calculated results are compared to experimental data.

MA 57.8 Thu 18:40 HSZ 403

Co-doped ZnO epitaxial films: signs of phase separation by means of hard x-ray absorption spectroscopy — •Verena Ney, Shunagli Ye, Katharina Ollefs, Tom Kammermeier, and Andreas Ney — Fakultät für Physik and CeNIDE, Universität Duisburg-Essen, 47057 Duisburg, Germany

X-ray absorption spectroscopy (XAS) using linear and circular polarized light offers a powerful toolbox of element-specific structural, electronic, and magnetic probes that is especially well suited for studying $Zn_{1-x}Co_xO$ (Co:ZnO) to unravel its intrinsic properties. We demonstrate that as long as phase separation or excessive defect formation is absent, Co:ZnO is paramagnetic [1]. We can establish quantitative thresholds based on four reliable quality indicators using XAS; samples which show ferromagnet-like behaviour fail to meet these quality indicators, and complementary experimental techniques indeed prove phase separation [2]. Careful analysis of XAS spectra is shown to provide valuable information of secondary phases in a highly sensitive, non-destructive manner.

[1] A. Ney et al., Phys. Rev. Lett. **100**, 157201 (2008).
[2] A. Ney et al., New J. Phys. **12**, 013020 (2010).

This work is supported by the DFG (Heisenberg-Programm) and the EU (MEXT-CT-2004-014195)

MA 58: Spintronics II (jointly with TT, HL)

Time: Thursday 17:15–19:15 Location: HSZ 401

MA 58.1 Thu 17:15 HSZ 401

Spin pumping by short-wavelength exchange-dominated magnons excited by parametric pumping — •Andrii V. Chumak[1], Christian W. Sandweg[1], Yosuke Kajiwara[2], Vitaliy V. Vasyuchka[1], Alexander A. Serga[1], M. Benjamin Jungfleisch[1], Eiji Saitoh[2], and Burkard Hillebrands[1] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

Spin pumping from a ferromagnet to a nonmagnetic metal detected by the Spin Hall effect (SHE) has great potential in the context of the development of spintronic devices. In addition, it offers exciting possibilities for the use of spin waves (or their quanta, magnons) for carrying and processing spin-information [Y. Kajiwara, et al., Nature 464, 262 (2010)]. Until now, all experimental investigations into spin pumping have been realized using dipolar-dominated magnons with long wavelengths (limited by the size of the exciting antenna).

Here, we present studies of spin pumping in an exchange-dominated magnon system. Magnons were excited in a ferrite Yttrium Iron Garnet (YIG) film by frequency doubled parametric pumping. The spin pumping was detected via the SHE in a Pt layer deposited directly onto the YIG. Contributions to the spin pumping from different magnon groups, including magnons from the lowest energy state were studied. We show that spin pumping is possible even for magnons without an associated dipolar field. However, the magnon localization, which is in general inversely proportional to wavelength, is of high importance.

MA 58.2 Thu 17:30 HSZ 401

Spin-quadrupole Currents in Spin-valves — •Michael Hell[1,2], Sourin Das[4], and Maarten Rolf Wegewijs[1,2,3] — [1]Intitute for Solid State Research Theory 3, Research Center Jülich — [2]JARA - Fundamentals of Future Information Technology — [3]Institute for Theoretical Physics A, RWTH-Aachen — [4]Department of Physics and Astrophysics, University of Delhi

Spin-quadrupole moments (SQM) quantify the magnetic anisotropy of a nanostructure, in addition to its spin-polarization. We illustrate the possibility of quantum transport of SQM for a simple tunnel junction between two spin-polarized leads. Inspired by this, we present a

more general spintronic transport theory for high-spin quantum dots coupled to ferromagnets. We show that SQM has to be treated as an independent degree of freedom, on the same footing as charge and spin polarization. Since SQM and its current are two-particle quantities, they have direct and exchange contributions as well as both local and non-local SQM sources. Moreover, the SQM current operator is derived which is shown to obey a continuity equation. We predict the electric control of the transfer of spin-anisotropy in elementary nanostructures.

MA 58.3 Thu 17:45 HSZ 401

Temporal evolution of spin pumping from a magnetic insulator detected via the inverse spin Hall effect — •Matthias Benjamin Jungfleisch[1], Andrii V. Chumak[1], Vitaliy I. Vasyuchka[1], Alexander A. Serga[1], Peter A. Beck[1], Eiji Saitoh[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

The spin pumping effect, which is the conversion of a magnetization precession into a pure spin current, and the inverse spin Hall effect (iSHE), which is the conversion of a spin current into a charge current, have recently been observed in a Platinum (Pt) / Yttrium Iron Garnet (YIG) structure [Y. Kajiwara, et al., Nature **464**, 262 (2010)]. Up to now the temporal properties of this combined effect is not known. We used the spin pumping effect to inject a spin current pulse from the magnetic insulator YIG into a thin non-magnetic Pt layer and investigated simultaneously the temporal evolution of both, the iSHE voltage using a wide-band oscilloscope and the intensity of the spin waves by means of time resolved Brillouin light scattering spectroscopy. It is revealed that the iSHE voltage evolves slowler in time than the causing spin-wave mode. This is due to the fact, that secondary spin waves created by two-magnon scattering of the externally excited spin-wave mode make a strong contribution to the iSHE signal. The contributions of the externally excited coherent precession and the non-coherent spin waves have been clearly distinguished in our experiment.

MA 58.4 Thu 18:00 HSZ 401

Anisotropic polar magneto-optical Kerr effect (MOKE) of thin epitaxial Fe films on GaAs in ab initio theory and experiment — •Sebastian Putz, Martin Gmitra, Georg Woltersdorf, Jaroslav Fabian, and Christian Back — Universität Regensburg, Universitätsstraße 31, 93053 Regensburg

We investigate the anisotropy of the polar magneto-optical Kerr effect (MOKE) of thin epitaxial Fe films on GaAs both in ab initio theory and experiment. The maximum Kerr rotation at almost normal incidence on Fe/GaAs is obtained from the height of the out-of-plane hard-axis magnetization curves of a perpendicularly magnetized Fe/GaAs sample. It is proportional to the off-diagonal terms of the optical conductivity tensor σ of the Fe/GaAs interface. The C_{2v} symmetric anisotropy of the spin-orbit coupling fields at this interface causes an analogous anisotropy of σ. This, in turn, is measured by our polar MOKE setup at almost normal incidence when the direction of polarization of the incoming linearly polarized light is varied, i.e. the direction of polarization is turned around the surface normal of the out-of-plane magnetized sample. Additionally, we use the linearized augmented plane-wave (LAPW) method, as implemented in WIEN2k, to calculate the optical conductivity tensor σ and obtain the anisotropic polar magneto-optical Kerr angle for experimentally relevant Fe/GaAs slabs.

We would like to thank Josef Ammerl from MueTec GmbH for developing and manufacturing essential parts of our experimental setup. This work is supported by the DFG SFB 689.

MA 58.5 Thu 18:15 HSZ 401

Unveiling the valence band nature of GaMnAs anisotropic carriers by inter-band tunneling spectroscopy — •Romain Giraud, Mara Granada, Edgar Briones, Ulf Gennser, Aristide Lemaitre, and Giancarlo Faini — CNRS/LPN, Route de Nozay, 91460 Marcoussis, France

The discovery of highly anisotropic properties of magnetic tunnel junctions based on GaMnAs [1] has led to new concepts for spintronics devices, such as magnetic memories based on anisotropy relaxation in nanostructures [2], or magnetic switches relying on electrical control of the magnetic anisotropy [3]. However, despite the success of mean-field theories of hole-induced ferromagnetism, a direct evidence of the existence of Bloch states is still missing, and the nature of carriers remains controversial (impurity-band vs. valence-band models).

Here, based on inter-band tunneling spectroscopy of p-GaMnAs/n-GaAs Zener-Esaki diodes [4], we directly evidence the valence band nature of GaMnAs carriers and, importantly, reveal the spin-split valence bands dependence of their cubic and uniaxial anisotropies (which can be tuned under applied bias or magnetic field). In particular, the Fermi energy is found well below the top of the valence band, and the energy dependence of Bloch states anisotropies shows some specific features predicted by a k.p modelling of the spin-split valence bands.

[1] C. Gould et al., Phys. Rev. Lett. 93, 117203 (2004) [2] K. Pappert et al., Nat Phys. 3, 573 (2007) [3] C. Bihler et al., Phys. Rev. B 78, 045203 (2008) [4] R. Giraud et al., Appl. Phys. Lett. 87, 242505 (2005)

MA 58.6 Thu 18:30 HSZ 401

Ferromagnetically contacted carbon nanotubes for spin injection — •Caitlin Morgan[1,2], Klaus Schmalbuch[2,3], Carola Meyer[1,2], and Claus Michael Schneider[1,2] — [1]Forschungszentrum Jülich, Peter Grünberg Institute 7, 52425 Jülich, Germany — [2]JARA Jülich Aachen Research Alliance, 52425 Jülich, Germany — [3]Physikalisches Institut, RWTH Aachen University, Otto-Blumenthal-Straße, 52074 Aachen, Germany

In addition to exhibiting ballistic transport, carbon nanotubes (CNTs) have small spin-orbit interactions and relatively few spin nuclei (13C). These properties suggest a long spin relaxation length in CNTs, giving them a potential application in the field of spintronics.

We study spin injection in CNT-based devices. Samples are fabricated via chemical vapor deposition growth of CNTs onto lithographically prepatterned substrates. The CNTs are then contacted by ferromagnetic leads to form 2 and 4 terminal devices for spin injection. Special attention has been given to choosing a ferromagnetic material and shape for contacts. Permalloy and Co-based alloys have been studied in order to find a material with good magnetic properties that also forms a stable electronic interface with CNTs. SQUID and X-ray measurements of thin films were used to select good material systems. The shape and size of the contacts have been optimized to have only one in-plane magnetic domain. SQUID and atomic/magnetic force microscopy were used to study the magnetic properties of nanocontacts. Magnetoresistance measurements of contacted CNT samples are shown and discussed.

MA 58.7 Thu 18:45 HSZ 401

Local formation of a Heusler type structure in a CoFe-Al CPP-GMR spin valve — •Sabine Wurmehl[1], Patrick J. Jacobs[2], Jürgen T. Kohlhepp[2], Henk J.M. Swagten[2], Bert Koopmans[2], Stefan Maat[3], Matthew J. Carey[3], and Jeff R. Childress[3] — [1]Institute for Solid State Research, IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands — [3]San Jose Research Center, Hitachi GST, 3403 Yerba Buena Road, San Jose, California 95135, USA

The magnetotransport properties of current-perpendicular-to-the-plane giant magnetoresistance devices consisting of ferromagnetic Co-Fe alloys have recently been shown to be significantly improved by addition of up to 28% Al. Nuclear magnetic resonance (NMR) is able to reveal the next neighboring shells of the ^{59}Co nuclei in the Co-Fe-Al magnetic films. This sensitivity to small changes in the local (magnetic and electronic) environment makes NMR an ideal method to determine the local modifications upon addition of Al to the Co-Fe alloy. In our present NMR study, we demonstrate the local formation of a Heusler-like structure by addition of Al to the Co-Fe alloy in CPP-GMR multilayers. The observed local formation of a highly spin-polarized Heusler compound may be correlated to the observed enhancement of the GMR effect [1].

[1] Wurmehl *et al.* Appl. Phys. Lett. accepted (2010).

MA 58.8 Thu 19:00 HSZ 401

Spin relaxation by impurity scattering in metallic systems — Swantje Heers, •Phivos Mavropoulos, Rudolf Zeller, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich

We present calculated results on spin relaxation in Cu, Ag and Au due to scattering at non-magnetic impurities of the 4th, 5th and 6th row of the periodic table ($3d$ up to $6sp$ elements). We consider the processes of spin-flip scattering by spin-orbit coupling (SOC) at the impurity as well as SOC at the host atoms (Elliott-Yafet mechanism). Our results show that the SOC in the host is not so important in Cu, especially for

heavy impurities with strong SOC, while it is essential in Au. In our approach we employ the full-potential Korringa-Kohn-Rostoker Green-function method (KKR) for the calculation of the electronic structure and the spin-flip transition probability $P^{ss'}_{\mathbf{kk'}}$, with s being the spin-index. A Fermi-surface integral of P over $\mathbf{k}$ and $\mathbf{k}'$ yields then the spin-relaxation rate $1/\tau_{ss'}$.

In order to go beyond the approximation of independent scattering events, implied by this approach, we calculate the scattering by impurity dimers at increasing distance from nearest to third-nearest neighbours. In this way we simulate possible effects of impurity clustering in the sample, caused *e.g.* by impurity attraction or increasing concentration. We find that the presence of nearest-neighbour dimers has a considerable effect on $\tau_{ss'}$, while the results for dimers with distance beyond second-nearest neighbours are practically the same as in the independent scattering approximation.

MA 59: Spin Excitations II/ Spin Scattering

Time: Thursday 17:15–19:15 Location: HSZ 04

MA 59.1 Thu 17:15 HSZ 04

Ab initio description of the spin-Hall effect in disordered ferromagnets — •Diemo Ködderitzsch, Stephan Lowitzer, and Hubert Ebert — Ludwig-Maximilians-Universität München, Department Chemie und Biochemie, Physikalische Chemie, Butenandtstraße 11, D-81377 München, Germany

Spin-orbit induced couplings are at the heart of interesting phenomena like the anomalous- and spin-Hall-effects (AHE, SHE), which recently received a lot of attention due to their potential application for spin-separating devices in the field of spintronics. During the last years several theoretical works have dealt with the intrinsic SHE, based on the band structure of pure materials and only a few of them use a parameter free *ab initio* approach.

We present a coherent *ab initio* description of the spin Hall effect that is applicable to pure **and** disordered alloys by treating all sources of the SHE on equal footing. We use an implementation of the Kubo-Středa equation employing the fully relativistic Korringa-Kohn-Rostoker (KKR) Green's function method in conjunction with the Coherent Potential Approximation (CPA) alloy theory.

Whereas former studies concentrate mainly on non-magnetic systems, we apply our recently developed relativistic spin-projection scheme [1] to ferromagnetic transition-metal alloys and give first results.

[1] S. Lowitzer, D. Ködderitzsch and H. Ebert, Phys. Rev. B 82, 140402(R) (2010).

MA 59.2 Thu 17:30 HSZ 04

Anisotropic Spin Hall Effect from First Principles — •Frank Freimuth, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We present first-principles calculations [1] of the intrinsic non-dissipative spin Hall conductivity (SHC) for 3*d*, 4*d* and 5*d* transition metals focusing in particular on the anisotropy of the SHC in nonmagnetic hcp metals and in antiferromagnetic bulk Cr. For the metals of this study we generally find large anisotropies. We derive a general relation between the SHC vector and the direction of spin-polarization and discuss the consequences for hcp metals. Especially, it is predicted that for systems, where the SHC changes sign due to the anisotropy, the spin Hall effect may be tuned such that the spin polarization is parallel either to the electric field or to the spin current. Additionally, we describe our computational method [2,3] emphasizing the Wannier interpolation technique and the definition of the conserved spin current. This work is supported by the HGF-YIG grant VH-NG-513.

[1] e-print: http://arxiv.org/abs/1011.2714
[2] F. Freimuth et al. Phys. Rev. B **78**, 035120 (2008)
[3] www.flapw.de

MA 59.3 Thu 17:45 HSZ 04

Unified *ab initio* description of the intrinsic and extrinsic anomalous Hall effect in disordered alloys — Diemo Ködderitzsch, •Kristina Chadova, Stephan Lowitzer, and Hubert Ebert — Ludwig-Maximilians-Universität München, Department Chemie und Biochemie, Physikalische Chemie, Butenandtstraße 11, D-81377 München, Germany

We present a coherent *ab initio*, i.e. parameter free, description of the anomalous Hall effect (AHE) that is applicable to pure as well as disordered alloy systems by treating all sources of the AHE on equal footing. We employ an implementation of the Kubo-Středa equation using the fully relativistic Korringa-Kohn-Rostoker (KKR) Green's function method in conjunction with the Coherent Potential Approximation (CPA) alloy theory. Applications to the pure elemental ferromagnets bcc-Fe, hcp-Co and fcc-Ni lead to results in full accordance to previous *ab initio* studies determining the intrinsic contribution only. However, the power of the approach presented is the ability to explicitly treat also extrinsic contributions to the AHE which is demonstrated by an application to the fcc alloy systems Fe_xPd_{1-x}, Co_xPd_{1-x} and Ni_xPd_{1-x}. We obtain a very satisfying qualitative agreement with experiment over the whole concentration range including the sign reversal of the AH-conductivity. A detailed discussion of skew and side-jump scattering processes exemplifies the capability of the proposed method.

MA 59.4 Thu 18:00 HSZ 04

Side-Jump Scattering Contribution to Anomalous Hall Effect from *ab initio* — •Jürgen Weischenberg[1], Frank Freimuth[1], Jairo Sinova[2], Stefan Blügel[1], and Yuriy Mokrousov[1] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics, Texas A&M University, College Station, Texas 77843-4242, USA

The anomalous Hall conductivity may be decomposed into a scattering-dependent and a scattering-independent term. The extrinsic disorder-driven contribution to the scattering-independent term, the so-called side jump, is usually obtained by extrapolation from calculations with finite disorder. Recently it has been shown [1] that the side jump contribution to the anomalous Hall effect may be calculated directly from the electronic structure of a perfect crystal if a delta-correlated Gaussian disorder model is assumed. We implemented this approach within the full-potential linearized augmented plane-wave method (FLAPW) and computed the side-jump induced transverse conductivity for a variety of ferromagnetic materials such as Fe, Ni, FePt and FePd by means of Wannier interpolation [2]. To interpret our findings we compare them to theoretical and experimental literature values. Financial support by the HGF-YIG Programme VH-NG-513 is gratefully acknowledged.

[1] A. A. Kovalev *et al.*, PRL **105**, 036601 (2010)
[2] F. Freimuth *et al.*, Phys. Rev. B **78**, 035120 (2008)

MA 59.5 Thu 18:15 HSZ 04

First-principles calculation of transport through magnetic impurities in metallic wires with strong spin-orbit coupling — •Björn Hardrat[1], Neng-Ping Wang[2], Frank Freimuth[3], Yuriy Mokrousov[3], and Stefan Heinze[1] — [1]Institut für Theoretische Physik und Astrophysik, CAU Kiel, Germany — [2]Physics Department, Ningbo University, P.R. China — [3]Peter Grünberg Institut and Institute for Advanced Simulation, FZ-Jülich and JARA, Germany

We report the application of our recently developed ballistic transport code for one-dimensional magnetic systems to the spin-dependent transmission through magnetic impurities in metal monowires including spin-orbit coupling (SOC). The electronic structure of the considered systems is obtained with the one-dimensional version of the full-potential linearized augmented plane wave (FLAPW) method as implemented in the FLEUR code. We calculate the transmission and conductance within the Landauer formalism using a Greens function approach. In order to apply the Greens function method we map the electronic structure from our FLAPW calculations to a tight-binding like Hamiltonian via Wannier functions, preserving the accurate description of magnetic systems within the FLAPW method for our transport calculations. We demonstrate the potential of our code by calculating the spin-dependent conductance of ferromagnetic Co monowires with a Pt impurity exhibiting strong SOC and Pt monowires with a Co scatterer. We discuss the energy-dependent transmission in terms of the spin-dependent channels and mixing due to SOC leading to the

phenomenon of ballistic anisotropic magnetoresistance (BAMR).

MA 59.6 Thu 18:30 HSZ 04

Magnetic friction in the Heisenberg spin chain — •Martin Magiera, Sebastian Angst, Alfred Hucht, and Dietrich E. Wolf — Faculty of Physics and CeNIDE, University of Duisburg-Essen, D-47048 Duisburg, Germany

Friction forces in purely magnetically interacting systems have been neglected for a long time, although they offer a broad spectrum of phenomena as recent studies show. We present theoretical calculations and simulations of the Heisenberg spin chain, scanned by a magnetic field with a constant velocity, where friction force may appear in a Stokesian way (force proportional to scanning velocity). In the same system additional (higher order) contributions due to spin wave excitations may be present. Finally the system may show non-adiabatic behavior, yielding a Coulomb friction force, which does not depend on velocity. In this talk we focus on the crossover from the Stokes- to the Coulomb-regime. This crossover can also be observed in the Ising model.

MA 59.7 Thu 18:45 HSZ 04

Confinement of kinks in a quantum one-dimensional Ising ferromagnet — •Sergei B. Rutkevich — Universität Duisburg-Essen, Duisburg, Deutchland

Confinement of topological excitations (the kinks) typically takes place in one-dimensional quantum systems having a discrete vacuum degeneracy, if the latter is explicitly broken by an external field. This phenomenon has been recently observed by Coldea et. al. (2010 Science **327** 177) in the Ising spin-chain ferromagnet $CoNb_2O_6$ at low temperatures. A phenomenological model has been proposed by Coldea et. al. to interpret the observed energy spectra of the magnetic excitations - the bound states of two kinks. We solve this model exactly and give explicit formulas for the kink bound state energies and for the related neutron scattering intensities. Possible modifications of the model are discussed as well.

MA 59.8 Thu 19:00 HSZ 04

spin-orbit scattering in molecular transport — •pengxiang xu and daniel wortmann — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

While many molecules considered for molecular transport devices contain only light elements and therefore the spin-orbit interaction generally plays not important role in these junctions, the use of heavier elements in molecules proposed for magnetic transport setups can lead to interesting behavior in spin-polarized transport due to the coupling of the spins to the electric polarization of the molecule.

Applying ab-initio density functional theory in the framework of the linearized-augmented plane-wave method [1] and the Green function formalism for transport, we study some model systems with different magnetization states (collinear/non-collinear) and molecular dipole moment. We report on our investigations of transport through molecules with transition-metal centers and demonstrate the influence of the spin-orbit coupling on the transmission properties of the molecule.

This work is supported by DFG priority program 1243.

[1]http://www.flapw.de

MA 60: Spin Structures and Magnetic Phase Transitions

Time: Thursday 17:30–19:15 Location: HSZ 103

MA 60.1 Thu 17:30 HSZ 103

Imaging the ferromagnetic phase transition in magnetic microstructures with PEEM — •Oliver Sandig[1], Julia Herrero-Albillos[1], Nils Nüsse[1], Florian Kronast[1], Florian M. Römer[2], and Michael Farle[2] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin — [2]Universität Duisburg-Essen, Duisburg

A fundamental question in ferromagnetic systems with reduced dimensions is, whether magnetic properties vary laterally at the edges of the sample, at defects or at steps due to the underlying substrate. Due to changes in the local fluctuation rate of the magnetic moments, the Curie Temperature (T_C) is a good quantity to detect such variations. Those changes of T_C and the involved length scales are of increasing interest for the stability of data storage and spintronic applications. We used x-ray photoelectron emission microscopy to image local variations of T_C in micro-structured Fe films. We grew well defined magnetic structures of different shape and size by in-situ Fe evaporation on pre-patterned Si substrates. Different areas on our sample were magnetically decoupled from each other due to the sample topography. To image local variations of T_C we used a special sample holder. It allows measuring the local AC susceptibility (χ_{ac}) as a function of temperature with a spatial resolution better than 100nm and temperature stability of 0.2K [1]. In our presentation we compare T_C of different magnetic structures to that of a continuous reference film which allows us to identify the onset of finite size effects in our sample.

MA 60.2 Thu 17:45 HSZ 103

Magnetic ordering and spin dynamics in the Swedenborgite $CaBaCo_2Fe_2O_7$ — •Johannes Reim[1], Werner Schweika[1], Erik Rosén[1], Martin Valldor[2], and Enrico Faulhaber[3] — [1]IFF-4, Forschungszentrum Jülich GmbH — [2]II. Phys. Institut, Universität zu Köln — [3]FRM II, Garching

The Swedenborgites [1] represent a new type of highly frustrated magnets with antiferro-magnetically coupled spins on staggered kagome layers. Geometrical frustration suppresses long-range magnetic order to evolve in many compounds that we have studied so far by polarised neutron diffraction on powder samples. However, a few chemical compositions do enter a Néel state at lower temperatures [2], for example $CaBaCo_2Fe_2O_7$.

By using neutron single crystal diffraction and diffuse neutron scattering we observed magnetic long-range order below 160 K exhibiting a $\sqrt{3} \times \sqrt{3}$ superstructure and a weak anisotropy as evidenced by polarisation analysis. Modelling a Heisenberg nearest neighbour Hamiltonian for different in- and out-of-plane coupling constants with Monte Carlo simulations we determine the phase diagram in dependence on these coupling constants. Neutron measurements of the spin dispersion exhibits unusually broad excitations indicating strongly damped spin vectors.

[1] M. Valldor, M. Andersson, Solid State Sciences 4 (2002) 923-931; [2] M. Valldor, Y. Sanders, W. Schweika, Journal of Physics: Conference Series 145, 012076 (2009)

MA 60.3 Thu 18:00 HSZ 103

Spin echo measurements of magnetic fluctuations in helical $Mn_{1-x}Fe_xSi$ — •Alexander Tischendorf[1], Wolfgang Häussler[1,2], Andreas Bauer[1], Peter Böni[1], and Christian Pfleiderer[1] — [1]Technische Universität München, Physik Department E21, 85748 Garching, Germany — [2]Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM-II), 85748 Garching, Germany

Manganese silicide (MnSi) is a 3d inter metallic compound and crystallizes in a cubic B20 structure. In absence of an external magnetic field for temperatures below T_c the magnetization caused by the spin of the electrons forms a chiral long-period ferromagnetic helix with a period of approximately 180 Å. Furthermore, the phase transition temperature in $Mn_{1-x}Fe_xSi$ changes with the conzentration x. At a critical concentration x_c the phase transition temperature $T_c = 0$ and there is a quantum phase transition (QPT).

By means of neutron spin echo we investiaged the linewidth of magnetic fluctuations in absence of an external magnetic field. The high energy resolution and the small angle scattering set up of the spin echo instrument RESEDA at the Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II) offer paramter ranges, which are not accessable in triple axes measurements. We measured the linewidth in dependence of different temperatures and Q-values in pure MnSi and also compared them to an iron doped sample. The measured linewidth will be discussed, regarding the spin-fluctuation theory of weakly magnetic itinerant-electron compounds, which allows the identification of anomalous behavior at QPTs.

MA 60.4 Thu 18:15 HSZ 103

Field-induced chirality in Dy/Y multilayer systems — •Dieter Lott[1], Sergey V. Grigoriev[2], Yury O. Chetverikov[2],

Roger C. Ward[3], Alexander Grünwald[1], and Andreas Schreyer[1] — [1]Helmholtz Zentrum Geesthacht, Geesthacht, Germany — [2]Petersburg Nuclear Physics Institute, Gatchina, Russia — [3]University of Oxford, Oxford, United Kingdom

In this work a series of Dy/Y multilayer samples with different Dy and Y layer thicknesses were studied to modify the interlayer and intralayer RKKY coupling mechanism in the system. Polarized neutron reflectometry studies reveal the occurrence of chirality effects which can be manipulated by the application of a magnetic field applied during the Field Cooling process. The studies show intriguing features giving experimental hints for the theoretical interpretation of the observed phenomena. The obtained results can be interpreted taking into account the interplay of the RKKY and Zeeman interactions. Upon Zero Field cooling a helix inside one Dy layer suffers from the domain walls between the right- and left skewed structures. The magnetic field applied upon cooling, firstly, removes the domain walls inside the Dy layer. Secondly, the Zeeman interaction, coupling the non-compensated moments of the Dy layer with the magnetic field, competes with the interlayer RKKY interaction. When at a certain condition the two interactions compensate each other, the third antisymmetric Dzyaloshinskii-Moriya interaction, appearing due to the lack of inversion symmetry on the interfaces, reveals itself through the sign of the average chirality of the structure.

MA 60.5 Thu 18:30 HSZ 103

Precursor states and Skyrmion confinement in cubic helimagnets — •Andrey A. Leonov, Anna B. Butenko, Alexei N. Bogdanov, and Ulrich K. Rössler — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Within the phenomenological Dzyaloshinskii model we show that precursor effects [1] experimentally observed in cubic helimagnets with B20 structure near the ordering temperature can be explained by the unconventional behavior of 'Skyrmion matter'[2]. Skyrmion states in the form of staggered half-Skyrmion configurations and $\pm\pi$-hexagonal lattices undergo confinement in the temperature range $\Delta T = T_N - T_L$ and can exist as bound liquid-like or ordered arrays [2]. Confined Skyrmion textures arise from the disordered state through a rare case of an instability-type nucleation transition. Their field-driven transformation is marked by the interplay of angular and longitudinal order parameters. The confinement temperature T_L separates the major part of the magnetic phase diagram with regular chiral modulations [3] from the precursor regime. The stabilization of Skyrmionic textures against the competing helical and conical modulations near magnetic ordering can be achieved by small additional interactions such as dipolar couplings, thermal fluctuations, cubic and uniaxial anisotropies, anisotropic exchange etc. [1] C. Pappas et al., Phys. Rev. Lett. **102**, 197202 (2009); [2] U. K. Rößler et al., J. Phys., in press; [3] A. Bogdanov, A. Hubert, J. Magn. Magn. Mater. **138**, 255 (1994); A.B. Butenko et al., Phys. Rev. B **80**, 134410 (2009).

MA 60.6 Thu 18:45 HSZ 103

Itinerant electrons on the Coulomb phase — •Ludovic Jaubert[1], Masud Haque[1], Swann Piatecki[1,2], and Roderich Moessner[1] — [1]MPI-PkS, Dresden — [2]ENS Paris, France

The Coulomb phase describes a state encountered in frustrated systems where geometrical constraints lead to the emergence of a gauge field. Its effective description is quite analogous to that of a free magnetic field, with large fluctuations coexisting with algebraic correlations.

In this talk, we shall use this exotic phase as a magnetic background for the motion of itinerant electrons. This permits us to study, within a largely analytical framework, the interplay between frustration and conduction on two- and three-dimensions lattice models. We shall in particular focus on how Coulomb phase fluctuations persist (or not) in the presence of electron doping, and whether they tend to favor insulating or metallic behaviour.

MA 60.7 Thu 19:00 HSZ 103

Effective magnetic Hamiltonians — •Vaclav Drchal[1], Josef Kudrnovsky[1], and Ilja Turek[2] — [1]Institute of Physics, AS CR, Praha, Czech Republic — [2]Institute of Physics of Materials, AS CR, Brno, Czech Republic

The effective magnetic Hamiltonian which can be used to derive magnetic structure of a solid or a nanostructure, consists of: (i) Local exchange part that describes formation of local moments on individual atoms. This part can be calculated using the fixed spin moment method. (ii) Isotropic Heisenberg Hamiltonian that describes interactions between spin moments on different atoms. It is responsible for ordering of magnetic moments. The isotropic exchange interactions are calculated from the Liechtenstein formula. (iii) Anisotropic part which includes relativistic effects and dipole-dipole interactions. These terms determine the orientation of magnetic moments with respect to crystallographic axes. The methods of statistical mechanics can be applied to the effective magnetic Hamiltonian in order to predict properties (such as the size and orientation of magnetic moments, the Curie/Néel temperature, magnon spectra, etc.) of complex magnetic systems. Simultaneous treatment of local exchange interactions and the interatomic exchange interactions makes possible to correctly describe the varying values of magnetic moments and origin of induced moments. We will show in some detail how to construct the effective magnetic Hamiltonian for 3d and 4d metals and their alloys from first principles, and the importance of anisotropic interactions for determination of the magnetic structure of magnetic monolayers on non-magnetic substrates.

MA 61: Surface Magnetism V - Invited Talk

Time: Friday 10:15–10:45 Location: HSZ 04

Invited Talk MA 61.1 Fri 10:15 HSZ 04

Spin-dependent quantum interference within a single magnetic nanostructure — •Dirk Sander[1], Hirofumi Oka[1], Pavel Ignatiev[1], Sebastian Wedekind[1], Guillemin Rodary[1,2], Larissa Niebergall[1], Valeri Stepanyuk[1], and Jürgen Kirschner[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]now at: LPNS, CNRS UPR20, Marcoussis, France

We present results of a combined experimental and theoretical study of spin-polarized electron confinement on individual nm small Co islands on Cu(111) [1]. Spin-polarized low-temperature STM in magnetic fields is used [2] to identify and prepare parallel (P) and antiparallel (AP) states of the magnetization orientation between a Co island and the magnetic tip of the STM. We find a pronounced spatial modulation of the differential conductance within one island, which is ascribed to electron confinement. The modulation patterns for P and AP magnetization states differ. Maps of the asymmetry of the differential conductance show strong spatial variations, where the contrast depends on the gap voltage. These results are ascribed to a spatial modulation of the spin-polarization within the Co islands. In conjunction with theory we conclude that the modulation of the spin-polarization, and its variation with energy, can be described by the relative magnitudes of the spin-resolved density of states, where the spatial modulation is mainly due to electron confinement of majority electrons. [1] H. Oka, P. Ignatiev, S. Wedekind, G. Rodary, L. Niebergall, V. Stepanyuk, D. Sander, J. Kirschner, Science 327, 843 (2010). [2] G. Rodary, S. Wedekind, H. Oka, D. Sander, J. Kirschner, Appl. Phys. Lett. 95, 152513 (2009).

MA 62: Magnetic Imaging

Time: Friday 10:45–12:00 Location: HSZ 04

MA 62.1 Fri 10:45 HSZ 04

Observation of superparamagnetism in image potential states using SP-STM — •Anika Schlenhoff, Andreas Sonntag, Stefan Krause, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg

Several eV above their Fermi energy ferromagnets exhibit image potential states (IPS) which are located nanometers above the surface in the vacuum. As these states are spin-split, their magnetization can be imaged by spin-polarized scanning tunneling microscopy (SP-STM) [1]. Due to the great tip-sample distance, the risk for destructive mechanical contact is minimized. Whereas magnetic IPS have been extensively studied by laterally averaging methods [2], only recently first SP-STM experiments on IPS were performed on *bulk-like* Fe/W(110) [1]. It is an open question wether magnetic IPS are also observable above atomic-scale, only one atomic layer high magnets. Therefore, we investigate IPS above Fe/W(110) monolayer islands consisting only of about 100 atoms. These nanoislands exhibit a monodomain magnetization state and thermally switch their magnetization at 40 K [3]. In our SP-STM experiments, this switching behavior is recorded within the IPS, thereby demonstrating that the exchange splitting of IPS is observable even above atomic-scale magnetic nanostructures. Influences of the increased bias voltage on the thermal switching behavior will be discussed.

[1] A. Kubetzka *et al.*, Appl. Phys. Lett. **91**, 012508 (2007).
[2] M. Donath *et al.*, Surf. Sci. **601**, 5701 (2007).
[3] S. Krause *et al.*, Phys. Rev. Lett. **103**, 127202 (2009).

MA 62.2 Fri 11:00 HSZ 04

Quantification of spin torque and Joule heating using SP-STM — •Stefan Krause, Gabriela Herzog, Anika Schlenhoff, Andreas Sonntag, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg

Spin-polarized scanning tunneling microscopy (SP-STM) is a powerful tool not only to image but also to manipulate magnetic nanostructures at ultimate lateral resolution. Using a high spin-polarized current originating from a magnetic tip the thermal magnetization switching behavior of an individual Fe/W(110) monolayer nanoisland with uniaxial anisotropy is influenced: Whereas Joule heating increases the switching frequency, the spin torque lifts the degeneracy of the two magnetic state lifetimes, forcing the island to favor one magnetic orientation.[1,2]

In general, the microscopic details of spin torque and Joule heating are still to be discovered. The capability of SP-STM to inject a high tunnel current into an individual nanoisland and simultaneously monitor its magnetic state allows for a direct quantification of spin torque and Joule heating from the observed switching behavior. The results are discussed in terms of current-dependent state lifetimes and interpreted as the modification of the switching energy barrier due to spin torque and an increased temperature of the nanoisland due to Joule heating.

[1] S. Krause *et al.*, Science **317**, 1537 (2007).
[2] G. Herzog, S. Krause and R. Wiesendanger, Appl. Phys. Lett. **96**, 102505 (2010).

MA 62.3 Fri 11:15 HSZ 04

Morphological, electronic and magnetic characterization of bulk Cr tips — •Marco Corbetta[1], Safia Ouazi[1], Fabio Donati[1,2], Yasmine Nahas[1], Hirofumi Oka[1], Sebastian Wedekind[1], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]CNISM, NEMAS and Dipartimento di Energia - Politecnico di Milano, Milano, Italy

The most delicate task for successful SP-STM measurements is the preparation of suitable tips offering high spatial resolution, high spin polarization and negligible magnetic stray field. Nonmagnetic tips covered with an ultrathin film of antiferromagnetic material as Cr have been largely and successfully used [1]. The main drawback of coated tips is that an in-situ preparation is required. Recently a simple and reliable method for the preparation of bulk Cr tips using only a standard electrochemical etching has been proposed [2]. We produced and used such tips for in-field spin-polarized STM measurements at 7 K on Co nano-islands on Cu(111). We obtain stable and reliable spin-resolved imaging and spectroscopy results. We measure symmetric hysteresis loops of the differential conductance, which show that the magnetization direction of the Cr tip apex follows the external magnetic field direction. Measuring dI/dV asymmetry curves on Co islands we find that the spin polarization of bulk Cr tips can be as large as 30%, which is larger as compared to Cr/Co/W tips [3]. [1] A. Kubetzka et al., Phys. Rev. Lett. 88, 057201 (2002). [2] A. Li Bassi et al., Appl. Phys. Lett. 91, 173120 (2007). [3] H. Oka et al., Science 327, 843 (2010).

MA 62.4 Fri 11:30 HSZ 04

Contrast formation and deconvolution of pinned UCS by MFM — •Sevil Ozer[1], Niraj Joshi[1], Hans Josef Hug[1,2], Miguel Marioni[2], and Sara Romer[2] — [1]Department of Physics, University of Basel, CH-4056 Basel, Switzerland — [2]EMPA, CH-8600 Dubendorf, Switzerland

In prior work we presented MFM images of pinned, uncompensated spins (UCS) at the antiferromagnet/ferromagnet (AF/F) interfaces in exchange-biased systems[1,2,3]. We argued that the MFM image obtained after saturation of the F arises from the pinned UCS. Here a detailed analysis of the different contributions to the measured MFM contrast is presented. To deconvolute the various contrast contributions, their behavior upon field reversal was studied. Our analysis reveals that the topography-induced variations of the vdW forces, the magnetic field mediated forces generated by variations in the F-layer thickness, roughness and saturation magnetization and those from the rotating UCS do NOT change sign upon field reversal. The contrast arising from the pinned UCS reverses, because the magnetization of the tip has flipped. After calibration of the imaging properties of the MFM tip by using the MFM data of F-domain image, the areal density of the pinned UCS can be devonvolved from the frequency shift MFM data of the pinned UCS.

[1] P. Kappenberger et al., Phys. Rev. Lett, 91 (2003) 267202
[2] I. Schmid et al., Europhys. Lett., 81 (2008) 17001
[3] I. Schmid et al., Phys. Rev. Lett., 105 (2010) 197201

MA 62.5 Fri 11:45 HSZ 04

A combined Laser-scanning / Wide-field Kerr Microscope to Investigate the Switching Behavior of Nanomagnetic Logic Devices — •Stephan Breitkreutz, Josef Kiermaier, Benedikt Neumeier, Markus Becherer, and Doris Schmitt-Landsiedel — Lehrstuhl für Technische Elektronik, TU München

Nanomagnetic Logic (NML) is a promising candidate for future computing devices with inherent logic and memory function in every single device. In order to observe and develop NML, fast and high-resolution measurement techniques are required.

Based on the polar magneto-optical Kerr effect (p-MOKE) we developed a scanning microscope combining two different mode to characterize single nanomagnets and record high-resolution images of magnetic samples. In laser-scanning mode the sample is scanned with a blue laser achieving a resolution down to 400 nm. This allows to measure hysteresis curves of single nanomagnets and high-resolution images of dot configurations. The setup provides field sweeping rates of 10 T/s and time resolved observation of switching events in the 10-μs-range. In wide-field mode the sample is illuminated by homogeneous, highly polarized LED light and analyzed with a 1280·1024 pixel CMOS-camera with 27 frames/s. This allows for fast image analysis of large arrays of nanomagnets e.g. to observe dot interactions due to coupling and signal propagation in nanomagnetic gates.

Performed measurements demonstrate the versatility of the combined measurement mode for development and optimization of NML devices.

MA 63: Poster II (Surface Magnetism/ Magnetic Imaging/ Topological Insulators/ Spin Structures and Magnetic Phase Transitions/ Graphene/ Magnetic Thin Films/ Magnetic Semiconductors/ Magnetic Half-metals and Oxides/ Spin-dependent Transport/ Spin Excitations and Spin Torque/ Spin Injection and Spin Currents in Heterostructures/ Spintronics/ Magnetic Storage and Applications)

Time: Friday 11:00–14:00 Location: P2

MA 63.1 Fri 11:00 P2

Spin-resolved microspectroscopy of Co thin films on Cu(100) using one- and two-photon photoemission — •Martin Ellguth, Christian Tusche, Cheng-Tien Chiang, A. Akin Ünal, Aimo Winkelmann, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

We measure spin-polarized photoelectron emission microscopy images of Co films with a thickness of 8 to 12 monolayers grown on Cu(100), using one- and two-photon (1PPE, 2PPE) photoemission (photon energy = 6.0 eV and 3.1 eV, respectively). Our photoelectron emission microscope (PEEM) is equipped with both a double hemispherical energy analyzer and an imaging spin-detector. Spin filtering of the full PEEM image is achieved by low-energy scattering of the photoelectrons at a W(100) crystal under specular reflection by 90 degrees. Compared to classical spin-resolved electron spectrometers, the two-dimensional detection scheme offers the simultaneous measurement of an entire spatial image and recording of the magnetic domain structure of the Co film at a selected energy.

Final-state energy spectra of the Co films in 1PPE and 2PPE show a positive spin-polarization background arising from the Co electronic structure. We find a superimposed reversal of the spin polarization due to the contribution of the surface resonance state of Co with minority spin character. In comparison, the unoccupied quantum well state of the Co thin film causes enhanced spin polarization in 2PPE, in a thickness-dependent energy range.

MA 63.2 Fri 11:00 P2

Vortex states in magnetic nanodisks in presence of a screw dislocation — •Anna B. Butenko, Ulrich K. Rössler, and Alexei N. Bogdanov — IFW Dresden

Defect structures in magnetic crystalline materials may locally change magnetic properties and can considerably influence the magnetic behavior of magnetic nanostructures. As an example, dislocations in magnets result in additional magnetic anisotropy [1] and break inversion symmetry of crystals which leads to chiral Dzyaloshinskii-Moriya (DM) couplings [2]. It was shown that similar surface-induced DM interactions can strongly affect vortex structures in magnetic nanodisks causing a chirality selection [3]. We present a phenomenological approach for dislocation-induced DM couplings and investigate effects of a screw dislocation at the center of a magnetic nanodisk with a vortex state. By numerical calculations on vortex profiles we analyze equilibrium parameters (the size, shape and stability) of the vortices as functions of applied magnetic field and the material and geometrical parameters.

[1] A.B. Dichenko et al., J. Magn. Magn. Mater. **53** (1985) 71.

[2] A. Arrott, J. Appl. Phys. **34** (1963) 1108; S.V. Maleev, Phys. Uspekhi **45** (2002) 569.

[3] A.B. Butenko et al., Phys. Rev. B **80** (2009) 134410.

MA 63.3 Fri 11:00 P2

Structure and magnetic properties of metal-TCNQ charge transfer networks on Ag(100) and Au(111) — •Nasiba Abdurakhmanova, TzuChun Tseng, Nan Jiang, Alexander Langner, Sebastian Stepanow, and Klaus Kern — MPI for Solid State Research, Stuttgart, Germany

Charge transfer networks of TCNQ with Ni and Mn on Ag(100) and Au(111) were investigated using Scanning Tunneling Microscopy (STM) and X-Ray Magnetic Circular Dichroism. STM reveals a diversity of structures for both Ni(TCNQ)x and Mn(TCNQ)x networks on Ag(100) that can be tuned by the x=TCNQ:Metal ratio, whereas on Au(111) only one type of network with x=1 was found. The fourfold coordinated Mn exhibits a high-spin d5 configuration and shows potential antiferromagnetic coupling between the Mn atoms. In contrast to Mn, Ni centers couple ferromagnetically. The electronic state is ascribed to a high-spin d8 configuration on Au(111), whereas Ni has predominant d9 character in the networks on Ag(100). The results are related to the different charge transfer modes of TCNQ present on the Ag and Au substrates.

MA 63.4 Fri 11:00 P2

Spin-structure of the Mn double layer on W(110) — •Silke Schröder, Paolo Ferriani, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, CAU Kiel, Germany

In ultrathin magnetic films Heisenberg exchange, Dzyaloshinskii-Moriya interaction (DMI) and magnetic anisotropy can compete and thus span a vast magnetic phase space containing also two- and three-dimensional complex magnetic structures [1]. Recent spin-polarized scanning tunneling microscopy measurements of the double layer of Mn on W(110) [2] suggest a short period ferromagnetic spin-spiral propagating along the [001] direction for an out-of-plane tip magnetization. However, an antiferromagnetic (AFM) contrast along the [1-10] direction is found for an in-plane tip magnetization which hints at a complex spin-structure. We studied the magnetic properties of this system by means of density functional theory calculation using the full-potential linearized augmented plane wave (FLAPW) method. We found a strong AFM nearest neighbour exchange and performed spin-spiral calculations resulting in a non-collinear ground state. Including spin-orbit coupling (SOC) in our calculations we determined the preferred magnetization direction due to magnetocrystalline anisotropy and studied the effects of the DMI. We finally considered three-dimensional spin-structures as possible explanations for the experimental results.

[1] Heide *et al.*: www.psi-k.org/newsletters/News_78/Highlight_78.pdf (2006)

[2] Y. Yoshida, K. von Bergmann, private communication

MA 63.5 Fri 11:00 P2

A New Highly Efficient Spin Detector for Electron Spectroscopy — •Matthias Escher[1], Nils B. Weber[1], Michael Merkel[1], Claus Michael Schneider[2], and Lukasz Plucinski[2] — [1]Focus GmbH, Hünstetten, Germany — [2]Peter Grünberg Institut, FZ Jülich, Germany

In order to overcome the restrictions in efficiency of conventional spin-detectors, e.g. Mott or SPLEED detectors, low energy electron scattering at a Fe(100)-p(1x1)O surface was first proposed by Bertacco et al. [1] as a system for highly efficient spin detection.

A new instrument based on that scheme is described here. It can be adapted to a spherical or a cylinder sector analyzer. An optimized optics and non-magnetic design enable the operation at very low energies without sacrificing the performance. The iron film is prepared in-situ on a W(100) crystal [2] without the need for separate sample preparation and exchange when using a MgO substrate [3]. We find an optimum working point at 6.5eV scattering energy consistent with [1]. First results obtained with UPS on Fe and Co films are shown.

With a Sherman-function of approx. 30% and a reflectivity up to 10% the figure of merit of this detector is more than one magnitude higher than conventional detectors. The oxidized iron film shows no degradation over days in UHV.

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[2] A. Winkelmann, D. Hartung, H. Engelhard, C.-T. Chiang and J. Kirschner, Rev. Sci. Instrum 79, 083303 (2008)

[3] T. Okuda et al., Rev. Sci. Instrum 79, 123117 (2008)

MA 63.6 Fri 11:00 P2

Modulation of magnetic anisotropy due to the quantization of Bloch states in ferromagnetic films on vicinal surfaces — Uwe Bauer, •Maciej Dabrowski, Marek Przybylski, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

Oscillatory magnetic anisotropy is attributed to the quantization of Bloch states along the growth direction and the resulting formation of quantum well states (QWS). With varying film thickness, QWS lead to periodic changes in the electronic structure and therefore can modulate

magnetic anisotropy.

To determine magnetic anisotropy by magneto-optic Kerr effect (MOKE), Fe thin films were grown on vicinal surfaces of Ag(001) and Au(001). The mono-atomic steps on the substrates induce an in-plane uniaxial anisotropy which determines the easy magnetization axis. Moreover, the magnetization can be tilted out of the film plane and result in an additional polar component to the Kerr signal which can result in hysteresis loops with a very complex shape. We provide a model, verified by experimental studies of Fe on Au(1,1,13), which explains why even small uncertainties in the experimental MOKE geometry can have a significant influence on the measured hysteresis loops.

The largest oscillation amplitude of Hs we obtained for Fe films grown on Ag(1,1,6). This shows that the larger the distorted fraction of the film volume (i.e. the larger the step density), the larger the amplitude of the anisotropy oscillations.

MA 63.7 Fri 11:00 P2

Magnetic Properties of Nanowires and Nanocorrals at the Classical Level — •Nikolaos P. Konstantinidis[1] and Samir Lounis[2,3] — [1]Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany — [2]Department of Physics and Astronomy, University of California Irvine, California, 92697 USA — [3]Institut für Festkörperforschung and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The bottom-up approach is one of the main focus research areas of nanoscience where various atomic structures, *e.g.* corrals of adatoms and nanowires, are engineered atom by atom with a scanning tunneling microscope [1,2]. Our contribution addresses the magnetic properties of such systems whereby one more or less adatom is crucial. We use a classical Heisenberg model for the spins of the nanostructures. If the magnetic exchange interaction between nearest neighbors is of antiferromagnetic type, complex magnetic textures can arise provided an external magnetic field is applied or a magnetic coupling to a ferromagnetic substrate exists. Within this model, the corral of adatoms forms an open or a closed chain. We show that the spin configuration of the system can be tuned to a non-collinear or to a ferromagnetic state by adjusting its number of sites, the location of the adatom or the strength of the coupling to the ferromagnetic substrate.

[1] Manoharan *et al.*, Nature **403**, 512 (2000).
[2] Gambardella *et al.*, Science **300**, 1130 (2003).

MA 63.8 Fri 11:00 P2

Preparation of bulk Chromium tips for SP-STM — •André Engel, Anika Schlenhoff, Andreas Sonntag, Stefan Krause, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg

Chromium has proven to be a very useful bulk tip material for spin-polarized scanning-tunneling-microscopy (SP-STM) [1,2]. Recent studies show that bulk Chromium tips allow for atomic resolution and are sensitive to both in-plane and out-of-plane sample magnetization. Compared to ferromagnetic Iron or Nickel, antiferromagnetic Chromium is expected to have a negligible magnetic stray field which otherwise may affect the sample magnetization. In contrast to coated tips, bulk tips do not require any in-situ evaporation or tip exchange mechanism.

Starting with the method and etching parameters proposed in [1,3] we enhanced the preparation of Chromium tips in order to get optimum results regarding tip sharpness and aspect ratio. We present scanning electron microscopy (SEM) images and chemical analysis by means of electron dispersive x-ray spectroscopy (EDX) of differently prepared tips. Influences of different etching solutions, applied voltages and the weight of the insulating polymer tube [3] which physically restricts the etching region to a small area will be discussed.

[1] Li Bassi *et al.*, Appl. Phys. Lett. **91**, 173120 (2007)
[2] Schlenhoff *et al.*, Appl. Phys. Lett. **97**, 083104 (2010)
[3] Ceballos *et al.*, Surface Science **523**, 131 (2003)

MA 63.9 Fri 11:00 P2

Thermal magnetization reversal of small Fe-nanoislands on W(110) — •Andreas Sonntag, Anika Schlenhoff, Gabriela Herzog, Stefan Krause, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Germany

Spin-polarized scanning tunneling microscopy (SP-STM) has been proven to be a powerful technique for investigating magnetic nanostructures [1]. Recently it has been applied to probe the thermal switching behavior of superparamagnetic Fe/W(110) nanoislands [2]. It turned out that the magnetization reversal of islands that consist of more than approx. 30 atoms takes place via the nucleation and propagation of a domain wall. The smallest island investigated in the study showed a significantly different behavior which could not be explained within this model.

In our experiments we studied very small iron islands using variable temperature SP-STM. The thermal switching of individual islands was characterized at various temperatures by measuring the mean lifetime between two consecutive switching events. The characteristic parameters as the energy barrier and attempt frequency can be calculated by matching the results with the Néel-Brown law. The results are discussed with regard to the elongation of the islands along special crystallographic axes in order to clarify what kind of processes play a role in the magnetization reversal.

[1] R. Wiesendanger, Rev. Mod. Phys. **81**, 1495 (2009).
[2] S. Krause *et al.*, Phys. Rev. Lett. **103**, 127202 (2009).

MA 63.10 Fri 11:00 P2

The application of a monopole-like probe for local magnetization measurements by means of Magnetic Force Microscopy — •Silvia Vock[1], Franziska Wolny[1], Thomas Mühl[1], Rainer Kaltofen[1], Ludwig Schultz[1], Bernd Büchner[1], Christoph Hassel[2], Jürgen Lindner[2], and Volker Neu[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

A local magnetization measurement was performed with a Magnetic Force Microscope (MFM) to determine magnetization in domains of an exchange coupled [Co/Pt]/Co/Ru multilayer with predominant perpendicular anisotropy. The basic requirement for quantitative evaluation of MFM data is the calibration of the used probes. For this purpose conventional and iron filled carbon nanotubes (Fe-CNT) were calibrated within the point probe approximations. The results show a monopole-like behavior for the Fe-CNT tips while the parameters of the conventional tip depend strongly on the calibration structure. Therefore the Fe-CNT tip was chosen for the local magnetization measurement. As a result we determined an additional in-plane magnetization component of the multilayer, which is explained by estimating the effective permeability of the sample within the μ^*-method.

MA 63.11 Fri 11:00 P2

Threshold photoemission magnetic circular dichroism of perpendicularly magnetized Ni films on Cu(001): theory and experiment — •Matthias Kronseder, Stefan Günther, Georg Woltersdorf, and Christian H. Back — Universität Regensburg, Regensburg, Deutschland

Threshold photoemission magnetic circular dichroism (TP-MCD) for perpendicularly magnetized Ni films on Cu(001) was measured with a total electron yield method. This dichroism was used to observe the magnetic domain structure of these samples in a photoemission electron microscope. A spin-polarized relativistic Korringa-Kohn-Rostoker Green's function calculation including a dynamical mean field theory approach within the one-step-photoemission model reproduces the measured asymmetry in the photocurrents for left and right circularly polarized light. In addition, a three-step photoemission model calculation based on the same ab-initio calculation is used to quantitatively explain the MCD effect near the photoemission threshold. Furthermore, the dependence of the MCD-asymmetry on the polarization state of the incoming photons is theoretically computed and experimentally verified.

MA 63.12 Fri 11:00 P2

X-ray holographic imaging of dot patterned perpendicular magnetic structures — •Felix Büttner[1,2,5], Christoforos Moutafis[1,2,3], Jan Rhensius[1,3], André Bisig[1,2,3], Bastian Pfau[5,6], Christian Günter[6], Carsten Tieg[6], Jyoti Mohanty[5], Stefan Schaffert[5], Samuel Flewett[5], Hermann Stoll[4], Laura Jane Heyderman[1], Mathias Kläui[1,2,3], and Stefan Eisebitt[5,6] — [1]Paul Scherrer Institut, 5232 Villigen, Switzerland — [2]LNSD, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland — [3]Universität Konstanz, 78457 Konstanz, Germany — [4]MPI für Metallforschung, 70569 Stuttgart, Germany — [5]Technische Universität Berlin, 10623 Berlin, Germany — [6]HZB, 12489 Berlin, Germany

Dot patterned magnetic data storage media with perpendicular magnetic anisotropy (PMA) are among the most promising candidates for future storage technology that is threatened by the superparamagnetic limit in conventional hard disk media. There is therefore industrial and fundamental scientific interest for dynamic and static imaging of spin

structures in these materials. Of particular interest are domain wall movement and domain switching processes. X-ray holography is a well suited imaging technology due to the immunity to drift, the absence of any cross talk between the excitation system and the imaging system and due to the perspective to take single shot time resolved images at free electron lasers. We present first holographic images of PMA material disks. The image quality was considerably improved by an advanced reconstruction algorithm accounting for finite gaps in the path of the x-rays.

MA 63.13 Fri 11:00 P2

A Scanning X-ray Microscope for Time-resolved and Surface-sensitive Measurements — •Markus Weigand[1], Daniela Nolle[1], Bartel van Waeyenberge[2], Michael Bechtel[1], and Eberhard Goering[1] — [1]MPI für Metallforschung, Stuttgart — [2]Ghent University, Belgium

MAXYMUS, an new UHV Scanning Transmission X-ray Microscope (STXM), has recently finished commissioning and became open for external users at HZB/Bessy II, Berlin, placed at a newly commissioned helical undulator Beamline. Activities up to now focused on magnetic measurements using XMCD as a contrast mechanism.

Key features of the microscope design are alternate acquisition methods: A fast APD detector with a custom FPGA system allows time resolved measurements with time resolutions below 50 ps and up to 100 time channels. Total electron yield, on the other hand, allows surface sensitive imaging on both transparent and bulk samples using the full range of soft x-ray spectroscopic methods. This is facilitated by a fully UHV compatible, bakeable microscope design with hot-pluggable sample transfer and UHV preparation chamber.

We will present and overview of current and near future capabilities as well as fist users and commissioning results with a focus of the above mentioned areas.

MA 63.14 Fri 11:00 P2

Quantifying magnetic moments $\vec{\mu}$ in magnetic force microscopy (MFM) tips — •Denny Köhler, Peter Milde, Ulrich Zerweck-Trogisch, and Lukas M. Eng — Institut für Angewandte Photophysik, TU Dresden, Deutschland

Measuring quantitative magnetic moments becomes one of the major tasks in nanomagnetic research. Here, we present a novel way to characterize magnetic force microscopy (MFM) tips in homogeneous external magnetic fields. Our methods basis on the deflection of the cantilever caused by the mechanical torque [1] as it is induced by an external magnetic field.

Low temperature measurements of the frequency-shift and static deflection of the cantilever in a variable external magnetic field are used to access the different vectorial components of the magnetic moment $\vec{\mu}$ of the tip. This allows to quantify both the magnitude and 3D spatial orientation of $\vec{\mu}$. Experimental results are compared with the theoretical behaviour of the magnetic dipole moment of the cantilever as calculated by combining a harmonic oscillator model with the minimization of the magnetic energy.

MA 63.15 Fri 11:00 P2

Bulk vs. surface effects in ARPES experiments on the topological insulator Bi_2Se_3 — •Richard C. Hatch[1], Marco Bianchi[1], Dandan Guan[1,2], Shining Bao[2], Jianli Mi[3], Bo Brummerstedt Iversen[3], and Philip Hofmann[1] — [1]Department of Physics and Astronomy, Interdisciplinary Nanoscience Center Århus University, 8000 Århus C, Denmark — [2]Department of Physics, Zhejiang University, Hangzhou, 310027 China — [3]Department of Chemistry, Interdisciplinary Nanoscience Center, Århus University, 8000 Århus C, Denmark

While the bulk of a topological insulator is insulating, fundamental symmetry considerations require the surfaces to be metallic. The dimensionality of states in the topological insulator Bi_2Se_3 were probed directly by performing ARPES measurements at different photon energies along $\bar{\Gamma}\bar{K}$ and $\bar{\Gamma}\bar{M}$. It was found that both the topological surface state and the state attributed to a two-dimensional electron gas [1] do not disperse with respect to the wave vector perpendicular to the surface k_z—thus confirming their two-dimensional nature. In contrast, strong k_z dispersions of the bulk conduction and valence bands are evident. From the experimental data, we derive the bulk band structure in the two high-symmetry slices throughout the Brillouin zone. Finally, we observe a state at a binding energy of 750 meV which does not disperse with k_z and is interpreted to be another surface state situated in a projected bulk band gap below the upper valence band.

[1] M. Bianchi *et al.* Nat. Communications 2010, DOI 10.1038/NComms1131.

MA 63.16 Fri 11:00 P2

Edge states in a spin-triplet multi-band superconductor — •Yoshiki Imai[1,2] and Manfred Sigrist[1] — [1]Institute for Theoretical Physics, ETH Zurich, Zurich, Switzerland — [2]Department of Physics, Saitama University, Saitama, Japan

Motivated by the multi-band spin triplet superconductor Sr_2RuO_4 we investigate the properties of a 2D two-band system with an electron- and hole-like Fermi surfaces within a tight-binding model including inter-orbital hybridization and spin-orbit coupling effects. The band structure is chosen as to support spontaneous spin currents flowing along edges in the normal state. In our study we focus on helical and chiral spin-triplet pairing states and their influence on the states at the edge. Both states have topological character and yield, despite a full quasiparticle excitation gap in the bulk, gapless edge states with contributions to spontaneous spin and/or charge currents. We elucidate how electron- and hole-like particles interfere with each other in the formation of these edge states and edge currents. In this context multi-orbital and topological properties are discussed.

MA 63.17 Fri 11:00 P2

Magneto-acoustic study of single crystalline $UCu_{0.95}Ge$ — •S. Yasin[1], A.V. Andreev[2], Y. Skourski[1], J. Wosnitza[1,3], S. Zherlitsyn[1], and A.A. Zvyagin[3,4] — [1]Hochfeld-Magnetlabor Dresden (HLD), Forschungszentrum Dresden-Rossendorf, 01314 Dresden, Germany — [2]Institute of Physics ASCR, Na Slovance 2, 18221 Prague 8, The Czech Republic — [3]Institut für Festkörperphysik, Technische Universität Dresden, 01069 Dresden, Germany — [4]B.I. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, Kharkov, 61103, Ukraine

We present results of a magneto-acoustic study on a $UCu_{0.95}Ge$ single crystal. This compound exhibits antiferromagnetic ordering at 48 K and shows a first-order metamagnetic phase transition at 38 T to a spin-polarized state, i.e., when the magnetic field is applied along the c direction a sharp jump in the magnetization appears. The sound velocity and sound attenuation demonstrate pronounced anomalies in the vicinity of both magnetic phase transitions proving the important role of magneto-elastic interactions in the physics of this actinide compound. Above T_N, the acoustic characteristics show some unusual frequency-dependent features which presumably can be related to the dynamics of Cu vacancies in $UCu_{0.95}Ge$. Our results are discussed in frame of a phenomenological model, which describes qualitatively the main experimental observations.

MA 63.18 Fri 11:00 P2

Investigation of spin- lattice interactions in Ho2Ti2O7 and Dy2Ti2O7 — •Salim Erfanifam[1], Sergei Zherlytsin[1], Joachim Wosnitza[1], and Oleg Petrenko[2] — [1]Dresden High Magnetic Field Laboratory, Forschungszentrum Dresden-Rossendorf, Germany — [2]University of Warwick, Department of Physics, Coventry, CV47AL, United Kingdom

Ho2Ti2O7 and Dy2Ti2O7 belong to the family of rare-earth titanates with pyrochlore structure which have attracted much interest in recent years because of their spin-ice ground state and unusual magnetic excitations. Ultrasound experiments have been carried out on Ho2Ti2O7 and Dy2Ti2O7 at low temperatures down to 0.3 K and applied magnetic fields of up to 17.5 T. The temperature as well as field dependences of the relative change of the sound velocity demonstrate some pronounced anomalies below 2 K for the acoustic modes c11 and cL. In addition we have performed magnetization measurements of these two compounds. The observed anomalies and features in the sound velocity and magnetization provide additional information about the spin-lattice interactions in these spin-ice compounds. The role of the lattice degrees of freedom in connection with the emergent quasiparticles (magnetic monopoles) is discussed.

Part of this work was supported by EuroMagNET II under EU contract 228043.

MA 63.19 Fri 11:00 P2

Magnetic properties and configuration of $Fe_{50}Pt_{50*x}Rh_x$ films — •Jochen Fenske[1], Dieter Lott[1], Wolfgang Schmidt[2], Karin Schmalzl[2], Gary J. Mankey[3], Frank Klose[4], Helena Tartakowskaya[5], and Andreas Schreyer[1] — [1]Helmholt-Zentrum Geesthacht, Germany — [2]IFF Forschungszentrum Juelich, JCNS at ILL, France — [3]MINT Center, University of Alabama, USA — [4]Ansto,

Bragg Institute, Australia — [5]Institute for Magnetism, National Accademy of Scinece, Ukraine

Ordered FePt alloys with $L1_0$ structure are known as materials with FM order and a high magnetic moment of Fe providing a large mangetization. The large atomic number of Pt on the other hand results in a high magnetic anisotropy. If grown in thin films, the high anisotropy often results in perpendicular magnetization which is the preferred orientation for current magnetic recording media. One way to control the magnetic properties in these materials is through the introduction of a third element into the crystal matrix e.g. Rh. When Rh is added to replace Pt in the equiatomic alloy, new magnetic phases emerge. Here we present neutron diffraction studies on the magnetic properties of different 200nm thick $Fe_{50}Pt_{50*x}Rh_x$ films in dependce of the temperature and external magnetic fields. Additional resonant x-ray measurements on the Fe and Pt absorption edges provide additional information about the magnetic moments on these sites.

MA 63.20 Fri 11:00 P2

Spin transport in graphene nanostructures — •Sebastian Schweitzer[1], Ajit Kumar Patra[1], Yenny Hernandez[2], Jan Rhensius[3], Jakoba Heidler[3], Matthias Eltschka[1], Mathias Kläui[1,3], Xinliang Feng[2], Laura Heyderman[4], and Klaus Müllen[2] — [1]FB Physik, Uni Konstanz, Universitätsstr. 10, D-78457 Konstanz, Germany — [2]MPI for Polymer Research, Ackermannweg 10, D-55128 Mainz, Germany — [3]SwissFEL, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland & Laboratory for Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [4]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

Graphene, a monolayer of carbon atoms packed into a two-dimensional honeycomb lattice, is an exciting and promising material for spintronic applications. Due to its high mobility [1] it has a long spin diffusion length λ up to 2 μm [2]. However, λ is currently limited by the strong interaction between graphene and the substrate and by the corrugation in the graphene sheet, respectively. This can be overcome by using more robust turbostratic graphene (TG), a multilayer graphene stack without the usual Bernal stacking [3]. Therefore, enhancements in the mobility and the spin lifetime in TG are expected. Our recent results on spin-injection experiments using graphene as well as TG will be presented.

[1] A. K. Geim et al., Nature Materials **6**, 183 (2007), Science **324**, 1530 (2009). [2] N. Tombros et al., Nature **448**, 571 (2007). [3] M. Orlita et al., Phys. Rev. Lett. **101**, 267601 (2008).

MA 63.21 Fri 11:00 P2

Ab initio treatment of spin relaxation in Graphene caused by adatoms — Martin Gradhand[1], •Dmitry Fedorov[2], Sergey Ostanin[1], Igor Maznichenko[2], Arthur Ernst[1], Peter Zahn[2], Ingrid Mertig[1,2], and Jaroslav Fabian[3] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Martin-Luther-Universität Halle, Institut für Physik, 06099 Halle, Germany — [3]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

The fast spin relaxation of conduction electrons in Graphene [1,2] is still an intriguing problem, since different experimental and theoretical investigations favour either the Elliott-Yafet or the Dyakonov-Perel spin relaxation mechanism. Nevertheless, it started to be a common opinion that the spin relaxation times obtained in experiments are due to the scattering of conduction electrons on adatoms which increase an effective spin-orbit interaction. However, in the theory the magnitude of the spin relaxation time is usually estimated using models where only a few parameters are taken from first principles calculations.

Here we present results of a consistent ab initio calculation of the spin relaxation time due to the Elliott-Yafet mechanism induced by adatoms. Our study is based on a recently developed fully relativistic approach for the spin-flip scattering at impurities [3]. We consider C and Si atoms as possible adatoms in the experiments.

[1] N. Tombros et al., Nature 448, 571 (2007) [2] N. Tombros et al., Phys. Rev. Lett. 101, 046601 (2008) [3] M. Gradhand et al., Phys. Rev. B 81, 020403(R) (2010)

MA 63.22 Fri 11:00 P2

Role of hybridization for the emergence of a giant Rashba effect in graphene — •Dmitry Marchenko[1], Andrei Varykhalov[1], Markus R. Scholz[1], Oliver Rader[1], Gustav Bihlmayer[2], Artem Rybkin[3], Anna Popova[3], Alexander M. Shikin[3], Emmanuel I. Rashba[4], and Thomas Seyller[5] — [1]Helmholtz-Zentrum Berlin — [2]Forschungszentrum Jülich — [3]St. Petersburg State University — [4]Harvard University — [5]Universität Erlangen-Nürnberg

We have recently created a giant Rashba splitting (100 meV) [1] of the Dirac fermions at the Fermi energy of graphene by intercalation of Au and attributed it to the high spin-orbit interaction in Au. Ab initio calculations and spin- and angle-resolved photoemission spectra of the interaction of graphene π with Au d states show a delicate dependence on the details of the hybridization which are not present in other systems. A giant Rashba splitting (200 meV) reported recently for graphene grown on SiC [2] is not confirmed by our measurements giving an upper limit of $\sim$ 10 meV. Moreover, we compare to the intercalation system graphene/Au/SiC.

[1] D. Marchenko, A. Varykhalov, M. R. Scholz, E. I. Rashba, G. Bihlmayer, A. Rybkin, M. A. Shikin, O. Rader, unpublished [2] I. Gierz et al., arXiv:1004.1573v1

MA 63.23 Fri 11:00 P2

X-ray absorption and magnetic circular dichroism of $LaCoO_3$, $La_{0.7}Ce_{0.3}CoO_3$, and $La_{0.7}Sr_{0.3}CoO_3$ films: Evidence for Co valency-dependent magnetism — •Michael Merz[1], Peter Nagel[1], Andrea Assmann[1,2], Stephan Uebe[1,2], Markus Wissinger[1,2], Hilbert von Löhneysen[1,3], Dirk Fuchs[1], and Stefan Schuppler[1] — [1]Institut für Festkörperphysik, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [2]Fakultät für Physik, Karlsruhe Institute of Technology, 76031 Karlsruhe, Germany — [3]Physikalisches Institut, Karlsruhe Institute of Technology, 76031 Karlsruhe, Germany

Epitaxial thin films of undoped $LaCoO_3$, of electron-doped $La_{0.7}Ce_{0.3}CoO_3$, and of hole-doped $La_{0.7}Sr_{0.3}CoO_3$ exhibit ferromagnetic order with a transition temperature $T_C \approx 84$ K, 23 K, and 194 K, respectively. The spin-state structure for these compounds was studied by soft x-ray magnetic circular dichroism and by near-edge x-ray absorption fine structure at the Co $L_{2,3}$ and O K edges. It turns out that superexchange between Co^{3+} high-spin and Co^{3+} low-spin states is responsible for the ferromagnetism in $LaCoO_3$. For $La_{0.7}Ce_{0.3}CoO_3$ a spin blockade between Co^{3+} low-spin and Co^{2+} high-spin ions naturally explains the low transition temperature and the insulating characteristics of $La_{0.7}Ce_{0.3}CoO_3$. For $La_{0.7}Sr_{0.3}CoO_3$, ferromagnetism and metallicity is induced by t_{2g} double exchange between Co^{3+} and Co^{4+} high-spin states. For all systems, a strong magnetic anisotropy is observed, with the magnetic moments essentially oriented within the film plane.

MA 63.24 Fri 11:00 P2

Electric, magnetic and THz optical properties of $La_{1-x}Ca_xMnO_3$ $(0.45 < x < 0.7)$ and $(La_{1-y}Pr_y)_{0.33}Ca_{0.66}MnO_3$ $(0 < y < 1)$ thin films — •S. Hühn[1], F. Fischgrabe[1], V. Moshnyaga[1], K. Samwer[1], M. Dressel[2], L. S. Kadyrov[3], A.A. Voronkov[3], E.S. Zhukova[3], and B.P. Gorshunov[3] — [1]I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [3]A. M. Prokhorov Institute of General Physics, Russian Academy of Science, 119991 Moscow, Russia

Multiferroic behaviour has been paid a lot of attention due to the rich physics and great potential for technological applications. Recent studies indicate a close correlation between charge ordering (CO) and the ferroelectricity. For this reason we investigate $La_{1-x}Ca_xMnO_3$ $(0.45 < x < 0.7)$ and $(La_{1-y}Pr_y)_{0.33}Ca_{0.66}MnO_3$ $(0 < y < 1)$, which both show competing ferromagnetic metallic and charge ordering insulating phases. The films were grown by metalorganic aerosol deposition technique on MgO(100) substrates. D.c. and a.c. transport $(f = 0-40MHz)$, magnetization and optical conductivity, in the THz range of the electromagnetic spectrum, were studied as a function of temperature $(5-350K)$ and magnetic field $(0-7T)$. THz spectroscopy provides a clear sign for the CO transition at $220-280K$, depending on Ca-doping x. Moreover an indication for possible ferroelectricity in half-doped LCMO was observed from d.c. and a.c. transport measurements. Financial support via SFB 602 TP A2 is acknowledged.

MA 63.25 Fri 11:00 P2

Characterisation of magnetic thin films on MgO(100) — •Hendrik Bettermann, Wolfgang Rosellen, and Mathias Getzlaff — Institute of Applied Physics,University Duesseldorf

Nanoparticles on surfaces become more and more interesting from a

technological point of view like storage technology due to their size dependent electronic and magnetic properties. Therefore it is important to have access to the structure of deposited particles at different magnetic substrates. In the past it was shown that the interaction between surface and nanoparticle plays a predominant role for the particle shape and morphology. Both are influenced by the landing process and the interface and therefore on the substrate.

The focus of our investigation is on magnetic particles consisting of Fe, Co, and their alloys preformed with an Arc Cluster Ion Source (ACIS) and subsequently deposited on magnetic thin films. MgO(100) substrates are used for quick and easy access to clean, well-defined and single crystalline Fe, Co, and Ni thin films. These ultrathin films are investigated and characterised by the means of LEED (low energy electron defraction), AES (Auger electron spectoscopy) and STM (scanning tunneling microscopy).

MA 63.26 Fri 11:00 P2

Micromagnetic investigation of domain walls in $NdCo_5$ thin films — •Marietta Seifert, Ludwig Schultz, and Volker Neu — IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany

$NdCo_5$ is a highly anisotropic magnetic material in which a spin reorientation takes place from a magnetic easy *c*-axis above a temperature of 310 K via an easy cone to a magnetic easy plane in the basal plane of the hexagonal crystal at temperatures below 255 K. This transition was experimentally investigated in thin epitaxial $NdCo_5$ films grown on Cr buffered MgO (110) substrates [1]. For a further understanding of the domain processes during this transition, micromagnetic simulations have been performed to elucidate the spin structure within the domain walls in all three regimes of magnetic anisotropy. In addition the evolution of the domain structure while cooling down through the spin reorientation transition was simulated by a sequence of micromagnetic simulations with varying anisotropy constants.

[1] M. Seifert, L. Schultz, V. Neu, JAP 106, 073915 (2009)

MA 63.27 Fri 11:00 P2

Ferrimagnetism and disorder in epitaxial $(Mn_{1-x}Co_x)_2VAl$ thin films — •Markus Meinert[1], Jan-Michael Schmalhorst[1], Günter Reiss[1], and Elke Arenholz[2] — [1]Dünne Schichten und Physik der Nanostrukturen, Fakultät für Physik, Universität Bielefeld, 33501 Bielefeld, Deutschland — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, CA 94720, USA

Thin films of the quarternary full Heusler compound $(Mn_{1-x}Co_x)_2VAl$ were prepared by DC and RF magnetron co-sputtering on heated MgO (001) substrates. The magnetic structure was examined by x-ray magnetic circular dichroism and the chemical disorder was characterized by x-ray diffraction. For $x = 0.5$ a full compensation of the magnetic moments is expected according to the Slater-Pauling rule $m = N_V - 24$. Ferrimagnetic coupling of V to Mn was observed for Mn_2VAl ($x = 0$) and $x = 0.25$. For $x = 0.25$, we also found ferrimagnetic order with V and Co antiparallel to Mn. The experimental results are interpreted with the help of band structure calculations. The total magnetic moment is strongly reduced in Mn_2VAl because of preferential $D0_3$-like Mn-Al disorder. Co_2VAl is only B2 ordered and has reduced magnetization. In the cases with $x \geq 0.45$ conventional ferromagnetism was observed, closely related to the atomic disorder in these compounds.

MA 63.28 Fri 11:00 P2

Ultrathin continuous CoPt films with perpendicular anisotropy — •Ludwig Reichel, Karin Leistner, Sebastian Fähler, and Ludwig Schultz — IFW Dresden, PF 270116, 01171 Dresden

The change of magnetic properties of ferromagnetic ultrathin films by an electric field would be an easy and fast way to control their behaviour in nanosized devices. Among the ordered L10 phases, DFT calculations [1] predict the highest E-field induced change of anisotropy for the CoPt phase. Experimentally, the application of the electric field can be achieved by using a film as electrode in an electrochemical cell. For this, continuous, conducting films are required.

In the present investigation, 2-10 nm thick continuous CoPt films were deposited by pulsed laser deposition on MgO(001) substrates with Cr and Pt(001) buffer layers. Magnetic hysteresis curves with the magnetic field applied perpendicular to the film plane were obtained by anomalous Hall effect measurements. For films deposited at low temperatures, the A1 CoPt phase is present and shape anisotropy in the film plane dominates. On the other hand, temperatures above 500°C lead to interdiffusion and a lower degree of texture. Optimum (001)-textured L10 phase formation occurs for deposition temperatures of 450°C to 500°C. In these films, perpendicular anisotropy and switching of magnetization is achieved. We will present first results on electrolyte-CoPt interactions and electrolytic charging of these films.

[1] Zhang et al.: New J. Phys. 11 (2009) 043007

MA 63.29 Fri 11:00 P2

Charge-induced reversible change of magnetic properties in ultrathin FePt films — •Norman Lange, Karin Leistner, Steffen Oswald, Sebastian Fähler, and Ludwig Schultz — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

FePt has attracted a lot of interest as hard magnetic material due its high magnetocrystalline anisotropy. For applications, e.g. in NEMS, fast and reversible changes of magnetic properties induced by an electric field would be ideal.Weisheit et al. [Science 315 (2007) 349] showed that the coercivity of ultrathin FePt films can be changed by 4 % by electronic charging. Larger E-field induced effects are expected at critical points. We study continuous FePt(001) films where perpendicular magnetocrystalline anisotropy competes with shape anisotropy. The 2 nm ultrathin FePt(001) films are prepared by pulsed laser deposition. The films are charged in a non-aqueous electrolyte by applying an electric voltage. In-situ magnetic hysteresis curves are measured using the anomalous Hall effect. We observe a large reversible change of anisotropy (up to 20 %) and of the magnitude of the anomalous Hall effect as a measure for the moment (up to 4 %) for a potential range of 2 - 3 V vs. Li/Li+. As XPS studies reveal an iron oxide layer on top of FePt, we suggest that the moment increase at lower potentials results from electrochemical reduction of surface iron oxide species to metallic iron. The perpendicular anisotropy of the composite film decreases when a soft magnetic Fe layer is exchange coupled to FePt. We conclude that the anisotropy of exchange coupled FePt/iron oxide composite films can be tuned reversibly by electrical charging.

MA 63.30 Fri 11:00 P2

An oxide MBE system for quasi *in-situ* neutron reflectometry studies — •Sabine Pütter[1], Alexander Weber[2], Alfred Richter[1], Ulrich Rücker[2], Stefan Mattauch[1], Aleander Ioffe[1], and Thomas Brückel[1,2] — [1]Jülich Centre for Neutron Science am FRM II, Forschungszentrum Jülich GmbH, Lichtenbergstr. 1, 85747 Garching — [2]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich

A state-of-the-art oxide-MBE (Molecular Beam Epitaxy) system has been commissioned at the Jülich Centre for Neutron Science (JCNS) in 2010. It is designed to create high quality epitaxial thin films and heterostructures of complex oxides utilizing co-deposition and *in-situ* oxidation for quasi *in-situ* neutron scattering studies at the new dedicated MAgnetism Reflectometer with high Incident Angle (MARIA) of the JCNS by transferring the sample in a UHV transport chamber to the neutron beam.

We report on progress in the fabrication of systems of metal and complex oxide thin films like $[Cr/Fe]_x/GaAs$ and $La_{1-x}Sr_xMnO_3/SrTiO_3$, respectively, with the fine control of stoichiometry, morphology, and thickness. We have carried out careful calibration of the deposition rates of the constituent elements by reflective high energy electron diffraction intensity oscillations, Auger intensity analysis and *ex-situ* X-Ray diffraction. Annealing steps have been optimized to obtain atomically smooth films which have been checked with atomic force microscopy.

MA 63.31 Fri 11:00 P2

Magnetic structure of one monolayer Fe on Ir(001)-(1$\times$1) — •yiqi zhang, zhen tian, kuntala bhattacharjee, masaki takada, dirk sander, and jürgen kirschner — Max-Planck-Institut für Mikrostrukturphysik,06120 Halle, Germany

The morphology and the magnetic structure of a Fe monolayer (ML) on Ir(001)-(1$\times$1) were investigated using a low-temperature scanning tunneling microscope (STM) operating in the constant-current mode with nonmagnetic and magnetic tips, respectively. Our STM studies with atomic resolution confirm pseudomorphic growth of Fe in the first layer [1,2], where our spin-resolved measurements identify a spin contrast with a 3 $\times$ 3 superstructure. As the magneto-optical Kerr-effect study [2] and the first-principles calculations [3] indicate that the first ML of Fe on Ir(001)-(1$\times$1) tends to order antiferromagnetically, we propose a noncollinear antiferromagnetic spin configuration of the Fe ML based on the spin contrast mapping.

\begin{flushleft} [1] V. Martin, W. Meyer, C. Giovanardi, L. Hammer, K. Heinz, Z. Tian, D. Sander, and J. Kirschner, Phys. Rev. B 76, 205418 (2007). [2] Z. Tian, D. Sander, and J. Kirschner, Phys. Rev.

B 79, 024432 (2009).

[3] J. Kudrnovsk\'{y}, F. M\'{a}ca., I. Turek, and J. Redinger, Phys. Rev. B 80, 064405 (2009). \end{flushleft}

MA 63.32 Fri 11:00 P2

Magnetic properties of $Mn_{2.6}Ga$ thin films with perpendicular anisotropy — •Daniel Ebke, Manuel Glas, Patrick Thomas, and Günter Reiss — Thin Films and Physics of Nanostructures, Physics Department, Bielefeld University, Germany

Spintronic devices have found a lot of attraction in the recent years due to possible new applications. To reach high storage densities and low spin transfer writing current densities it is essential to utilize magnetic tunnel junctions (MTJs) with perpendicular magnetic anisotropy. Materials with a high spin polarization like Heusler compounds are eligible to realize high tunneling magnetoresistance (TMR) ratios. The Heusler compound $Mn_{3-x}Ga$ is predicted to show a high spin polarization and a perpendicular magnetic anisotropie. In this work we have investigated the magnetic properties of Heusler $Mn_{2.6}Ga$ thin films. The results will be discussed with respect to the choice of substrate, deposition temperature and film thickness.

MA 63.33 Fri 11:00 P2

Preparation of $Mn_{3-x}Ga$ Heusler thin films with perpendicular magnetic anisotropy — •Manuel Glas, Daniel Ebke, Patrick Thomas, and Günter Reiss — Thin Films and Physics of Nanostructures, Physics Department, Bielefeld University, Germany

Recently, the integration of materials with perpendicular magnetic anisotropy into magnetic tunnel junctions (MTJs) has found a lot of attraction due to the predicted lowered current densities for spin transfer switching and a higher thermal stability. Because of the predicted high spin polarization and the low magnetic moment Mn_3Ga is a promising material for future spin torque transfer (STT) magnetic switching devices. For this work, we have fabricated $Mn_{3-x}Ga$ Heusler thin films with varying stoichiometries into half magnetic tunnel junctions. The effect of Heusler film composition will be discussed with respect to the magnetic and crystal properties.

MA 63.34 Fri 11:00 P2

In-Situ STM, LEED and MOKE Measurements of Ultrathin Epitaxially Flat Grown Fe Films on the GaAs(110) Surface — •Tim Iffländer, Martin Wenderoth, Thomas Druga, Lars Winking, and Rainer G. Ulbrich — IV. Phys. Inst., Georg-August-Universität Göttingen

Fe films of up to 8 ML thickness were deposited on in-situ cleaved n-, p-, and i-GaAs(110) in a two-step process combining low-temperature deposition at 130 K with a subsequent annealing to room temperature. LEED and STM measurements suggest an abrupt interface without any considerable amount of compound formation.

In-situ longitudinal MOKE measurements at RT were conducted for different in-plane orientations of the applied magnetic field with respect to the sample. In contrast to RT grown Fe films of 2-3 ML thickness, the easy and hard axes are interchanged, now parallel to [001] and [110], respectively. The hysteresis loop of films thicker than or equal to 5 ML is equivalent to magnetization curves observed in the case of RT grown films.

Furthermore, we observe a new phenomenon in the 2-3 ML thickness regime: the sense of the hysteresis loops for steep angles of incidence is not determined by the orientation of the magnetic field but linked to the crystallographic orientation of our substrate. From that we conclude a polar magnetization component induced by the epitaxially grown interface.

This work was supported by the DFG SFB 602 TP A7 and SPP 1285.

MA 63.35 Fri 11:00 P2

(001)-textured growth of $L1_0$-FePt thin films on MgO and Cr seed layers — •Patrick Matthes, Christoph Brombacher, Marcus Daniel, Gunther Beddies, and Manfred Albrecht — Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz - Germany

Chemically ordered FePt has a high uniaxial anisotropy with the easy axis in (001)-direction. It has been shown that (001)-textured MgO [1] and Cr [2] seed layers can be used to stabilize the (001)-texture of $L1_0$-chemically ordered FePt on amorphous substrates. In this study the growth of MgO and Cr seed layers was optimized by varying the process parameters (deposition temperature and rate as well as Ar pressure) and their influence on the magnetic properties of epitaxially grown FePt films have been analyzed. In addition, reference samples on MgO(100) single crystals were prepared. XRD measurements revealed a high degree of chemical order leading to a K_{eff} of $(8.5 \pm 1.3) \times 10^6$ erg/cm^3 after FePt deposition at 350 °C. The low deposition temperature results in a smooth film morphology and a reversal behaviour which is dominated by domain wall propagation.

[1] T.Shima et al., APL **81**, 1050 (2002)

[2] A.-C. Sun et al., JAP **88**, 076109 (2005)

MA 63.36 Fri 11:00 P2

UHV-chamber for broadband magneto-optical reflection and polarisation experiments — •Marc Tesch[1], Markus Gilbert[1], Hans-Christoph Mertins[1], Roman Adam[2], Herbert Feilbach[2], and Claus Michael Schneider[2] — [1]FH Münster, Stegerwaldstr.39, 48565 Steinfurt — [2]FZ Jülich, IFF-9, 52425Jülich

A new UHV-chamber for magneto-optical reflectometry and polarimetry experiments is presented. It enables measurements from the VIS to the soft X-ray range, using xenon- and deuterium-lamps or synchrotron radiation. The samplemagnetisation is generated by a quadrupolmagnetometer via rotating 8 NdFeB-permanentmagnets. The magnetic field is tunable from -500 mT to +500 mT in longitudinal or tranversal geometry. This device avoids thermal load, sophisticated UHV-compatible water cooling and offers reflection- and scattering experiments in a wide angular range. The presented 5-axes-polarimeter allows simple intensity measurements as well as polarisation analysis of the light after interaction with the magnetized sample in L- and T-MOKE-geometry. Practical features are in-situ sample transfer, easy chamber alignment and compatibility to synchrotron radiation beamlines as well as to light sources in the laboratory.

MA 63.37 Fri 11:00 P2

Ab initio study of MnSi thin films on the Si(111) surface — •Benjamin Geisler and Peter Kratzer — Fakultät für Physik, Universität Duisburg-Essen

One of the challenges in the field of spintronics is the injection of a spin-polarized electric current into a semiconductor. This can be achieved by combining the semiconducting material with a ferromagnetic one, e. g., by growing thin films of a transition metal like Mn on top of a Si(111) surface. Due to the high reactivity of Mn and Si, thin films of MnSi will form instead of pure Mn films.

We perform density functional theory calculations for thin films of MnSi on Si(111) in their ground state crystal structure, the B20 structure. This structure lacks inversion symmetry, and the (111) films show a periodicity of 12 layers, which can be decomposed into three groups, each consisting of four different layers: a dense Si, a sparse Mn, a sparse Si and a dense Mn layer. Changing the number of layers, the orientation and termination of the layer stack alters the thin film properties, resulting in different magnetic ordering, STM pattern or STM contrast. The calculated formation energies or surface energies can be used to compare the thermodynamic stability and / or probability of different film terminations. STM images are calculated in order to improve the understanding of recently observed experimental STM images. Furthermore, the question of ferro- vs. antiferromagnetism is addressed.

MA 63.38 Fri 11:00 P2

Proper Scaling of the Anomalous Hall Effect in Heusler Compounds — •Inga-Mareen Imort[1], Patrick Thomas[1], Günter Reiss[1], Andy Thomas[1], Franz D. Czeschka[2], Matthias Althammer[2], Alexander T. Krupp[2], Rudolf Gross[2], and Sebastian T. B. Goennenwein[2] — [1]Fakultät für Physik, Universität Bielefeld, Bielefeld, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany

The anomalous Hall effect (AHE) is a fundamental but controversially discussed physical phenomenon in ferromagnets. We have studied the AHE in thin films of the Heusler compound Co_2FeAl, at temperatures between 3 K and 300 K, with magnetic fields of up to 4 T perpendicular to the film plane. The Co_2FeAl layers were deposited using rf-magnetron sputtering on single-crystal MgO (001) substrates, and annealed at different temperatures ex-situ. The structural quality of our samples was tested by X-ray diffraction scans. After etching Hall-bar mesa structures, we measured the evolution of the anomalous Hall resistance ρ_{AHE} and the longitudinal resistance ρ_{xx} with the sample annealing temperature, in order to investigate the contribution of the different microscopic mechanisms to the anomalous Hall effect. For comparison, we also have measured the AHE in iron and cobalt thin

films. All our AHE data of the Heusler compound Co_2FeAl show the typical behavior of an itinerant ferromagnet, with skew scattering and side-jump terms.

This work was supported by the NRW MIWF.

MA 63.39 Fri 11:00 P2

vector magneto-optical generalized ellipsometry (VMOGE) — •Kahming Mok, Nan Du, and Heidemarie Schmidt — Institute of Ion-Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Bautzner Landstrasse 400, 01328 Dresden, Germany

Numerous techniques have been utilized as experimental tools for magneto-optical (MO) characterization and the Kerr effect (MOKE) has been the most widely used method for this purpose so far. Recently, magneto-optical generalized ellipsometry (MOGE) has been developed to study layer systems with optical anisotropy induced by an external magnetic field. In our work, we setup a Vector-Magneto-Optical Generalized Ellipsometer (VMOGE) with a generalized spectroscopic ellipsometer and an octupole magnet. Not only measuring the MOKE of a sample, VMOGE also allows to perform generalized Mueller matrix ellipsometry in a magnetic field of arbitrary orientation and magnitude up to 0.4 T at room temperature, which provides a more general analysis for arbitrarily anisotropic and depolarizing materials. The VMOGE features a new "field orbit" measurement that can be performed without physically moving the sample, which is important for the analysis of MO thin films and layered nanostructure samples to study, e.g., exchange phenomena in multilayer samples, confinement, and collective magnetism. We discuss here exemplarily the investigation of a Cr_2O_3/Co/sapphire multilayer sample prepared by molecular beam epitaxy (MBE) by means of VMOGE. This optically isotropic sample system is chosen due to the well-known ferromagnetic properties of Co.

MA 63.40 Fri 11:00 P2

Electronic and magnetic structure of (Ca,Sr)RuO_3 thin films — •Andrea Assmann[1,2], Stephan Uebe[1,2], Michael Merz[1], Markus Wissinger[1,2], Hilbert von Löhneysen[1,3], Dirk Fuchs[1], Peter Nagel[1], and Stefan Schuppler[1] — [1]Karlsruhe Institute of Technology, Institut für Festkörperphysik, Germany — [2]Karlsruhe Institute of Technology, Fakultät für Physik, Germany — [3]Karlsruhe Institute of Technology, Physikalisches Institut, Germany

The 4*d* transition metal oxide (Ca,Sr)RuO_3 exhibits ferromagnetic order in the doping range $0.4 \leq x \leq 1$ while it is a paramagnetic metal for $x < 0.4$. Since (Ca,Sr)RuO_3 remains essentially isostructural and has a similar electronic configuration throughout the doping series, the differences in the magnetic properties might be attributed to chemical pressure effects. To verify a possible dependence of direction and/or magnitude of the magnetic moments on pressure, (Ca,Sr)RuO_3 films were deposited on different substrates (LSAT, STO, $DyScO_3$=DSO). The magnetic and electronic structure of the samples was studied by soft x-ray absorption and magnetic circular dichroism at the Ru $M_{2,3}$ and O K edges. In addition, depth-dependent information on element-specific core levels was obtained by varying the photon energy in soft x-ray photoemission spectroscopy. Various implications will be discussed.

MA 63.41 Fri 11:00 P2

High quality electrodeposited $Fe_{100-x}Ga_x$ films for magnetostrictive applications — •Diana Iselt[1,2], Heike Schlörb[1], Sebastian Fähler[1], and Ludwig Schultz[1,2] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, 01171 Dresden, Germany — [2]TU Dresden, Faculty of Mechanical Engineering, 01062 Dresden

Magnetostrictive materials can be used to build electromagnetic sensing and actuating devices. A promising candidate to overcome the mechanical limitations of Terfenol-D is $Fe_{100-x}Ga_x$ with 15 to 25 at.% Ga, which exhibits high mechanical strength and low saturation fields. For sensor application an efficient, scalable preparation way is required for thin film and nanowire fabrication. In this study FeGa alloy films with a desired composition close to $Fe_{80}Ga_{20}$ have been fabricated electrochemically on Pt substrates. For a conventional deposition at constant potentials strong interactions of the electrolyte with the platinum coated substrate are identified to cause low reproducibility and high oxygen content. The use of optimised pre-treatment and pulsed potential conditions resulted in dense and homogeneous films with a (110) $\alpha - Fe_3Ga$ fibre texture. Oxygen content was reduced below 1 at.% and the saturation magnetization reaches up to 1.7 T, confirming the high quality of these films. In order to understand the influence of the substrate on morphology and oxygen content deposition on gold and copper coated substrates have been carried out.

MA 63.42 Fri 11:00 P2

Fabrication and characterisation of ferromagnetic layers for CEO Spin LEDs — Wera Fehl[1], Carsten Godde[1], Sani Noor[1], Arne Ludwig[2], Henning Soldat[3], Andreas Wieck[2], •Martin Hofmann[3], and Ulrich Köhler[1] — [1]Institut für Experimentalphysik IV, AG Oberflächen, Ruhr-Universität Bochum — [2]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum — [3]Lehrstuhl für Photonik und Terahertztechnologie, Ruhr-Universität Bochum

The purpose of this project is the spin injection via Fe and Fe/MgO on GaAs(110). We employ cleaved edge overgrowth (CEO) which means cleaving of the samples with an LED structure in UHV and in situ deposition of the ferromagnetic layers under variable angles with respect to the cleaved surface. This geometry allows us to use thin films with an in plane magnetization. Due to the sample structure we can produce spin injection lenghts in the μm range. The optically active region consists of quantum dots embedded in intrinsic GaAs. Polarization dependent electroluminescense measurements have been made in order to determine the degree of circular polarization as a function of the applied magnetic field. Furthermore, we made micromagnetic simulations using OOMMF to get information about possible effects of the ferromagnetic film boundary on the domain structure.

MA 63.43 Fri 11:00 P2

Orbital Ordering at the Interfaces in Transition Metal Oxide Heterostructures — •Alexandra Steffen, Artur Glavic, Daniel Schumacher, Jörg Voigt, Alexander Weber, Emmanuel Kentzinger, Ulrich Rücker, and Thomas Brückel — IFF-4, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

In heterostructures of oxide perovskites with the structure ABO_3 orbital ordering can be induced by Jahn-Teller distortions or strain-induced change of the lattice constants, influencing for example the Curie temperature of the compound [1]. The aim of this work is the investigation of orbital ordering in ultrathin layered structures with layer thicknesses below 2 nm.

We prepare multilayers consisting of $La_{1-x}Sr_xMnO_3$ or $La_{1-x}Ca_xMnO_3$ ($0.2<x<0.5$) and $SrTiO_3$ or $BaTiO_3$ by high pressure sputtering using an oxygen plasma. Combining ferromagnetic and dielectric resp. ferroelectric layers we expect strong magnetoelectric effects. The structural quality of the layered structures has been confirmed using the x-ray reflectometer and 4-circle diffractometer. With AFM and SQUID magnetometry we have investigated inhomogeneities and magnetization behaviour. In near future, we expect to gain further insights in the ordering phenomena and the interaction between the layers with resonant x-ray diffraction experiments giving access to orbital ordering phenomena and lattice distortions on an atomic length scale.

[1] A. Sadoc *et al.*, Phys. Rev. Lett. **104** 046804 (2010)

MA 63.44 Fri 11:00 P2

Semiconducting (Half-Metallic) Ferromagnetism in Mn(Fe) Substituted Pt and Pd Nitrides — •Abdeslam Houari[1], Samir Matar[2], and Volker Eyert[3] — [1]Theoretical Physics Laboratory, Department of Physics, University of Bejaia, Bejaia 06000. Algeria — [2]ICMCB, CNRS, Université de Bordeaux 1, 87 avenue du Docteur Albert Schweitzer, 33600, Pessac, France — [3]Center for Electronic Correlations and Magnetism, Institut Fur Physik, Universitat Augsburg, 86135 Augsburg, Germany

Using first principles calculations as based on density functional theory, we propose a class of so far unexplored diluted ferromagnetic semiconductors and half-metals. Here, we study the electronic properties of recently synthesized 4*d* and 5*d* transition metal dinitrides. In particular, we address Mn- and Fe-substitution in PtN_2 and PdN_2. Structural relaxation shows that the resulting ordered compounds, $Pt_{0.75}(Mn,Fe)_{0.25}N_2$ and $Pd_{0.75}(Mn,Fe)_{0.25}N_2$, maintain the cubic crystal symmetry of the parent compounds. On substitution, all compounds exhibit long-range ferromagnetic order. While both $Pt_{0.75}Mn_{0.25}N_2$ and $Pd_{0.75}Mn_{0.25}N_2$ are semiconducting, Fe-substitution causes half-metallic behavior for both parent materials.

MA 63.45 Fri 11:00 P2

Defect-induced ferromagnetism in crystalline SrTiO3 — •Julia Osten[1], Kay Potzger[1], Alexander. A. Levin[2], Artem Shalimov[1], Georg Talut[1], Helfried Reuther[1], Seda Arpaci[1],

Danilo Bürger[1], Heidemarie Schmidt[1], Tina Nestler[3], and Dirk C. Meyer[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, 01328 Dresden, Germany — [2]Institut für Strukturphysik, Technische Universität Dresden, 01062 Germany — [3]Institut für Experimentelle Physik, Technische Universität Bergakademie Freiberg, 09596 Freiberg

Ion irradiation of high-quality SrTiO3 single crystals leads to room-temperature ferromagnetism. Structural analysis revealed oxygen deficient (polycrystalline) SrTiO3, Sr2Ti6O13, or Ruddlesden-Popper like secondary phases at the sample surface induced by the irradiation. The lack of potentially ferromagnetic secondary phases suggests defects to be the origin of the observed ferromagnetic signal.

MA 63.46 Fri 11:00 P2

Magnetic coupling in Fe/(Ga,Mn)As based heterostructures — •M. Sperl[1], P. Torelli[2], M. Soda[1], F. Eigenmann[1], M. Utz[1], S. Polesya[3], G. Woltersdorf[1], G. Panaccione[2], D. Bougeard[1], and C. H. Back[1] — [1]Institut für Experimentelle Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]Laboratorio Nazionale TASC, INFM-CNR, in Area Science Park, S.S. 14, Km 163.5, I-34012 Trieste, Italy — [3]Department of Chemistry, Ludwig-Maximilians University Munich, Germany

(Ga,Mn)As is one of the most promising diluted magnetic semiconductors (DMS) for spintronics due to the compatibility with the GaAs MBE technology. Despite the promising features (Ga,Mn)As has a Curie temperature well below room temperature limiting its possible applications. One potential direction to tailor novel properties of DMS thus making integration in real devices feasible is to exploit interface effects in highly controlled heterostructures (HS). Following this route FM behaviour of Mn at room temperature in both epitaxial and non-epitaxial Fe/(Ga,Mn)As interfaces has been demonstrated [1].

We report results obtained with Synchrotron Radiation techniques, where we were able to monitor the evolution of the magnetic coupling between Fe and Mn as a function of Mn doping, temperature and thickness. In particular, XMCD experiments show a peculiar thickness dependence of the room temperature magnetic coupling between Fe and Mn, namely a switching from antiparallel to parallel, thus opening the possibility of controlling the magnetization state of the interface.

[1] F. Maccherozzi et al. Phys. Rev. Lett. 101 (2008) 267201.

MA 63.47 Fri 11:00 P2

Transparent field effect transistors with spin-polarized electrons — Tim Kaspar, Danilo Bürger, Ilona Skorupa, Vicki Kühn, Artur Erbe, Manfred Helm, and •Heidemarie Schmidt — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden

We focus our research on possible semiconductor spintronics devices. Our work is motivated by magnetoresistance effects in magnetic ZnO thin films that have been detected below 50 K and are due to spin-polarized electrons [1]. Our aim is to control the characteristics of a ZnO-based Junction Field Effect Transistor (J- FET) by manipulating spin polarized electrons in the magnetic channel of the J-FET by external electrical and magnetic fields. The magnetic channel layers have been deposited by pulsed laser deposition on Al_2O_3 and ZnO substrates. The gate, source and drain contact was structured by electron beam lithography. The gate contact was fabricated by reactive sputtering of Ag [2]. The main characteristics of the ZnO-based J-FET with magnetic channel will be presented.

[1] Qingyu Xu, H. Schmidt et al. , Phys. Rev. Lett. **101**, 076601(2008)

[2] H.Frenzel et al., Appl. Phy. Lett. **92**, 192108 (2008)

MA 63.48 Fri 11:00 P2

Spin precession and modulation in ballistic cylindrical nanowires due to Rashba effect — Andreas Bringer[1] and •Thomas Schaepers[2] — [1]Institute of Solid State Research and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Institute of Bio- and Nanosystems (IBN-1) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

The spin precession in a cylindrical semiconductor nanowire due toRashba spin-orbit coupling is theoretically investigated. We employed an InAs nanowire containing a surface two-dimensional electron gas as a model system. By solving the Schrödinger equation in a cylindrical symmetry the corresponding eigenstates, the energy-momentum dispersion, and the energy-magnetic field dispersion relation are determined. The combination of states with the same total angular momentum but opposite spin orientation results in a periodic modulation of the axial spin component along the wire axis. Spin-precession about the wires axis is achieved by interference of two states with different total angular momentum. Due to the fact that at zero magnetic field a superposition state with exact opposite spin precession exists an oscillation of the spin orientation can be obtained. In case that an axially oriented magnetic field is applied the spin gains a precessing component in addition.

Various injection and detection methods are studied to demonstrate the functionality of these modes in spin electronic devices.

MA 63.49 Fri 11:00 P2

ZnO thin films with (Li,Ni)-codoping — Senthil Kumar[1], Matthias Althammer[2], Deepak Venkateshvaran[2], Eva Karrer-Müller[2], Sebastian T.B. Goennenwein[2], M.S. Ramachandra Rao[1], •Matthias Opel[2], and Rudolf Gross[2] — [1]Materials Science Research Centre, Indian Institute of Technology Madras, Chennai, India — [2]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany

The wide bandgap II-VI semiconductor ZnO is controversially discussed with regard to both dilute magnetic doping and stable p-type conductivity. Following a recent report [APL **96**, 232504 (2010)], we investigated (Li,Ni)-codoping to establish ferromagnetism together with p-type conduction. Using laser-MBE, we deposited thin films from stoichiometric targets with compositions $Zn_{0.98-x}Li_xNi_{0.02}O$ ($x = 0, 0.02, 0.05, 0.09$). High-resolution x-ray diffraction reveals excellent structural quality and nearly perfect in-plane orientation. Magnetization measurements show an "S"-shaped behavior in $M(H)$ at room temperature and a clear difference after field cooling or zero-field cooling in $M(T)$ which is reminiscent of superparamagnetism. The saturation magnetic moment is around $0.7\,\mu_B$ per Ni and, hence, very close to the bulk value of Ni metal ($0.6\,\mu_B$). From thermopower measurements, we obtained negative Seebeck coefficients between $-400\,\mu$V/K and $-900\,\mu$V/K, with smaller absolute values corresponding to lower Li concentrations. In summary, we could not confirm p-type conductivity or ferromagnetism in (Li,Ni)-substituted ZnO thin films.

This work was supported by the DAAD and the DFG via SPP 1285.

MA 63.50 Fri 11:00 P2

The effects of short-range order and clustering in dilute magnetic semiconductors: a non-local, multi-sublattice CPA investigation — •Alberto Marmodoro[1,2], Julie Staunton[1], and Arthur Ernst[2] — [1]University of Warwick, Department of Physics, CV4 7AL Coventry, United Kingdom — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

The compound $(Ga, TM)As$, for TM transition metals such as Mn, represents a prototypical diluted magnetic semiconductor in which different magnetic coupling mechanisms coexist and are differently affected by dopant concentration, the nature of impurity states, formation of complexes etc.

We propose that the recently developed multi-sublattice, non-local coherent potential approximation (MS-NL-CPA) for a fully parameters-free multiple scattering investigation of disorder and short range ordering is well-suited to describe these effects beyond a single-site treatment. Our preliminary results demonstrate the enhanced accuracy of this generalized approach, and its potential to provide useful insights into the roles of Zener's $p-d$ and double-exchange effective interactions between the TM impurities, and the influence of other possible sources of defects such as co-dopants or interstitial and anti-site substitutions.

MA 63.51 Fri 11:00 P2

Optical and magnetic properties of Cr-implanted indium oxides thin films — •Scarlat Camelia, Shengqiang Zhou, Mykola Vinnichenko, Andreas Kolitsch, Manfred Helm, and Heidemarie Schmidt — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany

Dilute magnetic oxides using the electron spin rather than its charge as information carrier are expected to play a key role in the development of spinelectronics. As it has been shown recently, indium oxide (IO), a transparent conducting material, is of potential importance also as a material for spintronics [1]. Polycrystalline and amorphous (ca. 300 nm thick) n-type conductive IO films were grown on SiO_2/Si substrates using reactive magnetron sputtering. The films were implanted with 120 keV Cr^+ ions in order to reach Cr concentrations of 1, 2, 3, 4 and 5

at%. Cr is chosen as a dopant because of its large magnetic moment in the ionic state, and the antiferomagnetic nature of Cr metal segregations. Highly oxygen deficient 2%Cr:IO co-evaporated films revealed ferromagnetism. Here we study the effect of the post-growth treatment on the structural, electrical, magnetic, and optical properties of Cr-implanted IO films. It is shown that only the 2%Cr:IO implanted film is weakly ferromagnetic at 5 K. A reasonable model for the Cr:IO implanted films has been developed to extract optical constants from spectroscopic ellipsometry data below 3 eV in dependence on the Cr concentration. [1] C. Scarlat et al., Nuclear Instruments and Methods in Physics Research B 267 (2009) 1616.

MA 63.52 Fri 11:00 P2

Ferromagnetic Heusler alloy Co_2FeSi films on GaAs(110) substrates — •Thomas Hentschel, Bernd Jenichen, Achim Trampert, and Jens Herfort — Paul-Drude-Institut Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Ferromagnetic Heusler alloys may be promising material candidates for spintronic devices due to a theoretically full spin polarization at the Fermi edge. We have investigated the Heusler alloy Co_2FeSi grown by molecular beam epitaxy on GaAs(110) for different substrate temperatures T_S with respect to the structural and magnetic properties. The (110) ferromagnet/semiconductor (FM/SC) interface is predicted to maintain the half-metallic behaviour. Furthermore the (110) orientation reveals a significantly higher spin-lifetime in the semiconductor than its (001) counterpart.

We found ferromagnetic films entirely free of dislocations and an interface roughness below 1 nm up to $T_S = 225$ °C. The films exhibit an in-plane uniaxial magnetic anisotropy with an easy axis along the $[\bar{1}10]$ and a hard one along the [001] direction. With increasing T_S the hard [001] axis shifts into an intermediate one, while the easy axis remains stable but shows higher coercitive fields, indicating the formation of crystal defects. X-ray diffraction measurements reveal the lattice parameter expected for the correct composition. If the film thickness is continuously reduced from 40 to 4 nm, the uniaxial contribution increases. This gives evidence that the FM/SC interface plays an important role in the magnetic behaviour.

MA 63.53 Fri 11:00 P2

Inverse interface Cr magnetization at the CrO2/RuO2 interface: The origin for unexpected small GMR effects — •Khalid Zafahr[2], Manjit Pathak[1], Arunava Guptha[1], Patrik Audehm[2], and Eberhard Goering[2] — [1]MINT Center, University of Alabama, Tuscaloosa, Alabama 35487, USA — [2]MPI-MF, Heisenbergstraße 3, 70569 Stuttgart

Due to the 100% spin polarization in CrO2 and the good epitaxy CrO2/RuO2/CrO2 trilayers have been proposed to provide extraordinary magnetoresitive effects (GMR), but only very small GMR has been observed so far. We will provide soft X-ray resonant reflectivity results at the Cr L2,3 edges performed on a CrO2/RuO2 -bilayer. By the use of linear and circular polarized light this method is able to determine the chemical and the magnetic profiles including roughness or diffusion length. On one hand, we can clearly exclude the presence of an induced Ru magnetization at the CrO2/RuO2 interface as an origin for the reduced GMR effect. On the other hand we found instability to an antiparallel oriented CrO2 magnetization top layer at the RuO2 interface. No tendency of a dead layer could be found. This unexpected result directly explains the rather small GMR observed in this system.

MA 63.54 Fri 11:00 P2

Structural and magnetic properties of $Zn_{1-x}Fe_xO_4$ thin films grown by pulsed laser deposition — •Kerstin Brachwitz[1], Katja Mexner[1], Tammo Böntgen[1], Michael Lorenz[1], Jörg Lenzner[1], Kartik C. Ghosh[2], and Grundmann Marius[1] — [1]Institut für Experimentelle Physik II, Universität Leipzig, Linnéstraße 5, 04103 Leipzig, Germany — [2]Physics, Astronomy, and Materials Science Department, Missouri State University, Springfield, 901 South National Avenue, MO 65804, USA

Zinc ferrite ($ZnFe_2O_4$) is a semitransparent magnetic semiconductor with various potential applications, e.g. in magnetic tunnel junctions and spin filters. Using pulsed laser deposition $Zn_{1-x}Fe_xO_4$ thin films with target compositions $0 \leq x \leq 0.66$ were grown on a-plane sapphire substrates. Besides the target stoichiometry the oxygen partial pressure $p(O_2)$ applied during growth was varied. By increasing x the intensity of the ZnO (0001) reflex decreases while that of $ZnFe_2O_4$ (111) increases. For $x > 0.4$ single phase $ZnFe_2O_4$ layers are obtained. For these thin films energy dispersive X-ray spectroscopy shows an excess of iron for $p(O_2) = 5 \cdot 10^{-5}$ mbar and a strong influence of $p(O_2)$ on the thin film stoichiometry.
Further, the magnetic properties depend on $p(O_2)$ and x. The saturation magnetization ranges up to 30 emu/cm^3 for $x = 0.66$. Indications for an in-plane magnetization were found by magnetic force microscopy and magnetization measurements. The latter revealed that the coercive field increases with increasing Fe content.

MA 63.55 Fri 11:00 P2

Investigations of the ordering in $Co_2Mn(Si,Ge)$ and Co_2FeSi via transport, magnetization, XRD and Mößbauer measurements — •Britta Willenberg[1], Dirk Schulze Grachtrup[1], Jochen Litterst[1], Stefan Süllow[1], Jens Röder[2], and Dirk Menzel[1] — [1]Institut für Pysik der Kondensierten Materie, TU Braunschweig, Germany — [2]Physikalische und Theoretische Chemie, TU Braunschweig, Germany

Heusler alloys like Co_2MnSi, Co_2MnGe and Co_2FeSi have attracted interest, because some theoretical works predicted half-metallicity with 100 % spin polarization. So far, this high value has not been observed experimentally. Some calculations indicate that the lack of total spin polarization should be due to structural defects, which destroy the half-metallicity. We have investigated the effect of annealing on the quality of these compounds via transport, magnetization, XRD and Mößbauer measurements. Thermal annealing of Co_2MnSi and Co_2MnGe leads to an increase of the residual resistivity ratio. Furthermore, powder x-ray measurements on Co_2MnSi showed that a second phase occurs in the annealed sample due to a phase segregation during annealing. In contrast to this behavior the residual resistivity ratio for Co_2FeSi decreases during annealing. Moreover, by means of Mößbauer studies we found out that the disorder between some atomic sites increased during annealing and additionally a second phase arises. Thus, thermal annealing of this compound degrades the quality of the crystal.

MA 63.56 Fri 11:00 P2

The interface of the ferromagnetic metal CoS_2 and the nonmagnetic semiconductor FeS_2 — •Udo Schwingenschlögl and Safdar Nazir — PSE Division, KAUST, Thuwal 23955-6900, Kingdom of Saudi Arabia

The electronic and magnetic properties of the cubic pyrite CoS_2/FeS_2 interface are studied using the all-electron full-potential linearized augmented plane wave method. We find that this contact between a ferromagnetic metal and a nonmagnetic semiconductor shows a metallic character. The CoS_2 stays close to half-metallicity at the interface, while the FeS_2 becomes metallic. The magnetic moment of the Co atoms at the interface slightly decreases as compared to the bulk value and a small moment is induced on the Fe atoms. Furthermore, at the interface ferromagnetic ordering is found to be energetically favorable as compared to antiferromagnetic ordering.
Reference: Appl. Phys. Lett. 97, 183113 (2010)

MA 63.57 Fri 11:00 P2

The importance of the on-site electron-electron interaction for the magnetic coupling in the zigzag spin-chain compound In_2VO_5 — •Udo Schwingenschlögl and Hao Wang — PSE Division, KAUST, 23955-6900 Thuwal, Kingdom of Saudi Arabia

We present first-principles electronic structure calculations for the zigzag spin-chain compound In_2VO_5 using the generalized gradient approximation both with and without inclusion of an on-site Coulomb interaction. It has been proposed that In_2VO_5 is characterized by itinerant V 3d electrons at high temperature and localized electrons at low temperature. Consequently, it is to be expected that electronic correlations play an important role for the magnetic transition from ferromagnetic to antiferromagnetic exchange around 120 K. In this context, we study the electronic and magnetic properties of a set of possible spin configurations. Our calculations show that inclusion of an on-site Coulomb interaction in fact changes the ground state from ferromagnetic to antiferromagnetic.
Reference: J. Phys.: Cond. Matter 22, 416002 (2010)

MA 63.58 Fri 11:00 P2

Element specific magnetic moments and spin-resolved DOS of the half-metallic compounds CoFeMnZ (Z = Al, Ga; Si, Ge) — •Peter Klaer[1], Alijani Vajiheh[2], Benjamin Balke[2], Gerhard H. Fecher[2], Claudia Felser[2], and Hans-Joachim Elmers[1] — [1]Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz, Germany — [2]Institut für Anorganische Chemie und Analytis-

che Chemie, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany

A new class of materials based on the $L2_1$ Heusler crystal structure are quaternary CoFeMnZ (Z = Al, Ga; Si, Ge) alloys. CoFeMnSi with the LiMgPdSb-type structure is predicted to be a half-metallic ferromagnet[1].

We used circular dichroism in x-ray absorption spectroscopy (XMCD) to evaluate the magnetic moments for Co, Fe, and Mn. A comparison with calculations clearly allows to distinguish between various structure models confirming the proposed LiMgPdSb-type structure with predicted half-metallicity. Moreover, we show the element specific spin-resolved unoccupied density of states (DOS) for Co, Fe, and Mn evaluated from XMCD spectra. Exchange of the main group elements from group III (Al, Ga) by those from group IV (Si, Ge) fills majority states and shifts the Fermi energy with respect to the half-metallic band gap in the minority states. The authors are thankful for financial support from the DFG (Grant No. FOR 559).

[1] X. Dai, G. Liu, G. H. Fecher, C. Felser, Y. Li, and H. Liu, J. Appl. Phys., 105, 07E901 (2009).

MA 63.59 Fri 11:00 P2

AC electric transport in CMR-manganite thin films — •Florian Fischgrabe, Sebastian Hühn, Jon-Olaf Krisponeit, Konrad Samwer, and Vasily Moshnyaga — I. Physikalisches Institut, Göttingen

We report ac measurements on $(La_{0.6}Pr_{0.4})_{0.7}Ca_{0.3}MnO_3$ and $La_{1-x}Ca_xMnO_3$ thin films prepared by metalorganic aerosol deposition technique. The measurements were carried out for temperatures, T=10-300 K, frequencies, f=10 Hz-1 MHz and applied magnetic field ,B=0-1 T,to get a detailed view on the electric properties close to the phase transition. While the dc resistance as a function of temperature shows a well-known metal-insulator-transition behaviour, the other features appear when varying frequency. The imaginary part of the impedance demonstrates a strong phase shift near the metal insulator transition and even changes its sign directly after the metal insulator transition. Furthermore in a half-doped $LaCaMnO_3$ ($x \approx 0.5$) we observed a pronounced difference between ac and dc measurements for temperatures T<100 K. The influence of FM/AFM coexistence as well as of charge ordering on the ac electric transport will be discussed.

MA 63.60 Fri 11:00 P2

Sputtering deposition and characterization of epitaxial LSMO thin films — •Philipp M. Leufke, Ajay K. Mishra, Robert Kruk, and Horst Hahn — Karlsruher Institut für Technologie, Institut für Nanotechnologie, D-76344 Eggenstein-Leopoldshafen, Germany

We report on the heteroepitaxial deposition of $La_{1-x}Sr_xMnO_3$ (LSMO) thin films using RF and DC magnetron sputtering. Co-deposition from the two different LSMO targets with $x = 0.25$ and $x = 0.35$ was used to tailor the desired composition to control ferromagnetic Curie temperature of the films. The influence of different single crystalline substrates as well as the effect of varying the oxygen partial pressure on magnetic and structure properties during deposition was investigated. The chemical stoichiometry was determined by Rutherford backscattering spectroscopy (RBS). Transmission electron microscopy and high resolution X-ray diffractometry (HRXRD) confirmed epitaxial growth for substrates with low in-plane lattice mismatch. The temperature dependence of the electric resistance agrees with the T_{Curie} determined by (zero) field-cooling (FC/ZFC) superconductive quantum interference device SQUID measurements.

MA 63.61 Fri 11:00 P2

Temperature dependent antisymmetric Planar Hall effects in $Co_2FeAl_xSi_y$ Heusler alloys — •Jan Heinen[1], Jan Rhensius[2], Mathias Kläui[1,2], Tanja Graf[3], and Claudia Felser[3] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]SwissFEL, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland and Laboratory for Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [3]Institut für Anorganische Chemie und Analytische Chemie, Universität Mainz, 55128 Mainz, Germany

Very promising candidates for future spintronic devices are Co-based Heusler alloys like $Co_2FeAl_xSi_y$, which generally possess a high Curie temperature and a high spin polarization (>0.5) [1]. Here we report on magnetoresistance measurements of μm-wide nanowires using contacts in longitudinal magnetoresistance (AMR) and Hall geometry (planar Hall effect (PHE)) [2]. For the AMR we observe an overall decrease in resistance with increasing field, whilst first results indicate an antisymmetric contribution in the PHE, whose origin is still under debate. A correlation to crystal symmetry was suggested for semiconductors [3]. We therefore study its dependence on applied field, field angle, temperature and the direction of growth on the substrate to gain further insight into this effect. References: [1] T. M. Nakatani et al., J. Appl. Phys. 102, 033916 (2007). [2] P. K. Muduli et al., Phys. Rev. B 72, 104430 (2005). [3] H. T. He et al., J. Appl. Phys. 107, 063902 (2010).

MA 63.62 Fri 11:00 P2

***Ab initio* calculations of the magnetic properties of mixed-valence perovskite** — •Igor Maznichenko[1], Arthur Ernst[2], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle (Saale), Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle (Saale), Germany

Materials with perovskite and perovskite-like structures demonstrate a broad spectrum of physical properties. Colossal magnetoresistance, ferroelectricity, multiferroicity, superconductivity, charge ordering, metal-insulator transition, Jahn-Teller and other effects are observed in perovskites. These properties of the mentioned materials with the common formula ABO_3 are very sensitive to the type of the cations A and B. Manganites $La_{1-x}Sr_xMnO_3$ are strongly correlated 3d transition-metal oxides with different types of magnetic ordering (depending on the La/Sr ratio).

Here we perform *ab initio* calculations for the above mentioned manganites in different structural phases. We try to analyze the magnetic properties of mixed-valence mangatines depending on charge ordering in the system.

MA 63.63 Fri 11:00 P2

Optical tuning of manganese valence and conductivity in Ce-doped lanthanum manganite films — •Andreas Thiessen[1], Elke Beyreuther[1], Stefan Grafström[1], Kathrin Dörr[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden — [2]Institut für Metallische Werkstoffe, IFW Dresden, D-01171 Dresden

The preparation of epitaxial $La_{0.7}Ce_{0.3}MnO_3$ (LCeMO) films by pulsed-laser deposition is very challenging [1] – especially the oxygen partial pressure during deposition plays a crucial role to suppress the presence of a CeO_2 secondary phase [2]. As-prepared films typically suffer from overoxygenation and concomitant hole doping instead of the nominal and desired electron-doping. Post-deposition annealing however, using a reducing atmosphere seems to solve this problem [3]. These samples though are insulating and do not exhibit a phase transition from a paramagnetic insulating to a ferromagnetic metallic phase any more [4,5].

Here, we show the possibility to drive the Mn valence towards 2+ by photoexcitation, which renders LCeMO thin films conductive and recovers their phase transition [5]. Possible mechanisms behind the photoconductivity effect are presented, especially the role of the $SrTiO_3$ substrate and the influence of interface defect states.

[1] C. Mitra et al., J. Appl. Phys. 89, 524 (2001). [2] R. Werner et al., Phys. Rev. B 79, 054416 (2009). [3] E. Beyreuther et al., Phys. Rev. B 73, 155425 (2006). [4] D. J. Wang et al., Phys. Rev. B 73, 144403 (2006). [5] E. Beyreuther et al., Phys. Rev. B 80, 075106 (2009).

MA 63.64 Fri 11:00 P2

HIGH ENERGY X-RAY DIFFRACTION MEASUREMENTS ON $Gd_{0.5}Sr_{0.5}MnO_3$ — •Dinesh Kumar Shukla[1], Sonia Francoual[1], Martin von Zimmermann[1], Jörg Strempfer[1], Aditya Avinash Wagh[2], P S Anil Kumar[2], Suja Elizabeth[2], and H L Bhat[2] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, Hamburg, 22603, Germany — [2]Department of Physics, Indian Institute of Science, Bangalore, 560012, India

We report on high-energy (100 keV) x-ray diffraction measurements in high magnetic fields on $Gd_{0.5}Sr_{0.5}MnO_3$. This system is reported to have a charge ordered state below 90 K and a spin glass behaviour below 42 K. The experiment was performed at the high energy x-ray diffraction beamline BW5 at DORIS. A cryo cooled 10 T magnet was used with temperatures reaching down to 2 K. Superstructure peaks at (h±1/2, k±1/2, 0) and (0, 2k+1, 0) positions are observed. There is no evidence of magnetic peaks along (0 1 0) or (1 0 0), down to 1.7 K as observed for $GdMnO_3$. At 35 K, integrated intensity of the superstructure peaks increases with increasing field above the critical

field of 8.5 T. The exact origin of the superstructure peaks is under investigations.

MA 63.65 Fri 11:00 P2

Bulk ordering and surface segregation for defects in NiO — •Martin Hoffmann[1], Eero Nurmi[2], Kalevi Kokko[2], Arthur Ernst[3], and Wolfram Hergert[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Betty-Heimann-Str. 7, D-06120 Halle, Germany — [2]Department of Physics and Astronomy, University of Turku, FIN-20014 Turku, Finland — [3]Max-Planck-Institut für Mikrostrukturphysik,Weinberg 2, D-06120 Halle, Germany

Ordering of structural defects in NiO oxide has been studied using a combination of ab initio calculations and Monte Carlo simulations. In the framework of the general perturbation method a Korringa-Kohn-Rostoker method is used to obtain for the defects the effective cluster interactions (ECI's) which are mapped on an Ising Model. With this model a Monte Carlo method is applied to simulate the ordering behaviour and obtain the thermodynamic properties. Due to the magnetic moment of the defects in NiO the magnetic properties are derived via a Heisenberg model.

MA 63.66 Fri 11:00 P2

Magneto-electrical properties of $LaSrMnO_4$ epitaxial thin films — •Mehran Vafaee Khanjani, Philipp Komissinskiy, and Lambert Alff — Institut für Materialwissenschaft, Technische Universität Darmstadt, Petersenstraße 23, 64287 Darmstadt, Germany

The single layer manganite $LaSrMnO_4$ as an antiferromagnetic insulator was under numerous investigations in the last decade. Due to its layered structure, $LaSrMnO_4$ shows anisotropic electrical resistivity. Epitaxial thin films with extremely smooth surfaces were deposited on different substrates such as $NdGaO_3$ and $NdAlO_3$ by pulsed laser deposition (PLD) to reveal the influence of strain on the magneto-electrical properties. The authors would like to thank DFG GK 1035.

MA 63.67 Fri 11:00 P2

Using symmetry breaking for the directed transport of paramagnetic colloids on garnet films — •Saeedeh Aliaskarisohi[1], Tom.H Johansen[2], and Thomas.M Fischer[1] — [1]Institut für Experimentalphysik, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Department of Physics, University of Oslo, P.O.Box 1048, Blindern, 0316 Oslo, Norway

The transport behavior of paramagnetic particles on top of a ferrimagnetic garnet film is investigated in a modulated external magnetic field. Broken symmetries are required to direct the transport of the particles. We provide such symmetry breaking by tilting the external field modulation with respect to the garnet film normal and by the intrinsic geometrical symmetry breaking of the garnet film magnetic pattern. The interplay of both symmetry breaking mechanisms cause a rich variety in transport behavior and direction. We corroborate our experimetal transport directions by comparing experimental with theoretical transport phase diagrams. Directing the transport of paramagnetic colloids will be useful when they are loaded with biomedical cargo on a magnetic lab-on-a-chip device.

MA 63.68 Fri 11:00 P2

E-beam patterning of CoFeB/MgO/CoFeB-based magnetic tunneljunctions — •Johannes Christian Leutenantsmeyer[1], Marvin Walter[1], Vladyslav Zbarsky[1], Henning Schuhmann[2], Michael Seibt[2], and Markus Münzenberg[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen — [2]IV. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen

The tunnel magnetoresistance (TMR) in magnetic tunnel junctions (MTJs) is suitable for various applications such as next generation RAM-Cells, the MRAM. Our MTJs are fabricated by magnetron sputtered CoFeB and Ta and further e-beam evaporated material such as the MgO-barrier. After patterning, the samples are characterized by $R(H)$ measurements and optical hysteresis loop measurements. The samples show up to 200% TMR.
Since spin-transfer torque requires smaller dimensions we investigate downscaling of the junction size. We expect this to improve the switching behavior and increase the TMR-ratio of our MTJs. Thus we present a study of e-beam lithography, which gives us the capability to produce MTJs below $1\,\mu m$ edge length. We also aquire the ability to produce different shaped structures, with the aim to investigate the MTJs' structural anisotropy to optimize magnetic switching.
Research is supported by the DFG through SFB 602.

MA 63.69 Fri 11:00 P2

Influence of the buffer-layer on the tunnel barrier quality in CoFeB/MgO/CoFeB magnetic tunnel junctions on the tunnel magneto resistance (TMR). — •Vladyslav Zbarsky[1], Marvin Walter[1], Gerrit Eilers[1], Johannes Christian Leutenantsmeyer[1], Patrick Peretzki[2], Michael Seibt[2], and Markus Münzenberg[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen — [2]IV. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen

The optimization of MTJs is necessary for increasing of TMR and therefore is very important for the production of MRAM devices. The quality of the tunnel barrier of our CoFeB/MgO/CoFeB MTJs is essential for getting high TMR. For this reason we investigate the influence of roughness of the MgO layer on the TMR. Another important parameter which we could optimize is the choice and preparation of the buffer-layer. For example we compared two sorts of Ta buffer-layers: prepared via magnetron sputtering and via e-beam evaporation. Already by optimizing these two parameters we increase the TMR from 80% to above 200%. In addition we show the investigations of the influence of the annealing temperatures and annealing duration on the TMR. Fast annealing time prevents diffusion, however for short annealing time no full crystallization is observed.
We thank the DFG for funding the research through SFB 602.

MA 63.70 Fri 11:00 P2

Boltzmann equation for charged particles with spin — •Katarina Tauber[1,2], Martin Gradhand[1,2], Dmitry V. Fedorov[2], Ingrid Mertig[1,2], and Balazs Gyorffy[3] — [1]Max Planck Institute of Microstructure Physics — [2]Martin Luther University Halle-Wittenberg — [3]University of Bristol

The ordinary Boltzmann equation describes the transport of charge carriers in solids via distribution function f.

$$\frac{\partial f(\vec{r},\vec{k},t)}{\partial t}+\dot{\vec{r}}\cdot\frac{\partial f(\vec{r},\vec{k},t)}{\partial \vec{r}}-\frac{e}{\hbar}(\vec{E}+\dot{\vec{r}}\times\vec{B})\cdot\frac{\partial f(\vec{r},\vec{k},t)}{\partial \vec{k}}=\left(\frac{\partial f(\vec{r},\vec{k},t)}{\partial t}\right)_{scatt}.$$

In the era of spintronics it is desirable to investigate the change of charge and magnetic moment of an electron under the influence of external fields on the same footing by a Boltzmann theory. Therefore, we extended the Boltzmann equation to a 2×2 matrix form for the distribution function. The components describe the scalar distribution function for the charge and 3 components of the magnetic moment. Furthermore, we added a precession term to allow the change of the direction of the magnetic moments. We solved the modified Boltzmann equation for general, simple cases analytically with a relaxation time approximation for the scattering term. Thereby, we analyzed the effect of the different terms in the Boltzmann equation separately to investigate the influence of the electric and magnetic field.

MA 63.71 Fri 11:00 P2

Optical detection of spin transport in non-magnetic metals — Frederik Fohr[1], Steffen Kaltenborn[1], Jaroslav Hamrle[1], Helmut Schultheiss[1], •Alexander A. Serga[1], Hans Christian Schneider[1], Burkard Hillebrands[1], Yasuhiro Fukuma[2], Le Wang[2], and YoshiChika Otani[2] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany. — [2]ASI RIKEN, and ISSP, University of Tokyo, Japan.

We detect the dynamic magnetization in non-magnetic metal wedges, composed of silver, copper and platinum and grown on top of a $Ni_{80}Fe_{20}$ layer. The $Ni_{80}Fe_{20}$ layer is excited externally by the RF field of a coplanar waveguide (CPW), and generates the dynamic magnetization in the wedge layer via the spin pumping effect. The inelastically scattered light is collected as a function of the local wedge thickness and analysed by Brillouin light scattering (BLS) microscopy. The BLS signal originates from the metal wedges due to inelastic scattering from the spin polarization as well as from the magnetic layer below the wedge. To separate both contributions of the signal experimentally, reference samples are prepared with an interlayer between $Ni_{81}Fe_{19}$ and the respective metal wedge to block the spin pumping. By comparing the experimental results to a macroscopic spin-transport model we determine the transverse relaxation time of the pumped spin current which is much smaller than the longitudinal relaxation time.

Support by the DFG within the project JST-DFG Hi380/21-1 is acknowledged.

MA 63.72 Fri 11:00 P2

Spintransport through magnetically doped Quantum Dots — •Christoph Hübner, Daniel Becker, and Daniela Pfannkuche — I. Institut für Theoretische Physik, Universität Hamburg, 20355 Hamburg.

Spin transport between two non-polarized electron reservoirs via an idealized single level quantum dot with an incorporated magnetic impurity is investigated. A real time diagrammatic transport theory, based on the Keldysh formalism, is used to determine the current between the leads and the non-equilibrium occupation of quantum dot states in stationary limit [1]. In the weak coupling regime one can derive a master equation for diagonal elements of the density matrix by perturbatively expanding to second order in hybridization. This formalism gives insight into sequential and coherent transport in the stationary limit. Up to first order the electron impurity interaction leads to differently pronounced signals of sequential transport channels visible in the differential conductivity. Also a new type of spin blockade is found which is tunable by the coupling strength between electron and impurity spin. In second order spin flip processes occur, which depend on the interaction strength and lead to a spin excitation in the quantum dot. Research is supported by GRK 1286,DFG-CH265/4-1 as well as by the Hamburg's Excellence Cluster Spintronik.

[1] M. Leijnse, M.R. Wegewijs, *Phys. Rev. B* 78, 235424 2008

MA 63.73 Fri 11:00 P2

Anisotropic magneto-resistance as a measure for the phase coexistence in Co_2FeSi layers — •Pawel Bruski, Klaus-Jürgen Friedland, Rouin Farshchi, Jens Herfort, and Manfred Ramsteiner — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

The ferromagnetic Heusler alloy Co_2FeSi is closely lattice matched to GaAs but epitaxially grown layers exhibit, in general, the coexistence of the well-ordered $L2_1$ phase and the Fe-Si disordered $B2$ phase depending on the substrate temperature T_S. The former one is predicted to be half-metallic, i.e. to be 100 % spin polarized at the Fermi-energy whereas the latter one is not only expected to lack half-metallicity but also to compete with the $L2_1$ phase by injecting spins of opposite sign. Since the degree of anisotropy is larger in the well-ordered $L2_1$ phase, the admixture of the disordered $B2$ phase should reflect itself in anisotropic magnetoresistance (AMR) measurements.

We investigated a series of spin light emitting GaAs/(Al,Ga)As diodes with Co_2FeSi injection layers as well as Co_2FeSi layers on GaAs grown by molecular beam epitaxy at different T_S. The AMR amplitude reveals a monotonic dependence on T_S indicating the coexistence of both phases. The sign reversal of an additional anisotropy constant Δ, which takes into account the deviation from an isotropic structure, gives further evidence for the phase coexistence. Both the AMR amplitude as well as the anisotropy constant Δ can be utilized as a sensitive measure for the phase composition in Co_2FeSi layers.

MA 63.74 Fri 11:00 P2

Spin filter contacts to Silicon using magnetic insulators: EuS/Si(001) — •Martina Müller, Reinert Schreiber, and Claus M Schneider — Forschungszentrum Jülich, Institut für Festkörperforschung (IFF-9), 52425 Jülich, Germany

Efficient spin filtering through magnetic insulators has been envisioned for sensitive spin injection and -detection in semiconductors. In our work, focus is put on establishing spin filter functionality of ultrathin films of the magnetic insulator EuS grown directly on silicon. We investigate EuS tunnel barriers combined with nonmagnetic NM and ferromagnetic FM electrodes in the light of their possible application as dedicated spin tunnel contacts to silicon. Our study of the electrical transport across Si(001)/EuS/NM and Si(001)/EuS/FM tunnel contacts, which is supported by a detailed magnetic characterization of the samples, evidences the influence of the work function of the NM and FM electrodes on the bias dependent tunnel current. We assigned the temperature-dependent electrical transport mechanisms in our systems and addressed the question, how a Schottky barrier formation can be reduced in order to enhance the EuS spin filter effect. We finally could show, that tunnel magnetoresistance effects, though still moderate, arise in both Si(001)/EuS/FM spin valves and estimated a EuS spin filter efficiency of about 20%, which coincides very well for both systems. In general, our experimental findings point encouraging towards the successful implementation of spin filter tunnel contacts into silicon heterostructures.

MA 63.75 Fri 11:00 P2

Simulation of spin-polarized scanning tunneling microscopy and spectroscopy on magnetic nanostructures — •Krisztian Palotas[1], Werner Hofer[2], and Laszlo Szunyogh[1] — [1]Budapest University of Technology and Economics, Department of Theoretical Physics, Budapest, Hungary — [2]University of Liverpool, Surface Science Research Centre, Liverpool, UK

We developed a method for simulating spin-polarized scanning tunneling microscopy (SP-STM) and spectroscopy (STS) from first principles. It is based on the work of Heinze [Appl. Phys. A 85, 407 (2006)], where we made the following developments: (1) treatment of chemically inequivalent surface atoms is included, thus, enabling imaging of complex magnetism in supported atomic clusters. (2) We take into account local electron workfunction variations on the surface, which becomes particularly important in the vicinity of atomic steps. (3) Tip electronic structure is considered going beyond the Tersoff-Hamann model. (4) By including bias voltage in our model differential tunneling (dI/dV) spectra and other bias dependent properties can be calculated.

The main advantage of the presented method is that it can be applied based on results obtained by any ab initio electronic structure code. We present simulation results on a few magnetic surface structures and compare them to experiments, e.g. considering a Cr monolayer or island with noncollinear spin structure on Au(111).

Acknowledgements: Magyary Foundation, EEA and Norway Grants, Hungarian Scientific Research Fund (OTKA-K77771, OTKA-IN83114).

MA 63.76 Fri 11:00 P2

Effect of film roughness in Fe/MgO/Fe magnetic tunnel junctions: model calculations — •Saeideh Edalati Boostan[1], Hosein Moradi[2], and Christian Heiliger[1] — [1]I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany — [2]Department of Physics,Faculty of sciences, Ferdowsi University of Mashhad, Mashhad, Iran

We calculate how interface roughness affects the tunneling magnetoresistance (TMR) in Fe/MgO/Fe (100) junctions. The used method is based on a single-band tight-binding (SBTB) approximation [1] employing the Green's function formalism. We investigate the influence of disorder at the TMR ratio. Thereby, the disorder is modeled by considering different occupation probabilities of Fe and MgO at interface sites. We calculate the current densities for parallel and antiparallel configurations for different disorders. The results show that the roughness decreases the TMR that match well with experimental observations.

[1] H. Itoh, J. Phys. D: Appl. Phys. 40 1228.1233 (2007).

MA 63.77 Fri 11:00 P2

Calculations of spin dependent transport in MnAs — •Michael Czerner and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

Magnetic MnAs nanoclusters can be grown on a GaAs substrate in a controlled manner [1]. Such structures can be used to construct planar magnetic devices for spintronic applications. We perform ab initio calculations by means of the non-equilibrium Keldysh formalism implemented in the Korringa-Kohn-Rostoker Green's function method [2]. We study the spindependent transport of MnAs in the hexagonal NiAs structure along different crystallographic directions. Furthermore we discuss in detail the transport through interfaces formed by two MnAs clusters with different magnetic domains. We found a very large magnetoresistance ratio above 200% while the spin polarization is low, which is originated by the different Fermi surface topologies of the two spin channels. Furthermore we study the transport properties in a tunnel junction geometry with MnAs as lead material.

[1] S. Ito, S. Hara, T. Wakatsuki and T. Fukui, Appl. Phys. Lett. 94, 243117 (2009) [2] C. Heiliger, M. Czerner, B. Yu. Yavorsky, I. Mertig, M. D. Stiles, J. Appl. Phys. 103, 07A709 (2008)

MA 63.78 Fri 11:00 P2

Temperature and bias voltage dependence of Co/Pd multilayer-based magnetic tunnel junctions with perpendicular magnetic anisotropy — •Zoë Kugler, Volker Drewello, Markus Schäfers, Jan Schmalhorst, Günter Reiss, and Andy Thomas — Bielefeld University, Department of Physics, Universitätsstr. 25, 33615 Bielefeld, Germany

Temperature- and bias voltage-dependent transport measurements of magnetic tunnel junctions (MTJs) with perpendicularly magnetized Co/Pd electrodes are presented. Magnetization measurements of the

Co/Pd multilayers are performed to characterize the electrodes. The effects of the Co layer thickness in the Co/Pd bilayers, the annealing temperature, the Co thickness at the MgO barrier interface, and the number of bilayers on the tunneling magneto resistance (TMR) effect are investigated. TMR-ratios of about 11% at room temperature and 18.5% at 13 K are measured and two well-defined switching fields are observed. The results are compared to measurements of MTJs with Co-Fe-B electrodes and in-plane anisotropy.

MA 63.79 Fri 11:00 P2

The influence of multi-layer structure of Heusler compound electrodes on transport properties and magnon excitation of magnetic tunnel junctions — •Volker Drewello, Daniel Ebke, Markus Schäfers, Günter Reiss, and Andy Thomas — Bielefeld University, Bielefeld, Germany

Magnetic tunnel junctions with single layers and multilayers of the Heusler compounds Co_2FeAl, Co_2FeSi, and Co_2MnSi as the soft magnetic electrode are prepared. Pinned Co-Fe is used as the hard reference electrode. The junctions show a high tunnel magnetoresistance ratio up to 331 % at 13 K. The electronic transport characteristics are investigated by tunneling spectroscopy. The spectra of the different samples are compared by normalized IETS. The multilayered electrodes show unique influence on the spectra in the parallel state, and when tunneling out of the Heusler. In the other cases (antiparallel state, or tunneling into the Heusler) a hugh contribution prevails, which we identify as magnon excitation. A comparison to the temperature dependence of the TMR ratio is drawn.

MA 63.80 Fri 11:00 P2

Controlling the resistance of a micro-/nanostructured GMR device with current induced domain wall motion — •Jana Münchenberger, Jonathan Fetting, Patryk Krzysteczko, Günter Reiss, and Andy Thomas — Bielefeld University, Department of Thin Films and Physics of Nanostructures, Universitätsstr. 25 33615 Bielefeld

We investigated the possibility to control the resistance of a structured Giant Magnetoresistance (GMR) system via current induced domain wall motion. For a narrow spin valve structure current induced domain wall motion in the free layer is predicted as soon as the current density reaches a critical threshold. The resistance of the device then depends on the position of the domain wall. The GMR systems we investigated were kindly provided by Infineon and show a GMR ratio of 10% as prepared. They were structured with e-beam lithography and ion beam etching. We fabricated narrow stripes of varying length (between 100 and 25μm) and a width of 200nm with a diamond shaped domain wall nucleation pad. The samples were measured with four-point-method and a constant current source. We measure GMR ratios up to 8% in the stripes. The GMR curves also showed steps indicating the existence of domain walls. To switch the sample between the different resistance states a current is applied to the device at a small magnetic field.

MA 63.81 Fri 11:00 P2

Highly efficient spin-current assisted domain wall depinning — •Helmut Körner[1,2], Emil Tafra[2], Jakoba Heidler[2], Jan Rhensius[2,3], Laura Heyderman[3], and Mathias Kläui[2] — [1]Universität Konstanz, 78457 Konstanz, Germany — [2]SwissFEL, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland & Laboratory for Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [3]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, 5323 Villingen, Switzerland

We have recently shown, that the depinning of domain walls can be very efficiently assisted by pure diffusive spin currents in a non-local spin valve consisting of a Permalloy wire and a Permalloy halfring with Copper as a non-magnetic spin conduit. We have now further improved the sample design by replacing the ferromagnetic wire used for spin injection by an additional halfring to study the effect of different spin directions for the injected spin current. Spin diffusion length and spin polarization are deduced from the measurements and for the chosen geometry simulations of the angular dependence of the spin torque are determined.

[1] D. Ilgaz et al., Phys. Rev. Lett. 105, 076601 (2010)

MA 63.82 Fri 11:00 P2

Preparation and Characterization of Magnetic Tunnel Junctions with Spin Transfer Torque — •Marcel Höwler[1], Kerstin Bernert[1], Jeffrey McCord[1], Kay Potzger[1], Monika Fritzsche[1], Arndt Mücklich[1], Jürgen Fassbender[1], Konstantin Kirsch[2], Roland Mattheis[2], and Stefan Slesazeck[3] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P.O. Box 51 01 19, 01314 Dresden, Germany — [2]Institut für Photonische Technologien e.V. (IPHT), Postfach 10 02 39, 07702 Jena, Germany — [3]NaMLab gGmbH, Nöthnitzer Str. 64, 01187 Dresden, Germany

Current-perpendicular-to-plane (CPP) magnetic tunnel junctions (MgO-MTJ) have been prepared using electron beam lithography as well as argon ion beam etching. A tantalum hardmask was utilized for pattern transfer. The size of the elliptical nanopillars could be decreased down to 90nm x 150 nm while preserving a TMR ratio of 92.5 %. TEM images proof the absence of redepositions at the MgO layer edge and give an insight into the interface quality.

Magnetization switching was performed using either static magnetic fields and/or dc current (spin torque). The nanopillars could be characterized at temperatures ranging from 5 K to 150 K and room temperature. The analysis of magnetization dynamics included single-shot time-resolved magnetoresistance measurements as well as dc current induced oscillations of the free-layer magnetization.

MA 63.83 Fri 11:00 P2

Magnetic polarizability of Rh atoms and spin-waves in FeRh. — •Leonid Sandratskii, Pawel Buczek, and Arthur Ernst — Max Planck Institute of Microstructure Physics, Halle, Germany

Recent femtomagnetic experiments revealed a sub-picosecond generation of the magnetisation after laser irradiation of antiferromagnetic FeRh. This strongly enhanced the interest in the magnetic dynamics and thermodynamics of this system. The available first-principles theories of the properties of FeRh outside the ground state differ cardinally in the treatment of magnetic excitations. This, in particular, concerns the account for the appearance of the induced Rh moment in the antiferromagnetic phase and the variable value of the Rh moment in the ferromagnetic phase. We report the calculation of the spin-waves in the antiferromagnetic and ferromagnetic FeRh with account for the specific properties of the Rh moment. The study is performed within both frozen magnon and dynamic susceptibility approaches. The comparison of the results of two approaches is given.

MA 63.84 Fri 11:00 P2

Higher-order corrections to the magnon dispersion in the Heisenberg model — •Julian Hüser, Thomas Kendziorczyk, and Tilmann Kuhn — Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

It is well known that in thin magnetic films the magnon energy spectrum exhibits a minimum at nonzero wavevectors where Bose-Einstein condensation can take place. The main mechanism which leads to this minimum is a competition between exchange and dipole-dipole interactions. Most fundamental work is based on the Heisenberg model in the spirit of the 1/S-approximation which is able to explain this complex dispersion relation. Because of the nonlinearity of the Holstein-Primakoff transformation higher-order terms react on the linear terms and thus modify the dispersion relation. However this correction has been neglected so far and barely investigations were made to confirm the validity of the 1/S-approximation. The present work provides an analysis of the higher-order terms and shows in which cases the corrections are negligible or not.

MA 63.85 Fri 11:00 P2

Anisotropic Spin wave propagation in ferromagnetic layers with an inplane magnetic field — •Thomas Kendziorczyk, Julian Hüser, and Tilmann Kuhn — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Spin waves are a quickly developing topic and have great potential in application for magnetic nanodevices because of their remarkable property, that the dispersion relation can be very easily tuned by an external magnetic field. In a ferromagnetic layer spin waves can be generated by a spin polarized current through a nanocontact which gives rise to a spin-torque on the spin system in the layer. The propagation process of the spin waves can be theoretically described by the Landau-Lifschitz equation taking into account exchange and dipole interaction for a finite layer thickness. If an external inplane magnetic field is applied the spin waves align themselves perpendicular to the direction of the field. We will show analytical calculations of the dispersion re-

lation and group velocity, that explain this anisotropic behavior, and compare these with micromagnetic simulations.

MA 63.86 Fri 11:00 P2

Spin excitations in Dy/Y and Gd/Y superlattices — •Alexander Grünwald[1], Elena Tartakovskaya[2], Andrew Wildes[3], Wolfgang Schmidt[4], Peter Link[5], Astrid Schneidewind[6], Gregor Nowak[7], Katharina Theis-Bröhl[8], Roger Ward[9], and Andreas Schreyer[1] — [1]Helmholtz-Zentrum Geesthacht, Germany — [2]Institute for Magnetism of National Ukrainian Academy of Science, Ukraine — [3]Institut Laue-Langevin, France — [4]IFF, Forschungszentrum Jülich, JCNS at ILL, France — [5]Forschungs-Neutronenquelle Heinz Maier-Leibnitz, Germany — [6]Helmholtz-Zentrum Berlin / TU Dresden, Germany — [7]Ruhr-Universität Bochum, Germany — [8]Hochschule Bremerhaven, University of Apllied Sciences, Germany — [9]Oxford University, Clarendon Laboratory, United Kingdom

Neutron inelastic measurements of magnetic excitations propagating normal to the interfaces in rare-earth multilayers are presented. The measurements show multiple peak features at different energies for a given momentum transfer, indicating discrete energy modes, and a renormalization of the spin waves with an applied magnetic field on Dy/Y [1] and Gd/Y [2] superlattices, respectively. The results can be quantitatively explained with long-range intralayer and interlayer RKKY exchanges and a significant contribution of the Dzyaloshinsky-Moriya interaction in Dy/Y.

[1] A. T. D. Grünwald et al., Phys. Rev. B, 82, 014426 (2010)
[2] A. T. D. Grünwald et al., Appl. Phys. Lett., 96, 192505 (2010)

MA 63.87 Fri 11:00 P2

Ab initio calculations of spin dynamics in magnetic tunnel junctions — •Michael Czerner and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

Magnetic tunnel junctions are widely used in spintronics. A key issue is a deep understanding of the physical mechanisms of spin dynamics in these systems. In particular, it is useful to have a theoretical model that can calculate the spin transfer torque as well as the magnetic damping in tunnel junctions. For this purpose we extend our non-equilibrium Keldysh formalism implemented in the Korringa-Kohn-Rostoker Green's function method [1] to treat the system full relativistically. In addition, we extend our implementation to a full potential description to investigate the role of exact cell treatment. The full relativistic treatment as well as the full potential description are compared to our previous results [2]. We will discuss different magnetic lead materials including Fe, Co, and FeCo alloys. These different materials are discussed with respect to their applicability for storage elements in magnetic memory. For this purpose a high spin-transfer torque but a low magnetic damping is desired. We calculate the spin-transfer torque for the whole tunnel junction whereas for the damping we use the bulk material neglecting interface effects.

[1] C. Heiliger, M. Czerner, B. Yu. Yavorsky, I. Mertig, M. D. Stiles, J. Appl. Phys. 103, 07A709 (2008)
[2] C. Heiliger and M.D. Stiles, Phys. Rev. Lett. 100, 186805 (2008).

MA 63.88 Fri 11:00 P2

Optical Investigation of Spin Injection from (Ga,Mn)As into n-GaAs — •Bernhard Endres, Matthias Sperl, Martin Utz, Dieter Schuh, Andreas Einwanger, Mariusz Ciorga, Christian Back, and Günther Bayreuther — Universität Regensburg

Spin injection from a Ga(Mn,As) contact into a n-GaAs channel through an Esaki diode structure was investigated. Details of the layer structure are described in Ref 1. After lithographic patterning the spin polarization in the GaAs was measured by p-MOKE at low temperatures across a cleaved edge as described in Ref. 2. From the distribution of the spin polarization below the injecting contact the spin diffusion length and the drift dependent spin decay length can be estimated, which are important parameters for the calculation of the spin lifetime from Hanle-measurements. However, several contributions to the Hanle curves as the stray field, dynamic nuclear polarization and a tilted magnetization of the injector make the calculation of the spin lifetime more complex. In this contribution the different parameters of the sample are characterized by fitting experimental data with a one-dimensional drift-diffusion equation. A spin diffusion length of about 5 μm and a spin lifetime of 10 ns was observed.

[1] M. Ciorga et al., Phys. Rev. B, 79(16):165321 (2009)
[2] P. Kotissek et al., Nature Phys. 3, 872 (2007)

MA 63.89 Fri 11:00 P2

Modification of the interface in Co_2FeSi/(Al,Ga)As hybrid structures by insertion of ZnO barriers — •Yori Manzke, Rouin Farshchi, Abbes Tahraoui, Jens Herfort, and Manfred Ramsteiner — Paul-Drude-Institut Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Thin ZnO layers of various thicknesses at the hybrid interface of Co_2FeSi/(Al,Ga)As spin light-emitting diodes (spin-LEDs) are being investigated, particularly regarding their usability as diffusion barriers for Co and Fe atoms, which have previously been found to strongly deteriorate the semiconductor (SC) material. The insertion of the ZnO layers is found to drastically alter the ferromagnetic injector layer properties, leading to a decrease in the saturation magnetization as well as a drastic increase in sheet resistance. Both of these findings indicate a strong intermixing of ZnO and Co_2FeSi. Consequently, electroluminescence from the LEDs containing ZnO is only observed close to contact rings, as opposed to the homogeneous emission over the entire LED mesa area observed for a reference sample prepared without any oxide layer. The diffusion of Co and Fe atoms which takes place during Co_2FeSi growth at 280 °C was studied by secondary ion mass spectrometry. Only thicker ZnO barriers were found to act as efficient diffusion barriers, while very thin ZnO layers even lead to an increase of the Co and Fe concentrations in the SC. From these findings it is concluded that ZnO appears not to be promising for the use as a barrier layer in ferromagnet/SC spin injection devices.

MA 63.90 Fri 11:00 P2

Detection of Spin-Wave Modes in Microscopic Magnetic Ellipses by Means of Dynamic Scanning Near-field Optical Microscopy — •Johann Jersch[1], Vladislav E. Demidov[1], Harald Fuchs[2], and Sergej O. Demokritov[1] — [1]WWU Münster, Institut für Angewandte Physik — [2]WWU Münster, Physikalisches Institut

Development of spintronic nano-devices demands a direct knowledge about spin dynamics in magnetic nanostructures. Recent achievements in nano-optics have allowed development of scanning near-field optical microsopes with a lateral resolution below 50 nm. Here we present a novel setup based on near-field Brillouin light scattering spectroscopy. This setup allows detection and mapping of spin-wave dynamics simultaneously with the imaging of the topography of the studied nanoelement. The lateral resolution achieved is of below 60 nm. The technique is also applicable for near-field Raman, acoustic and fluorescence spectroscopies. A mapping of spin-wave dynamic modes in in-plane magnetized permalloy micro-ellipses was carried out. Both center and strongly localized edge modes were observed and studied. The localization width of the edge modes depends on the applied magnetic field and reduces to about 85 nm for high fields.

MA 63.91 Fri 11:00 P2

Dr. — •Zhen Gang Zhu and Jamal Berakdar — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany

We propose a new efficient way to control the spin dynamics in a quantum wire with spin orbit interaction via the application of subpicosecond, linearly polarized electromagnetic pulses with appropriate shapes. If the electric field of the pulse is aligned along the direction of the wire, the carriers experience a momentum boost while keeping the spin coherence in the different spin channels. When the polarization of the pulse is perpendicular to the 2 dimensional plane in which the wire is engraved, a further dynamical spin precession is induced in addition to the static one. The former is comparable to the latter and can be tuned by changing the pulse field parameters, an effect utilizable for optically controlled spintronics devices

MA 63.92 Fri 11:00 P2

Interference of coherent spin waves in $Ni_{81}Fe_{19}$ microstripes — •Thomas Brächer, Philipp Pirro, Björn Obry, Helmut Schultheiss, Peter Andreas Beck, Britta Leven, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Propagating spin waves have attracted increasing interest during the past years due to their potential use in signal processing and in logical devices. The propagation in metallic ferromagnets like $Ni_{81}Fe_{19}$ is of particular interest because these materials offer the ability of microstructuring with industrial standard processes.

We report on the observation of interference of spin waves and their coherent propagation in $Ni_{81}Fe_{19}$ microstripes by using space-

and phase-resolved Brillouin light scattering microscopy (μBLS). By employing these techniques, we observe stationary interference patterns formed by counterpropagating spin-wave beams and the emerging phase profile. The spin waves are excited by two phase-locked microwave antennas on top of the $Ni_{81}Fe_{19}$ stripes.

The observed intensity and phase distributions along the stripe can be reconstructed with a simple model of interfering plane waves with sinusoidal transverse profiles. In addition, we were able to map a wide part of the spin-wave dispersion by extracting the spin-wave wavelength out of the interference patterns.

Financial support by the DFG, by the Carl-Zeiss-Stiftung, the Graduiertenkolleg 792 and Graduate School of Excellence "MAterials Science IN MainZ" is gratefully acknowledged.

MA 63.93 Fri 11:00 P2

Finite Element Model of Non-Local Spin Valves — •Xianzhong Zhou, Daniel E. Bürgler, and Claus M. Schneider — Peter Grünberg Institute, PGI-6, Research Center Jülich, D-52425 Jülich, Germany

We study lateral ferromagnetic/nonferromagnetic/ferromagneitc (F/N/F) non-local spin valve with transparent interfaces using the finite element model. The electrical injection and detection of spin accumulation in the non-local spin valve can be described by the diffusion theory of F/N/F junctions. We derive two equations, the diffusion equation and the Poisson equation, which we solve in three-dimensional case using a finite element differential equations analysis library. We obtain the spin up and down electrochemical potentials as well as the spin accumulation signal accessible in experiments. We assume the following parameter: conductivity of F and N $\sigma_F = 6.6 \cdot 10^6\,\mathrm{S/m}$, $\sigma_N = 3.5 \cdot 10^7\,\mathrm{S/m}$, spin diffusion lengths of F and N $\lambda_F = 5\,\mathrm{nm}$, $\lambda_N = 350\,\mathrm{nm}$, and the spin polarization is 30%. When both the width of spin injector and detector increase from 30 to 150 nm, the spin signal decreases from 313 to 82 $\mu\Omega$. However, if the widths of both injector and detector are fixed to 100 nm, but the thickness of the N increases from 50 to 250 nm, the spin signal first increases and then decreases. Therefore, there is a optimal thickness of the N yielding a maximum spin signal of 192 $\mu\Omega$.

MA 63.94 Fri 11:00 P2

Structural and magnetic properties of tetragonal Heusler compounds $Mn_{2-x}Fe_{1+x}Ga$ — •Teuta Gasi, Jürgen Winterlik, Benjamin Balke, Gerhard H. Fecher, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

Heusler compounds such as tetragonal phase of $Mn_{3-x}Ga$ are currently receiving increased interest. These materials play an important role due to their multifunctional properties and high potential for applications in STT-MRAM technology. STT-MRAMs require high Curie temperatures, low Gilbert damping constants, and low magnetic moments. This contribution focuses on the structural and magnetic properties of tetragonal Heusler compounds $Mn_{2-x}Fe_{1+x}Ga$. These compounds are of exceptional importance due to their large diversity of adaptive magnetic properties and their tunability by variation of several physical parameters such as temperature, magnetic field, or electron-doping. The series of samples was successfully synthesized by arc-melting and characterized. The magnetic measurements show that all these materials show high T_Cs above 600 K and diverse magnetic hardness. Additionally, we found that the compound Fe_2MnGa shows magnetic shape memory behavior. This work is supported by the Deutsche Forschungsgemeinschaft through the ASPIMATT projects TP 1.2-A (CH 952/1-1) and TP 2.3-A (FE 633/11-1).

MA 63.95 Fri 11:00 P2

Extrinsic Spin Hall Effect in Metallic Slab Systems — •Christian Herschbach[1], Martin Gradhand[2], Dmitry V. Fedorov[1], Peter Zahn[1], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

After the first measurement of the *gigantic* spin Hall effect (SHE) in Au [1], a discussion about the responsible mechanism has been started [2-3]. Recently, a new experiment with Pt-doped Au films [4] showed a large spin Hall angle (SHA) as was reported before in Ref. [1].

Here we present *ab initio* calculations in order to describe the skew scattering mechanism of the spin Hall effect in free-standing Au slabs of different thicknesses. The computation is based on a fully relativistic Korringa-Kohn-Rostoker Green's function method [1]. The dependence of the SHA on the position of the substitutional Pt impurities in the slab is investigated.

[1] T. Seki et al., Nature Mater. **7**, 125 (2008)
[2] G. Guo et al., PRL **102**, 036401 (2009)
[3] M. Gradhand et al., PRL **104**, 186403 (2010)
[4] B. Gu et al., PRL **105**, 216401 (2010)

MA 63.96 Fri 11:00 P2

Non-Abelian Berry Curvature by the KKR method — •Martin Gradhand[1], Dmitry V. Fedorov[2], Falko Pientka[2], Peter Zahn[2], Ingrid Mertig[2,1], and Balazs L. Györffy[3] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Martin-Luther-Universität Halle, Institut für Physik, 06099 Halle, Germany — [3]H.H.Wills Physics Laboratory, University of Bristol, United Kingdom

The existence of the geometrical phase, discovered by Michael Berry [1], for a quantum mechanical system with an adiabatically varied parameter is known since 25 years. However, its influence on many aspects of modern physics turned out during the last decade only. Nowadays the concept is used to describe transport phenomena as the anomalous and spin Hall effect as well as quantities such as the orbital magnetization and electrical polarization. In spite of the broad application of the Berry curvature, used for the description of these phenomena, a few *ab initio* methods only were developed for its calculation.

Here, within the Korringa-Kohn-Rostoker method, we present a new implementation of the Berry curvature calculation extended to the non-Abelian case where degenerate electron states exist. We discuss the method in detail and show results for metals as Cu, Ag, Au, and Pt.

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MA 63.97 Fri 11:00 P2

Gigantic spin Hall effect in Au caused by interstitial impurities — •Martin Gradhand[1], Dmitry V. Fedorov[2], Christian Herschbach[2], Peter Zahn[2], and Ingrid Mertig[2,1] — [1]Max-Planck-Institut fär Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Martin-Luther-Universität Halle, Institut für Physik, 06099 Halle, Germany

The *gigantic* spin Hall effect (SHE) observed in Au [1] two years ago is still not fully understood. Several proposals such as a Kondo resonance on Fe impurities [2], a quantum renormalization of the SHE [3], Pt impurities on the thin Au [4] film were discussed in the literature. Among them, as was discussed in Ref. [3], the explanation with the Kondo resonance has been questioned already both theoretically and experimentally.

Meanwhile our fully relativistic *ab initio* calculation [5] showed that C and N substitutional impurities in Au should provide large spin Hall angle comparable to the experimentally found one. However, a practical realization of such stable substitutional alloys is quite questionable. Here we present a study of the skew scattering mechanism in gold caused by interstitial impurities such as C, N, and Ar. With this study we propose a new possibility for the gigantic SHE.

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The Heusler compound $Co_2FeAl_{0.4}Si_{0.6}$ on its way to industry — •Frederick Casper[1], Tanja Graf[1], Gerhard Jakob[2], and Claudia Felser[1] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz — [2]Institute of Physics, Johannes Gutenberg - University, 55099 Mainz

Half-metallic compounds Co-based Heusler compounds have been predicted to have a high spin polarization even at room temperature due to their high Curie temperature of around 1000 K. Recently, many different Heusler compounds were studied as potential candidates for TMR- and GMR-devices. High TMR-ratios of up to 220% at room temperature could be reached. On the other hand these experiments were performed on small MgO-substrates which are not suitable for an industrial application. We implemented the Heusler compound into an industrial production. A twelve inch target is used to sputter thin films of $Co_2FeAl_{0.4}Si_{0.6}$ (CFAS) on a five inch silicon wafer. Since the electronic structure of CFAS is very sensitive to its atomic order, the influence of the substrate, the buffer layer, and the annealing temper-

ature on the structure and the magnetic properties of the films were studied by X-ray diffraction, VSM measurements and TEM measurments, respectively. Diffetrent TMR-stags with a MgO barrier were deposited and show a TMR ratio up to 30 % at room temperature. This work is supported by the Federal Ministry for Education and Research BMBF, project "Multimag".

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Magnetic tunnel junctions based on zinc ferrite and cobalt — •Michael Bonholzer, Kerstin Brachwitz, Katja Mexner, Jan Zippel, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für experimentelle Physik II, Linnéstraße 5, 04103 Leipzig, Germany

Magnetic tunnel junctions (MTJs) will play an important role in future computer architecture and spintronic systems. We have designed a magnetic tunnel junction out of zinc ferrite, magnesium oxide and cobalt. Zinc ferrite, acting as soft magnetic bottom electrode, was grown by pulsed laser deposition (PLD) on MgO and STO substrates. The thin films ($d \approx 200\,\mathrm{nm}$) were characterized by atomic force microscopy (AFM), X-ray diffraction (XRD), SQUID- and Hall-effect measurements and optimized in their conductivity ($\sigma \approx 50\,\mathrm{S/m}$) and surface roughness (rms $\approx 0.2\,\mathrm{nm}$). The thickness of the barrier material magnesium oxide was varied between 10 and 100 nm, the surface and stuctural properties have been measured by AFM and XRD. The cobalt top-electrode, which serves as hard electrode, was produced by thermal evaporation. The MTJ-structure was defined by multi-step photolitography with wet-chemical etching, using crossed-over masks in order to limit the contact area to 50×50 or $100 \times 100\,\mu\mathrm{m}^2$. Current-voltage measurements in dependence of an external magnetic field were performed.