Magnetism Division
Fachverband Magnetismus (MA)

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Overview of Invited Talks and Sessions

(lecture rooms: invited talks EB 301, sessions EB 202, H 1012, H 1028, and H 0112 (only Monday);
Posters Tuesday and Friday Neubau Physik EG 1)

Invited Talks

MA 1.1	Mon	9:30–10:00	EB 301	**Composite nanoparticles and nanopatterns for ultrahigh density magnetic recording** — •Dagmar Goll
MA 6.1	Mon	14:00–14:30	EB 301	**Genuine bulk electronic structures of strongly correlated transition metal oxides revealed by high energy photoelectron spectroscopy** — •Shigemasa Suga
MA 6.2	Mon	14:30–15:00	EB 301	**Probing spin excitations in magnetic nanostructures and half metals** — •Markus Münzenberg
MA 12.1	Tue	9:30–10:15	HE 101	**Electrons at Surfaces Taking an Unexpected Turn** — •Stefan Blügel
MA 17.1	Tue	14:00–14:30	EB 301	**FePt nanomagnets from the gas phase** — •Bernd Rellinghaus, Elias Mohn, Ute Queitsch, Ludwig Schultz
MA 17.2	Tue	14:30–15:00	EB 301	**Influence of composition inhomogeneities and symmetry reduction on the magnetism of FePt nanoparticles** — •Carolin Antoniak
MA 25.1	Thu	12:00–12:30	EB 301	**Magnetization dynamics due to pure spin currents** — •Georg Woltersdorf, Olexandr Mosendz, Christian H. Back, Bret Heinrich
MA 25.2	Thu	12:30–13:00	EB 301	**Time-Resolved Imaging of Domain-Wall and Vortex Motion Driven by Spin-Polarized Currents** — •Guido Meier
MA 25.3	Thu	13:00–13:30	EB 301	**Controlling Magnetism by light** — •Theo Rasing

FV Internal Symposium in Honour of Nobelprice 2007 to Peter Grünberg and Albert Fert

MA 24.1	Thu	9:30–10:00	EB 301	**Physics and applications of tunneling magnetoresistance effect** — •Shinji Yuasa
MA 24.2	Thu	10:00–10:30	EB 301	**From giant magnetoresistance to current-induced magnetic switching: theoretical aspects** — •Jozef Barnas
MA 24.3	Thu	10:30–11:00	EB 301	**Magnetoresistive Sensors and Magnetic Nanoparticles for Biotechnology** — •Günter Reiss, Andreas Hütten, Inga Ênnen, Alexander Weddemann, Andy Thomas, Jan Schmalhorst
MA 24.4	Thu	11:00–11:30	EB 301	**Status and Future of Magnetic Recording** — •Dieter Weller

Invited talks of the joint symposium SYPT

See SYPT for the full program of the Symposium.

SYPT 1.1	Mon	14:00–14:35	H 0105	**Dark order in the metallic state** — •Andrew John Schofield
SYPT 1.2	Mon	14:35–15:10	H 0105	**Quantum criticality in $YbRh_2Si_2$** — •Philipp Gegenwart
SYPT 1.3	Mon	15:10–15:45	H 0105	**Elementary Excitations in Quantum Critical Antiferromagnets** — •Christian Ruegg
SYPT 1.4	Mon	16:00–16:35	H 0105	**How to have fun with frustrated ferromagnets** — •Nic Shannon, Tsutomu Momoi, Philippe Sindzingre

SYPT 1.5	Mon	16:35–17:10	H 0105	**Towards Quantum Magnetism with Ultracold Quantum Gases in Optical Lattices** — •Immanuel Bloch
SYPT 1.6	Mon	17:10–17:45	H 0105	**Correlated inhomogeneous systems: from trapped atoms to heterostructures** — •Achim Rosch

Invited talks of the joint symposium SYNF

See SYNF for the full program of the Symposium.

SYNF 2.1	Tue	14:30–15:00	A 151	**Tunable two-dimensional electron gases in correlated electronic systems** — •J. Mannhart, G. Hammerl, T. Kopp, C. Richter, C.W. Schneider, S. Thiel, N. Reyren, A.D. Caviglia, S. Gariglio, D. Jaccard, J.-M. Triscone, L. Fitting-Kourkoutis, D. Muller, C. Cheng, J. Levy
SYNF 2.2	Tue	15:00–15:30	A 151	**New physics from electron correlations at oxide interfaces** — •Warren E. Pickett, Rossitza Pentcheva
SYNF 2.3	Tue	15:30–16:00	A 151	**Gigantic magnetoelectic responses in hellimagnets** — •Y. Tokura
SYNF 2.4	Tue	16:00–16:30	A 151	**Electrical field control of ferromagnets using multiferroics** — •Ramamoorthy Ramesh
SYNF 2.5	Tue	16:30–17:00	A 151	**Spintronics with multiferroic materials** — •Agnes Barthelemy
SYNF 2.6	Tue	17:00–17:30	A 151	**Magnetoelectric effects at multiferroic interfaces** — •Evgeny Tsymbal

Sessions

MA 0.1–0.1	Sun	14:00–17:00	EW 202	**Tutorial: Magnetic Shape Memory Alloys**
MA 1.1–1.1	Mon	9:30–10:00	EB 301	**Invited Talk Goll**
MA 2.1–2.11	Mon	10:15–13:00	EB 301	**Micro and Nanostructured Magnetic Materials I**
MA 3.1–3.11	Mon	10:15–13:00	H 1012	**Magnetic Semiconductors**
MA 4.1–4.9	Mon	10:15–12:30	H 1028	**Magnetic Coupling Phenomena; Exchange Bias**
MA 5.1–5.11	Mon	10:15–13:00	H 0112	**Spindependent Transportphenomena I**
MA 6.1–6.2	Mon	14:00–15:00	EB 301	**Invited Talks Suga / Münzenberg**
MA 7.1–7.13	Mon	15:15–18:30	EB 301	**Micro and Nanostructured Magnetic Materials II**
MA 8.1–8.6	Mon	15:15–16:45	H 1012	**Magnetic Imaging**
MA 9.1–9.6	Mon	16:45–18:15	H 1012	**Micromagnetism/Computational Magnetics**
MA 10.1–10.13	Mon	15:15–18:30	H 1028	**Magnetic Materials**
MA 11.1–11.9	Mon	15:15–17:30	H 0112	**Spindependent Transportphenomena II**
MA 12.1–12.1	Tue	9:30–10:15	HE 101	**Invited Talk Blügel / joint session O & MA**
MA 13.1–13.11	Tue	10:30–13:15	EB 301	**Surface Magnetism**
MA 14.1–14.11	Tue	10:30–13:15	EB 202	**Magnetic Half Metals and Oxides**
MA 15.1–15.11	Tue	10:30–13:15	H 1012	**Magnetic Thin Films I**
MA 16.1–16.10	Tue	10:30–13:00	H 1028	**Magnetic Particles and Clusters I**
MA 17.1–17.2	Tue	14:00–15:00	EB 301	**Invited Talks Rellinghaus / Antoniak**
MA 18.1–18.85	Tue	15:15–18:30	Poster E	**Poster I : Bio Magn. (1-2); Mag.Imgaging (3-9); Magn. Semiconductors (10-16); Half Metals & Oxides (17-20); Coupl.Phenomena (21-27); Magn. Mat. (28-41); Micro & Nanostr. Magn. Materials (42-61); Micro Magn. (62-64); Surface Magnetism (65-70); Transport Phenomena (71-85)**
MA 19.1–19.18	Wed	14:00–18:45	EB 301	**Spin Dynamics / Spin Torque I**
MA 20.1–20.16	Wed	14:00–18:15	EB 202	**Multiferroics**
MA 21.1–21.18	Wed	14:00–18:45	H 1012	**Magnetic Thin Films II**
MA 22.1–22.10	Wed	14:00–16:30	H 1028	**Magnetic Particles / Clusters II**
MA 23.1–23.8	Wed	16:45–18:45	H 1028	**Spinelectronics/ Spininjection in Heterostructures**
MA 24.1–24.4	Thu	9:30–11:30	EB 301	**FV Internal Symposium in honour of Nobelprice 2007 to Peter Grünberg and Albert Fert**
MA 25.1–25.3	Thu	12:00–13:30	EB 301	**Invited Talks Woltersdorf / Meier / Rasing**
MA 26.1–26.16	Thu	14:30–18:45	EB 301	**Spin Dynamics / Spin -Torque II**
MA 27.1–27.14	Thu	14:30–18:00	EB 202	**Bio- and Molecular Magnetism**
MA 28.1–28.12	Thu	14:30–17:30	H 1012	**Magnetic Thin Films III**
MA 29.1–29.5	Thu	17:45–19:00	H 1012	**Spin Structures / Magnetic Phase Transitions**
MA 30.1–30.15	Thu	14:30–18:30	H 1028	**Electron Theory**

MA 31.1–31.4	Fri	9:30–11:10	EB 301	**ThyssenKrupp Electrical Steel Dissertationspreis der 2008 der AG Magnetismus**
MA 32.1–32.79	Fri	11:15–14:00	Poster E	**Postersession II: Spinstruct./Phase Trans. (1-10); Spinelectronics (11-15); Thin Films (16 - 36); Particles/Clusters (37-45); Multiferroics (46-54); Spindynamics/Spin Torque (55 - 76); Post Deadlines (77-79)**

Annual General Meeting of the Magnetism Division

Donnertag 19:00–20:00 Raum H 1028

- Bericht des Vorsitzenden
- ICM 2009
- Verschiedenes

MA 0: Tutorial: Magnetic Shape Memory Alloys

Time: Sunday 14:00–17:00 Location: EW 202

Tutorial MA 0.1 Sun 14:00 EW 202

Magnetic Shape Memory Alloys – From Fundamentals to Applications — •Sebastian Fähler[1] and Annika Raatz[2] — [1]IFW Dresden, 01069 Dresden — [2]Inst. F. Werkzeugmaschinen TU Braunschweig, 38106 Braunschweig

Magnetic Shape Memory (MSM) Alloys occupy a unique position within the class of smart materials due to their outstanding strain of up to 10% in moderate magnetic fields. This tutorial introduces the phenomenology of two actuation mechanisms and their experimental and theoretical verification. Both mechanisms, magnetically introduced reorientation (MIR) of variants and magnetically induced martensite (MIM) formation, are analyzed with respect to their material requirements. The specific actuation and sensing properties of MSM materials are compared with other smart materials. Their specific advantages, such as relatively high working frequency, will be discussed. The challenges for system integration are analysed by means of existing system designs.

MA 1: Invited Talk Goll

Time: Monday 9:30–10:00 Location: EB 301

Invited Talk MA 1.1 Mon 9:30 EB 301

Composite nanoparticles and nanopatterns for ultrahigh density magnetic recording — •Dagmar Goll — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart

Perpendicular magnetic recording on the basis of exchange coupled composite (ECC) media is currently considered to be the most straightforward method to realize ultrahigh recording densities of 1 Tbit/in^2 and more. ECC media are nanopatterns of magnetically isolated grains each consisting of a hard magnetic and a soft magnetic layer which are coupled by exchange interaction. The composite system combines both high thermal stability of the stored information even for reduced grain dimensions close to the superparamagnetic limit and moderate switching fields which can be afforded by conventional write heads. Composite $L1_0$-FePt/Fe bilayers have been prepared by ion beam sputter deposition on MgO(001) substrates. By using electron beam lithography the bilayers have been nanopatterned into arrays of squared nanodots covering 3 mm x 3 mm. The magnetic properties of these nanostructures are discussed within the framework of analytical and numerical micromagnetism. The dependencies of switching fields, switching times and thermal stability of the composite nanoparticles on material parameters, shape and film thicknesses are systematically analyzed. The results allow explicit predictions for the development of optimum high-density recording devices based on ECC media.

MA 2: Micro and Nanostructured Magnetic Materials I

Time: Monday 10:15–13:00 Location: EB 301

MA 2.1 Mon 10:15 EB 301

Interaction effects in Fe nanoparticle/permalloy thin-film hybrid systems — •Jens Müller[1,2], Yongqing Li[1,3], Stephan von Molnár[1], and Steffen Wirth[2] — [1]Florida State University, Tallahassee, USA — [2]MPI-CPfS Dresden — [3]MPI-FKF Stuttgart

Elongated magnetic nanoparticles attract continuing attention in view of potential technological applications in data storage or spintronics. Using gated Hall magnetometers made from GaAs/AlGaAs 2DEG heterostructures we recently demonstrated a moment sensitivity of $10^4\,\mu_B$ by measuring the switching of a single magnetic Fe particle. Particles of 5 - 15 nm in diameter and generally 80 - 250 nm in height may be grown by STM-assisted CVD, an advantageous technique for exact positioning of individual Fe particles on different substrate materials.

The investigation of such nanoparticles is not only driven by the quest for a more detailed picture of the magnetization behavior of the particles themselves but ultimately to apply these small and local magnetic flux sources to intentionally influence and investigate other materials. A first step in this direction is to study hybrid systems of magnetic particles and an underlying magnetic film. Growing arrays or individual particles onto a permalloy thin film strongly enhances interactions between adjacent particles.

Also, the particles alter the magnetic domain structure of the magnetic thin film making its transport properties sensitive to the magnetization state of the particle array grown on top. We find and discuss a distinct (negative) switching effect in the magnetoresistance that persists up to room temperature.

MA 2.2 Mon 10:30 EB 301

Micro-Hall-Magnetometry for the investigation of magnetic nanoparticles — •Bastian Büttner, Florian Lochner, Christoph Brüne, Charles Gould, Georg Schmidt, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Nanoscale ferromagnetic thin films and particles are of great interest for spintronic applications. The non-volatility offers capabilities for data storage and novel electronic devices. Micro-Hall-Magnetometry is known as a simple, reliable and highly sensitive measurement method which is capable of investigating the magnetization of individual nanoscale particles over a wide temperature range [1]. Here we present the fabrication and comparison of micro-Hall bars in different material systems, namely InAs, HgTe, and (Al,Ga)As. In order to achieve high sensitivity for single, isolated nanoparticles it is essential to decrease the dimensions of the Hall cross to a size where crystal defects and sidewall depletion become an important factor; we have developed various different designs to mitigate these effects. The micro-Hall bars have been characterized using lithographically defined metallic nanomagnets. As an application, we want to use the micro-Hall bars to characterize chemically synthesized randomly orientated nanoparticles. We additionally developed a process which allows for exact positioning and aligning the Hall bar without damaging the nanoparticle. We will present details of the processing and experimental results.

[1] A. K. Geim et al., Appl. Phys. Lett. 71, 2379 (1997)

MA 2.3 Mon 10:45 EB 301

CoCrPt-SiO2 films on SiO2 spherical particle arrays — •Christoph Brombacher[1], Felix Springer[2], Hartmut Rohrmann[3], Martin Kratzer[3], Magdalena Parlinska[4], Stephan Meier[4], Peter Kappenberger[4], and Manfred Albrecht[1] — [1]Chemnitz University of Technology, Institute of Physics, Germany — [2]University of Konstanz, Department of Physics, Germany — [3]OC Oerlikon Balzers AG, Data Storage, Liechtenstein — [4]Empa - Materials Science & Technology, Dübendorf, Switzerland

CoCrPt-SiO2 is a granular material consisting of small magnetically decoupled grains and is commonly used for perpendicular magnetic recording applications. In this study, the system was deposited onto SiO2 spherical particle arrays with diameters down to 10nm to form arrays of magnetic nanostructures. TEM studies reveal that the growth of CoCrPt-SiO2 particles remains columnar with the (0001) orientation of individual grains pointing perpendicular to the particle surface. By varying the growth conditions of a Ru seed-layer, the degree of intergranular exchange coupling was controlled, leading to pronounced differences in the magnetic domain structure and its magnetic reversal

behavior. Multidomain magnetic caps have been obtained for magnetically decoupled grains and increasing the coupling results in the formation of single-domain magnetic caps. In this presentation, the magnetic properties depending on the particle size as well as the angular dependence of the reversal behavior will be discussed with respect to the differences in intergranular exchange coupling.

This work was supported by the European project MAFIN.

MA 2.4 Mon 11:00 EB 301

Co-Pt films and nanostructures by electrodeposition into diblock copolymer templates — •Manvendra Singh Khatri[1], Heike Schlörb[1], Sebastian Fähler[1], Ludwig Schultz[1], Bhanu Nandan[2], Marcus Böhme[2], Radim Krenek[2], and Manfred Stamm[2] — [1]IFW Dresden, P.O. Box 27 00 16, 01171 Dresden, Germany — [2]IPF Dresden, Postfach 120 411, 01005 Dresden, Germany

Co-Pt and Fe-Pt alloys are favored materials for future magnetic data storage due to good hard magnetic properties like high coercivity and anisotropy. The Co-rich $Co_{80}Pt_{20}$ was chosen for this study because it does not require post annealing in contrast to the ordered $L1_0$ CoPt or FePt. The Co-Pt films have been deposited from an aqueous bath containing Pt-p-salt and Co sulphamate at different current densities. The influence of deposition current density on film properties was investigated. As an alternative to the porous alumina templates, diblock copolymer templates have been proposed that allow smaller feature sizes and thus yield to higher pore densities. Templates have been fabricated by dip-coating a conducting substrate into a solution of polystyrene-block-poly(4-vinylpyridine) (PS-b-P4VP) and 2-(4-hydroxybenzeneazo) benzoic acid (HABA). Depending on the polymer composition lamellar or cylindrical structures can be achieved. By dissolving the HABA the pores are opened and afterwards electrodeposition of Co-Pt was carried out. Due to the inhomogeneous filling shape anisotropy parallel to the substrate surface is observed, whereas shape anisotropy along the wire axis (perpendicular to the surface) is expected for ideally filled Co-Pt nanowires.

MA 2.5 Mon 11:15 EB 301

CoPt alloy films on SiO_2 nanoparticle arrays — •Denys Makarov[1], Esteban Bermudez[2], Christoph Brombacher[3], Fabiola Liscio[4], Mireille Maret[4], Oliver G. Schmidt[2], Günter Schatz[1], and Manfred Albrecht[3] — [1]University of Konstanz, Department of Physics, 78457 Konstanz, Germany — [2]IFW Dresden, 01069 Dresden, Germany — [3]Chemnitz University of Technology, Institute of Physics, D-09107 Chemnitz, Germany — [4]ENSEEG, Saint Martin d'Heres, France

Combining self-assembled SiO_2 nanoparticle arrays with magnetic film deposited onto the particles, enables an elegant possibility to create magnetic nanostructure arrays with defined magnetic properties. In this regard, materials such as CoPt alloy are of particular interest due to their large magnetic anisitropy required for thermal stability in the high density magnetic recording applications. In order to induce high perpendicular magnetic anisotropy in CoPt alloys, the $L1_0$ phase with (001) texturing is required. For this purpose, a 10nm thick MgO(001) seed layer was introduced. Results on planar amorphous SiO_2 substrates reveal an uniaxial out-of-plane magnetic anisotropy and saturation magnetization for the CoPt alloy grown at 450°C of about $5x10^5 J/m^3$ and 800kA/m. These properties were transfered to CoPt alloy deposited onto arrays of SiO_2 particles with diameters down to 50nm. The formed CoPt nanocaps are in a magnetic single domain state with a large out-of-plane coercivity, which increases with decreasing particle size. In this presentation, the structural and magnetic properties will be discussed and compared to the planar film.

MA 2.6 Mon 11:30 EB 301

The first ternary intermetallic Heusler nanoparticles: Co_2FeGa. — •Lubna Basit[1], Aswani Yella[1], Sergej A. Nepijko[2], Vadim Ksenofontov[1], Gerhard H. Fecher[1], 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

Synthesis of materials with controlled particle size on the nanometer scale is an active area in the field of materials research. With the control over particle size, the electronic and magnetic properties of materials can be easily tuned. To study the effect of nanometer dimensions on the properties of Heusler alloys, a first example of Heusler nanoparticles is presented. Co_2FeGa Heusler *nanoparticles* were produced by reducing a methanol impregnated mixture of $CoCl_2.6H_2O$, $Fe(NO_3)_3.9H_2O$, and $Ga(NO_3)_3.xH_2O$ after loading on fumed silica. The dried samples were heated under pure H_2 gas at 900°C. The synthesized Co_2FeGa Heusler nanoparticles were characterized by HRTEM, XRD and Mößbauer spectroscopy. All peaks of the XRD pattern can be attributed to a $L2_1$ Heusler structure with a lattice constant of $a = 4.37$ Å. The size of the particles, as determined by transmission electron microscopy, is between 16 nm and 20 nm. The ferromagnetic behaviour of the particles as determined by the SQUID measurements is presented and compared with the bulk Co_2FeGa Heusler alloy.

MA 2.7 Mon 11:45 EB 301

Size dependence of the magnetization switching field of nano-island — •Guillemin Rodary, Sebastian Wedekind, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle (Saale), Deutschland

We have explored the magnetization switching field of Co nano-islands grown on Cu(111). We apply spin-polarized scanning tunneling microscopy (SP-STM) at 7 K to measure the magnetocurrent hysteresis loop of a magnetic tunnel junction composed of a single nanostructure and the magnetic tip of the STM. We measure directly the magnetic response by spin-dependent scanning tunneling spectroscopy of an individual Co nano-island as a function of magnetic field of up to 4 T, oriented perpendicular to the sample surface [1].

We observe a transition from superparamagnetic to ferromagnetic behavior with increasing island size. In the ferromagnetic state, the switching of the magnetization of the island is identified by a sharp drop of the differential conductance as a function of magnetic field. Switching fields of the order of 1 T are observed [2], and we discuss our result in view of the Stoner-Wohlfarth model of magnetization rotation and also with regard to magnetic domain formation. Our work opens the way for studies of magnetic anisotropy of single nano-objects.

[1] G. Rodary, S. Wedekind, D. Sander and J. Kirschner, unpublished.

[2] O. Pietzsch, A. Kubetzka, M. Bode and R. Wiesendanger, Phys. Rev. Lett. 92, 057202 (2004).

MA 2.8 Mon 12:00 EB 301

Magnetic ordering in 2 dimensional arrays of polarized particles with higher order multipole moments — •Matthias Schult, Nikolai Mikuszeit, Elena Vedmedenko, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

In arrays of polarized nanoparticles the stray field couples each particle to all others as stray field interaction is of long range nature. For nonspherical or multidomain polarized particles the stray field deviates from that of a point dipole and in dense arrays higher order moments must be taken into account [1].

Finite arrays of polarized single and two domain particles with spheroidal shape are investigated by means of Monte-Carlo simulation. Typical magnetic self-energy is neglected as the system is regarded as a model for spinor Bose-Einstein condensates. The simulation uses analytical solutions for the higher order moments [2]. For systems with a strong quadrupolar contribution a new ground state, different from the well known dipolar ground state, is found. Lattices of different symmetry are investigated. Lattice-symmetry-induced as well as particle-geometry-induced phase transitions are observed.

[1] E. Y. Vedmedenko, N. Mikuszeit, H. P. Oepen, and R. Wiesendanger, 2005, Phys. Rev. Lett. **95**, 207202

[2] M. Schult, N. Mikuszeit, E. Y. Vedmedenko, and R. Wiesendanger, 2007, J. Phys. A, *accepted*

MA 2.9 Mon 12:15 EB 301

Magnetische Neutronenkleinwinkelstreuung an edelgaskondensierten Ferromagneten — •MIHDI ELMAS[1], FRANK DÖBRICH[1], STEFAN MONZ[1], MELISSA SHARP[2], HELMUT ECKERLEBE[2], RAINER BIRRINGER[1] und ANDREAS MICHELS[1] — [1]Technische Physik, Universität des Saarlandes, Saarbrücken, Germany — [2]GKSS Forschungszentrum, Geesthacht, Germany

Die magnetische Neutronenkleinwinkelstreuung ist eine weit verbreitete Methode zur Untersuchung der magnetischen Mikrostruktur nanokristalliner Materialien. Insbesondere eignet sie sich zum Studium der Volumeneigenschaften dieser Materialien. Streuuntersuchungen an zweiphasigen Nanokompositen weisen eine ungewöhnliche "kleeblattförmige" Anisotropie im Streubild auf. Zur tiefer gehenden Analyse dieser Beobachtung wurden edelgaskondensierte magnetische Materialien verwendet. Neben einer Korngrösse von 10-20 nm zeich-

nen sich diese Materialien durch einen signifikanten Anteil an Porosität aus. Hierbei manifestieren sich die Poren als nichtmagnetische Gebiete in einer magnetischen Matrix. Dahingehend stellt ein edelgaskondensierter magnetischer Festkörper ein zweiphasiges System dar, beidem einerseits die zufällige Orientierung der kristallographischen Achsen zwischen benachbarten Kristalliten, andererseits der Sprung in der Sättigungsmagnetisierung an der Phasengrenzfläche zu einem starken magnetischen Streusignal führen. Gegenstand dieses Beitrags ist die Untersuchung nanoporöser edelgaskondensierter Ferromagnete mittels magnetischer Neutronenkleinwinkelstreuung.

MA 2.10 Mon 12:30 EB 301

Ion irradiation induced local creation of ferromagnetism in $Fe_{60}Al_{40}$ alloys — •T. Strache[1], M. O. Liedke[1], J. Fassbender[1], W. Möller[1], E. Menendez[2], J. Sort[2,3], T. Gemming[4], A. Weber[5], L. J. Heyderman[5], K. V. Rao[6], S. C. Deevi[7], and J. Nogues[3,8] — [1]Forschungszentrum Dresden-Rossendorf, Germany — [2]Universitat Autonoma de Barcelona, Spain — [3]ICREA Barcelona, Spain — [4]IFW Dresden, Germany — [5]PSI Villigen, Switzerland — [6]Royal Institute of Technology, Stockholm, Sweden — [7]Research Center Philip Morris, Richmond, USA — [8]Institut Catala de Nanotecnologia, Spain

Ion irradiation of $Fe_{60}Al_{40}$ alloys results in the phase transformation from the paramagnetic, chemically ordered B2-phase to the ferromagnetic, chemically disordered A2-phase. The magnetic phase transformation is related to the number of displacements per atom (dpa) during the irradiation. For heavy ions (Ar^+, Kr^+, Xe^+) a universal curve is observed with a steep increase in the fraction of ferromagnetic phase reaching saturation, i. e., a complete phase transformation, at about 0.5 dpa. This proves the purely ballistic nature of the disordering process. If light ions are used (He^+, Ne^+) a pronounced deviation from the universal curve is observed. This is attributed to bulk vacancy diffusion from dilute collision cascades, which leads to a partial recovery of the thermodynamically favored B2-phase. Comparing different noble gas ion irradiation experiments allows to asses the corresponding counteracting contributions. In addition, the potential to create local ferromagnetic areas embedded in a paramagnetic matrix is demonstrated.

MA 2.11 Mon 12:45 EB 301

Entwicklung eines magnetischen Lab-on-a-Chip für die Point-of-Care Diagnostik — •Astrit Shoshi, Joerg Schotter und Hubert Brueckl — Austrian Research Centers GmbH - ARC, Nano-Systemtechnologien, Wien, Oesterreich

Der Begriff Lab-on-a-Chip (LOC) bezeichnet mikrofluidische Systeme, welche in der Lage sind, eine Vielzahl der bislang händisch durchgeführten Schritte der molekularen Diagnostik automatisiert anhand von kaum vorpräparierten Proben schnell und sensitiv durchzuführen.

Eine sehr viel versprechende Variante solcher LOC's sind magnetische Biochips, bei welchen magnetische Partikel zur Aufreinigung und Detektion der Zielmoleküle verwendet werden. Da alle benötigten Komponenten leicht in ein Desktop-Gerät integriert werden können, sind magnetische Biochips sehr gut für den Einsatz im Bereich der Point-of-Care Diagnostik geeignet.

In diesem Vortrag stellen wir das von uns verfolgte Konzept eines magnetischen LOC vor. Hierbei werden die Zielmoleküle in einer Probenkammer spezifisch an funktionalisierte magnetische Partikel (Marker) angebunden, welche zur Beschleunigung des Bindungsprozesses mit Hilfe von magnetischen Gradientenfeldern durchmischt werden. Anschließend werden die Marker magnetisch auf bis zu 8 unterschiedlich funktionalisierte GMR-Sensoren gezogen, welche die Oberflächenbelegung mit magnetischen Markern nachweisen. Es können sowohl anziehende als auch abstoßende magnetische Kräfte auf die Marker ausgeübt werden, wodurch unspezifische Bindungen stark reduziert werden.

MA 3: Magnetic Semiconductors

Time: Monday 10:15–13:00 Location: H 1012

MA 3.1 Mon 10:15 H 1012

Influence of correlation effects on the magnetic properties of half-metallic ferromagnets — •Stanislav Chadov[1], Jan Minár[1], Hubert Ebert[1], Mikhail Katsnelson[2], and Alexander Lichtenstein[3] — [1]Dept. Chemie und Biochemie, Physikalische Chemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany — [2]Institute for Molecules and Materials, Radboud University Nijmegen, NL-6525 ED Nijmegen, The Netherlands — [3]Institute of Theoretical Physics, University of Hamburg, Germany

In contrast to the Heisenberg magnets and itinerant ferromagnets an interesting feature of the half-metallic Heusler alloys is that the Rodes-Wolfarth ratio can be essentially smaller than unity. This property can be used for their preliminary experimental identification. We present results for magnetic moments of the half-metallic ferromagnets calculated within the relativistic full potential Korringa-Kohn-Rostoker (KKR) method. Particular attention is paid to the influence of local correlation effects which make a noticeable influence on the reduction of the local magnetic moment with increase of the temperature. Local correlations are taken into account within the framework of the Dynamical Mean Field Theory (DMFT) combined with the KKR in a fully self-consistent scheme. The relativistic version of the DMFT solver used in the present work allows to take the temperature dependence of the local correlations explicitly into account. A comparison of theoretical results with corresponding experimental data is presented.

MA 3.2 Mon 10:30 H 1012

First-principles studies on dilute magnetic semiconductor based on ZnO — •Sanjeev Nayak[1], Alfred Hucht[1], Peter Entel[1], Masako Ogura[2], and Hisazumi Akai[2] — [1]Physics Department, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany — [2]Department of Physics, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan

First-principles density functional theory is used to study the electronic properties of transition metal doped ZnO. Based on the experimental observation for low doping concentrations, only the substitutional doping of transition metal atoms in ZnO is considered. Our results shows spin-glass type of state for magnetic arrangement of Co spins as the lower energy state. Addition of on-site correlation energy in terms of Hubbard U, and the exchange coupling constants of cobalt spins suggest no long-range magnetic order in the diluted limit case. Our results can be compared to recent experiments, where no ferromagnetism has been observed in the system. Thus, this poses the questions whether ferromagnetism in the system can be from secondary phases?

MA 3.3 Mon 10:45 H 1012

Magnetic and structural properties of nanocrystals embedded in semiconductors — •Shengqiang Zhou, Kay Potzger, Johannes v. Borany, Wolfgang Skorupa, Manfred Helm, Jörg Grenzer, and Jürgen Fassbender — Forschungszentrum Dresden-Rossendorf, Bautzner Landstrasse 128, 01328 Dresden

Traditional electronics can be greatly stimulated by an additional degree of freedom, i.e. the electron spin. In diluted magnetic semiconductors (DMS), transition metal (TM) ions are substituted onto cation sites of the host semiconductor. In case of magnetic coupling via the free charge carriers, spin polarized currents can be generated. However, most experimental investigations have only concentrated on reporting a high Curie temperature (T_C) and interpreted the observed ferromagnetism in terms of DMS without detail structural characterization. In this work, TM implant-doped ZnO, TiO_2 and Si samples are described by correlating magnetic and structural properties [1-2]. By means of synchrotron radiation x-ray diffraction, phase separations (Fe, Ni, Co and Mn-silicide nanocrystals) are observed. Those are the origin of the observed ferromagnetism. Depending on their crystalline structure, those nanocrystals are crystallographically oriented with respect to the host matrix. If they are randomly oriented, these nanocrystals are very difficult to detect by a simple Bragg-Brentano scan. This nature results in the pitfall of using XRD to exclude secondary phases in DMS materials.

[1] Shengqiang Zhou, et al., J. Appl. Phys. 100, 114304 (2006).
[2] Shengqiang Zhou, et al., J. Phys. D: Appl. Phys. 40, 964 (2007).

MA 3.4 Mon 11:00 H 1012

X-band magnetic resonance investigation of wide band gap dilute magnetic semiconductors — •Tom Kammermeier[1], Ver-

ena Ney[1], Shuangli Ye[1], Subhabrata Dhar[2], Klaus Ploog[2], Fang-Yuh Lo[3], Andreas Wieck[3], Tiffany Kaspar[4], and Scott Chambers[4] — [1]Experimentalphysik, Universität Duisburg-Essen, Duisburg — [2]Paul-Drude-Institut, Berlin — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum — [4]Pacific Northwest National Laboratory, Richland, Washington USA

ZnO and GaN are the most prominent wide band gab semiconductors expected to show ferromagnetic behaviour when doped with transition metals or rare earths. Although intensely studied by several groups the experimental results are inconsistent up to now [1,2]. We present electron paramagnetic resonance (EPR) studies on Co:ZnO, Gd:ZnO and Gd:GaN, respectively. Different growth techniques enable investigations of magnetic resonance properties in relation to structural quality and dopant content. Here we discuss magnetic anisotropies caused by crystal fields and/or phase separation as well as temperature dependencies. As EPR is a very sensitive technique for investigation of any kind of paramagnetic impurities, we can compare our findings with models favouring an interplay of the dopant with defects as the origin of ferromagnetic like behaviour in these materials [3].

[1] S. Dhar et al, Appl. Phys. Lett. 89, 062503 (2006) [2] A. Ney et al., Appl. Phys. Lett. 90, 252515 (2007) [3] S. Dhar et al., PRL 94, 037205 (2005)

MA 3.5 Mon 11:15 H 1012

Element specific investigations of the strutural and magnetic properties of Co-doped ZnO — •Katharina Ollefs[1], Shuangli Ye[1], Verena Ney[1], Tom Kammermeier[1], Andreas Ney[1], Fabrice Wilhelm[2], Andrei Rogalev[2], Tiffany Kaspar[3], and Scott Chambers[3] — [1]Fachbereich Physik, Universität Duisburg-Essen, Duisburg, Germany — [2]Pacific Northwest National Laboratory, Richland, Washington, USA — [3]ESRF, Grenoble, France

Element specific structural and magnetic properties of the dilute magnetic semiconductor (DMS) Co:ZnO were studied using synchrotron radiation in the hard x-ray regime. It was shown by means of x-ray linear dichroism (XLD) measurements at the Co and Zn K-edge that the local crystallographic environment of both Cobalt and Zinc is the wurtzite structure of the ZnO bulk material, and virtually all Co dopant atoms are incorporated on cation lattice sites. The respective XLD spectra were simulated employing the FDMNES code [1] using the multiple scattering formalism within the muffin tin approximation. Various samples fabricated with different preparation methods display significant differences in the local structural quality. X-ray magnetic circular dichroism (XMCD) and the corresponding element specific hysteresis at the Co K-edge reveal pure paramagnetic behaviour for samples of high structural quality. This is corroborated by SQUID measurements. Similar results are known for the DMS Cr:TiO_2 [2].

Supported by the EU, 6. FP, Grant No. MEXT-CT-2004-014195.

[1] Y. Joly, Phys. Rev. B **63**, 125120 (2001)
[2] T.C. Kapar *et al.*, Phys. Rev. Lett. **95**, 217203 (2005)

MA 3.6 Mon 11:30 H 1012

Ferromagnetism and magnetic clusters in cobalt-doped ZnO — Matthias Opel[1], Karl-Wilhelm Nielsen[1], Sebastian Bauer[1], •Sebastian T. B. Goennenwein[1], Rudolf Gross[1], Júlio C. Cezar[2], Dieter Schmeisser[3], Jürgen Simon[4], and Werner Mader[4] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]European Synchrotron Radiation Facility, Grenoble, France — [3]Angewandte Physik II, Brandenburgische Technische Universität Cottbus, Germany — [4]Institut für Anorganische Chemie, Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

Ferromagnetic semiconductors (FMS) - i.e. semiconductors exhibiting long-range magnetic ordering - are intriguing materials. However, in spite of intensive research in the last decade, the existence of homogeneous FMS with a Curie temperature around or above room temperature still is controversial. A particularly tedious issue are local sample inhomogeneities or magnetic clusters, which can yield strong magnetic signals resembling the behaviour expected for a homogeneous FMS. Using pulsed laser deposition, we have grown cobalt-doped ZnO films on single crystalline ZnO substrates. Combining x-ray magnetic circular dichroism, DC magnetometry, and AC susceptibility measurements with a detailed structural analysis by high resolution x-ray diffraction, transmission electron microscopy, and electron-spectroscopic imaging, we can unambigously trace the characteristic, ferromagnetic-like behaviour of our ZnO:Co samples at room-temperature to nanometer-sized superparamagnetic metallic cobalt precipitates.

MA 3.7 Mon 11:45 H 1012

Induced Ferromagnetic Order at Room Temperature in (Ga,Mn)As — F. Maccherozzi[1], •M. Sperl[2], G. Panaccione[2], M. Hochstrasser[3], G. Rossi[1,4], J. Minár[5], S. Polesya[5], H. Ebert[5], U. Wurstbauer[2], G. Woltersdorf[2], W. Wegscheider[2], and C. H. Back[2] — [1]Laboratorio Nazionale TASC, INFM-CNR, in Area Science Park, S.S. 14, Km 163.5, I-34012, Trieste, Italy — [2]Institut für Experimentelle Physik, Univ. Regensburg, D-93040 Regensburg, Germany — [3]Laboratorium für Festkörperphysik, Wolfgang-Pauli-Strasse 16, ETH Hönggerberg, CH-8093 Zürich, Switzerland — [4]Dipartimento di Fisica, Univ. di Modena e Reggio Emilia, Via A. Campi 231/A, I-41100, Modena, Italy — [5]Department of Chemistry, Ludwig-Maximilians University Munich, Germany

The low Curie temperature of Diluted Ferromagnetic Semiconductors (DMS) has been an obstacle for the integration of DMS into electronic prototypes. Here we demonstrate that this disadvantage can be overcome by using ferromagnetic proximity polarization. We show that a thin layer of (Ga,Mn)As can be spin polarized at room temperature by the proximity to an iron layer. X-ray magnetic circular dichroism and superconducting quantum interference device magnetometry are used to study magnetic order in the iron film and in (Ga,Mn)As film. We conclude that the induced magnetic order in the (Ga,Mn)As layer extends over more than 2 nm, even at room temperature. Furthermore, we show by experiment as well as by theory that the magnetic moment of the Mn ions couples antiferromagnetically to the moment of the Fe layer.

MA 3.8 Mon 12:00 H 1012

Control of Magnetic Anisotropy by Strain Engineering in (Ga,Mn)As Nanostructures — •Jan Wenisch, Charles Gould, Lars Ebel, Jan Storz, Katrin Pappert, Manuel J. Schmidt, Christian Kumpf, Georg Schmidt, Karl Brunner, and Laurens W. Molenkamp — Physikalisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

Understanding and utilizing the magnetic properties of semiconducting materials is one of the key issues in the field of modern electronic device technology. In this presentation, we report control of magnetic anisotropy in ferromagnetic epitaxial (Ga,Mn)As by anisotropic strain relaxation. A thin MBE-grown, pseudomorphic (Ga,Mn)As layer is patterned lithographically into an array of 200nm x 100μm stripes, which induces a large degree of elastic strain relaxation perpendicular to the stripe axis, while retaining pseudomorphic conditions along this axis. We find that the magnetic anisotropy, which shows biaxial easy axes along [100] and [010] before patterning, is replaced by a hard axis in the direction of large elastic strain relaxation and a uniaxial easy axis along the stripes. We model the strain distribution in such nanostructures by finite element simulations and find the results to be in good agreement with real structures characterized by x-ray techniques. We anticipate that this technique of local, lithographic engineering of magnetism in (Ga,Mn)As nanostructures, especially when used in conjunction with simulations to optimize sample parameters, proves very useful for realizing novel spintronic memory and logic devices.

MA 3.9 Mon 12:15 H 1012

A non-volatile memory device based on locally engineered anisotropies in (Ga,Mn)As — •Kia Tavakoli, Katrin Pappert, Charles Gould, Jan Wenisch, Karl Brunner, Georg Schmidt, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Ferromagnetic semiconductors (FS) promise the integration of magnetic memory functionality and semiconductor information processing within the same material system. Recently we have shown that improvements in lithographic patterning enable the fabrication of a novel class of devices in which the anisotropy of many individual elements can be independently engineered [1]. Here, we present a first device application of anisotropy engineering; we consider two (Ga,Mn)As nanobars coupled via a small constriction and contacted with sub-micron sized Ti/Au-contacts [2]. The device behaves as a non-volatile memory element, where information can be written by setting the relative orientation of the magnetization of the nanobars, and read by measuring the constriction resistance.

[1] J. Wenisch et al., Phys. Rev. Lett. 99, (2007) 077201
[2] K. Pappert et al., Nature Physics 3, (2007) 573

MA 3.10 Mon 12:30 H 1012

Hydrogen in GaN:Mn — •Christoph Bihler, Tobias Graf, Mario Gjukic, Moritz Hauf, Martin Stutzmann, and Martin S.

Brandt — Walter Schottky Institut, Technische Universität München, Garching, Germany

Post-growth hydrogenation is known to switch the ferromagnetic semiconductors GaAs:Mn and GaP:Mn from their ferromagnetic to a paramagnetic state via passivation of Mn acceptors. In the wide-bandgap material GaN, the $Mn^{2+/3+}$ charge transfer level is too deep for Mn to lead to effective p-type doping. Rather, a combination of optical absorption spectroscopy, elastic recoil detection and electron spin resonance (ESR) has led to the conclusion that Mn is predominantly in the 3+ oxidation state in this material. Nevertheless, a similar change of the oxidation state to 2+ by hydrogenation is expected, as found for GaAs:Mn and GaP:Mn. GaN:Mn with [Mn] $\approx 10^{20}$ cm^{-3} was subjected to hydrogenation in a remote DC hydrogen plasma for 2 hours at temperatures above 500°C. We find that the ESR signal intensity of substitutional Mn^{2+} is increased by a factor of about 3 after this treatment. Moreover, hydrogenated samples exhibit further anisotropic hyperfine-split ESR lines which can be explained via additional uniaxial crystal field contributions along the different Ga-N bond axes in the spin Hamiltonian. The latter are attributed to local lattice distortions caused by the formation of Mn-H complexes with the hydrogen atom incorporated in a bond-centred or back bonded position. The changes in the ESR spectra upon hydrogenation can be reversed via annealing for 1 hour at temperatures above 600°C.

MA 3.11 Mon 12:45 H 1012

Domain Wall Dynamics in GaMnAs — •Liza Herrera Diez[1], Matthias Rössle[1], Erhan Arac[1], Violetta Sessi[1], Fabrizio Arciprete[2], Ernesto Placidi[2], Axel Enders[1], Jan Honolka[1], and Klaus Kern[1] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]Dipartimento di Fisica, Università di Roma 'Tor Vergata' , Rome, Italy

GaMnAs is among the most prominent representatives of ferromagnetic semiconductor materials for spintronics. The linkage between carrier density and magnetic properties like Tc [1] and magnetic anisotropy enables the tuning of magneto-transport properties [2], which makes this material a potential candidate for the development of magneto-logic devices. However, the latter requires full control over magnetic reversal dynamics, which in most cases happens via the nucleation and propagation of domain walls.

Based on the energy landscape given by the interplay of biaxial and uniaxial anisotropy contributions in this material, we are able to directly observe and identify magnetization reversal processes mediated by 90° and 180° domain walls using Kerr microscopy as well as magneto-transport measurements.

Results obtained from the analysis of the nucleation and propagation processes give valuable information for controlling domain wall dynamics and for the development of single domain devices.

[1]T. Dietl, et al., Science 287, 1019 (2000).

[2]D. Chiba, M. Yamanouchi, F. Matsukura, H. Ohno, Science 301, 943 (2003).

MA 4: Magnetic Coupling Phenomena; Exchange Bias

Time: Monday 10:15–12:30 Location: H 1028

MA 4.1 Mon 10:15 H 1028

MOKE and BLS measurements of interlayer exchange coupling on epitaxial Fe/Cr/Fe wedge system — •Patrik Grychtol, Roman Adam, Matthias Buchmeier, and Claus Michael Schneider — Institute of Solid State Research, IFF-9 "Electronic Properties" , Research Center Juelich, D-52425 Juelich

Within the scope of a study on the magnetization dynamics of thin multilayer systems, a preliminary investigation of the interlayer exchange coupling in an epitaxially grown wedge shaped sample comprising two layers of iron (top 10nm, bottom 15nm) separated by a layer of chromium varying from 0.5nm to 5nm is carried out. Magneto-optic Kerr effect (MOKE) magnetometry as well as Brillouin light scattering (BLS) spectroscopy is employed in combination with an external field applied along the hard and easy axis of the magneto-crystalline anisotropy in order to extract the magnetic coupling parameters. While initially utilizing MOKE to characterize the interlayer coupling statically, BLS provides an additional tool to elaborate on the coupling behaviour, as the measured frequency of the optical magnons distinctly depends on the torque exerted by the coupling of the magnetization across the chromium layer. The results derived from both techniques are discussed and compared with model calculations.

MA 4.2 Mon 10:30 H 1028

Chemical Order-Induced Magnetic Exchange Bias — •Dieter Lott[1], Frank Klose[2,3], Hailemarian Ambaye[3], Gary J. Mankey[4], Prakash Mani[4], Max Wolff[5], Andreas Schreyer[1], Hans M. Christen[3], and B.C. Sales[3] — [1]GKSS Research Center, Max-Planck Str. 1, 21502 Geesthacht, Germany — [2]ANSTO, Bragg Institute, Menai, NSW, 2234, Australia — [3]Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA — [4]MINT Center, University of Alabama, Tuscaloosa, AL, 35487, USA — [5]Department of Physics, Ruhr-University Bochum, 44780 Bochum, Germany

We report on chemical order-induced magnetic exchange bias in FePt3, a material which - due to partial chemical disorder - has both ferromagnetic (FM) and antiferromagnetic (AFM) domains. Epitaxial thin films of this material were investigated by polarized neutron reflectivity and SQUID magnetometry in a superlattice system consisting of FePt3 and ferromagnetic CoPt3 layers. The onset of AFM order in the chemically ordered part of the FePt3 layers induces a strong exchange bias of the hysteresis loop. We demonstrate that the observed exchange bias originates intrinsically from within the FePt3 layer, i.e. we observe exchange bias between two different magnetic phases of a single crystal material having virtually the same chemical composition.

MA 4.3 Mon 10:45 H 1028

Direct observation of dual behaviour of Mn uncompensated spins in the IrMn/NiFe exchange biased bilayers — •S. K. MISHRA[1], F. RADU[1], D. SCHMITZ[2], E. SCHIERLE[2], H. A. DÜRR[1], and W. EBERHARDT[1] — [1]BESSY GmbH,Albert Einstein Str. 15, D-12489 ,Berlin, Germany — [2]Hahn-Meitner-Institute Berlin, Glienicker Str. 100, D-14109 Berlin, Germany

Exchange bias (EB) refers to the exchange interaction at an interface between ferromagnetic (FM) and antiferromagnetic (AF) bilayers. It is thought to be directly controlled by AF uncompensated spins. Contradictory observations [1,2] assign the origin of the EB to uncompensated AF spins pinned to the AF and FM layers respectively .We have utilized element specific X-ray Resonant Magnetic Scattering (XRMS) to directly probe the Mn uncompensated spins in IrMn/NiFe exchange biased bilayers. XRMS measurements performed by flipping the helicity of X-rays as well as the magnetic field allow us to separate pinned and unpinned AF uncompensated spins. We observed that the number of uncompensated AF spins scale with the EB strength. Up to 100 percent of uncompensated Mn spins are pinned indicating high quality of the interface.

References:

[1] H. Ohldag, A. Scholl, F. Nolting, E. Arenholz, S. Maat, A.T. Young, M. Carey, and J. Stöhr. Phys. Rev. Lett. 91, 017203 (2003)

[2] M. Tsunoda, T. Nakamura, M. Naka, S. Yoshitaki, C. Mitsumata, M. Takahashi Appl. Phys. Lett. 89, 172501 (2006)

MA 4.4 Mon 11:00 H 1028

Combined magnetic X-ray scattering and polarized neutron diffraction study of the origin of extinct exchange bias in the epitaxial Py(111)/CoO(111) bilayer — •F. Radu[1], S. K. Mishra[1], I. Zizak[1], A. I. Erko[1], H. A. Dürr[1], W. Eberhardt[1], D. Schmitz[2], E. Schierle[2], S. Buschhorn[3], G. Nowak[3], M. Wolff[3,4], K. Zhernenkov[3,4], and H. Zabel[3] — [1]BESSY GmbH, Albert-Einstein Strasse 15, D-12489, Berlin, Germany — [2]Hahn Meitner Institut, Glienicker Str. 100, D-14109 Berlin, Germany — [3]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität, Bochum, D-44780 Bochum, Germany — [4]Institut Laue-Langevin, F-38042 Grenoble Cedex 9, France

We have employed Soft X-ray Resonant Magnetic Scattering (XRMS), Polarised Neutron Diffraction (PND) and Reflectivity (PNR) to study the magnetic interface and the bulk AF domain state of the archetypal epitaxial Py(111)/CoO(111) exchange bias (EB) bilayer. The exchange bias field extracted from the magnetization curve is several orders of

magnitude lower than expected. The element specific hysteresis loops exhibit a vertical shift for the CoO interface which appears at the onset of the exchange bias field, at the blocking temperature. PNR resolves the magnetization reversal which proceeds by nucleation and domain wall movement at both branches of the hysteresis loop. PND on the CoO ($\frac{1}{2}\frac{1}{2}\frac{1}{2}$) magnetic Bragg peak reveals an isotropic in-plane orientation for the 3.5 nm thick AF domains. This particular AF domain state provides a virtually compensated interface for the F layer which explains the low EB field.

MA 4.5 Mon 11:15 H 1028

Exchange coupling between an amorphous ferromagnet and a crystalline antiferromagnet — •Marian Fecioru-Morariu[1], Manfred Rührig[2], Alessio Lamperti[3], Brian Tanner[3], and Gernot Güntherodt[1] — [1]Physikalisches Institut (IIA), RWTH Aachen University, 52056 Aachen, Germany — [2]SIEMENS AG, Corporate Technology, CT MM 1, Innovative Electronics, 91052 Erlangen, Germany — [3]University of Durham, Durham DH1 3LE United Kingdom

We have investigated the exchange bias (EB) effect in bilayers of an amorphous ferromagnet (CoFeB) and a crystalline antiferromagnet (IrMn) in a top-pinned configuration [1]. When the crystalline IrMn layer was deposited on top of the amorphous CoFeB layer, no EB was observed. Upon insertion of a thin crystalline ferromagnetic layer of NiFe between the amorphous CoFeB and the crystalline IrMn, EB appeared and it depended on the thickness of the NiFe layer. An enhancement of the blocking temperature of the CoFeB/NiFe/IrMn layers was observed upon increasing the thickness of the NiFe layer. These effects were directly correlated with the (111) texture in the antiferromagnetic phase of the IrMn layer, which developed progressively with increasing thickness of the NiFe layer. Such a NiFe interlayer can be used to introduce an additional source of anisotropy in a GMR sensor, by exchange coupling the free FM layer of CoFeB in an orthogonal direction to the anisotropy direction of the pinned FM layer of the GMR sensor. // The support through the EU RTN NEXBIAS (HPRN-CT-2002-00296) is acknowledged. [1] M. Fecioru-Morariu, et al., J. Appl. Phys. 102, 053911 (2007).

MA 4.6 Mon 11:30 H 1028

The strong correlation between structural properties of the buffer layer and the exchange bias phenomena — •Maciej Oskar Liedke, Valentina Cantelli, Jörg Grenzer, Daniel Markó, Arndt Mücklich, and Jürgen Fassbender — FZ Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstr. 128, 01328 Dresden, Germany

The exchange coupling strength as a function of the buffer layer thickness is investigated for several carefully chosen seed materials. The crystal microstructure of the ferromagnetic(FM)-antiferromagnetic(AF) interface is directly related to the roughness and dimensionality of the buffer layer surface, which scales not only with such parameters as a texture and grain sizes but can be discussed as well in the frame of the wetting behavior of subsequent films. Particularly, it is shown that strong wetting between the substrate and the next layer can decrease the surface dimensionality and improve the growth conditions for the subsequent films. Thus, the smoothness of the FM-AF interface improves significantly which leads to a much stronger exchange coupling across the interface. In addition, it is demonstrated that the magnitude of the exchange bias is proportional to the grain sizes distribution, which is in good agreement with theoretical predictions.

MA 4.7 Mon 11:45 H 1028

Magnetic anisotropies in ferromagnetic and exchange-coupled systems on rippled surfaces — •Maciej Oskar Liedke[1], Bartosz Liedke[1], Daniel Markó[1], Adrian Keller[1], Arndt Mücklich[1], Stefan Facsko[1], Jürgen Fassbender[1], Erik Čižmár[2], Sergei Zvyagin[2], and Joachim Wosnitza[2] — [1]FZ Dresden-Rossendorf, FWI, Bautzner Landstr. 128, 01328 Dresden, Germany — [2]FZ Dresden-Rossendorf, HLD, Bautzner Landstr. 128, 01328 Dresden, Germany

The influence of a surface and interface modulation on the magnetic properties of ferromagnetic materials (Py, Fe and Co) and an exchange bias system (Py/FeMn) is studied. A periodic surface modulation (the so-called ripples) is achieved by low energy ion erosion. Subsequently the magnetic stack is deposited. Due to the film morphology a strong uniaxial anisotropy is induced in the ferromagnetic layers, which is fixed in its orientation along ripples elongation. In the case of the exchange bias system the direction of the induced unidirectional anisotropy can be varied by means of different field annealing cycles. For all mutual orientations both anisotropy contributions are superimposed independently. The angular dependence of the magnetization reversal behavior can be described perfectly by a coherent rotation model [1]. In addition, the magnitude of the uniaxial and the unidirectional anisotropy scales with the step density or wave length of the rippled substrate, which is in full agreement with theoretical predictions.

[1] M. O. Liedke et al., Phys. Rev. B **75**, 220407(R) (2007)

MA 4.8 Mon 12:00 H 1028

Spatially resolved magnetic reversal in a multilayered exchange bias system — •Kai Schlage[1], Ralf Röhlsberger[1], Torsten Klein[2], Eberhard Burkel[2], Cornelius Strohm[3], and Rudolf Rüffer[3] — [1]Deutsches Elektronen Synchrotron (DESY), Hamburg, Germany — [2]Universität Rostock, Rostock, Germany — [3]European Synchrotron Radiation Facility, Grenoble, France

We have observed the magnetic reversal of an exchange bias [1] model system on both sides of the FM/AFM interface via nuclear resonant scattering of synchrotron radiation from 57Fe sensor layers. This yields a clear picture because one obtains the spin direction [2] and the fraction of uncompensated moments with nm depth resolution. The reversal of the ferromagnet along the easy axis proceeds via formation of a domain structure with perpendicular domain walls that extends across the FM/AFM interface. This is responsible for archetypal exchange bias characteristics like the small magnitude of the bias and the asymmetric shape of the hysteresis loop. On the other hand, along the hard axis coherent rotation of the FM winds up a planar domain wall into the AFM which is in accordance with the Mauri model.

[1] A. E. Berkowitz et al., J. Magn. Magn. Mater. 200, 522 (1999)
[2] R. Röhlsberger et al., Phys. Rev. Lett. 89, 237201 (2002)

MA 4.9 Mon 12:15 H 1028

Magnetic structure and domain walls of coupled antiferromagnetic films investigated by PEEM using polarized soft x-rays — •Ingo P. Krug[1], Franz U. Hillebrecht[1], Maurits W. Haverkort[2], Arata Tanaka[3], Liu H. Tjeng[2], Helen Gomonaj[4], and Claus M. Schneider[1] — [1]IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH — [2]PI-II, Univ. Köln — [3]Dept. of Quantum Matt., ADSM, Hiroshima Univ. - Higashi-Hiroshima, 739-8530, Japan — [4]Bogolyubov Inst. for Theor. Phys. NAS of Ukraine - st. Metrologichna, 14-b, 03143, Kiev, Ukraine

Antiferromagnetic (AF) thin films have a large potential for application in spintronics, as for example as pinning layers in spin-valves or , if insulating, as barriers in magnetic tunnel junctions. Unlike ferromagnets, these materials have no net magnetic moment, limiting the means of access to few techniques. Among them, one of the most powerful is PEEM using polarized soft x-rays, which can provide element-sensitive information about the AF domain state and – as a special focus in this work – the AF domain walls. The magnetic structure of the latter is in many cases still unknown. In this work, we provide an overview over the magnetic properties of epitaxial antiferromagnetic NiO films coupled to single crystalline magnetite substrates. We will show details of the interfacial and bulk magnetic structure of those layers gained by evaluation of the linear dichroism and discuss the influence of the crystallographic interface orientation. In a second step we will evaluate the magnetic structure of the constrained antiferromagnetic domain walls arising in the AF due to the interfacial coupling.

MA 5: Spindependent Transportphenomena I

Time: Monday 10:15–13:00 Location: H 0112

MA 5.1 Mon 10:15 H 0112

Resistance Switching in Nanocolumnar La0.7Sr0.3MnO3 Films — Markus Esseling[1], Lakshmana Sudheendra[1], •Vasily Moshnyaga[1], Konrad Samwer[1], Oleg I. Lebedev[2], and Gustaaf van Tendeloo[2] — [1]I. Physikalisches Institut, Universität Göttinge, Friderich-Hund-Platz 1, 37077 Göttingen, Germany — [2]EMAT, University of Antwerp, Groenenborgerlaan 171, B2020 Antwerpen, Belgium

We report large (700 %) and reversible electric field induced switching of the resistance in LSMO films, grown by a metalorganic aerosol deposition technique on Al2O3(0001) substrates. The films show nanocolumnar microstructure, formed predominantly by (0001) out-of-plane oriented triangle shaped grains. Magnetotransport behaviour is dominated by the epitaxial (10-10) 60°- and (1-210) 30°- grain boundaries (GB), yielding a pronounced tunnelling magnetoresistance effect. The I(V) curves of microstructured samples (˜1x1 mkm2) are strongly nonlinear for small voltages and show reversible switching from a high to the low resistance state at +-7 V. A mechanism for resistance switching is suggested based on the reversible voltage induced change of the angle of Mn-O-Mn bindings at the GB's. SFB 602 TP A2 is acknowledged.

MA 5.2 Mon 10:30 H 0112

Influence of spin-orientation on Tc in superconducting spin-valves CoFeHf/Nb/CoFeHf — •Yuansu Luo and Konrad Samwer — I. physikalisches Institut, Universität Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

Spin-valve-like structures CoFeHf/Nb/CoFeHf were investigated to show a potential influence of the spin orientation on superconducting transition temperature Tc of the space layer Nb, where the alloy of CoFeHf with 25at.%Hf was chosen as magnetic layers due to its amorphous and soft magnetic properties, having a high resistivity and a low saturation magnetization which may effectively diminish the proximity effect. The layer thicknesses used are 2-6nm for CoFeHf and 15nm for Nb, i.e. less than the coherence length. The upper magnetic layer deposited at room temperature exhibits a coercive field of a few Oe, which is smaller than that of the bottom magnetic layer prepared at 300°C and pinned additionally by a hard magnetic layer of CoFe(2nm). Transport measurements were carried out at low temperatures with an electric current and a magnetic field both in plan. The critical temperature Tc was measured to be 5.40K for the multilayered samples. It slightly shifts upwards about 25mK when changing the spin configuration of two magnetic layers from parallel to antiparallel. The small superconducting spin-valve effect might be related to strongly enhanced critical magnetic field. (Supported by DFG-Leibniz program)

MA 5.3 Mon 10:45 H 0112

Tunneling magnetoresistance and tunneling anisotropic magnetoresistance in ferromagnet/semiconductor/ferromagnet tunnel junctions — •Alex Matos-Abiague and Jaroslav Fabian — Institue for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

We investigate transport properties of asymmetric ferromagnet/semiconductor/ferromagnet tunnel junctions. We show that in such structures both the tunneling magnetoresistance (TMR) and anisotropic tunneling magnetoresistance (TAMR) effects can coexist. Three different terms contribute to the total magnetoresistance. The dominant contribution corresponds to the TMR which depends on the relative but not on the absolute magnetization directions in the ferromagnets. Conversely, the TAMR contribution is determined by the absolute orientation of the magnetization in one of the ferromagnets [1]. A third mixed contribution exhibits a dependence on both relative and absolute magnetization orientations. This contribution, like the TAMR, originates from the interference of Rashba and Dresselhaus spin-orbit couplings at the ferromagnet/semiconductor interfaces [1,2]. Model calculations for Fe/GaAs/Fe tunnel junctions are presented. Furthermore, based on rather general considerations, we present a simple model that reveals the magnetoresistence dependence on the absolute and relative magnetization directions in the ferromagnets. [This work was supported by the DFG through SFB 689]

[1] J. Moser et al., Phys. Rev. Lett. 99, 056601 (2007).

[2] J. Fabian et al. Acta Phys. Slov. 57, 565 (2007).

MA 5.4 Mon 11:00 H 0112

Ballistic and Diffusive Current Spin Polarization in $L1_o$-ordered FePt and FePd — •Klaus M Seemann[1], Vincent Baltz[1], Mark C Hickey[1], Maureen MacKenzie[2], Jorge Miguel[3], Florian Kronast[4], Wolfgang Kuch[3], John N Chapman[2], Christopher H Marrows[1], and Bryan J Hickey[1] — [1]E.C. Stoner Laboratory, School of Physics and Astronomy, University of Leeds, Leeds, United Kingdom — [2]Department of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom — [3]Institut für Experimentalphysik, Freie Universität Berlin, Berlin, Germany — [4]BESSY, Albert-Einstein-Strasse 15, Berlin, Germany

We report on the discrepancy of the current spin polarization in the ballistic and diffusive electron transport regime in $L1_o$-ordered epitaxial FePt and FePd layers. The films studied displayed a chemical long range order parameter of $0.4 < S < 0.9$ and a very strong perpendicular magnetic anisotropy. XMCD-PEEM results confirm the magnetic domain structure that we obtain from simulations employing the Landau-Lifshitz-Gilbert equation very well. By evaluating the spin current conductivity asymmetry based on the Levy-Zhang spin mistracking model we are able to assess the diffusive spin current polarization to be 80-90% [1]. On the other hand, to study the ballistic transport regime we have performed point-contact Andreev-reflection measurements at 4.2K. We obtained a value for the ballistic current spin polarization of 50%.

[1] K.M. Seemann, V. Baltz, M. MacKenzie, J.N. Chapman, B.J. Hickey, and C.H. Marrows, Phys. Rev. B at press, arXiv:0707.2943

MA 5.5 Mon 11:15 H 0112

Spin polarized tunneling into superconducting Al-Si and Al-Cu with MgO tunnel barrier — •Sarah Dierk[1], Oliver Schebaum[1], Andy Thomas[1], Günter Reiss[1], and Jagadeesh Moodera[2] — [1]Department of Physics, University of Bielefeld, D-33615 Bielefeld, Germany — [2]Francis Bitter Magnet Laboratory, Massachusetts Institute of Technology, Cambridge MA, USA

The determination of the tunneling spin polarization with superconducting tunnel junctions plays an important role in spintronics.

The tunneling spin polarization can be measured directly with a great accuracy [1]. Superconducting tunnel junctions with Al-Si and Al-Cu as superconductors have been prepared using two different shadow masks in a magnetron-sputter-deposition system. MgO has been used as the barrier material. The spin polarization of Co on top of the barrier was measured using the method of R. Meservey and P.M. Tedrow [1]. The results of annealed and not-annealed samples were compared, to determine the differences in cristallinity. The measurements were accomplished in an 3He/4He-cryostat at 0.46K and H=2.9T and H=3.31T. The spin-orbit scattering rates of Al-Si and Al-Cu have been compared in order to determine the influence of the higher atomic number of Cu on the spin-orbit-scattering.

[1] R. Meservey, P.M. Tedrow, Phys. Rep. 238, No. 4 (1994), 173-243.

MA 5.6 Mon 11:30 H 0112

Investigation of MTJs with MgO / Al_2O_3 composite tunnel-barriers — •Oliver Schebaum, Andy Thomas, and Günter Reiss — Bielefeld University, Thin Films and Physics of Nanostructures, Universitätsstraße 25, 33615 Bielefeld

Recently, large tunneling magnetoresitances (TMR) ratios have been reported in magnetic tunnel junctions (MTJs) with cristalline MgO tunneling barriers. The TMR ratio of MTJs with tunneling barriers made of Al_2O_3 on the other side seems to be limited to a much lower value. This behavior is interpreted to be due to coherent tunneling in the case of MgO as the tunneling barrier.

We have investigated the TMR ratio of MTJs with tunneling barriers made of a MgO/Al_2O_3 bilayer system. The samples were fabricated using an automatic magnetron sputtering machine with a base pressure of 1×10^{-7}mbar. The MgO layers were formed by RF-sputtering MgO, whereas the Al_2O_3 layers were fabricated by sputtering metallic aluminum and post oxidization utilizing a electron cyclotron plasma oxidization in pure Oxygen.

The dependence of the TMR ratio of the thickness of the MgO and

Al_2O_3 layers has been investigeted and the results are compared to the highest TMR ratios with either single MgO or single Al_2O_3 tunneling barriers.

MA 5.7 Mon 11:45 H 0112

Reduction of the tunnel magnetoresistance in Fe/MgO/Fe by disorder — •Peter Bose[1], Jürgen Henk[2], and Ingrid Mertig[1] — [1]Martin Luther University Halle-Wittenberg, Halle, Germany — [2]Max Planck Institute of Microstructure Physics, Halle, Germany

Spin-dependent ballistic transport is usually computed for ideal tunnel junctions, leading to magnetoresistance (MR) ratios much larger than their experimental counterparts. Disorder at the interfaces is believed to reduce the MR ratios considerably. A proof of this assumption is hardly possible in experiments and very demanding for *ab initio* transport theory.

We report on a theoretical investigation of the MR in Fe/FeO/-MgO/Fe junctions with substitutional disorder. In particular, partially occupied O sites in the FeO layer—as found in experiments [1]—are addressed. Within our layer-KKR approach to Landauer-Büttiker theory, a supercell method is implemented and applied for selected O concentrations.

The MR ratio is significantly reduced for the disordered samples, thus improving essentially the agreement with experimental results. The decomposition of the conductance into a specular and a diffusive contribution allows to discuss the transport properties in detail.

[1] C. Tusche et al., Phys. Rev. Lett. **95** (2005) 176101.

MA 5.8 Mon 12:00 H 0112

Anisotropic tunnel magnetoresistance in Fe/MgO/Fe junctions — Mayukh Nilay Khan[1], •Jürgen Henk[2], and Patrick Bruno[2] — [1]Indian Institute of Technology, Kharagpur, India — [2]Max Planck Institute of Microstructure Physics, Halle, Germany

The tunnel magnetoresistance (TMR) of a magnetic tunnel junction is defined as the difference of the currents for the parallel and the antiparallel configuration. Due to spin-orbit coupling it becomes anisotropic, that is, dependent on the magnetization directions.

We report on a detailed theoretical investigation of the tunnel anisotropic magnetoresistance (TAMR) in Fe/MgO/Fe by means of relativistic first-principles electronic structure and transport calculations. The TAMR ratio can be as large as 30 %. It is shown that the anisotropy originates from both the Rashba spin-orbit interaction at the interfaces and from resonant tunnelling. Spin-orbit induced band gaps in the leads show no considerable effect.

MA 5.9 Mon 12:15 H 0112

Correlation effects in the magnetoresistance of Fe/FeO/-MgO/Fe tunnel junctions — •Hossein Mirhosseini[1], Kamal Krishna Saha[2], Arthur Ernst[1], Jürgen Henk[1], and Patrick Bruno[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Oak Ridge National Laboratory, Oak Ridge, U. S. A.

Localized electrons are rather badly described within the local spin density approximation (LSDA) to density functional theory because the LSDA electron interacts with itself. The local self-interaction correction (LSIC) improves the description of these electrons significantly, as was shown especially for transition metal oxides [1]. Since an FeO layer is formed in Fe/MgO/Fe tunnel junctions [2], a considerable effect on the theoretical magnetoresistances is expected if the LSIC is applied to that layer.

We report on first-principles electronic-structure and transport calculations of Fe/FeO/MgO/Fe tunnel junctions with an application of the LSIC in the FeO layers. The transmittances for the LSDA and the LSDA+LSIC cases are compared, thus highlighting a proper description of oxide layers.

[1] M. Lüders et al., Phys. Rev. B **71** (2005) 205109.
[2] H. L. Meyerheim et al., Phys. Rev. Lett. **78** (2001) 076102.

MA 5.10 Mon 12:30 H 0112

Inelastic electron tunneling spectra of MgO based tunnel junctions with various soft electrode materials — •Volker Drewello, Jan Schmalhorst, Andy Thomas, and Günter Reiss — Universität Bielefeld, Germany

We have prepared MgO based magnetic tunnel junctions which show up to 180% TMR ratio at room temperature and 250% at 12 K using a commonly used CoFeB/MgO/CoFeB layer stack. Several ferromagnetic materials were also used as the soft electrode and we have measured inelastic electron tunneling spectra for each of these systems. The spectra show the typical magnon and phonon features as well as additional features which are not known from amorphous Alumina barriers. We compare the spectra with respect to the different electrode materials and compare our findings to the Alumina based junctions.

MA 5.11 Mon 12:45 H 0112

Tunneling junctions with the Heusler electrode $Co_2Cr_{0.6}Fe_{0.4}Al$ — •Christian Herbort, Elena Arbelo, and Martin Jourdan — Institute of Physics, Johannes Gutenberg University, 55099 Mainz, Germany

Some ferromagnetic Heusler compounds are theoretically predicted to be half metallic materials, i. e. to be characterized by a huge spin polarization at the Fermi energy. We investigate the correlations between junction preparation conditions, morphology and transport properties of planar $MgO - Co_2Cr_{0.6}Fe_{0.4}Al - AlO_x - Co/CoO_x - Pt$ tunnelling junctions. Epitaxial $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA) thin films were deposited by dc- and rf-sputtering on different buffer layers (Cr, Fe, MgO) on MgO (1,0,0) substrates. By RHEED, LEED and in-situ STM investigations very different surface morphologies were observed for the different preparation processes. With dc-sputtered CCFA films (island morphology) on Fe buffer layers we determined a maximum spin polarization of the Heusler compound of 54% (Jullière model, T=4K). Atomically flat surfaces with CCFA unit cell sized steps (B2 structure) were obtained by rf-sputtering on MgO substrates with e-beam evaporated MgO buffer layers. Considering that the TMR of the CCFA based junctions depends strongly on the interface at the tunneling barrier, the AlO_x layer needs to be optimized separately for the different CCFA morphologies. The barrier optimization process on the new atomically flat CCFA surfaces (rf-sputtered on MgO buffer) is in progress and current results of spectroscopic and TMR measurements will be shown.

MA 6: Invited Talks Suga / Münzenberg

Time: Monday 14:00–15:00 Location: EB 301

Invited Talk MA 6.1 Mon 14:00 EB 301

Genuine bulk electronic structures of strongly correlated transition metal oxides revealed by high energy photoelectron spectroscopy — •Shigemasa Suga — Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka, Japan

It was gradually revealed that conventional photoelectron spectroscopy (PES) in the 20-130 eV energy range mainly probes the surface electronic structures - noticeably different from bulk electronic structures - in strongly correlated electron systems such as ruthenates, high Tc cuprates, manganites as well as vanadates.

Soft X-ray angle-resolved PES in several hundred eV energy region is very powerful to probe three dimensional (3D) bulk band dispersions and 3D Fermi surface topology by properly tuning the photon energy. The Fermiology in such phases and such crystals, which are not accessible by dHvA measurements, can be performed by this methodology.

Further bulk sensitive PES is now available in the hard X-ray region in several keV with modest resolution down to 50 meV. This technique (HAXPES)is not only available for core level spectroscopy but also for valence band spectroscopy in spite that the photoionization cross sections are generally several orders of magnitude lower than in the conventional PES. Genuine bulk electronic structures as well as surface and subsurface electronic structures can be studied by changing the photon energy from few keV up to 10 keV. Long standing controversies are now gradually solved by the state of the art photoelectron spectroscopy.

Invited Talk MA 6.2 Mon 14:30 EB 301

Probing spin excitations in magnetic nanostructures and half metals — •Markus Münzenberg — IV. Phys. Institute, University of Göttingen

The understanding of single spin-flip processes, ps pulsed excitation of magnetic spin packets and spin currents is of importance to develop a magnetic switching concept for spin-electronic devices beyond the 50 ps time scale. A tool to study these processes is the demagnetization by intense laser pulses. The first systems presented are half metals. They are most interesting because of their electronic properties; in particular the peculiar property that one spin-channel has no states at the Fermi energy: the ultrafast electronic demagnetization channel via spin-flip processes is prohibited. Only the very slow channel, via anisotropic fluctuations of the crystal field, thermalizes the spin system with the lattice. This can be used as a new method to identify the half metallic character of a material. Second, in magnetic nanostructures magnetic inhomogeneities are generated and self amplified in spin-torque experiments. Here I will present mechanisms that connect the high energy spin waves with the magnetic eigen modes of the nanostructures. The mechanism generates a broad spectrum of modes that can be identified by a resistance reduction or increase respectively. The experiments support the role of an Elliot-Yafet type like electron-spin interaction responsible for the THz response of the ultrafast demagnetization in ferromagnets. Research was supported by the DFG priority research program 1133 Ultrafast magnetization processes.

MA 7: Micro and Nanostructured Magnetic Materials II

Time: Monday 15:15–18:30 Location: EB 301

MA 7.1 Mon 15:15 EB 301

The Effect of Step Atoms on the Switching Behavior of Superparamagnetic Nanoislands — •Gabriela Herzog[1], Stefan Krause[1], Matthias Bode[2], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Center for Nanoscale Materials, Argonne National Laboratory, USA

Spin-polarized scanning tunneling microscopy (SP-STM) is a well-established tool to investigate not only static but also dynamic magnetic properties at lateral resolution down to the atomic scale [1]. Our variable temperature STM is suitable to investigate the superparamagnetic switching behavior of single nanoislands consisting of about 100 Fe atoms on W(110) over a wide temperature range between 30 K and 50 K.

From the Arrhenius-like switching behavior we can derive the anisotropy energy barrier that has to be surmounted by thermal agitation to switch the magnetization of a particular nanoisland. An analysis of the data reveals that the energy barrier is neither in agreement with a coherent switching, nor a switching by the nucleation of a domain wall.

Recently, it has been shown that the anisotropy of edge and center atoms of Co islands on Pt(111) varies by more than one order of magnitude due to different coordination [2]. Our experimental results will be presented and discussed in terms of anisotropy contributions in dependence of atom coordination number.

[1] M. Bode *et al.*, Phys. Rev. Lett. **92**, 067201 (2004)
[2] S. Rusponi *et al.*, Nature Mater. **2**, 546 (2003)

MA 7.2 Mon 15:30 EB 301

Magnetic ratchet — •Alexander Auge, Alexander Weddemann, and Andreas Hütten — Bielefeld University, Universitätsstr. 25, 33615 Bielefeld

Transport phenomena in spatially periodic magnetic systems far from thermal equillibrium are considered. The emphasis is put on directed transport of magnetic beads in a so called magnetic ratchet (Brownian motor). An asymmetric magnetic potential and Brownian motion of magnetic beads are the basic concepts for a magnetic ratchet. Two main concepts to achieve an asymmetric magnetic potential are considered. On the one hand this is achievable by a gradient in current density, on the other hand asymmetric geometries of magnetic materials can be used.

In this thesis simulations are carried out to find asymmetric magnetic potentials, which can be used for directed transport. Promising simulated geometries are experimentally realised.

MA 7.3 Mon 15:45 EB 301

Two distinct reversal modes in ordered arrays of magnetic iron oxide nanotubes prepared by atomic layer deposition — •Julien Bachmann[1,2], Jing Jing[1], Juan Escrig[1,3], Dora Altbir[3], Sven Barth[4], Sanjay Mathur[4], Ulrich Goesele[1], and Kornelius Nielsch[2] — [1]Max Planck Institute of Microstructure Physics, Halle — [2]Institute of Applied Physics, University Hamburg — [3]Departamento de Fisica, Universidad de Santiago de Chile — [4]Institute of Inorganic Chemistry, University Wuerzburg

Ordered arrays of Fe_3O_4 nanotubes have been prepared by atomic layer deposition (ALD) in a structured substrate used as template, porous anodic alumina. With these tools, the length, diameter, and wall thickness of the tubes can be tuned accurately between 1 and 5 μm, between 40 and 160 nm, and between 1 and 40 nm, respectively. This enables one to systematically study how physical properties are affected by geometry. Such arrays give rise to a ferromagnetic response that strongly depends on geometry. Variations of the tube wall thickness result in non-monotonic changes in coercive field. Theoretical modeling of the magnetization reversal between the two magnetically saturated states reproduces the experimental data. For thin tubes the reversal occurs by propagation of a "vortex"domain boundary, while in thicker ones it is driven by propagation of a "transverse"domain boundary. The optimal wall thickness thus corresponds to the crossover between the vortex and transverse modes of magnetization reversal. We envision that the method may be generalized to nanoobjects of more complex geometries.

MA 7.4 Mon 16:00 EB 301

Magnetic correlations of nanostructures created by optical interference lithography on thin films — •Artur Glavic, Stefan Mattauch, and Thomas Brückel — Institut f. Festkörperforschung-Streumethoden, Forschungszentrum Jülich GmbH, 52425 Jülich

With increasing miniaturization, coupling effects between magnetic structures used in information technology become ever more important. In order to get a better understanding of these coupling mechanisms, we prepared as model systems laterally patterned epitaxial iron films consisting of stripes with periods between 500 nm and some μm by optical interference lithography. Polarised neutron reflectometry is the method of choice to study magnetic correlations in these systems as one can separate atomic and magnetic scattering and as the lengths scales accessible by off specular scattering match quite well the periods mentioned.

The preparation of the samples by Molecular Beam Epitaxy MBE and interference lithography will be presented. The advantages of interference lithography for this application and the setup we build for this purpose will be shown. The methods of x-ray and polarised neutron reflectometry will be introduced, as well as the setup of the used neutron reflectometer, TREFF at the FRM II research reactor in Munich. Off-specular scattering allows us to deduce the magnetic domain structure as function of the external field. The results will be discussed in comparison to the magnetic behaviour on lager scales measured with MOKE, and compared with earlier works.

MA 7.5 Mon 16:15 EB 301

Nucleation and propagation of transverse and vortex domain walls in nanowires with a thickness gradient — •Oleg Petracic[1,3], Hartmut Zabel[1], Detlef Görlitz[2], Kornelius Nielsch[2], Dan Read[3], and Russell P. Cowburn[3] — [1]Institut für Experimentalphysik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Institute of Applied Physics and Microstructure Research Center, University of Hamburg, D-20355 Hamburg — [3]Physics Department, Imperial College London, London SW7 2AZ, UK

Permalloy nanowires with a thickness gradient along the nanowire axis have been prepared by electron beam lithography and studied using a magneto-optic Kerr effect setup. The nucleation and propagation of either transverse or vortex domain walls is strongly modified by a slope in the thickness. For relatively narrow and thin wires, i.e., width w = 150nm and thickness t=8nm, wires with a slope have a strongly decreased coercive field compared to wires without a slope. However, wider and thicker wires, i.e., w=500...2000nm and t=18nm show a much smaller effect of the slope. We assume that in the sloped region a transverse domain wall nucleates for all wire geometries. For narrow and thin wires the transverse wall is the energetically preferred config-

uration, while wider and thicker wires show a vortex wall. The initial transverse wall either can propagate through the entire wire or has to transform to a vortex wall, respectively. Micromagnetic simulations confirm our experimental investigations.

MA 7.6 Mon 16:30 EB 301

Thermische und magnetsiche Charakterisierung von Fe + Co Streifenstrukturen mittels Rastersondenmikroskopie basierter Detektion der ferromagnetischen Resonanz — •Sven Stienen, Ralf Meckenstock, Jürgen Lindner, Igor Barsukov und Michael Farle — Fachbereich Physik und Center for Nanointegration (CeNIDE), Universität Duisburg-Essen, 47048 Duisburg

Es wurden Fe und Co Streifenstrukturen mit einer Länge von 100 μm und einer Breite von 0.5 - 2 μm mittels ortsaufgelöster ferromagnetischer Resonanz (FMR) untersucht. Die Schichtdicke betrug 15 - 25 nm. Für diese Streifenstrukturen erwartet man formanisotropiebedingte, nicht homogene magnetische Mikrowellenanregungen.

Zur ortsaufgelösten Detektion dieser FMR-Anregungen wurde ein Rasterkraftmikroskop verwendet, welches mit einer thermischen Spitze ausgerüstet ist, die den thermischen Nahfeldeffekt ausnutzt (SThM-FMR)[1]. Dabei wird eine örtliche Auflösung von 30nm und eine thermische Auflösung von 1mK erreicht. Die Spitze befindet sich in Kontakt zu der magnetischen Struktur. Im Falle der ferromagnetischen Resonanz erwärmt sich die Struktur durch die Absorption von Mikrowellenleistung.

Mittels der SThM-FMR konnten sowohl die homogene FMR-Resonanz einer einzelnen Nano-Struktur als auch über die Nano-Struktur lateral verteilte Randresonanzen und Spinwellen detektiert werden. Mit diesem Verfahren ist man sensitiv auf ca. 10^6 Spins. Dieser Beitrag wurde von der DFG SFB491 gefördert.

[1] R.Meckenstock et.al., Appl.Phys.Let. 91, 142507, 2007

MA 7.7 Mon 16:45 EB 301

Temperature-dependent investigation of domain wall depinning in nanowires by ballistic Hall micromagnetometry — •Peter Lendecke, René Eiselt, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg, Germany

We use ballistic Hall micromagnetometry [1] to determine depinning fields of domain walls in permalloy nanowires in the temperature range between 1.6 and 50 K. The walls are pinned in lithographically defined triangularly shaped constrictions. Pinning and depinning of single domain walls is detected via the stray field of the walls. The high sensitivity of our Hall magnetometer to the local micromagnetic structure allows the detection of single domain walls and a distinction of different wall types. A strong decrease of depinning fields at raised temperature is observed. For temperatures above 20 K additional domain wall types occur that can be distinguished by different stray field strengths as well as by different depinning field values [2]. We fit the depinning field decrease to a model describing the depinning process by hopping over a single energy barrier [3].

[1] A. K. Geim et al., Appl. Phys. Lett. **71**, 2379 (1997)
[2] P. Lendecke, R. Eiselt, U. Merkt, and G. Meier, submitted.
[3] J. Kurkijärvi, Phys. Rev. B. **6**, 832 (1972).

MA 7.8 Mon 17:00 EB 301

On the aspect ratio and packing factor dependence of magnetostatic interactions in densely-packed Co nanowire arrays — •Giray Kartopu[1], Orhan Yalçin[2], Ali Cemil Başaran[3], Morten Madsen[4], Horst-Günter Rubahn[4], and Mohammed Es-Souni[1] — [1]Institute for Materials and Surface Technology, University of Applied Science of Kiel, Grenzstrasse 3, 24149, Kiel, Germany — [2]Department of Physics, Bozok University, 66500 Yozgat, Turkey — [3]Department of Physics, Gebze Institute of Technology, 41400 Gebze, Kocaeli, Turkey — [4]Mads Clausen Institute, NanoSYD, University of Southern Denmark, Alsion 2, DK-6400, Sønderborg, Denmark

Densely-packed and ordered cobalt nanowire (NW) arrays with aspect ratio (wire legth/diameter) varying between 5-250 have been fabricated via electrodeposition into porous alumina templates (<60 nm channel diameter). For a fixed diameter the NW length was controlled by monitoring the total deposited charge, and for high-aspect ratio NWs with variable diameters the template pores were adjusted by a post-anodization wet etching. Room temperature magnetization measurements (M-H loops) show that the magnetic behaviour of Co NW arrays is governed largely by aspect ratio- or packing factor-dependent magnetostatic wire-wire interactions.

MA 7.9 Mon 17:15 EB 301

Dipolar interactions on lateral structured square lattices — •Alexandra Schumann[1], Arndt Remhof[3], Andreas Westphalen[1], Hartmut Zabel[1], Torsten Last[2], Ulrich Kunze[2], Elena Vedmedenko[4], and Nikolai Mikuszeit[4] — [1]Institut für Experimentalphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [3]EMPA, Hydrogen & Energy, Überlandstrasse 129, 8600 Dübendorf, Switzerland — [4]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11a, 20355 Hamburg, Germany

We investigated the remanent states of laterally structured permalloy dipole arrays. A single permalloy island has a length of L = 3 μm and a width of w = 0.3 μm. Due to the arrangement on a square lattice the magnetic dipoles are inherently frustrated and show different ground states depending on their separation. We implemented separations in the range of a = 0.42 μm to 3.4 μm. Theory predicts that for this geometry either an onion, a horseshoe or a vortex state may be realized in the remanent magnetic state. To achieve a vortex state a high energy barrier is required to overcome, therefore it is more likely to observe the onion or the horseshoe state. We could confirm these predictions of theory in our experiments by MFM images. Our experiments show that the remanent configuration of the dipoles depends on the direction of the initial magnetization as well as on the distance between the single elements.

This work was supported by the SFB 491 and the SFB 668.

MA 7.10 Mon 17:30 EB 301

Magnetoresistance in epitaxial Fe wires on GaAs(110) — •Christoph Hassel, Florian M. Römer, Jürgen Lindner, and Günter Dumpich — Fachbereich Physik and Center for Nanointegration (CeNIDE), Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

From epitaxial Fe films grown on GaAs (110) wires of different widths are prepared using electron beam lithography and Ar sputtering. Before processing, the structural properties of the substrate and the Fe films are determined by AES, LEED and IV-LEED. For further processing, the films are capped with Ag and Pt to prevent oxidation of the Fe films under ambient conditions. The anisotropy constants of the capped films are quantified using ferromagnetic resonance. After preparing the wires, their magnetic properties are studied in a magnetic force microscope. These measurements confirm the epitaxial structure of the Fe wires. To investigate the magnetoresistance of the Fe nanowires, the wires are contacted by gold leads in a second EBL process. These measurements also clearly show the epitaxial structure of the wires. The magnetoresistance behaviour allows to determine anisotropy fields of the wires.

This work is financially supported within the SFB 491.

MA 7.11 Mon 17:45 EB 301

Spin structure of nanocrystalline Gadolinium studied by magnetic small-angle neutron scattering — •Frank Döbrich[1], Mihdi Elmas[1], Adrian Ferdinand[1], Jürgen Markmann[1], Melissa Sharp[2], Helmut Eckerlebe[2], Rainer Birringer[1], and Andreas Michels[1] — [1]Technische Physik, Universität des Saarlandes, Saarbrücken, Germany — [2]GKSS Forschungszentrum, Geesthacht, Germany

We report on magnetic-field-dependent small-angle neutron scattering (SANS) experiments on nanocrystalline inert-gas condensed bulk Gd, which was synthesized using the low-capturing isotope ^{160}Gd. The angular dependency of the scattering cross section is in very good agreement with recent theoretical predictions. Rather unexpected for this type of material, we observe a "clover-leaf" anisotropy in the SANS signal, the origin of which is attributed to the existence of longitudinal magnetization fluctuations associated with a disordered grain-boundary component.

MA 7.12 Mon 18:00 EB 301

Exchange coupled $L1_0$-FePt/Fe thin films and nanopatterns — •Achim Breitling and Dagmar Goll — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart, Germany

Bilayered $L1_0$-FePt/Fe composite nanopatterns are a very promising possibility to push data storage density up to 1 Tbit/inch^2 and beyond. The hard magnetic $L1_0$-FePt layer with its high uniaxial anisotropy constant of $K_1 = 6.6 \cdot 10^6$ J/m^3 guarantees long-term stability even at

small particle sizes whereas the addition of a Fe layer creates moderate switching fields achievable by conventional write heads. Therefore in a first step the magnetic properties of $L1_0$-FePt/Fe films were investigated as a function of the Fe film thickness. It is found that the coercive field $\mu_0 H_c$ can be tailored between 0.29 T and 2.75 T by the appropriate choice of the thickness of the Fe film. In a second step $L1_0$-FePt and $L1_0$-FePt/Fe nanopatterns respectively were produced using various electron lithography techniques. The magnetic properties of the nanopatterns are compared with those of the continuous films.

MA 7.13 Mon 18:15 EB 301

Magnetische Eigenschaften und kritisches Verhalten von nanokristallinem Terbium — •Stefan Philippi, Rainer Birringer und Andreas Michels — Technische Physik, Universität des Saarlandes, Saarbrücken, Germany

Die Mikrostruktur eines ferromagnetischen Materials hat starken Einfluss auf dessen magnetische Eigenschaften. In nanostrukturierten Materialien wirken sich insbesondere die konkurrierenden Längenskalen der charakteristischen magnetischen Austauschlänge und der durch die Geometrie eingeschränkten strukturellen Längen aus.

An nanokristallinem Terbium manifestiert sich dieses Wechselspiel u.a. durch die Unterdrückung der antiferromagnetischen Helixphase bei mittleren Korngrößen von etwa 20 nm: Die im grobkristallinen Material charakteristischen Peaks in der temperaturabhängigen Anfangssuszeptibilität um 221 K und 229 K, die der Curie- bzw. Neél-Temperatur zugeordnet sind, verschwinden zugunsten eines einzelnen Maximums bei 224 K.

Die Charakterisierung dieses veränderten Phasenüberganges erfolgte anhand von Magnetisierungs- und Suszeptibilitätsmessungen an edelgaskondensiertem Terbium für verschiedene mittlere Korngrößen im betreffenden Temperaturbereich. Der Phasenübergang wurde hinsichtlich der Übergangstemperatur und der kritischen Exponenten analysiert.

MA 8: Magnetic Imaging

Time: Monday 15:15–16:45 Location: H 1012

MA 8.1 Mon 15:15 H 1012

Bubble domains in [Co/Pt]/Ru multilayers — •Cristina Bran[1,2], Ulrike Wolff[1], Olav Hellwig[3], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany — [2]IMPRS "Dynamical Processes in Atoms, Molecules and Solids", Nöthnitzer Str. 38 — [3]San Jose Research Center, Hitachi Global Storage Technologies, 650 Harry Road, San Jose, CA 95120, USA

[Co/Pt]/Ru multilayers present a large variety of different magnetic domain configurations due to the competition between ferromagnetic dipolar coupling and antiferromagnetic coupling through the Ru spacer layer. In this study we focused on $[(Co(4Å)/Pt(7Å))_8 Co(4Å)/Ru(9Å)]_{18}$ multilayers which present a predominant dipolar coupling at room temperature. We used a Digital Instruments Dimension 3100 to image the domain structure as a function of an external perpendicular field. In a zero field state, due to the perpendicular anisotropy, band domains with average domain width of 180 nm are observed. By increasing the external magnetic field the domains which are aligned parallel to the field grow, while the oppositely aligned domains shrink. This process is gradually, until the domains transform into worms and, in the end, into a bubble domain structure at 0.34 T. Theoretical calculations, previously developed for single layer film with perpendicular anisotropy [1], are in good agreement with our experimental results, revealing little influence of the antiferromagnetic coupling.

[1] A.A. Thiele, J. Appl. Phys, 41, 1139 (1970).

MA 8.2 Mon 15:30 H 1012

spin-polarized scanning tunneling spectroscopy on individual magnetic adatoms — •lihui zhou, focko meier, jens wiebe, and roland wiesendanger — Institue of Applied Physics, Hamburg University, Jungiusstrasse 11, D-20355 Hamburg, Germany

Using spin-polarized scanning tunneling spectroscopy the spin-resolved electronic states of single Co adatoms on Pt(111) are studied as a function of an external magnetic field, which allows to access the magnetization curves of individual adatoms directly. Surprisingly, we find that the adatoms show paramagnetic behaviour at very low temperature despite of their large magnetic anisotropy [1]. Although the adatoms have identical electronic configurations the magnetic field necessary for saturation shows a strong variation from atom to atom. We ascribe this effect to their mutual RKKY interaction. Indeed, we find experimental evidence for the magnetic interaction between the adatoms and a Co monolayer stripe, which oscillates back and forth between ferromagnetic and antiferromagnetic coupling over a distance of several nanometers.

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

MA 8.3 Mon 15:45 H 1012

Real space imaging of 2-dimensional 120° Néel structure: one monolayer Mn on Ag(111) — •Chunlei Gao[1], Wulf Wulfhekel[1,2], and Jürgen Kirschner[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Physikalisches Institut, Universität Karlsruhe (TH), Wolfgang-Gaede Strasse 1, Karlsruhe, Germany

In magnetic materials, the competing exchange interaction between neighboring atoms very often leads to frustrated spin structures. Magnetic frustration may have chemical or topological origin. A classical example of a topological frustration is a 2-dimensional triangular lattice of antiferromagnetic atoms in which a noncollinear 120° Néel structure stabilizes. In this report, we demonstrate the 120° Néel structure of Mn monolayer on Ag(111) with spin-polarized scanning tunneling microscopy (Sp-STM) operating in the constant current mode [1]. Mn grows as monolayer triangular islands either on fcc or hcp atomic sites. The existence of structurally equivalent, but magnetically distinguished Mn islands of the same atomic site is observed. The fcc and hcp islands are found to have the same 120° Néel structure but with different orientation of the moments which means the fcc and hcp islands have different magnetic anisotropy.

[1]D. Wortmann, S. Heinze, Ph. Kurz, G. Bihlmayer, and S. Blügel, Phys. Rev. Lett. 86, 4132 (2001)

MA 8.4 Mon 16:00 H 1012

Slow magnetic dynamics observed by photon correlation spectroscopy — Stan Konings[1], •Christian Schüssler-Langeheine[2], Holger Ott[2], Eugen Weschke[3], Enrico Schierle[3], and Jeroen B. Goedkoop[1] — [1]Van der Waals Zeeman Institute, University of Amsterdam — [2]II. Physikalisches Intitut, Universität zu Köln — [3]Institut für Experimentalphysik, Freie Universität Berlin

Slow dynamics on nm length scales and time scales longer than 1 μs is best observed by x-ray photon-correlation spectroscopy (XPCS). The method uses the static interference pattern caused by the scattering of coherent x-rays from a sample containing disorder (speckle). When the system fluctuates the speckle pattern changes on the time scale of the fluctuations in the sample itself. From the dynamics of the speckle pattern the dynamics in the sample can hence be determined. We present the first application of this approach to slow magnetic domain fluctuations in an antiferromagnetic system using PCS in soft x-ray resonant magnetic diffraction. Ultrathin Ho metal films show a decay of long-range magnetic order over an unusually broad temperature range. Using PCS we can identify domain wall pinning as the dominant mechanism causing this broadened phase transition [1].

[1] S. Konings et al., cond-mat/0707.2765

MA 8.5 Mon 16:15 H 1012

Standard samples to determine the influence of external in-plane magnetic fields on magnetic force microscopy probes — •Tanja Weis[1], Dieter Engel[1], Arno Ehresmann[1], Volker Höink[2], Jan Schmalhorst[2], and Günter Reiss[2] — [1]Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [2]University of Bielefeld, Department of Physics, Nano Device Group, P.O. Box 100131, D-33501 Bielefeld

Analyzing magnetic force microscopy images measured in external in-plane magnetic fields is always hampered by the tilt of the magnetic

moment of the MFM tip due to the external magnetic fields. To determine this tilt we use magnetically patterned samples whose magnetic state is independent on the magnetic field in a certain field range. For the fabrication of such topographically planar patterns we used standard lithography methods and keV He ion bombardment of exchange biased bilayers. We will present the production of standard samples and a procedure to determine the influence of external in-plane magnetic fields on the magnetic dipole moment of MFM tips.

MA 8.6 Mon 16:30 H 1012

Tip Effects in Magnetic Exchange Force Microscopy — •Uwe Kaiser, Alexander Schwarz, and Roland Wiesendanger — Institut für Angewandte Physik, Jungiusstr. 11, 20355 Hamburg

Magnetic Exchange Force Microscopy (MExFM) is a novel technique that was invented in order to perform magnetic imaging of insulating or conducting surfaces with atomic resolution [1]. It is based on conventional atomic force microscopy but uses a magnetic tip, which is approached very closely to a magnetic sample to detect the magnetic exchange interaction between tip and sample.

In our study we analyze the (001) surface of NiO by means of MExFM. The measurements have been carried out in a home-built microscope, operated in UHV at a temperature of 8 K. As magnetic probes we used supersharp silicon cantilevers that were coated with 22 nm of iron as a ferromagnetic layer. To get a favourable alignment between the spins of tip and sample we applied a magnetic field of 5 T perpendicular to the sample surface. Using this set-up we obtained magnetic resolution of the antiferromagnetically arranged nickel atoms on the atomic scale. However, some of our experimental results show sudden changes or even a contrast reversal of the magnetic contrast. These experimental findings are discussed with respect to the influence of the orientation of the spin at the tip apex and the applied magnetic field.

[1] U. Kaiser, A. Schwarz, and R. Wiesendanger, Nature **446**, 522 (2007).

MA 9: Micromagnetism/Computational Magnetics

Time: Monday 16:45–18:15 Location: H 1012

MA 9.1 Mon 16:45 H 1012

Magnetic Contribution to Friction — •Martin P. Magiera and Dietrich E. Wolf — Department of Physics, University of Duisburg-Essen, 47048 Duisburg, Germany

We theoretically study the magnetic contribution to friction force by simulating an atomic anisotropic ferromagnetic Heisenberg system moving relative to a nanometer scaled extra spin. Interaction in between them is described by dipole interaction (cut off to avoid finite size effects). For integration of the dynamic system we use the Landau Lifshitz Gilbert equation. Langevin dynamics provide an insight into thermal effects. Friction force is calculated by derivation of energy dissipation terms and distinction of thermal and magnetic energy flow contributions.

We find a linear velocity dependence of the friction force, analogous to mechanical models like the Tomlinson model. Its slope is proportional to the phenomenological damping parameter in the Landau Lifshitz Gilbert equation, in agreement with the fluctuation dissipation theorem. Finally we find a nonzero friction and slope in the paramagnetic phase, as well as a rather complex friction force vs. velocity behavior at higher velocities. Hence we interpret the dissipation mechanism as an excitation of spin waves with a finite spectrum.

MA 9.2 Mon 17:00 H 1012

Hybrid FEM-BEM method for Oersted field calculation — •Riccardo Hertel — Forschungszentrum Jülich, Institut für Festkörperforschung IFF-9, D-52425 Jülich

Various exciting aspects of the current-induced magnetization dynamics in nanostructures due to spin-transfer torque effects have attracted overwhelming interest recently, particularly in the past five years. The interest in this new kind of spin dynamics is in fact so great, that the classical interaction between the magnetization and electric currents due to Maxwell has almost been overlooked. In the case of nanomagnets excited by a spin-polarized current in a pillar geometry, however, the magnetic field created by the current (i.e., the Oersted field) often provides a non-negligible contribution to the magnetization dynamics. Hence, micromagnetic simulations on current-driven dynamics require methods for accurate calculation of the Oersted field. In principle, the whole current-carrying structure (including, e.g., the contacting leads and the magnetic pillar) needs to be considered for reliable Oersted field calculation, i.e., a region which is much larger than the nanomagnet itself. In this talk I will present a hybrid finite-element / boundary method for the calculation of current density distributions and the resulting Oersted field in general geometries. This method can be easily implemented in finite-element micromagnetic simulation techniques because the involved matrix elements are the same as those used for the magnetostatic (dipolar) interaction.

MA 9.3 Mon 17:15 H 1012

Resonant and non-resonant current-induced vortex core switching — •Sebastian Gliga, Yaowen Liu, Riccardo Hertel, and Claus M. Schneider — Institut für Festkörperforschung (IFF-9), Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

It has recently been demonstrated that the core of magnetic vortices in thin-film elements can be switched by in-plane electrical currents [1,2]. Presently, two distinct routes are known by which electric currents flowing in the sample plane can switch a magnetic vortex core. In the resonant switching, the gyrotropic mode of the vortex is excited by applying a sinusoidal electric current tuned at the corresponding frequency [1], typically below one GHz for mesoscopic thin film elements. In contrast, the non-resonant switching consists in applying a single current pulse [2] to trigger the core reversal within a few hundreds of picoseconds. Using fully three-dimensional micromagnetic simulations based on the finite-element method, we have compared the electrical core switching processes for both routes. We have found that the reversal is mediated by the temporary creation of a vortex-antivortex pair in both cases. Moreover, the core switching occurs as soon as the total and the exchange energies reach critical threshold values in the sample. These thresholds are the same for the resonant and the non-resonant cases, and do not depend on the amplitude of the applied current. The time needed to switch the vortex core thus depends on the rate at which the sample energy increases due to the applied current.

[1] K. Yamada et al., Nat. Mat. **6**, 270 (2007)
[2] Y. Liu et al., Appl. Phys. Lett. **91**, 112501 (2007)

MA 9.4 Mon 17:30 H 1012

Influence of the Oersted field on the current-induced dynamics of nanodisks — •Attila Kakay, Riccardo Hertel, Ronald Lehndorff, Daniel Bürgler, and Claus Michael Schneider — Institut für Festkörperforschung IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich, GmbH, D-52425 Jülich, Deutschland

Stationary oscillations of the magnetization in nanopillars with characteristic frequencies in the GHz range can be induced by a spin-polarized dc current. The frequency of these oscillators is tunable by changing the current value or other external parameters. Experimental research shows that in some cases the frequency increases with increasing current density, an effect known as blue-shift. This blue-shift effect has been studied both experimentally and numerically. In the commonly used macrospin model, where the exchange energy is neglected, this blue-shift is assigned to out-of-plane precessional modes of the magnetization. Our full-scale micromagnetic simulation provides a different explanation for the blue-shift, showing that it originates from the Oersted field. The mode profiles of the characteristic magnetization dynamics around 8 GHz are extracted using spatial Fourier filtering. In the presence of the Oersted field the mode profile is changing with increasing current in such way, that the distance between the oscillating regions decreases, which leads to the increase of the oscillating frequency, thereby explaining the observed blue-shift. Good quantitaive agreement is obtained between simulations and experiment regarding both the main frequency and its shift.

MA 9.5 Mon 17:45 H 1012

three-dimensional magnetic normal modes in mesoscopic permalloy prisms — •Ming Yan, Riccardo Hertel, and Claus Michael Schneider — Institut für Festkörperforschung, IFF-9,

Forschungszentrum Jülich, D-52425 Jülich

Three-dimensional (3D) magnetic normal modes in Permalloy prisms (aspect ratio 4:2:1, thickness 60-80 nm) with 3D Landau structure [1] are studied using micromagnetic finite-element simulations. Magnetic normal modes are extracted with Fourier analysis from the dynamical response of the magnetization to a weak sub-nanosecond field pulse. Among the rich excitation spectra in the range of several GHz, three well-defined types of modes are resolved: the oscillations of the asymmetric Bloch wall, of the corners, and of the 90° domain walls [2]. The modes connected with the asymmetric Bloch wall can be interpreted as the oscillations of a distorted, stretched vortex core. Instead of just one gyrotropic vortex core mode as it is known from 2D systems, multiple core modes are observed in our 3D samples. The other two types of modes, although similar to those known from 2D systems, show different characteristics consistent with the 3D character of the sample and the asymmetry of the magnetic ground state. These simulations provide precise predictions on the excitation spectra in 3D prisms and extend the knowledge of dynamic modes in confined magnetic structures from two dimensions to three. [1] R. Hertel, O. Fruchart, S. Cherifi, P.-O. Jubert, S. Heun, A. Locatelli, and J. Kirschner, Phys. Rev. B 72, 214409 (2005). [2] M. Yan, R. Hertel, C. M. Schneider, Phys. Rev. B 76, 094407 (2007).

MA 9.6 Mon 18:00 H 1012

Computer experiments on standing spin wave resonances using Landau-Lifshitz-Gilbert dynamics — •Robert Wieser, Elena Y. Vedmedenko, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, D-20355 Hamburg

A new method to explore standing spin wave patterns based on the solution of the Landau-Lifshitz-Gilbert equation in two-dimensional nanostructures will be presented. We calculate numerically the power spectrum P of magnetic moments in an oscillating field. The simulations are directly comparable with classical ferromagnetic resonance experiments, where the imaginary part of the susceptibility $\chi'' \propto P$ is observed. The advantage of this method is the direct information about the position and phase of the spin wave resonance as function of frequency or external magnetic field.

In the second part of the talk, the temperature dependence of the resonance spectrum of Fe/Ag(111) will be discussed. The temperature causes a shift in the $T = 0$ resonance peaks as well as additional spin wave patterns.

ACKNOWLEDGMENTS: This work has been supported by the Deutsche Forschungsgemeinschaft (SFB 668).

MA 10: Magnetic Materials

Time: Monday 15:15–18:30 Location: H 1028

MA 10.1 Mon 15:15 H 1028

Spin Density Wave state in Chromium: density functional calculations — •Mathias Bayer, Manuel Richter, Klaus Koepernik, and Helmut Eschrig — IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany

The ground state of Chromium is an incommensurable spin density wave with a period of about 42 atomic layers. Recent electronic structure calculations for Cr, including up to 40 layers, found an anti-ferromagnetic groundstate. We have used the full-potential local-orbital code FPLO, which has allowed us to consider up to 42 layers at a high accuracy of the total energy in LSDA. We have additionally applied a lattice distortion to simulate the effects of the concomitant charge density wave. The results are compared with experimental data and other calculations in the literature.

MA 10.2 Mon 15:30 H 1028

Temperature induced changes of the Ni electronic structure — •Ruslan Ovsyannikov, Mihaela Gorgoi, Florian Kronast, Hermann A. Dürr, and Wolfgang Eberhardt — BESSY GmbH, Albert-Einstein-Str. 15, 12489 Berlin, Germany

Temperature dependent changes for surface and bulk states in valence band photoemission are well known [1] and often assigned to an expanding lattice. A similar explanation was proposed for core levels of transition metals such as W [2]. Here we show that the crystalline field is not the only origin of a temperature induced core level shifts. We show using bulk sensitive high kinetic energy photoemission that in the case of Ni a more pronounced temperature effect is visible in core level satellites compared to the main peak. A similar behavior is also observed with XAS. We discuss a model where this behavior can be explained by a reduced hybridization between 3*d* and 4*sp* orbitals on neighbor Ni atoms with increasing temperature.

[1] R. Paniago et al., J. Phys.: Condens. Matter 7, 2095 (1995)
[2] H.-S. Tao et al., Phys. Rev. B 56, 6982 - 6986 (1997)

MA 10.3 Mon 15:45 H 1028

Magnetic and thermodynamic properties of the frustrated ferromagnetic square lattice $BaCdVO(PO_4)_2$ — •Ramesh Nath[1], A. A. Tsirlin[1,2], H. Rosner[1], and C. Geibel[1] — [1]MPI CPfS, Nöthnitzer Str. 40, 01187 Dresden, Germany — [2]Department of Chemistry, Moscow State University, 119992, Moscow, Russia

The spin 1/2 Heisenberg model on a square lattice with antiferromagnetic (AF) nearest J_1 and next nearest neighbour J_2 interactions has been a focus of extensive theoretical research for the last decades. Experimentally, only a limited number of compounds of this model have been realized so far. Very recently new materials, $(Pb_2, SrZn)VO(PO_4)_2$ were found to be square lattice systems with mixed ferromagnetic (F) and AF exchange interactions which stimulated the theoretical research to extend the phase diagram including F J_1 and J_2. In this context, we would like to present a new compound $BaCdVO(PO_4)_2$, which is isostructural to $SrZnVO(PO_4)_2$ and more exciting from the magnetic point of view. Magnetization and specific heat measurements on powder sample evidence that $BaCdVO(PO_4)_2$ is a $S = 1/2$ frustrated square lattice with F J_1 and AF J_2. The absolute values were estimated to be $J_1 \simeq -3.6$ K and $J_2 \simeq 3.2$ K which are consistent with a strongly reduced (or vanishing) Curie temperature θ_{CW}. $BaCdVO(PO_4)_2$ undergoes a magnetic ordering at about 1 K, likely towards a columnar antiferromagnetic state as expected from the ratio $J_2/J_1 \simeq -0.85$ and the saturation field $B_{sat} \simeq 4.5$ T. This ratio, places the system more close to the quantum critical regime in the phase diagram than previously reported compounds.

MA 10.4 Mon 16:00 H 1028

Simultaneous magnetoresistance measurements and Kerr microscopy of iron whiskers — •Michael Kirsch, Ivo Knittel, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P.O.Box 151150, D-66041

Measurements of magnetoresistance and (giant) magnetoimpedance of single crystals have been carried out at room temperature as a function of applied longitudinal magnetic field, current amplitude and current frequency. Simultaneously, the magnetic surface domain structure of the probes was imaged by Kerr microscopy (MOKE). Iron whiskers of 70 to 105 micrometer in diameter with <100> and <111> growing directions have been used for the experiments. Crystallography, zero-field domain structure and MOKE imaging properties will be discussed in detail. The correlation between circumferential magnetic permeability, magnetoimpedance and magnetoresistive effects is discussed on the basis of MOKE and resistivity data. The results permit to model changes of the domain structure during the magnetoimpedance measurement. Magnetoimpedance in iron whiskers can be understood in close analogy to the "giant magnetoimpedance" known from amorphous wires with a "bamboo" domain structure.

MA 10.5 Mon 16:15 H 1028

Magnetism in $Pb_3Mn_7O_{15}$ — •J. C. E. Rasch[1,2], D. Cheptiakov[2], M. Boehm[1], J. Schefer[2], N. V. Volkov[3], K. A. Sablina[3], and G. A. Petrakovskii[3] — [1]Institut Laue-Langevin, 6 rue Jules Horowitz, BP 156, 38042 Grenoble, Cedex 9, France — [2]Laboratory for Neutron Scattering, ETH Zurich and Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [3]L.V. Kirensky Institute of Physics SB RAS, Krasnoyarsk 660036, Russia

The wide variety of physical properties in perovskite manganites stimulates the study of other Mn oxide families without perovskite structure, but a mixed valence state of the Mn ions (Mn^{3+}/Mn^{4+}).The material under investigation is the quasi 2D compound $Pb_3Mn_7O_{15}$. Both ex-

isting models describing the crystal structure [1,2] were disproved and a new model based on the orthorhombic space group *Pnma* could be identified. Magnetisation measurements give evidence of strong antiferromagnetic correlations. A huge step at $T = 70$ K indicates a 3D long range ordered state and a second smaller step at $T = 20$ K is interpreted as reorientation of some moments due to a variation of the magnetic anisotropy with temperature. Neutron single crystal and powder diffraction measurements revealed two magnetic phases in PbO-MnO_2-Mn_2O_3 indicating the presence of different oxidation states. The disappearance of magnetic peaks at $T = 20$ K and $T = 70$ K coincides with the magnetisation measurement. [1] R. E. Marsh, and F. H. Herbstein, Acta Cryst. B **39**, 280 (1983). [2] Y. Le Page, and L. D. Calvert, Acta Cryst. C **40**, 1787 (1984).

MA 10.6 Mon 16:30 H 1028

Incommensurate Spin Ordering and Fluctuations in Underdoped $La_{2-x}Ba_xCuO_4$ — •Sarah Dunsiger[1], Yang Zhao[2], Bruce Gaulin[2], Hanna Dabkowska[2], Zahra Yamani[3], William Buyers[3], Yiming Qiu[4], John Copley[4], Yvan Sidis[5], and Philippe Bourges[5] — [1]Physics Department E21, Technical University of Munich, D-85748 Garching, Germany — [2]Department of Physics and Astronomy, McMaster University, Hamilton, ON, Canada — [3]Canadian Neutron Beam Centre, NRC, Chalk River Laboratories, Chalk River, ON, Canada — [4]National Institute of Standards and Technology, Gaithersburg, Maryland, USA. — [5]Laboratoire Léon Brillouin, CEA-Saclay, 91191 Gif-sur-Yvette Cedex, France.

The diverse magnetic properties of the $La_{2-x}(Sr,Ba)_xCuO_4$ transition metal oxides may be tuned in a controllable way by doping with mobile holes. In one interpretation, the holes are believed to organise into correlated static or dynamic stripes. We report the first observation of static *incommensurate* spin ordering in underdoped $La_{2-x}Ba_xCuO_4$ (x=0.025, 0.05, 0.08) using neutron diffraction. Elastic collinear incommensurate peaks are observed below the superconducting transition (T_C ∼27 K) in $La_{2-x}Ba_xCuO_4$ (x=0.08). In marked contrast, diagonal satellite peaks have been observed at low temperature in positions rotated by 45° within the (HK0) plane for $La_{2-x}Ba_xCuO_4$ (x∼0.025, 0.05). Our neutron scattering results are compared with analogous studies on $La_{2-x}Sr_xCuO_4$ which indicate that such a rotation of the spin structure may be a generic feature of the underdoped La-214 cuprates.

MA 10.7 Mon 16:45 H 1028

Electronic, magnetic, and transport properties of quaternary (Cu,Ni)MnSb Heusler alloys — •Josef Kudrnovsky[1], Vaclav Drchal[1], Peter Weinberger[2], and Patrick Bruno[3] — [1]Institute of Physics AS CR, Prague — [2]Computational Materials Science Center, Vienna — [3]Max-Planck Institut, Halle

Heusler alloy NiMnSb is ferromagnetic halfmetal while its counterpart CuMnSb is the antiferromagnet. The concentration dependence of the the total magnetic moment (resistivity) exhibits a dramatic decrease (increase) with increasing Cu-concentration starting from about 70% of Cu. On the other hand, the Curie temperature decreases monotonically with the Cu-content. We present the first-principles study of the concentration dependence of magnetic moments, Curie temperatures, and residual resistivities. Results are in a fair agreement with available experimental data. The electronic origin of the observed concentration trends will be also discussed.

MA 10.8 Mon 17:00 H 1028

Magnetocaloric effect in nickel rich Ni-Mn-Ga Heusler alloys — Kalyan Mandal[1,2], Julia Lyubina[2], Debabrata Pal[1], Nils Scheerbaum[2], and •Oliver Gutfleisch[2] — [1]Magnetism Laboratory, S. N. Bose National Centre for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata 700 098, India — [2]Leibniz Institute für Festkörper- und Werkstoffforschung Dresden (IFW Dresden), Institut für Metallische Werkstoffe, Postfach 270116, 01171 Dresden, Germany

Heusler alloys with nickel-rich compositions Ni(2+x)Mn(1-x)Ga (x=0.16, 0.18, 0.20, 0.22, 0.24, 0.26) have been prepared by arc-melting and subsequent annealing. A large magnetic entropy change, |DS| ˜96 J/Kg.K has been observed around 291 K for the composition Ni(2.22)Mn(0.78)Ga where the martensite-austenite structural transition almost coincides with ferromagnetic-paramagnetic magnetic transition. The effect of hydrostatic pressure up to 8kbar on martensitic transition, magnetic transition and magnetocaloric effect has been studied. The martensitic transition temperature as well as the Curie temperature Tc was found to increase whereas |DS| decreases slightly due to the application of hydrostatic pressure. The large hysteresis observed in M vs H curve at ambient pressure was reduced significantly at 8kbar.

MA 10.9 Mon 17:15 H 1028

Mößbauer spectroscopy of $Co_2Mn_{1-x}Fe_xAl$. — •Verena Jung, Gerhard H. Fecher, Benjamin Balke, Vadim Ksenofontov, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

Heusler compounds have been recognized as suitable materials for magneto-electronics. The Co_2 based compounds are of special interest for applications as they exhibit a wide range of magnetic properties and Curie temperatures up to 1100 K. In this work solid solutions of $Co_2Mn_{1-x}Fe_xAl$ with $x = 0, 0.1, \ldots, 1$ were prepared by arc melting and annealed for 7 days at 800°C. The structure was characterized by XRD and a single $B2$ phase was found over the entire range of compositions. The magnetic properties were measured with a SQUID magnetometer revealing that the moments are higher than expected for half-metallic ferromagnetism. The local environment and hyperfine magnetic fields of the iron atoms were studied by ^{57}Fe Mößbauer spectroscopy in transmission geometry at room temperature for $Co_2Mn_{1-x}Fe_xAl$ samples with $x = 0.2 \ldots 1$. The obtained spectra are explained by hyperfine magnetic field distributions implying 7 contributions with different values and line widths in agreement with the local structure in the cubic lattice. A shift of the relative intensities of the seven hyperfine magnetic fields is explained by the appearance of an additional ordered portion with $L2_1$ structure for samples with Fe concentrations of $x > 0.7$ not being detected by XRD.

The authors gratefully acknowledge financial support by the DfG (Research Unit 559).

MA 10.10 Mon 17:30 H 1028

High energy high resolution photoemission from Heusler compounds in half tunnelling-junctions. — •Andrei Gloskovskii[1], Benjamin Balke[1], Siham Ouardi[1], Gerhard H. Fecher[1], Claudia Felser[1], and Masafumi Yamamoto[2] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz — [2]Graduate School of Informatic Science and Technology, Hokkaido University, Sapporo, Japan.

This work reports on high resolution photoelectron spectroscopy from the valence band of buried Co_2MnSi thin films excited by photons of about 5.9 keV energy. The measurements were performed on Co_2MnSi thin films covered by $MgO(z)/AlO_x(1nm)$ with different thickness z from 2 nm to 20 nm of the MgO interlayer. The film structure corresponds to half a tunnelling magnetoresistive (TMR) junction. It is shown that the high energy spectra reveal the bulk electronic structure of the Heusler compound close to the Fermi energy even through the MgO layer. The high resolution measurements of the valence band close to the Fermi energy indicate a very large electron mean free path of the electrons through the MgO layer. The spectra of the buried thin films agree well with previous measurements from bulk samples.

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MA 10.11 Mon 17:45 H 1028

Effect of hydrostatic pressure on the magnetic and magnetocaloric properties of La(Fe,Si)$_{13}$-type alloys — •Julia Lyubina, Konstantin Nenkov, Kalyan Mandal, Oliver Gutfleisch, and Ludwig Schultz — IFW Dresden, Institute for Metallic Materials, Helmholtzstr. 20, 01069 Dresden, Germany

The magnetic refrigeration based on the magnetocaloric effect (MCE) is becoming a promising technology to replace the conventional gas-compression/expansion technique. The MCE is the emission or absorption of heat in response to a changing magnetic field and is present in all magnetic materials. A very promising magnetic refrigerator is the $La(Fe,Si)_{13}$ compound, as it shows a giant MCE near room temperature due to a first-order magnetic phase transition. Among important advantages of $LaFe_{13-x}Si_x$ alloys are the reduced hysteresis in melt-spun ribbons[1], the abundance of main constituents and the possibility of adjusting the Curie point T_c by varying x and/or by hydrogenation [2]. In this work, $LaFe_{11.8}Si_{1.2}$ and $LaFe_{11.6}Si_{1.4}$ alloys prepared by melt-spinning and subsequent annealing at 1000 °C/1 h have been studied. The effect of hydrostatic pressure up to 10 kbar on the Curie temperature and itinerant electron metamagnetic transition has been investigated. On applying pressure, a shift of T_c to lower temperatures at a rate of 13 K/kbar is observed. Moreover, it leads to a gradual change from the first- to second-order-type transition. The influence of pressure on the MCE is discussed. [1] O. Gutfleisch et al., J. Appl.

Phys. 97 (2005) 10M305. [2] K. Mandal et al., J. Magn. Magn. Mater. 290-291 (2005) 673.

MA 10.12 Mon 18:00 H 1028

Variation of the Si content and its influence on the structure of rare-earth silicides — •Tilmann Leisegang[1], Torsten Weissbach[1], Julia Dshemuchadse[1], Christian Graf[2], Thomas Doert[2], Enrico Faulhaber[3], Matthias Frontzek[3], Oliver Stockert[4], Dimitri Souptel[5], Günter Behr[5], Hirale S. Jeevan[4], Christoph Geibel[4], and Dirk C. Meyer[1] — [1]Institut für Strukturphysik — [2]Institut für Anorganische Chemie — [3]Institut für Festkörperphysik — [4]Max-Planck-Institut f. Chemische Physik fester Stoffe — [5]Leibniz-Institut für Werkstoffforschung; Dresden, Germany

Rare-earth silicides (RES) exhibit a large variety of interesting low temperature physical properties depending on the Si content. $CeSi_2$, as an example, exhibits ferromagnetic ordering at low and Kondo behavior at higher Si content. As another example, in $CeCu_2Si_2$, a heavy Fermion compound, the variation of the Si content can result in dominant antiferromagnetic behavior (Si excess) or superconductivity (Si deficiency). To investigate the influence of the Si content on the crystal structure of several RES and to correlate these results with the physical properties, single crystals with certain compositions were synthesised. The investigations were performed by means of single crystal X-ray diffraction and X-ray absorption spectroscopy at ambient conditions. Modulated structures due to vacancy ($CeSi_{1.82}$) and atom (Ho_2PdSi_3) ordering were observed as well as specific additional maxima within electron density maps ($CeCu_2Si_2$) indicating stacking fault defects.

We thank the DFG within the SFB 463 for financial support.

MA 10.13 Mon 18:15 H 1028

Magnetism of the high spin molecules $[Mn_4L_6](BF_4)_2{\cdot}2CH_3CN{\cdot}H_2O$ and $[Cr^{III}Mn^{II}_3(PyA)_6Cl_3]$ — •Manuel Prinz[1], Michael Raekers[1], Karsten Kuepper[2], Phalguni Chaudhuri[3], Simon J. George[4], and Manfred Neumann[1] — [1]Universität Osnabrück, Fachbereich Physik, Barbarastr. 7, D-49069 Osnabrück — [2]FZ Dresden-Rossendorf, Dresden, Germany — [3]MPI, Mülheim an der Ruhr, Germany — [4]LBNL, Berkeley, CA, USA

We have studied the electronic and magnetic structure of high spin molecules by spectroscopic investigations in combination with theoretical calculations. We present results on $[Mn^{II}_4L_6](BF_4)_2{\cdot}2CH_3CN{\cdot}H_2O$ (**Mn_4**)and the hetero nuclear, spin frustrated molecule $[Cr^{III}Mn^{II}_3(PyA)_6Cl_3]$ (**$CrMn_3$**), which have been studied using X-ray photoelectron spectroscopy (XPS), X-ray absorption and emission spectroscopy (XAS, XES), and X-ray magnetic circular dichroism (XMCD). Magnetic measurements of **Mn_4** show a magnetization saturation of about 20 μ_B/f.u. at a magnetic field of $B = 7$ T and a temperature of $T = 2$ K. From XMCD measurements of **Mn_4** at $T = 5$ K and $B = 5$ T we obtained a high magnetic moment of 18.5 μ_B/f.u, whereas a quenching of the Mn orbital moments was observed ($m_{\rm orb} = 0.4$ μ_B/f.u.). The element selective Mn^{II} and Cr^{III} dichroic signals of the **$CrMn_3$** complex at $B = 5$ T and $T = 5$ K where recorded. For the three Mn^{II} ions a magnetic moment of ≈ 15 μ_B was determined. For both complexes we will present a comparison to XAS/XMCD charge transfer multiplet calculations.

MA 11: Spindependent Transportphenomena II

Time: Monday 15:15–17:30 Location: H 0112

MA 11.1 Mon 15:15 H 0112

Current-induced domain wall motion and vortex core displacements — •Lutz Heyne[1], Dirk Backes[1,2], Stephen Krzyk[1], Mathias Kläui[1], Ulrich Rüdiger[1], Laura Heyderman[2], Arantxa Fraile-Rodriguez[2], Frithjof Nolting[2], Miguel Nino[3], Tevfik Mentes[3], Andrea Locatelli[3], Konstantin Kirsch[4], and Roland Mattheis[4] — [1]Universität Konstanz, 78457 Konstanz, Germany — [2]Paul Scherrer Institut, 5232 Villigen, Switzerland — [3]Sincrotrone Trieste, 34012 Trieste, Italy — [4]Institute of Photonic Technology, 07702 Jena, Germany

The feasibility of the manipulation of magnetic domains by spin-polarized current injection is of great scientific interest and has large potential for applications. Theoretically the influence of the current is described by an adiabatic and a non-adiabatic term added to the Landau-Lifshitz-Gilbert equation of motion. Here especially the magnitude of the non-adiabatic term is currently much under debate.

We present new results on current induced domain wall motion. Direct X-ray photoemission electron microscopy imaging has been used to probe the magnetization configuration. In Permalloy wires we observe spin-torque induced domain wall transformations from vortex walls to transverse walls and vice versa. These transformations agree with predictions made by theory for the non-adiabatic term mentioned above. Furthermore we observe current induced vortex core displacements in magnetic disks. It is shown that the direction of the displacement depends on the vortex core polarity, i.e. the direction of the out-of-plane vortex core magnetization component.

MA 11.2 Mon 15:30 H 0112

Field- and current-induced single domain wall motion in Permalloy nanowires — Philipp Möhrke[1], Thomas Moore[1], •Mathias Kläui[1], Stephen Krzyk[1], Dirk Backes[1,2], Laura Heyderman[2], and Ulrich Rüdiger[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]Paul Scherrer Institut, 5232 Villingen PSI, Switzerland

Current-induced domain wall (DW) motion in ferromagnetic nanowires has been found to be a stochastic process. Therefore single shot measurements, rather than static imaging or averaging techniques, are needed in order to gain a full understanding of this phenomenon.
We present measurements of field- and current-induced single DW dynamics in Permalloy ($Ni_{80}Fe_{20}$) nanowires (thickness ∼20 nm, width down to 400 nm) by nanosecond time-resolved focused MOKE. The velocity of an individual DW is captured at various positions on the nanowire. By repeatedly preparing and probing a DW of specific spin structure, velocity distributions with high statistics are gathered. The most probable velocity in 1500 nm wide wires measured at a location 10 μm from the starting position at fields close to the depinning field of ∼10 G was ∼70 m/s, but velocities up to a few 100 m/s occur. The velocity distributions allow quantitative information about the DW motion to be extracted, such as the variation of the pinning field amplitude along the wire or the fluctuation of the DW velocity.
Support by the DPG within the SPP1133 and the EU (Human Resources and Mobility Programme) is acknowledged.

MA 11.3 Mon 15:45 H 0112

Time-dependent spin transport through ferromagnet-metal junction — •Yao-Hui Zhu and Hans Christian Schneider — Physics Department, Kaiserslautern University of Technology, Germany

Time-dependent spin transport is studied theoretically for magnetic multilayers using a dynamical version of the Valet-Fert theory [1]. Starting from a Boltzmann transport equation we find the equivalent of a telegraph equation for the spin current. The wave character inherent in this type of equation enables us to define a finite propagation velocity for spin-switching processes. We show that spin diffusion can be regarded as an approximation of the diffusion-wave behavior of spin transport in the long-time limit. We analyze magnetization switching, current reversal and alternating currents for ferromagent-normal metal contancts.

[1] T. Valet and A. Fert, Phys. Rev. B. 48, 7099 (1993).

MA 11.4 Mon 16:00 H 0112

In situ magnetoresistance measurements of FIB- milled nanoconstrictions — •Daniel Stickler[1], André Kobs[1], Genhua Pan[2], and Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]CRIST, Faculty of Technology, University of Plymouth, Plymouth, Devon PL4 8AA, UK

Several fundamentally and technologically interesting physical effects emerge when spin polarized currents in ferromagnets pass through a laterally confined domain wall. We perform in situ structuring and consecutive magnetoresistance measurements utilizing a micromanipulator in our UHV FIB/SEM dualbeam system. The flexibility of FIB structuring is used to carve microstructures, which exhibit different micromagnetic behaviour, into a thin 30nm permalloy film, capped with

3nm Pt. In CIP (current in plane) geometry, the magnetoresistance of a constriction connecting two elliptical microstructures is measured. The magnetic vortex structure in the two permalloy structures induces a domain wall in the constriction. In a sequence of measurements with the same film, the width of the constriction was varied from sub-20nm to 200nm. The size dependence of the magnetoresistance will be presented and discussed with respect to the field induced magnetic fine structure in the adjacent microstructures. Financial support by the EU via EU04-586 BMR is gratefully acknowledged.

MA 11.5 Mon 16:15 H 0112

Effects of Ga^+ irradiation on the magnetotransport in NiFe — •André Kobs, Daniel Stickler, Matthias Scholz, Germar Hoffmann, and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The influence of irradiation by 30 keV Ga^+ on Pt capped NiFe wires were studied and quantified with in situ magnetotransport measurements. The wires were milled from 33 nm thick film and then irradiated with 30 keV Ga^+ varying the dose from $5 \cdot 10^{14}$ to $1 \cdot 10^{17}$ Ions/cm^2 using focused ion beam (FIB). The magnetoresistance (MR) behaviour of the structures was determined in current-longitudinal-to- and current-transversal-to-applied-field-geometry via in situ measurements utilizing a micromanipulator. The NiFe wires exhibit the typical anisotropic MR. In the transversal setup an enhancement of ΔR up to doses of $8 \cdot 10^{15}$ Ions/cm^2 in comparison to the untreated NiFe was observed. For higher doses an exponential decrease of ΔR with dose occurred. The increase of the resistance on ion bombardment can be explained with impurity scattering caused by gallium implantation and intermixing of Pt and NiFe, roughening of surface and material removal. The rate of material removal and the root-mean-square roughness have been determined by means of atomic force microscopy (AFM). The changes of composition were monitored by energy-dispersive x-ray spectroscopy (EDX). The magnetic properties were investigated by longitudinal magneto-optical Kerr effect (MOKE). The results of the latter investigation demonstrate the correspondence of features in the magnetisation and MR behaviour.

MA 11.6 Mon 16:30 H 0112

Anomalous Hall effect in epitaxial magnetite thin films — •Andrea Boger, Wolfgang Kaiser, Matthias Opel, Sebastian T. B. Goennenwein, and Rudolf Gross — Walther-Meissner-Institut, BayerischeAkademie der Wissenschaften, 85748 Garching, Germany

The ferrimagnet Fe_3O_4 is an attractive candidate for spintronic devices due to its Curie temperature of about 860 K, and a high spin polarization of $P \leq -(55 \pm 10)\%$ [1]. Although magnetite is already in the focus of research for decades, the anomalous Hall effect of epitaxial thin films, in particular the dependence of the transverse conductivity σ_{xy} on the longitudinal conductivity σ_{xx}, has not yet been studied in detail.

We have grown epitaxial Fe_3O_4 thin films in three different crystalline orientations by pulsed laser deposition. X-ray diffractometry proves the high crystalline quality of the films, demonstrated by a FWHM of the rocking curves of the (004), (440) and (222)-reflection of only 0.04° for (001), (110) and (111) orientation, respectively. Electrical transport measurements were performed at temperatures between 90 K and 375 K at magnetic fields up to 14 T. We have found that σ_{xy} is proportional to σ_{xx}^{β} with $\beta \simeq 1.6$ for (001) and (111) orientation. In contrast, (110) oriented samples show a change, likely due to the Verwey transition [2], from $\beta = 1.5$ below 120 K to $\beta = 1.8$ above.

[1] M. Fonin et al., Phys. Rev. B **72**, 104436 (2005)
[2] E. J. W. Verwey, Nature **144**, 327-328 (1939)

This work is supported by the DFG via priority program 1157.

MA 11.7 Mon 16:45 H 0112

Electronic structure and its influence on the magnetic properties of uranium ternaries UTM — •Malgorzata Samsel-Czekala — Leibniz-Institut für Festkörper- und Werkstoffforschung, IFW Dresden, PF 270116, D-01171 Dresden, Germany — Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P.O. Box 1410, 50-950 Wrocław 2, Poland

The electronic structure of uranium UTM compounds, where (T = Ru, Ir; M=Al, Ga, Si), is reviewed. The obtained results of band-structure calculations, employing the modern full-potential local-orbital (FPLO) minimum basis code [1], are compared with experimental data of x-ray photoelectron spectroscopy (XPS) and transport and magnetic properties, obtained for single-crystalline samples [2,3]. Good agreement is achieved between theoretical and experimental results, showing a high degree of 5f electrons delocalization in these compounds. Such phenomena as spin fluctuation or Kondo-like behavior have been revealed in the experiments.

[1] FPLO-5.00-18 (improved version of the original FPLO code by K. Koepernik and H. Eschrig, Phys. Rev. B **59**, 1743 (1999)]; http://www.FPLO.de;
[2] M. Samsel-Czekała, E. Talik, R. Troć, J. Stepien-Damm, submitted to Phys. Rev. B.
[3] M. Samsel-Czekała, E. Talik, R. Troć, to be published.

MA 11.8 Mon 17:00 H 0112

Giant magnetoresistance and extraordinary magnetoresistance in inhomogeneous semiconducting *RE*NiBi compounds — •Frederick Casper and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

Some inhomogeneous semiconducting $C1_b$ compounds *RE*NiBi (*RE* = Gd, Dy, Er) show a negative giant magnetoresistance (GMR) above the magnetic ordering temperature in the paramagnetic temperature regime. Except for a weak deviation, this magnetoresistance scales roughly with the square of the magnetization in the paramagnetic state, and is related to the metal-insulator transition. At low temperature, a positive magnetoresistance is found, which can be suppressed by high magnetic fields. The nonmagnetic inhomogeneous semiconducting compound LuNiBi shows a large postitve MR ratio of 25% at room temperature. The positive MR may be due to metallic bismuth impurities in the sample that cause an extraordinary magnetoresistance (EMR).

This work was supported by DFG grant FE633/1-1 within SPP1166

MA 11.9 Mon 17:15 H 0112

Electrical Nonlinearity in Manganite Films — •Vasily Moshnyaga[1], Kai Gehrke[1], Lakshmana Sudheendra[1], Stephanie Raabe[1], Konrad Samwer[1], Alexandr Belenciuc[2], Oleg Shapoval[2], Oleg I. Lebedev[3], and Gustaaf van Tendeloo[3] — [1]I. Physikalischers Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Institute of Applied Phyiscs, Academiei 5, MD-2028, Chisinau, Moldova — [3]EMAT, University of Antwerp, Groeneborgerlaan 171, B-2020 Antwerpen, Belgium

We address the nature of nonlinear electrical 3rd harmonic voltage in epitaxial La0.7Ca0.3MnO3 (LCMO) and La0.7Sr0.3MnO3(LSMO) manganite films. In LCMO the nonlinearity is strongly enhanced only close to the para-ferromagnetic phase transition (Tc=270 K) and can be suppressed by magnetic field, showing very large nonlinear CMR˜10(5) %. In the low temperature ferromagnetic metallic state the nonlinearity is small, -90 dB, and comparable to that for a metallic resistor. In contrast, LSMO is an essentially linear metallic material in the whole range of temperatures, T=4-400 K, and magnetic fields, B=0-5T. Such an intrinsic nonlinear behaviour is consistent with the temperature dependence of correlated polarons in LCMO and the absence of correlated polarons in LSMO.

MA 12: Invited Talk Blügel / joint session O & MA

Time: Tuesday 9:30–10:15 Location: HE 101

Invited Talk MA 12.1 Tue 9:30 HE 101

Electrons at Surfaces Taking an Unexpected Turn — •Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich, Germany

Electrons in the vicinity of surfaces are in a space asymmetric environment. This causes a number of interesting phenomena, like the Rashba spin-orbit effect [1], spin-depending scattering [2] and spin-polarized electrons [3] at non-magnetic surfaces, which little attention had been paid to in the past. For electrons at magnetic surfaces, thin films and nanostructures also time-inversion symmetry is broken. This can give

rise to an unidirectional exchange interaction, known as Dzyaloshinsky-Moriya (DM) interaction. Although this interaction, favoring spatially rotating spin structures, is known for nearly 50 years, its consequences for the magnetic structure in low-dimensional magnets remained basically unexplored. We show by *ab initio* calculations that the DM interaction can cause homochiral magnetic phases at achiral surfaces – phases, which had been overlooked during the past 20 years – but have been observed recently in terms of a left rotating cycloidal spiral for Mn on W(110) [4]. Theoretical models [5] display a rich phase diagram of possible magnetic phases. At the end, I will present arguments motivating the search for the existence of a lattice of nano-skyrmions.

[1] Yu. M. Koroteev *et al.*, Phys. Rev. Lett. **93**, 046403 (2004).
[2] J.I. Pascual *et al.*, Phys. Rev. Lett. **93**, 196802 (2004).
[3] T. Hirahara *et al.*, Phys. Rev. Lett. **97**, 146803 (2006).
[4] M. Bode *et al.*, Nature **447**, 190 (2007).
[5] M. Heide *et al.*, submitted to Phys. Rev. B.

MA 13: Surface Magnetism

Time: Tuesday 10:30–13:15 Location: EB 301

MA 13.1 Tue 10:30 EB 301

Advances in Magnetic Exchange Force Microscopy — •Schwarz Alexander, Kaiser Uwe, Schmidt Rene, and Wiesendanger Roland — Department Physik, Institut für Angewandte Physik, Universität Hamburg, Jungíusstr. 11, 20355 Hamburg

Recently, the feasibility of magnetic exchange force microscopy (MExFM), which allows to visualize magnetic structures with atomic resolution, has been demonstrated [1]. This novel technique utilizes a force microscopy set-up to detect the short-ranged magnetic exchange interaction between two atomic magnetic moments (spins) residing on an atomically sharp tip as well as on the probed surface. Atomically resolved data obtained with an iron coated tip on two very different antiferromagnetic systems are compared: (i) a 3D insulator with localized spins that are coupled via superexchange and (ii) a 2D metallic bandferromagnet with delocalized spins coupled via itinerant exchange. In (i) latter case, a direct exchange between tip and sample spins at small separations seems to be necessary to observe a magnetic signal. For system (ii) the magnetic signal appears to be stronger and detectable at larger separations. Both systems exhibit a peculiar interplay of chemical and magnetic interactions, because they are approximately of the same range.

[1] U. Kaiser, A. Schwarz, R. Wiesendanger, Nature **4**46, 522 (2007).

MA 13.2 Tue 10:45 EB 301

Ab initio calculation of symmetric and antisymmetric exchange parameters — •Marcus Heide, Gustav Bihlmayer, and Stefan Blügel — Institut für Festk"orperforschung (IFF), Forschungszentrum Jülich

A simple approximation to the energy of a spin configuration is the classical Heisenberg model $E = \sum_{i,j} J_{i,j}\, \mathbf{S}_i^\dagger\, \mathbf{S}_j$. It's exchange integrals $J_{i,j}$ are dominated by non-relativistic effects. Staying within a bilinear approximation but accounting for spin-orbit coupling effects, the model can be generalized by $E = \sum_{i,j} \mathbf{S}_i^\dagger\, \mathsf{M}_{i,j}\, \mathbf{S}_j$ with the 3×3 matrices $\mathsf{M}_{i,j}$ [1]. This matrices contain terms describing the symmetric and antisymmetric (Dzyaloshinskii-Moriya) exchange as well as the magnetocrystalline anisotropy.

In this talk, we focus on thin magnetic surface films of hexagonal geometry and estimate the matrices $\mathsf{M}_{i,j}$ from first principles. Thereby, we employ spin-spiral calculations in order to obtain the exchange terms. The resulting ground states are discussed within our model ansatz.

[1] T. Moriya, Phys. Rev. **120**, 91 (1960)

MA 13.3 Tue 11:00 EB 301

Dzyaloshinskii-Moriya interaction driven non-collinear magnetic order of a Mn monolayer on W(001) — •Paolo Ferriani[1], Elena Vedmedenko[1], Kirsten von Bergmann[1], Stefan Heinze[1], Marcus Heide[2], Gustav Bihlmayer[2], Matthias Bode[1], Andre Kubetzka[1], Roland Wiesendanger[1], and Stefan Blügel[2] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

The Dzyaloshinskii-Moriya (DM) interaction, arising from inversion symmetry breaking, has been found to play a crucial role at nanostructure surfaces, as recently established by the discovery of chiral magnetic order in ultrathin films [1]. Such interaction, favouring non-collinear magnetism, competes with the Heisenberg exchange and the magnetic anisotropy, leading to a complex magnetic phase space [2] that is so far largely unexplored. Here, we investigate the magnetic state of one monolayer Mn/W(001), based on density functional theory and Monte Carlo calculations. Using the full-potential linearized augmented plane wave method, we find that the DM interaction stabilizes a spin-spiral state on the nanometer scale. Monte Carlo simulations of the domain boundary between spirals propagating along equivalent crystallographic directions show the formation of intriguing labyrinth structures. The theoretical results are in agreement with spin-polarized scanning tunneling microscopy measurements.

[1] M. Bode *et al.*, Nature **447**, 190 (2007).
[2] Rößler *et al.*, Nature **442**, 797 (2006).

MA 13.4 Tue 11:15 EB 301

Giant positive magneto-crystalline anisotropy in ferromagnetic Mn/W(001) overlayer. — Martin Ondračeк, Alexander Shick, •František Máca, and Tomas Jungwirth — Institute of Physics ASCR, Prague, Czech Republic

Proposal of the ferromagnetic (FM) ground state for Mn monatomic overlayer on W(001) is reported recently by Ferriani *et al.* [1] on the basis of first-principles calculations. We study the magneto-crystalline anisotropy (MAE), spin (M_S) and orbital (M_L) magnetic moments, and tunneling anisotropic magneto-resistance (TAMR) of FM-Mn/W(001). The anisotropic properties of Mn/W(001) were investigated making use of the relativistic version of the FP-LAPW method [2], in which SO coupling is included in a self-consistent second-variational procedure. The magnetic force theorem was used to evaluate the MAE and the DOS anisotropy.For the Mn atom, out-of-plane $M_S = 3.18\mu_B$ and $M_L = 0.09\mu_B$ are calculated. There is a strong induced W-interface $M_S = -0.34\mu_B$ and $M_L = -0.06\mu_B$. The spin and orbital polarizations of W are quickly decaying away from the interface, showing slow oscillations. When the magnetization is rotated in-plane, there is no anisotropy in M_S, and a pronounced reduction of in-plane M_L. Accordingly, the very big positive MAE of 5.6 meVper Mn-atom is calculated, which is shown to originate from the W contribution. In addition, the TAMR is estimated from the densities of states anisotropy. [1] Ferriani P., Heinze, S., Bihlmayer, G., Blügel, S., Phys. Rev. **B 72** (2005), 024452. [2] A.B. Shick, D.L. Novikov, and A.J. Freeman, Phys. Rev. B **56**,R14259 (1997).

MA 13.5 Tue 11:30 EB 301

Ab-initio simulation of magnetic exchange force microscopy of antiferromagnetic Fe/W(001) — •Cesar Lazo[1], Vasile Caciuc[2], Hendrik Hölscher[3], and Stefan Heinze[1] — [1]Institute of Applied Physics, University of Hamburg, Hamburg, Germany — [2]Institute of Physics, University of Münster, Germany — [3]Center for Nanotechnology, University of Münster, Germany

Magnetic exchange force microscopy (MExFM) is a promising new technique to perform magnetic imaging with atomic resolution by measuring the magnetic exchange force between a magnetically coated tip and a magnetic sample [1]. Here, we apply density functional theory using the full-potential linearized augmented plane wave (FP-LAPW) method to investigate the exchange forces on the antiferromagnetic monolayer Fe on W(001) [2]. We use an Fe cluster as a tip model and include relaxations of the cluster and the surface. Interestingly, relaxation effects of tip and sample depend sensitively on the local magnetic configuration. Therefore, relaxations play a crucial role for the magnetic signal. In particular, the onset of the exchange forces is shifted to larger distances, which facilitates their experimental observation. Based on the calculated force-distance curves we simulate MExFM images which display a competition of chemical and magnetic forces.

[1] U. Kaiser et al., Nature 446, 522 (2007).
[2] A. Kubetzka et al., Phys. Rev. Lett. 94, 087204 (2005).

MA 13.6 Tue 11:45 EB 301

High wave vector spin waves in 1 ML Fe/W(110) — •Jacek Prokop, Yu Zhang, Wen Xin Tang, Ioan Tudosa, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

We report on a first observation of the high wave vector spin wave (SW) excitations in the ferromagnetic Fe monolayer (ML) epitaxially grown on a W(110) single crystal. Using a spin-polarized electron energy loss spectroscopy (SPEELS) we measured a spin wave dispersion along the [001] direction. The ML Fe was deposited at room temperature (RT), and annealed at 900 K in ultrahigh vacuum (UHV) condition. The SPEELS measurements were performed at 120 K. The SW excitations show up as fine unique features emerging from an elastic peak shoulder in the minority electron spectrum. The measured asymmetry for the Fe ML magnon peaks achieves 30 %. The magnons in the iron ML are much softer than that in the bulk Fe, and those in the 2 ML Fe/W(110) film [1]. We show that the energies of the SW excitations in the Fe ML are also lower than the surface mode of the bcc Fe(110) surface, and the SW are strongly damped. The obtained results will be discussed and compared with the existing calculations performed within the itinerant electron theory.

[1] W. X. Tang, Y. Zhang, I. Tudosa, J. Prokop, M. Etzkorn, and J. Kirschner, Phys. Rev. Lett. 99, 087202 (2007).

MA 13.7 Tue 12:00 EB 301

Unique playground for non-collinear magnetism : Fe monolayers on hexagonal transition-metal surfaces — •Börn Hardrat, Paolo Ferriani, and Stefan Heinze — Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

Recently, the complexity of magnetic order even in simple systems such as single monolayer (ML) thick magnetic films on non-magnetic substrates has been dramatically demonstrated by the discovery of a spin-spiral state for a Mn ML on W(110) [1] and a nanoscale magnetic structure for an Fe ML on Ir(111) [2].

Here, we use density functional theory calculations based on the full-potential linearized augmented plane wave (FLAPW) method to systematically study the magnetic order of an Fe ML on hexagonal hcp (0001) and fcc (111) surfaces of 4*d*- and 5*d*-TMs. We demonstrate that due to substrate *d*-band filling the exchange coupling changes gradually from antiferromagnetic (AFM) on Tc, Ru, Re, and Os to ferromagnetic (FM) on Rh, Ir, Pd, Os and Pt. On Ru and Re the AFM coupling leads to a non-collinear Néel ground state due to topological frustration of exchange interaction. On Ru, Rh and Ir, the nearest-neighbor exchange coupling is small and exchange beyond nearest-neighbors, higher order spin interactions, and anisotropic exchange interaction compete making these systems a playground for intriguing magnetic order.

[1] M. Bode *et al.*, Nature **447**, 190 (2007).
[2] K. von Bergmann *et al.*, PRL **96**, 167203 (2006).

MA 13.8 Tue 12:15 EB 301

Orbital magnetic moment of single Co atom on Pt(111) surface - a view from correlated band theory — •Alexander Shick[1] and Alexander Lichtenstein[2] — [1]Institute of Physics ASCR, Na Slovance 2, Prague, Czech Republic — [2]University of Hamburg, Jungiusstrasse 9, 20355 Hamburg

The electronic and magnetic character of Co adatom on the Pt(111) surface is investigated. The relativistic version of the correlated band theory LSDA+U method (including spin-orbit coupling) is employed to induce the orbital polarization. It is shown that with a reasonable choice of Coulomb-U, LSDA+U calculations give the orbital magnetic moment of Co adatom in a good agreement with experimental XMCD data (P. Gambardella *et al.*, Science 300 (2003) 1130). Both the electron correlation induced orbital polarization and the structural relaxation play an essential role in the orbital moment formation. Microscopic origins of the orbital moment enhancement are discussed.

MA 13.9 Tue 12:30 EB 301

Magnetic Anisotropy of a single Fe atom on Pt(111) — •Tobias Schuh[1], Timofey Balashov[1], Albert F. Takacs[1], Arthur Ernst[2], Sergey Ostanin[2], Jürgen Henk[2], Patrick Bruno[2], Toshio Miyamachi[3], Shigemasa Suga[3], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Universität Karlsruhe (TH), Wolfgang- Gaede Str. 1, 76131 Karlsruhe — [2]MPI für Mikrostrukturphysik, Weinweg 2, 06108 Halle — [3]Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka 560-8531, Japan

The storage of data in modern hard disks relies on the stability of the magnetization of magnetic bits. Reducing the size of the bits allows higher storage density. The smallest bit can be realized by a single atom and its stability by the magnetic anisotropy of the atom.

We used a scanning tunneling microscope to image single Fe atoms on Pt(111) at 4 K. With inelastic tunneling spectroscopy the spin excitations of individual Fe atoms were measured. The excitations were detected in the second derivative of the tunneling current exhibiting a peak and a dip symmetric with respect to the Fermi energy. From the position of the extrema the excitation energy was determined. Assuming a spin of $S = 1\hbar$ for the Fe atom, the excitation energy is found to be identical to the uniaxial magnetic anisotropy.

We determined the magnetic anisotropy to 5.7±0.1 meV per atom in good agreement to XMCD measurements of single Co atoms on Pt(111) [1]. The experimental energy is compared with theoretical calculations.

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

MA 13.10 Tue 12:45 EB 301

Differences in growth and magnetism between thin Fe films on vicinal and flat Au(111) — •Tobias Allmers and Markus Donath — Physics Institute, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

In this contribution we report on differences in growth behavior and magnetic properties of Fe films deposited on vicinal (v-) and flat Au(111). The different growth mode results in a different magnetic behavior: We found that the transition from out-of-plane to in-plane magnetization as a function of film thickness is delayed for the system Fe/v-Au(111) with respect to Fe/Au(111). Furthermore, we found no distinguished easy in-plane magnetization direction for Fe/Au(111), while the easy in-plane magnetization direction for Fe/v-Au(111) is perpendicular to the step edges. In addition, the spin-dependent electronic structure below and above the Fermi level was investigated with respect to the symmetry character and the sensitivity towards adsorbates of the respective spectral features.

MA 13.11 Tue 13:00 EB 301

Quantitative determination of spin-dependent quasiparticle renormalization in ferromagnetic 3d metals — •Jaime Sánchez-Barriga, Andrei Varykhalov, Jörg Fink, Oliver Rader, Hermann Dürr, and Wolfgang Eberhardt — Bessy GmbH, Albert Einstein str. 15, D-12489, Berlin, Germany

Spin dependent low-energy electronic excitations in 3d ferromagnets are of special interest due to the need of a microscopic understanding of the electronic structure of solids. Low-energy electrons (or holes) become dressed by a cloud of excitations resulting in quasiparticles of a finite lifetime and a different effective mass. These type of excitations have been studied by many theoretical methods, and it has been found that because of many body effects no sharp quasiparticle peaks exist for binding energies larger than 2 eV. Interestingly, it has been shown that strong correlation effects could particularly affect majority spin electrons, leading to a pronounced damping of quasiparticles at binding energies around 2 eV and above. In order to give an experimental corroboration to these findings, we have performed a systematic study of the spin-dependent quasiparticle lifetime and band structure of ferromagnetic 3d transition metal surfaces by means of spin and angle-resolved photoemission spectroscopy. On hcp Co(0001), fcc Ni(111) and bcc Fe(110), we have found a more pronounced renormalization of the majority spin quasiparticle spectral weight going from Ni to Co which are both strong ferromagnets. For Fe, a weak ferromagnet, such a process becomes more prominent in the minority channel.

MA 14: Magnetic Half Metals and Oxides

Time: Tuesday 10:30–13:15 Location: EB 202

MA 14.1 Tue 10:30 EB 202

Onset of magnetic order in 3d transition metal oxides — •Guntram Fischer[1], Ian Hughes[2], Markus Däne[3], Arthur Ernst[3], Wolfram Hergert[1], Julie B. Staunton[2], Martin Lüders[4], Zdzislawa Szotek[4], and Walter Temmerman[4] — [1]Institute of Physics, MLU Halle-Wittenberg, Von-Seckendorff-Platz 1, 06120 Halle — [2]Department of Physics, University of Warwick, Coventry, CV4 7AL, UK — [3]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle — [4]Daresbury Laboratory, Daresbury, Warrington, WA4 4AD, UK

The finite temperature magnetic properties of 3d transition metal oxides (TMO) will be discussed based on ab initio methods. Self-interaction corrections are taken into account in a local implementation (LSIC) within the KKR multiple-scattering theory.[1] The calculation of exchange parameters by means of the magnetic force theorem [2] allows us to calculate the Neel temperatures via Mean Field Approximation, Random Phase Approximation and Monte Carlo simulations. The use of LSIC-KKR in combination with the disordered local moment (DLM) method [3] opens up the alternative to calculate the transition temperatures without any mapping to a Heisenberg model.The results of the different approaches will be compared and discussed. The dependence of the transition temperatures on the lattice constant and the magnon spectra of the TMO will be discussed as well. - [1] M. Lüders et al. Phys. Rev. B, 71, 205109 (2005), [2] A.A. Liechtenstein et al. JMMM, 67, 65 (1987), [3] Gyorffy et al., J. Phys. F: Met. Phys. 15, 1337 (1985)

MA 14.2 Tue 10:45 EB 202

Origin of magnetism in hematite-ilmenite system from first principles — •Hasan Sadat Nabi and Rossitza Pentcheva — Department of Earth and Environmental Sciences, University of Munich, Theresienstr. 41, 80333 Munich, Germany

The high remanent magnetization measured in exsolutions of the canted antiferromagnet hematite (Fe_2O_3) and room-temperature paramagnet ilmenite ($FeTiO_3$) has received considerable attention in recent years[1]. To resolve the microscopic origin of magnetism at the interface of hematite and ilmenite, we have performed density functional theory calculations, varying systematically the concentration, distribution, and charge state of Ti (Fe) in a hematite (ilmenite) host. Our investigation shows that including electronic correlation within the LDA+U approach is decisive to obtain the correct magnetic ground state and band gap of the end members, α-$Fe^{3+}{}_2O_3$ and $Fe^{2+}Ti^{4+}O_3$. We find that Ti substituting for Fe^{3+} in the hematite host is not inert as commonly assumed but plays an active role in compensating the charge mismatch at the interface and the emergence of magnetism: In a single Ti layer in a hematite host, the preferred charge state is Ti^{3+}, Fe^{3+}. As soon as a thicker ilmenite-like block forms, the most favorable compensation mechanism is through Ti^{4+} and a disproportionation in the Fe contact layer in Fe^{2+}, Fe^{3+} giving first theoretical evidence for the *lamellar magnetism hypothesis* [1]. The substitution of Ti (or Fe) in Fe_2O_3 ($FeTiO_3$) leads to impurity levels in the band gap and in some cases to half-metallic behavior.
[1] Robinson, P. *et al.* Nature **418**, 517 (2002).

MA 14.3 Tue 11:00 EB 202

Investigations of the Co_2MnSi/MgO(001) heterojunction - Looking for half-metallicity — •Björn Hülsen[1], Peter Kratzer[2], and Matthias Scheffler[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin — [2]Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

Magnetic memory devices that exploit the tunneling magnetoresistance (TMR) effect depend crucially on the spin polarization of the electrode materials. Ferromagnetic half-metals make perfect electrodes leading to a (theoretically) infinite TMR ratio. The full Heusler alloy Co_2MnSi is predicted to be half-metallic and has recently been integrated in a magnetic tunnel junction[1] where a high TMR value and huge spin polarization have been measured.

Here, we use density functional theory (DFT) calculations to model an epitaxially grown Co_2MnSi/MgO(001) interface as potential TMR device. Different terminations of Co_2MnSi (stoichiometric Co- and MnSi- and non-stoichiometric Mn- and Si- planes) and different registry with respect to the insulating barrier (Mg-top, O-top, bridge, and hollow site) are investigated. For all terminations the O-top site is the stable configuration whereas the bridge site is unstable. By investigating the electronic and magnetic properties we find that the existence of the spin gap depends strongly on the termination. In most cases it is closed by interface states but in one case the half-metallicity is preserved.

[1] M. Oogane *et. al.*, J. Phys. D: Appl. Phys. **39** 834 (2006)

MA 14.4 Tue 11:15 EB 202

Magnetic anisotropy and exchange interaction in Co_2-based Heusler compounds — •Jaroslav Hamrle[1], Oksana Gaier[1], Burkard Hillebrands[1], Horst Schneider[2], Gerhard Jakob[2], Martin Jourdan[2], Yuya Sakuraba[3], Takahide Kubota[4], Mikihiko Oogane[4], and Yasuo Ando[4] — [1]FB Physik and FFSP MINAS, TU Kaiserslautern, Erwin Schrödinger-Str. 56, D-67663 Kaiserslautern, Germany — [2]Institut für Physik, Johannes-Gutenberg-Universität, D-55128, Mainz, Germany — [3]Institute of Materials Research, Tohoku University, 2-1-1 Katahira, Sendai 980-8577, Japan — [4]Graduate School of Engineering, Tohoku University, Aoba-yama 6-6-05, Sendai 980-8579, Japan

Co_2-based Heusler compounds are promising candidates to provide 100% spin polarization. We report on magnetic anisotropy, exchange interaction and magnetization reversal in Co_2FeSi, $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA), Co_2MnSi and $Co_2MnAl_xSi_{1-x}$ Heusler compounds using Mageto-Optical Kerr effect magnetometry and Brillouin ligh scattering spectroscopy. The samples are studied as a function of sample composition, sample ordering and sample thickness. It is shown that inside ordered CCFA or Co_2FeSi films, there is a wide distribution of the internal field, smearing out the internal 4-fold anisotropy and providing a constant coercive field independent of the sample orientation. The values of the exchange stiffness constant for various Heusler compounds are presented. The project was financially supported by the Research Unit 559 "New materials with high spin polarization" funded by the DFG and by the NEDO Programm 2004/T093.

MA 14.5 Tue 11:30 EB 202

Solving the problem of structure determination in 3d transition metal based Heusler compounds. — •Benjamin Balke, Gerhard H. Fecher, Christian Blum, Lubna Basit, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

This work reports on the structural investigation of Fe-containing, Co2-based Heusler compounds (Co_2FeZ with Z = Al, Si, Ga, Ge) using anomalous X-ray diffraction (XRD) and extended X-ray absorption fine structure spectroscopy (EXAFS). Using XRD, it was shown that Co_2FeAl crystallizes in the $B2$ structure whereas Co_2FeSi crystallizes in the $L2_1$ structure. For compounds containing Ga or Ge, the XRD technique with regular laboratory sources for excitation can not be used easily to distinguish the two structures. For this reason, EXAFS was used to elucidate the structure of these two compounds. The absorption experiments close to the K-edges of Co, Fe, Ga, and Ge indicated that both compounds crystallize in the $L2_1$ structure. Exciting the XRD at the K-edges of Co and Fe leads to anomalous X-ray scattering. The dependence of the scattering parameters on the energy close to the absorption edges was used to identify the $L2_1$ structure of the Ga and Ge containing compounds unambiguously. The applicability of the techniques on nano-scaled materials will be demonstrated for the example of Co_2FeGa nano-particles with sizes of below 25 nm.

The authors gratefully acknowledge financial support by the DfG (Research Unit 559).

MA 14.6 Tue 11:45 EB 202

Modification of structural and magnetic properties of Co_2FeSi and Co_2MnSi Heusler compounds by ion irradiation — •Oksana Gaier[1], Jaroslav Hamrle[1], Burkard Hillebrands[1], Horst Schneider[2], Gerhard Jakob[2], Yuya Sakuraba[3], Sumito Tsunegi[3], Mikihiko Oogane[3], Yasuo Ando[3], Jürgen Fassbender[4], Bernhard Reuscher[5], Alexander Brodyanski[5] und Michael Kopnarski[5] — [1]TU Kaiserslautern, 67663 Kaiserlautern — [2]Johannes-Gutenberg-Universität, 55128 Mainz — [3]Tohoku University, Sendai 980-8579, Japan — [4]Forschungszentrum Dresden-Rossendorf, 01328 Dresden — [5]IFOS, TU Kaiserslautern, 67663 Kai-

serslautern

Spin polarization in Co_2FeSi and Co_2MnSi Heusler compounds is believed to be very sensitive to the degree of $L2_1$ order. In thin films, the transition from the disordered to the $L2_1$ ordered phase is usually achieved by an annealing step after film deposition. This procedure, however, is not suitable if local modifications of crystallographic properties are required. In such a case irradiation with keV ions is a convenient tool as reported for FePd and FePt films. Here, we report on the dependence of structural and magnetic properties of thin Co_2FeSi and Co_2MnSi films on the irradiation by 30 keV He^+ and Ga^+ ions.

The project was financially supported by the Research Unit 559 "New materials with high spin polarization"funded by the DFG, by the NEDO International Joint Research Grant Programm 2004/T093 and by the Stiftung Rheinland-Pfalz für Innovation.

MA 14.7 Tue 12:00 EB 202

Magnetism in Re-based ferrimagnetic double perovskites — Andreas Winkler[1], Narendirakumar Narayanan[1], Daria Mikhailova[1], Helmut Ehrenberg[2], Hartmut Fuess[1], Fabrice Wilhelm[3], Andrei Rogalev[3], and •Lambert Alff[1] — [1]Institut für Materialwissenschaft, TU Darmstadt — [2]IFW Dresden — [3]ESRF, Grenoble, France

We have investigated spin and orbital magnetic moments of the Re $5d$ ion in the double perovskites A_2FeReO_6 (A = Ba, Sr, Ca) by X-ray magnetic circular dichroism (XMCD) at the Re $L_{2,3}$ edges. In these ferrimagnetic compounds an unusually large negative spin and positive orbital magnetic moment at the Re atoms was detected. The presence of a finite spin magnetic moment in a 'non-magnetic' double perovskite as observed in the double perovskites Sr_2ScReO_6 proves that Re has also a small, but finite *intrinsic* magnetic moment. These results further support a kinetic energy driven exchange model for the ferrimagnetic double perovskites. We further show for the examples of Ba and Ca that also the usually neglected alkaline earth ions undoubtedly also contribute to the magnetism in the ferrimagnetic double perovskites.

MA 14.8 Tue 12:15 EB 202

Ab initio cluster calculations of Co^{3+} spin states in $RBaCo_2O_{5.5}$ (R=Ho,Gd) — Luidmila Siurakshina[1,2], •Beate Paulus[3], and Viktor Yushankha[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden — [2]Joint Institute for Nuclear Research, 141980 Dubna, Russia — [3]Physikalische und Theoretische Chemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

We investigated the different Cobalt spin-states of two members of oxygen-deficient perovskites $RBaCo_2O_{5.5}$(R=Ho, Gd). These materials are promising compounds for ionic conductors necessary for solid oxide fuel cells. The studies involve ab-initio calculations for clusters at the multi-reference configuration interaction level to describe all spin-states at equal footing. The emphasis is made on the peculiar behaviors of the trivalent ions $Co^{3+}(3d^6)$ in an octahedral and a pyramidal oxygen coordinations, which is related to a structural first-order phase transition in both compounds. Relative energy positions of low spin ($S = 0$), intermediate spin ($S = 1$) and high spin ($S = 2$) cluster electron configurations are calculated for the low- and high-temperature lattice structures of $RBaCo_2O_{5.5}$. The calculated results and experimental structural data are analyzed and comprised in a model that enables us to catch the most prominent features common to the phase transition in both compounds.

MA 14.9 Tue 12:30 EB 202

Influence of MBE growth rate on the structural and magnetic properties of epitaxial NiMnSb layers — •Florian Lochner, Peter Bach, Charles Gould, Christian Kumpf, Georg Schmidt, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

NiMnSb is a promising material for application in future spintronic devices because of its expected half-metallicity and the high Curie temperature of 730 K. In addition, NiMnSb crystallizes in the C_{1b} structure [1] which is compatible to various Zincblende-type III/V semiconductors. We have shown previously that high quality NiMnSb layers can be deposited on (In,Ga)As buffer layers by molecular beam epitaxy [2]. Here we demonstrate that lowering the growth rate from 0.2178 Å/s to 0.0442 Å/s leads to changes in the structural and magnetic properties of the NiMnSb layers. While the interface flatness is reduced, as can be inferred from X-ray diffraction, the line width in ferromagnetic resonance (FMR) decreases, indicating a low damping and high magnetic quality. We will show results of samples deposited on (001) and (111) oriented InP substrates with a thin (In,Ga)As buffer which is almost lattice matched to the NiMnSb. The growth process and structural properties (including relaxation dynamics) are characterized by RHEED patterns and HRXRD measurements, respectively. The magnetic properties are investigated by MOKE and FMR. We acknowledge the support of the EU project Dynamax.

[1] R.A. de Groot et al., Phys. Rev. Lett. **50** (1983) 2024
[2] Peter Bach et al., J. Cryst. Growth **251** (2003) 323-326

MA 14.10 Tue 12:45 EB 202

The local structure of Co_2FeZ (Z=Si, Al, Ga, Ge) Heusler compounds probed by ^{59}Co NMR — •Sabine Wurmehl[1], Jürgen T. Kohlhepp[1], Henk J. M. Swagten[1], Bert Koopmans[1], Marek Wojcik[2], Christian G. F. Blum[3], Benjamin Balke[3], Gerhard H. Fecher[3], Vadim Ksenofontov[3], and Claudia Felser[3] — [1]Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands — [2]Polish Academy of Sciences, 02-668 Warszawa, Poland — [3]Johannes Gutenberg - Universität, 55099 Mainz, Germany

A thorough structural characterisation is one of the key tools in understanding the properties of spin polarised materials as the Heusler compounds Co_2FeZ with Z=(Si, Al, Ge, Ga). Spin echo nuclear magnetic resonance (NMR) spectroscopy provides a tool to probe the local structure by measuring the resonance frequencies and to probe the local hyperfine fields including the unique possibility to resolve the occupation and hyperfine fields of the neighboring shells. Thus, NMR was used to study the local (magnetic) structure of Co_2FeZ (Z=Al, Si, Ga, Ge) Heusler compounds, revealing different types of multiplet resonance lines for different types of Z atoms. The observed splitting of the resonance lines originates from different local environments of the ^{59}Co nuclei. Analysis of the spectra yields the corresponding resonance frequencies and hyperfine magnetic fields as well as the spacing between consecutive resonance lines which leads to macroscopic structural models for the investigated Co_2FeZ Heusler compounds with Z=(Si, Al, Ge, Ga). (This work is funded by the DFG (FG 559) TP1. SW gratefully acknowledges funding by DFG in project WU 595/1-1.)

MA 14.11 Tue 13:00 EB 202

Exotic, anionogenic magnetism in the alkali sesquioxide Rb_4O_6. — •J. Winterlik[1], G. H. Fecher[1], C. Felser[1], C. Mühle[2], M. Jansen[2], L. M. Sandratskii[3], and J. Kübler[4] — [1]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg - Universität, 55099 Mainz — [2]Max - Planck - Institut für Festkörperforschung, 70569 Stuttgart — [3]Max - Planck - Institut für Mikrostrukturphysik, 06120 Halle — [4]Institut fü Festkörperphysik, Technische Universität, 64289 Darmstadt

The chemical formula Rb_4O_6 implies a simple alkali oxide. Taking into account its black color and its mixed valency, things get much more complicated in the case of this so-called rubidium sesquioxide. Up to the present, an accurate description of its electronic structure has not yet been provided. The investigation of temperature dependent magnetic properties indicated p-electron based magnetic frustration. Here, we present experimental results that confirm this proposed magnetic frustration. In addition, we provide a theoretical model for the exceptional crystal of Rb_4O_6. The introduction of electron-electron correlations on the oxygen p-electrons together with the consideration of the broken crystal symmetry that is caused by the mixed valency lead to results that are consistent with the magnetic experiments. According to these calculations, Rb_4O_6 exhibits a highly degenerate ground state with a large number of frustrated non-collinear magnetic configurations.

MA 15: Magnetic Thin Films I

Time: Tuesday 10:30–13:15 Location: H 1012

MA 15.1 Tue 10:30 H 1012

Magnetic properties of ultrathin Fe_3Si films on MgO(001) and GaAs(001) — •Bernhard Krumme[1], Claudia Weis[1], Ellen Schuster[1], Pankaj Srivastava[1], Julia Kurde[2], Subhankar Bedanta[1], Marco Walterfang[1], Ulrich von Hörsten[1], Natalia Utochkina[1], Wolfgang Kleemann[1], Werner Keune[1], and Heiko Wende[1] — [1]Universität Duisburg-Essen, Lotharstraße 1, D-47048 Duisburg, Germany — [2]Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

Fe_3Si is considered a promising candidate for future spintronic devices. Spininjection at room temperature has been demonstrated successfully. With its Curie temperature of $T_C = 840$ K well above room temperature it exhibits a high thermal stability. We present a combined XMCD, Mössbauer spectroscopy and SQUID investigation to analyze the magnetic properties of ultrathin Fe_3Si films on MgO(001) and GaAs(001). From the XMCD measurements we derived a total Fe magnetic moment of about 1 μ_B on MgO while the total Fe magnetic moment on GaAs is smaller. These results agree well with the averaged moments from the SQUID investigation. We also determined the Fe spin and orbital moments. Together with the Mössbauer spectroscopy results we can conclude that the magnetical ordering on the MgO substrate is higher as compared to the GaAs substrate. One explanation for this result is a possible larger interdiffusion occurring on the GaAs substrate. This is consistent with a smaller averaged Fe spin moment for the GaAs substrate determined from XMCD.

– Supported by DFG (SFB 491) and BMBF (05 KS4 KEB/5).

MA 15.2 Tue 10:45 H 1012

Aufbau eines UHV-kompatiblen multifrequenz FMR-Spektrometers — •Florian M. Römer, Ralf Meckenstock, Jürgen Lindner und Michael Farle — Fachbereich Physik und Center for Nanointegration (CeNIDE) Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

Die Bestimmung des Verhältnisses des magnetischen Bahn- zu Spinmomentes (g-Faktor) kann nur mit frequenzabhängigen Ferromagnetischen Resonanzmessungen über einen möglichst großen Frequenzbereich durchgeführt werden.

In dem Vortrag wird eine UHV-kompatible, mit der Mikrowellen-Stripline-Technik verwandte apparative Anordnung vorgestellt, welche die oben genannten Messungen quasi kontinuierlich im Bereich von 4-18 GHz erlaubt. Die Ergebnisse werden beispielhaft durch die g-Faktorbestimmung eines epitaktischen 8 nm Fe_3Si/MgO(100)-Filmes mit konventionellen Messungen **[1]** unter Verwendung von Mikrowellenresonatoren verglichen und diskutiert. Der g-Faktor ist mit 2,075 im Vergleich zu reinem Eisen mit g = 2,09 reduziert.

Durch SQUID-Messungen konnten mit Hilfe der Kittel-Formel Spin- und Bahnmoment separiert werden. Es zeigte sich, dass das Bahnmoment stärker reduziert wird als das Spinmoment, wodurch der verminderte g-Faktor erklärt wird.

Die Arbeiten wurden durch die DFG, SFB 491 finanziell unterstützt.

[1] Kh. Zakeri et. al. eingereicht bei PRB

MA 15.3 Tue 11:00 H 1012

***Ab initio* investigation of the interface structure in Fe_3Si/GaAs multilayers** — •Heike C. Herper and Peter Entel — Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg

The combination of ferromagnetic materials with semiconductors is of large interest in view of new microelectronic devices. One important point regarding such devices is the interface between the ferromagnet and the semiconductor which should be of good structural quality and high spin-polarization. In this connection, the Fe_3Si/GaAs system is discussed as part of a semiconductor/ferromagnet hybrid structure.
Here, we investigate Fe_3Si/GaAs multilayers grown in (001) and (110) direction with respect to their electronic and magnetic properties of the interface. In particular, the influence of the termination of the semiconductor surface is studied.
The calculations are done within the density functional theory employing the Vienna Ab-initio Simulation Package (VASP) by using the Projector Augmented Wave (PAW) method [1]. In order to investigate interdiffusion effects additional calculations are performed by using the Korringa-Kohn-Rostoker (KKR) method within the coherent potential approximation (CPA) [2].

[1] G. Kresse and J. Furthmüller, Phys. Rev. B **54**, 11169 (1996)
[2] H. Akai, Code: Machikaneyama2002

MA 15.4 Tue 11:15 H 1012

Effects of interdiffusion at Fe/GaAs interfaces — •Ellen Schuster[1], Werner Keune[1], Heiko Wende[1], Ahmed Naitabdi[2], and Beatriz Roldan Cuenya[2] — [1]Universität Duisburg-Essen, Germany — [2]University of Central Florida, Orlando, USA

Fe/GaAs is an interesting candidate among ferromagnet/semiconductor heterostructures for realization of spintronic devices in particular for the injection of a spinpolarized current. For this purpose a well ordered structure and prevention of dead magnetic layers at the interface are essential. The presented investigations adress the interdiffusion at the interface of room-temperature grown Fe(001) layers on top of Ga terminated GaAs(001)-(4x6) surfaces. X-Ray photoelctron spectroscopy (XPS) measurements of up to 4 monolayers (ML) thick Fe layers prove the segregation of Ga atoms to the Fe surface. Further, structural and magnetic properties are inferred from ^{57}Fe conversion electron Mössbauer spectroscopy (CEMS) at 5 nm thick Fe layers. For this purpose, different samples are deposited with Mössbauer active 2 ML thick ^{57}Fe tracer layers at different distances from the interface. With this technique the effect of interdiffusion at the Fe/GaAs interface can be detected up to a distance of 14 ML within the Fe layer. RHEED measurements during initial Fe growth by MBE show a non-monotonic behaviour of the in-plane lattice parameter. This result is in agreement with CEMS. Supported by DFG (SFB491).

MA 15.5 Tue 11:30 H 1012

Untersuchungen von FeSi Diffusionsbarrieren in austauschgekoppelten Fe/FeSi/Si/FeSi/Fe Multilagen mittels Mössbauereffekt — •Frank Stromberg, Werner Keune, Heiko Wende, Subhankar Bedanta, Wolfgang Kleemann, Carolin Antoniak, Michael Farle, Andreas Gondorf und Axel Lorke — Universität Duisburg-Essen, 47048 Duisburg

Fe/Si/Fe-Sandwich-Strukturen sind wegen der starken antiferromagnetischen (AF) Austauschkopplung für zukünftige magnetoelektronische Anwendungen interessant. Da die Stärke der Austauschkopplung mit der Reinheit der Si-Zwischenschicht zunimmt, ist eine Unterdrückung der Diffusion an der Fe/Si- bzw. Si/Fe-Grenzfläche vorteilhaft. Daher wurde der Einfluss von als Diffusionsbarrieren dienenden c-$Fe_{50}Si_{50}$-Grenzschichten unterschiedlicher Dicke in Fe/c-$Fe_{50}Si_{50}$/Si/c-$Fe_{50}Si_{50}$/Fe-Strukturen mittels ^{57}Fe-Konversionselektronen-Mössbauerspektroskopie (CEMS) in Kombination mit der ^{57}Fe-Sondenschicht-Technik untersucht. Aufgrund der Empfindlichkeit gegenüber Änderungen der Hyperfeinwechselwirkungen in der lokalen Umgebung der ^{57}Fe-Kerne eignet sich CEMS zur Untersuchung von Fe-Si-Phasenbildungsprozessen innerhalb der Si-Zwischenschicht. Ab einer Dicke von 10 Å FeSi wird eine starke Unterdrückung der Diffusion vom Si in die Fe-Schichten beobachtet. SQUID Messungen weisen auf eine schwächere Kopplung der Fe-Schichten hin. Für dünnere Schichten findet man eine Abfolge von AF-FM-AF Kopplungen. Gefördert durch DFG Projekt Ke 273/18-2.

MA 15.6 Tue 11:45 H 1012

Influences of thermal treatment on the As valence in MnAs thin films on GaAs substrate — •Benjamin Schmid[1], Sebastian Engelbrecht[1], Markus Paul[1], Michael Sing[1], Jan Wenisch[2], Charles Gould[2], Karl Brunner[2], Lorenz Molenkamp[2], Wolfgang Drube[3], and Ralph Claessen[1] — [1]Experimentelle Physik IV, Universität Würzburg, Würzburg, Germany — [2]Experimentelle Physik III, Universität Würzburg, Würzburg, Germany — [3]HASYLAB, DESY, Hamburg

Manganese arsenide has attracted a great deal of interest as a possible candidate for ferromagnet-semiconductor heterostructures. Compared to diluted magnetic semiconductors it offers advantages such as compatibility to gallium arsenide and a Curie-temperature as high as 317 K. While it has been shown that the structural and magnetic properties can be improved by post-growth annealing under As flux

the microscopic origin at work is still unclear.
Using photoemission spectroscopy various chemcial states can be distinguished. By going to the hard X-ray regime the volume sensitivity is significantly increased. Thus it is possible to observe the intrinsic electronic structure despite surface contamination. On the other hand, informations on surface states can be regained by angle dependent measurements. In order to obtain oxygen and carbon free surfaces for future industrial and scientific purposes the effects of *in situ* annealing with and without As flux are discussed. The relative amounts of covalently bonded, elemental and oxidized As depend dramatically on sample treatment and in turn determine the magnetic properties.

MA 15.7 Tue 12:00 H 1012

Strain-modulated ferromagnetic resonance of Co thin films — •Andreas Brandlmaier[1], Mathias Weiler[1], Stephan Geprägs[1], Matthias Opel[1], Sebastian T. B. Goennenwein[1], Rudolf Gross[1], Christoph Bihler[2], Hans Huebl[2], and Martin S. Brandt[2] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meissner-Str. 8, 85748 Garching — [2]Walter Schottky Institut, Technische Universität München, 85748 Garching

Ferromagnetic resonance spectroscopy (FMR) is a powerful technique for the quantitative measurement of magnetic anisotropy in ferromagnetic materials. To improve sensitivity, most FMR setups are equipped with magnetic field modulation and lock-in detection. In this regard, an interesting alternative is the modulation of the ferromagnetic properties of the sample *itself*. This can be achieved by exploiting the magneto-elastic effect, via the application of a time-varying stress to the ferromagnetic sample.

We use piezoelectric actuators to generate a time-varying strain in Co or Ni thin films. The ferromagnetic films are evaporated directly onto the actuators to achieve perfect strain transmission. Using a X-band FMR spectrometer operating at 9.3 GHz, we have recorded the FMR of the films. We hereby used both conventional magnetic field modulation, as well as strain-modulation. We compare both detection techniques, and show that strain-modulated FMR allows to directly measure the magneto-elastic coefficients, given that the applied strain is quantitatively known.

This work is supported by the DFG via SPP 1157.

MA 15.8 Tue 12:15 H 1012

Reorientation transition in Fe/Pt multilayers studied by means of depth-selective x-ray magnetic dichroism — •Nora Darowski, Enrico Schierle, Hermann Rossner, Detlef Schmitz, and Eugen Weschke — Hahn-Meitner-Institute, Berlin, Germany

The reorientation transition from in-plane magnetization of a Pt/Fe/Pt trilayer to perpendicular magnetic anisotropy in the $L1_0$ ordered FePt structure has been investigated. The FePt system is of considerable research interest due to its large magnetic anisotropy. The transformation at 350 °C of the disordered fcc phase to the ordered face-centred tetragonal $L1_0$ phase has been attributed to be the reason for the high pependicular magnetic anisotropy. Recently, Mössbauer spectroscopy indicated an exchange coupling between hard magnetic $L1_0$ and soft magnetic fcc phase during the reorientation transition including an out-of-plane rotation of the magnetization of the fcc phase proir to formation of $L1_0$ phase. X-ray magnetic circular dichroism (XMCD) was used to elucidate the phase formation and for characterization of the magnetic properties, such as spin and orbital moments of the 2 nm thin Fe film. Soft x-ray standing waves produced by a multilayer interference substrate were used to add depth selectivity to the L-edge XMCD. Wis this method we were able to determine the magnetic properties with a depth resolution better than 1 nm.

MA 15.9 Tue 12:30 H 1012

Untersuchung der magnetischen Phasenübergänge in $Fe_{50}Pt_{50-x}Rh_x$ Filmen mittels Neutronendiffraktion — •Jochen Fenske[1], Dieter Lott[1], Prakash Mani[2], Gary J. Mankey[2], Wolfgang Schmidt[3], Frank Klose[4] und Andreas Schreyer[1] — [1]GKSS Research Centre, Geesthacht — [2]MINT Center, The University of Alabama, Tuscaloosa, AL, USA — [3]JCNS, Jülich, Germany — [4]ANSTO, Bragg Institute, Menai, NSW, Australia

Seit einigen Jahren nimmt die Methode der senkrechten Anordnung der magnetischen Momente eine zentrale Rolle bei magnetischen Speichersystemen ein. Hier werden Materialien mit hoher Anisotropie verwendet, die eine gute thermische Stabilität liefern, gleichzeitig aber ein hohes magnetisches Schreibfeld benötigen. Durch magnetische Unterschichten kann dieses Schreibfeld reduziert werden. Ein viel versprechender Kandidat für eine solche Unterschicht ist das System $Fe_{50}Pt_{50-x}Rh_x$. Untersuchungen des Magneto-Volumens und der Gitterverformung des Volumensystems weisen daraufhin, dass für Proben mit x=10 beim Erhitzen ein antiferromagnetischer (AF)/ferromagnetischer (FM) Phasenübergang bei etwa 150K stattfindet. Eingesetzt als Unterschicht senkt die FM Phase die Koerzivität des Speichermediums und damit das benötigte Schreibfeld. In diesem Vortrag werden Ergebnisse vorgestellt, die mit polarisierter und unpolarisierter Neutronendiffraktion an dünnen $Fe_{50}Pt_{40}Rh_{10}$ Filmen gewonnen wurden. Im Gegensatz zum Volumensystem ist jedoch kein AF-FM Phasenübergang zu erkennen, sondern eine Umorientierung der magnetischen Momente bei Beibehaltung der AF Ordnung.

MA 15.10 Tue 12:45 H 1012

The AFM-FM phase transition in FeRh investigated using XMCD — •Christian Stamm[1], Christian Back[2], Ilie Radu[1,2], Jan-Ulrich Thiele[3], Hermann A. Dürr[1], and Wolfgang Eberhardt[1] — [1]BESSY, Albert-Einstein-Str. 15, 12489 Berlin — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstr. 31, 93040 Regensburg — [3]Hitachi Global Storage Technologies, 3403 Yerba Buena Road, San Jose, CA 95135, USA

The phase transition from antiferromagnetic to ferromagnetic ordering in FeRh is investigated in an element specific way by means of x-ray absorption spectroscopy. Dichroism sum rules allow us to determine spin and orbital moments of the two elements. Increasing the temperature from 300 to 450 Kelvin, the magnetic moments in Fe and Rh both evolve from zero to their final value, while the ratio of Rh to Fe moments stays constant. We attribute this to a coexistence of the AFM and FM phases.

MA 15.11 Tue 13:00 H 1012

Exchange coupled ordered and disordered FePt layers on MgO (100) — •Claudia Hürrich, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, Institute for Metallic Materials, P. O. Box 270116, 01069 Dresden, Germany

Due to the high magnetocrystalline anisotropy FePt is a possible future medium for magnetic recording systems. Highly ordered FePt however can reach coercivities above 7 T, a field excluding any writing field. In order to obtain both, thermal stability and writability, exchange coupled media have been suggested [1]. Here experimental results on granular hard/soft FePt-bilayers are presented, which were prepared depositing the first layer at high temperatures and then reducing the deposition temperatures. Series of epitaxial bilayers deposited at different thicknesses and temperatures are used to show that indeed thermal stability can be maintain partially while coercivity is reduced significant. [1] D. Suess, T. Schrefl, S. Fähler, M. Kirschner, G. Hrkac, F. Dorfbauer and J. Fidler, Appl. Phys. Lett. 87, 2005, 012504

MA 16: Magnetic Particles and Clusters I

Time: Tuesday 10:30–13:00 Location: H 1028

MA 16.1 Tue 10:30 H 1028

Magnetrelaxometrie superparamagnetischer Fe_3O_4 Nanoteilchen in Streptavidin-Biotin Bindungsassays — •Erik Heim, Amel Charni, Frank Ludwig und Meinhard Schilling — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Strasse 6, 38106 Braunschweig

Die Verwendung superparamagnetischer Fe_3O_4 Nanoteilchen (MNPs) als spezifische Marker zum Nachweis von biologischen Substanzen bietet aussergewöhnliche Eigenschaften. Der nicht toxische magnetische Fe_3O_4 Teilchenkern wird durch eine Hülle vor chemischer Veränderung stabilisiert. Weiterhin lassen sich hieran Liganden wie z.B. Antikörper oder andere Biomoleküle anbringen, um das MNP spezifisch an eine Zielsubstanz zu binden. Das magnetische Relaxationsverhalten der

so funktionalisierten MNPs nach Ausrichten in einem Magnetfeld unterscheidet sich je nach gebundenem Zustand. Das superparamagnetische Verhalten wird ausgenutzt, um ohne Auswaschschritte in trüben Medien gebundene von ungebundenen MNPs zu unterscheiden. Es ist so möglich, einen Flüssigphasenassay im Zeitraum einiger Sekunden durchzuführen. In diesem Beitrag werden anhand des Modellsystems Streptavidin/Biotin Kopplungen quantifiziert und Kopplungskinetiken untersucht. Die Messungen wurden mit unserem fluxgate-basierten Magnetrelaxometrie Messplatz durchgeführt. Gefördert durch die DFG über SFB 578 und InnoNet des BMWi, Förderkennzeichen: 16 INO 0548.

MA 16.2 Tue 10:45 H 1028

A fluxgate magnetorelaxometry-based measurement technique for the quality control of magnetic core-shell nanoparticles for applications in medicine and bioanalytics — •Frank Ludwig, Erik Heim, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Str. 66, D-38106 Braunschweig

Magnetic nanoparticles (MNPs) find wide application in medicine and bioanalytics. For various applications like MRI-contrast enhancement, magnetofection, drug delivery, hyperthermia, protein and cell separation, as well as immunoassays, the requirements on the particles are quite different. In addition, for in-vivo applications one has to guarantee that the MNPs do not aggregate in the given medium. For applications, such as the magnetic relaxation immunoassay (MARIA), only specific bindings of the functionalized MNPs may occur. Consequently, there is a strong need for a fast, reliable and inexpensive technique for the MNP characterization which is important for both manufacturers and users of core-shell MNPs. We show that the measurement of the magnetorelaxometry (MRX) utilizing a differential fluxgate setup along with the analysis of the MRX curves with the moment superposition model is a quick and powerful tool for the estimation of structure parameters like core and hydrodynamic size distributions as well as anisotropy constant. To verify the estimated size distributions, the results are compared with other measurements, such as TEM and dynamic light scattering. Financial support by the DFG via SFB 578 and the BMBF under contract number 13N9174 is acknowledged.

MA 16.3 Tue 11:00 H 1028

Untersuchung von Magnetosomen mittels temperaturabhängiger Magnetrelaxometrie — •Markus Büttner[1], Frank Schmidl[1], Paul Seidel[1], Michael Röder[2], Peter Görnert[2], Claus Lang[3] und Dirk Schüler[3] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Germany — [2]Innovent e.V., Jena, Germany — [3]Department Biologie I Bereich Mikrobiologie, Ludwig-Maximilians-Universität München, Germany

Magnetosomen werden von magnetotaktischen Bakterien erzeugt und dienen diesen zur Orientierung im Erdmagnetfeld. Die hier untersuchten Magnetosomen, eine Wildform (Durchmesser 37 nm bis 42 nm) und eine natürliche Mutante (Durchmesser 25 nm bis 28 nm), bestehen aus Magnetit (Fe3O4) und wurden vom Magnetospirillum gryphiswaldense erzeugt. Bei dem verwendeten Meßverfahren wird das magnetische Signal der Probe von einem SQUID-Gradiometer zweiter Ordnung (Arbeitstemperatur 4,2 K) detektiert. Die Probentemperatur kann hierbei durch einen entsprechenden Antikryostaten im Bereich von 4,2 K bis 320 K variiert werden. Es werden die gemessen magnetischen Signale, die ihren Ursprung zum Teil in der Nêel-Relaxation und zum Teil in der Änderung der Kristallstruktur beim sogenannten Verwey-Übergang haben sowie die im Temperaturbereich von 4 K bis 110 K gefundenen Effekte diskutiert. Die Arbeiten werden im Rahmen des EU-Projektes Biodiagnostics Nr. 017002 gefördert.

MA 16.4 Tue 11:15 H 1028

Submicron Tunneling Magnetoresistance Sensors for Detection of Magnetic Nanoparticles — •Camelia Albon, Michael Schilling, Karsten Rott, Günter Reiss, and Andreas Hütten — Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, P.O. Box 100131, 33501 Bielefeld, Germany

The application of thin films science in bimolecular field enables the possibility to investigate the processes that gives molecules their identity and specificity.

We will show that the detection of biomolecules attached to magnetic nanoparticles ranging from 14 nanometers to 1 micron can accurately be done by employing tunneling magnetoresistance (TMR) sensors. The general advantage of tunneling magnetoresistance (TMR) sensors is that they can be downscaled without a loss of their resulting TMR amplitude which makes them preferentially suitable for biomolecules detection. Moreover, by using MgO as the tunneling barrier material their sensitivity is highly improved and the detection can be done with increasing precision.

In this work we focus on the development and application of a TMR sensor array for magnetic nanoparticles detection. The sensors consist of 20 elliptical magnetic tunnel junctions distributed on an 18.2 micrometers squares area. Each TMR element in this array has submicron size area and has been pattern by using e-beam lithography techniques.

MA 16.5 Tue 11:30 H 1028

Ferromagnetic resonance on biogenic and synthetic magnetite nanoparticles — •Jiandong Wei[1], Knittel Ivo[1], Ralf Meckenstock[2], Claus Lang[3], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, University of Saarbrücken, 66041 Saarbrücken, Germany — [2]Institute of Experimental Physics, University of Duisburg-Essen, 47048 Duisburg, Germany — [3]Institute of Microbiology, Ludwig-Maximillians-University of Munich, 80638 Munich, Germany

A series of biogenic and synthetic magnetite nanoparticles (MNP) have been studied by ferromagnetic resonance (FMR). Samples including bacteria, isolated MNP extracted from bacteria, synthetic MNP in various sizes and complexes were deposited on a mica surface in the presence and absence of external magnetic fields and measured by FMR in the X-band frequency range. The intact chains of MNP produced by the bacterium Magnetospirillum gryphiswaldense MSR-1 (wild type) and the mutant MSR-1K exhibit a distinct feature in the FMR spectra with secondary derivative peaks at relatively small external fields. For other isolated MNP, a broad secondary derivative peak is always found on a high field side of the main absorption field. The size, the shape distribution and the magnetostatic interaction among MNP are represented in the FMR spectra. The dependence of FMR absorption on the biasing field orientation has been investigated. The origins and natures of magnetic anisotropies have been studied by a numerical simulation.

MA 16.6 Tue 11:45 H 1028

Ferromagnetische Resonanz an oxidfreien FeRh Nanopartikeln — •Anastasia Trunova[1], Diana Ciuculescu[2], Catherine Amiens[2], Jürgen Lindner[1] und Michael Farle[1] — [1]Fachbereich Physik und Center for Nanointegration (Cenide), Universität Duisburg-Essen, 47048 Duisburg — [2]Laboratoire de Chimie de Coordination, 31077 Toulouse

Chemisch hergestellte, oxidfreie Kern-Hülle $Fe_{50}Rh_{50}$- und $Fe_{80}Rh_{20}$-Nanopartikel mit einem Durchmesser von 1.7 * 2.4 nm wurden mittels Ferromagnetischer Resonanz zwischen 15 K und 290 K untersucht. Je nach Herstellungsprozess liegen die Nanopartikel als Kern-Hülle Teilchen mit einem Kern aus Fe oder Rh und einer Hülle aus Rh oder Fe vor. Aus den temperaturabhängigen Messungen wurden die Anisotropiefelder H_A gemäß [1] für die unterschiedlichen Konzentrationen mit unterschiedlichen Kern-Hülle-Strukturen bestimmt. Für $Fe_{50}Rh_{50}$ mit Fe-Kern und Rh-Schale finden wir $H_A = 0.091$Tesla, und für den Fall Rh-Kern mit Fe-Hülle finden wir $H_A = 0.19$Tesla, bei 15K.
Unterstützt durch EU-Netzwerk „SyntOrbMag“ und DFG, SFB 445.
[1] C. Antoniak et al., Europhys. Lett. 70 (2005) 250

MA 16.7 Tue 12:00 H 1028

Self-ordering of cobalt nanoparticles on a Si substrate — •Katharina Theis-Bröhl[1], Maximilian Wolff[1], Boris P. Toperverg[1], Inga Ennen[2], and Andreas Hütten[2] — [1]Department of Experimental and Solid State Physics, Ruhr-University Bochum, 44780 Bochum — [2]Thin films and nanostructures, Faculty of Physics, Bielefeld University, D-33615 Bielefeld

Magnetic nanoparticles are potential candidates for future data storage as well as vehicles for biomedical, e.g., in therapy and diagnosis, applications. From this point of view nanoparticles with high magnetic moments are under consideration as a new magnetic particle generation and deserve detailed and comprehensive investigation using various physical methods. In this study a combination of polarized neutron reflectometry and grazing incident small angle scattering was employed to deduce the structural and magnetic arrangement of cobalt-oelamin nano-complexes prepared by layer-by-layer dropping on a Si substrate. For this study we used Co nanoparticles with a diameter of 13.2 nm and prepared a relatively thick film of 20 layers. It was found that the magnetization of the Co nanoparticles maintains its saturation value. Inside the film the nanoparticles are self-organized into a 3D para-

crystalline-like lattice with the positional order well defined over a few inter-particle spacings.

We acknowledge funding by BMBF (O3ZA6BC1) and by ILL. Furthermore we would like to thank C. Waltenberg and D. Meißner for the synthesis of the nanoparticles.

MA 16.8 Tue 12:15 H 1028

Coexistence of superparamagnetism and optical activity in Ni_xPt_{1-x}/CdSe hybrid nanoparticles — •Ole Albrecht[1], Torben Menke[1], Jan Niehaus[2], Kirsten Ahrenstorf[2], Horst Weller[2], Kornelius Nielsch[1], and Detlef Görlitz[1] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg — [2]Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg

NiPt-nanoparticles, the synthesis of which have been described previously together with their magnetical properties[1], where used as starting point for the synthesis of new complex hybrid nanoparticles. Covering Ni_xPt_{1-x}-particles with CdSe, an optically active semiconductor, a core-shell hybrid particle is formed featuring magnetic and, moreover, optical properties: the particles luminesce between 680 nm and 695 nm, detected by ensemble photoluminescence spectroscopy. The pure Ni_xPt_{1-x}-particles exhibit a superparamagnetic behavior with a blocking temperature $T_b \approx 4$ K shown by SQUID-magnetometry. In the hybrid particles, T_b is shifted to lower temperatures. Possible reasons for this are discussed.

[1] K. Ahrenstorf et al., Small 3, 271(2007)

MA 16.9 Tue 12:30 H 1028

Magnetic and structural properties of size-selected $Fe_{50}Co_{50}$-clusters on surfaces — •Furkan Bulut[1], Wolfgang Rosellen[1], Joachim Bansmann[2], Armin Kleibert[3], Karl-Heinz Meiwes-Broer[2], Renate Kerstin Gebhardt[1], and Mathias Getzlaff[1] — [1]Institut für Angewandte Physik, Universität Düsseldorf, 40225 Düsseldorf — [2]Institut für Oberflächenchemie und Katalyse, Universität Ulm, 89069 Ulm — [3]Institut für Physik, Universität Rostock, 18051 Rostock

Mass-filtered $Fe_{50}Co_{50}$-clusters were produced by a continuously working arc cluster ion source [1]. The diameter of these size selected clusters can be tuned between 6-12 nm. We could prove a crystalline structure and determine the stoichiometry of the corresponding nearly free alloy clusters by HRTEM and EDX, resp. The clusters were deposited on Ni/W(110) and W(110) surfaces. Element specific spin and orbital magnetic moments were investigated by XMCD. We also performed in-situ STM. We could show that the clusters being deposited under soft landing conditions exhibit no fragmentation. We have proved that the clusters have no preferential adsorption sites on W(110) and are irregularly distributed on the terraces. They are slightly flattened due to particle surface interactions [2, 3].

[1] A. Kleibert et al., J. Appl. Phys. 101, 114318 (2007)
[2] M. Getzlaff et al., Appl. Phys. A 82 (2006) 95
[3] R. K. Gebhardt et al., Eur. Phys. J. D (submitted)

MA 16.10 Tue 12:45 H 1028

Magnetic anisotropy and Dzyaloshinski-Moriya type coupling in small magnetic clusters — •Sergiy Mankovsky, Sven Bornemann, Jan Minar, and Hubert Ebert — Dept. Chemie und Biochemie/Phys. Chemie, LMU München, Butenandtstr. 11, D-81377 München, Deutschland

The results of a theoretical study of relativistic influences on the exchange coupling of small magnetic clusters will be presented. The use of the torque method allowed to investigate the magnetic anisotropy and angular dependence of the exchange coupling in detail and to determine the contribution of the Dzyaloshinski-Moriya-type coupling. Results will be presented for Fe and Co clusters deposited on Pt(111) surface, that have been investigated by means of the fully relativistic TB-KKR Green's function method within the framework of spin-density functional theory. The data are analysed concerning their relation to the electronic structure and symmetry of the clusters. The influence of the substrate will be discussed as well.

MA 17: Invited Talks Rellinghaus / Antoniak

Time: Tuesday 14:00–15:00 Location: EB 301

Invited Talk MA 17.1 Tue 14:00 EB 301

FePt nanomagnets from the gas phase — •Bernd Rellinghaus, Elias Mohn, Ute Queitsch, and Ludwig Schultz — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Unlike other approaches, the gas phase preparation of nanoparticles provides the advantage to thermally anneal such particles prior to their deposition onto a substrate. Control of the in-flight annealing conditions thereby allows to either thermally equilibrate likewise prepared nanosized materials or to adjust metastable phases on them. The potential and the challenges of this approach for the preparation of metallic nanomagnets which may be used as future materials in high density magnetic data storage media will be reviewed.

FePt is still among the most intensively studied materials when it comes to pushing the superparamagnetic limit towards minimum particle sizes. It will be demonstrated that gas phase synthesis allows for the preparation of $L1_0$ ordered FePt nanoparticles without any post-deposition thermal treatment. Along with the formation of the $L1_0$ phase goes a significant increase of the switching fields to above 1T even at room temperature. The effect of varying annealing times and temperatures on the particles' structure provides substantial insight into the ordering mechanism. Pre-conditioned substrates may be used to initiate a regular arrangement of gas-phase prepared nanomagnets via self-assembly. Although these findings are promising in view of applications, obstacles such as the widening of the particle size distribution as a consequence of the in-flight annealing or a still limited degree of $L1_0$ order in the annealed particles are yet to be overcome.

Invited Talk MA 17.2 Tue 14:30 EB 301

Influence of composition inhomogeneities and symmetry reduction on the magnetism of FePt nanoparticles — •Carolin Antoniak — Fachbereich Physik and Center for Nanointegration, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

The magnetic properties of nanoparticles may differ significantly from those of the corresponding bulk material. In the case of bimetallic alloys, not only the break of symmetry at the surface but also local deviations from the averaged composition should be taken into account for data interpretation. For wet-chemically synthesised, oxide-free FePt nanoparticles, the break of symmetry at the surface, changes in the crystal symmetry [1] and the inhomogeneous composition [2] influence the magnetic properties, yielding reduced effective spin magnetic moments and an enhanced orbital magnetism at the Fe sites with respect to the bulk material. The experimental results presented in this talk will also be discussed in terms of lattice relaxations [3] and recent results of ab-initio calculations concerning the energetics of different stable and metastable particle morphologies [4].

In collaboration with K. Fauth, F. Wilhelm, A. Rogalev, U. Wiedwald, H.-G. Boyen, M. Cerchez, O. Dmitrieva, A. Trunova, M. Acet, M. Spasova, J. Lindner, M. Farle and S. Sun. Financially supported by the DFG (SFB445), the BMBF, the EU and the ESRF.

[1] C. Antoniak et al., Phys. Rev. Lett. 97, 117201 (2006)
[2] C. Antoniak, M. Farle, Mod. Phys. Lett. B 21, 1111 (2007)
[3] R. M. Wang et. al., Phys. Rev. Lett., accepted
[4] M. E. Gruner et al., Phys. Rev. Lett., submitted

MA 18: Poster I : Bio Magn. (1-2); Mag.Imgaging (3-9); Magn. Semiconductors (10-16); Half Metals & Oxides (17-20); Coupl.Phenomena (21-27); Magn. Mat. (28-41); Micro & Nanostr. Magn. Materials (42-61); Micro Magn. (62-64); Surface Magnetism (65-70); Transport Phenomena (71-85)

Time: Tuesday 15:15–18:30 Location: Poster E

MA 18.1 Tue 15:15 Poster E

An Optimized Method for the Deposition of Mn_{12} Single-Molecule Magnets on the Au(111) Surface via a Short Acidic Linker — •Michael Burgert, Sönke Voss, Mikhail Fonin, Ulrich Groth, and Ulrich Rüdiger — Universität Konstanz, 78457 Konstanz

Mn_{12} single-molecule magnets (SMMs) have attracted much attention during the past decade due to their unique magnetic properties. At very low temperatures (∼2K) Mn_{12}-acetate and its derivatives exhibit a magnetic hysteresis of pure molecular origin without any magnetic long-range ordering effects. Quantum tunneling of magnetization shows up in terms of steps in the hysteresis loop of SMMs. The magnetic properties of bulk SMMs have been determined to a large extent during the past years. However, experiments using isolated Mn_{12} clusters are still rare. In this contribution we present a modified deposition technique, which offered the electronic characterisation of monolayers of Mn_{12}-clusters by scanning tunneling microcopy (STM), x-ray absorption (XAS) and scanning tunnelling spectroscopy (STS). This technique is based upon a two step procedure, in which the surface is functionalized with a short conducting linker like e.g. mercaptotetrafluorbenzoic acid. The Mn_{12}-complexes are fixed to the functionalized Au(111)-surface via a ligand-exchange-reaction. As an example for the common use of these technique we demonstrate the deposition of new Mn_{12} derivatives on the functionalized Au(111)-surface. Furthermore we present its chemical synthesis and the structural as well as magnetic characterisation

MA 18.2 Tue 15:15 Poster E

Raman-spectroscopic investigations of the Keplerates Mo_yM_x (M=V, Cr) — •Dietrich Wulferding[1], Peter Lemmens[1], Manash Ghosh[1,3], Patric Scheib[1], Ana Maria Todea[2], Tamoghna Mitra[2], and Achim Müller[2] — [1]IPKM, TU-Braunschweig, Germany — [2]Fakultät für Chemie, Uni Bielefeld, Bielefeld — [3]Department of Spectroscopy, IACS, Kolkata, India

We report on a Raman scattering investigations of the nanoscale magnetic cluster compounds Mo_yM_x, with M = transition metal ion (Cr and V). Phonon and magnetic scattering are observed and correlated with structural and electronic properties of the systems. Magnetic frustration is evident as a broadening of a shoulder with a high energy cut-off comparable to the magnetic exchange energy. Multiphonon scattering is observed up to third order.

MA 18.3 Tue 15:15 Poster E

Probing Magnetic Properties of (Ga,Mn)As by TEM — •Jürgen Gründmayer and Josef Zweck — Universität Regensburg, Germany

(Ga,Mn)As is a typical and highly interesting member of diluted magnetic semiconductors (DMS). These materials may lead to charge and spin sensitive electronics - known as spintronics - in the near future.

While the theoretical mechanism leading to ferromagnetism in (Ga,Mn)As is quite well known nowadays, the micromagnetic structure and behaviour of thin layers, small particles etc. are still to be determined in detail. We want to investigate domain formation, switching characteristics, stray fields and their temperature dependence at a sub micrometer scale which can only be done by transmission electron microscopy.

In order to do so, advanced TEM techniques like Electron Holography and Differential Phase Contrast (DPC) in combination with a field-free Lorentz lens are used and adapted for our material system.

We show first results obtained with our FEI TECNAI F30 microscope and discuss special techniques necessary for treating (Ga,Mn)As in the TEM.

MA 18.4 Tue 15:15 Poster E

Iron filled carbon nanotubes as probes for magnetic force microscopy — •Franziska Wolny, Thomas Mühl, Uhland Weissker, Albrecht Leonhardt, and Bernd Büchner — Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW) Dresden

Iron filled carbon nanotubes (Fe-CNTs) were used to prepare probes for magnetic force microscopy (MFM) by attaching them to the tip of non-magnetic atomic force microscopy cantilevers.

These Fe-CNTs can be regarded as cylinder shaped single domain nanomagnets that are protected from oxidation by a carbon shell. Carbon nanotubes are known to possess both great mechanical stability and elasticity which lead to a much longer lifetime of these probes compared to conventional magnetically coated probes. They exhibit a very high aspect ratio leading to improved topographic imaging on the one hand and better magnetic resolution in MFM on the other hand. In the limit of very long iron nanowires, the lower wire end can be considered as an effective magnetic monopole moment which allows straightforward quantitative stray field measurements.

It has also been shown that attached Fe-CNTs can subsequently be tailored by electron-beam induced oxidation (e.g. to remove disturbing empty carbon shell parts or sharpen the tip) to better fit the requirements of an MFM tip.

MA 18.5 Tue 15:15 Poster E

Imaging of electric transport mechanisms in a ferromagnetic $Ga_{0.96}Mn_{0.04}As$ thin film by low-temperature scanning laser microscopy — •Jochen Tomaschko[1], Stefan Guenon[1], Sebastian T. B. Goennenwein[2], Andreas Brandlmaier[2], Matthias Althammer[2], Wladimir Schoch[3], Wolfgang Limmer[3], Reinhold Kleiner[1], and Dieter Koelle[1] — [1]Physikalisches Institut - Experimentalphysik II, Universität Tübingen, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [3]Institut für Halbleiterphysik, Universität Ulm, Germany

Due to its possible applications in spintronic devices the diluted magnetic semiconductor (DMS) $Ga_{1-x}Mn_xAs$ has been the subject of intense research. Integral measurements revealed an anisotropic magnetoresistance (AMR) and magnetothermopower (AMTP). Thus, both resistivity and thermopower depend on the orientation of magnetization. By examining a 250nm thick epitaxially grown $Ga_{0.96}Mn_{0.04}As$ Hall-bar with scanning laser microscopy these two quantities (more precisely the bolometric signal dR/dT and the Seebeck-coefficient S_{xx}) could be imaged at temperatures down to 3K with a spatial resolution of $\sim 1\mu m$. We developed simple models to describe these signals and identified them as electric dipole and monopole plus quadrupole signals, respectively. Efforts to image ferromagnetic domains have been made. Furthermore, we discovered inhomogeneities, not visible with conventional optical microscopy and observed a signal possibly due to the diffusion of electron-hole-pairs created by the laser spot.

This work was supported by the DFG (KO 1303/8-1, GO 944/3-1).

MA 18.6 Tue 15:15 Poster E

Time-resolved PEEM measurements on single-crystalline Fe-structures — •Alexander Kaiser, Carsten Wiemann, Stefan Cramm, and Claus M. Schneider — Forschungszentrum Jülich, Institut für Festkörperforschung IFF-9, 52425 Jülich, Deutschland

Time-resolved photo-electron emission microscopy (TR-PEEM) provides a method for investigating the spatial and temporal magnetodynamics of micron-sized magnetic elements. By the use of e-beam evaporation thin films of (100)-oriented Iron in bcc-structure can be epitaxially grown on GaAs substrates with a Silver buffer layer. Due to their single-crystallinity the films exhibit a four-fold in-plane magnetocrystalline anisotropy. The films have been microstructured by lithographic techniques and the micromagnetic response on a short magnetic field pulse was investigated by the TR-PEEM technique. Compared to well-studied polycrystalline Permalloy samples the magnetocrystalline anisotropy gives rise to additional terms in the effective magnetic field, leading to different magnetodynamic behaviour. Results of the time-resolved measurements are presented and compared to those of anisotropy-free Permalloy structures.

MA 18.7 Tue 15:15 Poster E

Gated detector for time-resolved photoemission microscopy — •Carsten Wiemann, Alexander Kaiser, Stefan Cramm, and

Claus M. Schneider — Forschungszentrum Jülich

Photoemission microscopy in combination with X-ray circular dichroism is a well established tool to image magnetic domain patterns in micrometer sized structures. APart from imaging static magnetization patterns, the microscope can be integrated in a time-resolved setup. Here a magnetic field pulse is used to excite a dynamic response of the micromagnetic ordering in the structures, which is in turn imaged by pulsed x-ray illumination from a synchrotron source. With this technique, precession dynamics and domain wall movements in polycristalline permalloy structures have already been successfully investigated. However, the timing requirements make it necessary to use single-bunch beam conditions for these experiments.

Here, we present and compare two different approaches for fast switching of the imaging unit of the microscope in order to exploit the hybrid bunch in the normal injection pattern of Bessy II for time-resolved experiments.

MA 18.8 Tue 15:15 Poster E

Magnetic domain imaging of Co/Pt multilayers by soft x-ray holography — •Carsten Tieg[1], Robert Frömter[2], Christian Menk[2], Holger Stillrich[2], Daniel Stickler[2], Hans Peter Oepen[2], Christian Gutt[3], Olaf Leupold[3], Simone Streit-Nierobisch[3], Lorenz-M. Stadler[3], and Gerhard Grübel[3] — [1]European Synchrotron Radiation Facility, Grenoble, France — [2]Institut für Angewandte Physik, Universität Hamburg, Germany — [3]Deutsches Elektronen Synchrotron, Hamburg, Germany

Soft x-ray holography is a promising technique for magnetic domain imaging. This diffractive imaging technique is based on the interference of resonantly tuned soft x-rays through an ion beam patterned sample-mask assembly. Magnetic contrast is achieved by using the x-ray magnetic circular dichroism effect at the L_3 absorption edges of $3d$ metals. Magnetic domain images are reconstructed by a Fourier transform of the difference of two diffraction patterns recorded by illuminating the sample with coherent circularly polarised light of opposite helicities. We have adapted the concept to the beamline ID08 at the ESRF. Several design parameters like size and number of reference pinholes, size of beam-defining primary pinhole, and the sample to CCD sensor distance were systematically varied in order to study their effect on magnetic contrast and resolution. We present magnetic domain images of Co/Pt multilayer films prepared by sputtering onto a silicon nitride membrane. Applying an out-of-plane magnetic field we imaged the magnetic domain structure throughout the full hysteresis loop of a 8×[Co(0.7nm)/Pt(1.0nm)] multilayer system.

MA 18.9 Tue 15:15 Poster E

XRMR and ReMagX - New tools to tackle magnetic reflectivity — •Sebastian Brück, Bernd Ludescher, Sebastian Macke, and Eberhard Goering — Max Planck Institute for Metals Research, Heisenbergstrasse 3, D-70569 Stuttgart, Germany

Magnetic circular dichroism is one of the most versatile techniques for the investigation of magnetic samples. Especially its application to existing techniques like x-ray reflectivity (XRR) constitutes this claim. Resonant x-ray magnetic reflectivity with circularly polarized light (XRMR) adds an additional contrast to the reflectivity spectra and one can obtain chemical as well as magnetic depth profiles of the sample. Recently this technique has attracted much attention due to its outstanding ability to investigate element specific magnetic effects even at buried interfaces. We present a new experimental setup for the investigation of soft-x-ray magnetic reflectivity from thin-film samples. Optimized to be as versatile as possible its key features are: a temperature range from 30K up to 500K, magnetic fields up to 0.5T at a field resolution better 0.5mT, motor driven azimuthal sample rotation, and a fast load lock and UHV transfer. In terms of data analysis conventional XRR uses the so called Parratt algorithm. The additional resonant magnetic contrast, surface and magnetic roughness phenomena require a more sophisticated approach. In the last years we have developed a powerful software tool to simulate and fit magnetic reflectivity spectra, which has been extended on the basis of the 4x4 matrix formalism. We will present recent experimental and fit results of FeMn/Co and NiCoO/Co exchange bias systems.

MA 18.10 Tue 15:15 Poster E

STM investigation of MBE-grown GaMnAs — •Henning Gutzmann, Andrea Stemmann, Florian Adler, Jens Wiebe, Felix Marczinowski, Christian Heyn, Wolfgang Hansen, and Roland Wiesendanger — Hamburg University, Institute of Applied Physics, Jungiusstr. 9-11, D-20355 Hamburg, Germany

The detailed understanding of the hole mediated magnetic coupling in Mn doped III-V semiconductors is an important step towards room temperature ferromagnetism in semiconductors. Scanning tunneling spectroscopy (STS) has already been used to detect the exchange interaction between Mn acceptors in GaAs [1]. We want to extend this method and directly image the magnetization of Mn in GaAs using spin-polarized STS at low temperatures [2]. The (001) oriented samples are grown in the Hamburg molecular beam epitaxy (MBE) facility. We built a mobile ultra-high-vacuum (UHV) transfer-system which is used to transfer the samples from the MBE into our scanning tunneling microscope (STM) facility [3]. We present the concept of the UHV-transfer system and show first STM measurements at room temperature.

[1] D. Kitchen et al., Nature 442, 426 (2006)
[2] A. Wachowiak et al., Science 298, 577 (2002)
[3] J. Wiebe et al., Rev. Sci. Instrum. 75, 4871 (2004)

MA 18.11 Tue 15:15 Poster E

Influence of sputtering growth parameters on the conductivity of ion-implanted SnO_2:Co thin films — •Ali Awada[1], Dirk Menzel[1], Joachim Schoenes[1], Frank Ludwig[2], and Meinhard Schilling[2] — [1]Institut für Physik der Kondensierten Materie, TU Braunschweig — [2]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig

Magnetic measurements of cobalt doped SnO_2 films show ferromagnetic ordering with Curie temperatures well above 300 K. The magnetic moment per Co ion varies between 0.1 μ_B and 1.5 μ_B [1,2]. Since the magnetic exchange is most likely mediated by free carriers, it is important to correlate the different magnetic moments with the free carrier concentrations. As the conductivity of the tin dioxide is presumably determined by a donor level originating from oxygen vacancies, it is anticipated that the stoichiometry of the sputtered SnO_2 plays a dominant role. In addition, increasing the cobalt concentration lowers the conductivity of the ion implanted SnO_2:Co, which can be interpreted as a charge carrier compensation effect [1]. Parameters like the sputtering power, oxygen partial pressure, total pressure or annealing temperatures have been varied to study the influences on the film growth and the results are correlated with the magnetism in doped SnO_2:Co.

[1] D. Menzel, A. Awada, J. Schoenes, F. Ludwig, M. Schilling, JAP 52th MMM Conference Proceedings (2008)
[2] J. Schoenes, U. Pelzer, D. Menzel, K. Franke, F. Ludwig, and M. Schilling, PSS C **3**, 4115 (2006)

MA 18.12 Tue 15:15 Poster E

Influence of sputtering growth parameters on the conductivity of ion-implanted SnO_2:Co thin films — •Ali Awada[1], Dirk Menzel[1], Joachim Schoenes[1], Frank Ludwig[2], and Meinhard Schilling[2] — [1]Institut für Physik der Kondensierten Materie, TU Braunschweig — [2]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig

Magnetic measurements of cobalt doped SnO_2 films show ferromagnetic ordering with Curie temperatures well above 300 K. The magnetic moment per Co ion varies between 0.1 μ_B and 1.5 μ_B [1,2]. Since the magnetic exchange is most likely mediated by free carriers, it is important to correlate the different magnetic moments with the free carrier concentrations. As the conductivity of the tin dioxide is presumably determined by a donor level originating from oxygen vacancies, it is anticipated that the stoichiometry of the sputtered SnO_2 plays a dominant role. In addition, increasing the cobalt concentration lowers the conductivity of the ion implanted SnO_2:Co, which can be interpreted as a charge carrier compensation effect [1]. Parameters like the sputtering power, oxygen partial pressure, total pressure or annealing temperatures have been varied to study the influences on the film growth and the results are correlated with the magnetism in doped SnO_2:Co.

[1] D. Menzel, A. Awada, J. Schoenes, F. Ludwig, M. Schilling, J. Appl. Phys. 52th MMM Conference Proceedings (2008)
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MA 18.13 Tue 15:15 Poster E

Investigations of different oxide diluted magnetic semiconductors — •Milan Gacic, Gerhard Jakob, and Hermann Adrian — Institut für Physik, Universität Mainz, Staudinger Weg 7, 55128 Mainz

Though many groups are working for years now on finding the origin of room temperature ferromagnetism in oxide diluted magnetic semiconductors as ZnO or TiO_2 doped with different transition metals, there is still no breakthrough in sight. The results are controversial and it is even not clear whether it is an intrinsic effect. However, the growth process and the growth conditions seem to play an important role.
We did extensive investigations on the wide bandgap semiconductors ZnO and ZrO_2 with different doping combinations. Here we present and compare our results concerning magnetic and transport properties of ZnO:Co, ZnO:(Co, Li), ZnO:C and ZrO_2:Mn thin films. All films were deposited by pulsed laser deposition on sapphire or ZrO_2 substrates at different growth conditions. The magnetic properties were extremely sensitive to the preparation condition. However, there is evidence that mostly defect rich films exhibit ferromagnetism. Most of the samples showed a small anomalous Hall effect as well as a clear and strongly temperature dependent magnetoresistance, which seems to be much more influenced by the doping than the magnetic properties.

MA 18.14 Tue 15:15 Poster E

XMCD study of doped ZnO and Si magnetic semiconductors — •Thomas Tietze[1], Sebastian Brück[1], Saroj Dash[1], Eberhard Goering[1], Milan Gacic[2], Gerhard Jakob[2], Christian Herbort[2], and Hermann Adrian[2] — [1]Max-Planck-Institue for Metal Research, Heisenbergstrasse 3, 70569 Stuttgart, Germany — [2]Institute of Physics, University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany

Diluted magnetic semiconductors (DMS) doped with a few percent (<10%) of magnetic ions, as Co or Mn, have shown room temperature ferromagnetism transforming these to a promising candidate for spintronic devices. Previously, we have unexpectedly found pure paramagnetic behavior of the magnetic ion dopants. Additional Li doping has been used to enhance the ferromagnetic signature of the DMS. Therefore, we have investigated ZnO doped with 5% Co and co-doped with 10% Li thin films and pure Si doped with 5 % implanted Mn. Clear ferromagnetic room temperature properties have been found by SQUID magnetometry. In order to identify the element which is responsible for the ferromagnetic moment, we have performed X-ray Magnetic Circular Dichroism studies at the TM and Si L2,3 edges and the O K edge. We found only a paramagnetic XMCD-signal on the Co and Mn L2,3-edges. With a very high signal to noise ratio of better than 1/10000 we did not find any significant XMCD effect on neither the Si L2,3 nor the O K-edges. In order to clearly probe bulk properties, we have also investigated the resonant magnetic responses in reflection geometry and TFY mode, but no ferromagnetic signature has been found.

MA 18.15 Tue 15:15 Poster E

Magnetic properties of patterned (Ga,Mn)As films — •Matthias Sperl, Frank Hoffmann, Daniel Neumaier, Ursula Wurstbauer, Florian Götz, Christian H. Back, and Günther Bayreuther — Institut für Experimentelle Physik, Univ. Regensburg, D-93040 Regensburg

To study transport properties of the ferromagnetic semiconductors (Ga,Mn)As structures of sub-micron dimensions are frequently used. The question whether magnetic properties in laterally confined (Ga,Mn)As structures are different from extended films has been investigated in the present work.

(Ga,Mn)As films were epitaxially grown on GaAs (001) by means of molecular beam epitaxy. The films are patterned by electron beam lithography and ion etching into large area arrays of uniform circular dots with diameters between 500 nm and 10 micron. The magnetic properties of the dot arrays are measured with magnetooptical Kerr effect and superconducting quantum interference device (SQUID) magnetometry. Additionally, the magnetic anisotropy of single dots is studied with spatially resolved FMR. We find a large increase of the coercive field in patterned films. Furthermore, the influence of the dot size on the Curie temperature and on the magnetic anisotropy is discussed.

MA 18.16 Tue 15:15 Poster E

volume dependence of the curie temperatures in diluted magnetic semiconductors — •brahim belhadji[1], lars bergqvist[1], silvia picozzi[2], and peter h. dederichs[1] — [1]Institut fuer Festkoerperforschung, Forschungszentrum juelich, D-52425 juelich, germany — [2]Dipartimento di Fisica Universit degli Studi di L'aquila, Via Vetoio 10 L'aquila, Italy

Using electronic structure methods and statistical methods we have studied theoretically the volume dependence of the exchange interactions and Curie temperatutes in diluted magnetic semiconductors. In both Mn-doped GaAs and Mn-doped InAs, the calculated Curie temperatures from numerical exact Monte Carlo simulations are more or less constant for a large volume interval. We have compared the exchange mechanisms in Mn-doped GaAs using both the local density approximation (LDA) and the LDA+U method. It is demonstrated that the magnetic properties are determined within Zener's p-d exchange model for the LDA+U, while in LDA it is a mixture between double and p-d exchange mechanisms. Moreover, it is shown that the antiferromagnetic superexchange, which mostly affects the nearest neighbour exchange couplings, becomes more pronounced upon compression of the lattice.

MA 18.17 Tue 15:15 Poster E

Magnetic anisotropy of (100)− **and** (110)−**oriented CrO_2 thin films** — •Manuel J. Schwarz[1], Sebastian T.B. Goennenwein[1], Matthias Opel[1], Rudolf Gross[1], Arunava Gupta[2], Christoph Bihler[3], and Martin S. Brandt[3] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]MINT Center, University of Alabama, Tuscaloosa, AL, USA — [3]Walter Schottky Institut, Technische Universität München, Garching, Germany

Ferromagnetic materials with high spin polarization P are very attractive for spin electronics. In this context, chromium dioxide (CrO_2) as a well established half-metallic ferromagnet with a spin polarization $P \approx 0.98$ and a Curie temperature $T_C \approx 390$ K well above room temperature is a promising material. Therefore its magnetic properties, in particular the magnetic anisotropy of strained thin film samples, have to be understood in detail.
We have investigated a series of thin CrO_2 films with thicknesses ranging from 10 nm to 100 nm grown by chemical vapor deposition (CVD) on either (100)−oriented or (110)−oriented TiO_2 single crystal substrates. Using ferromagnetic resonance (FMR) spectroscopy in the X-band (9.3 GHz), we have quantitatively determined the magnetic anisotropy of these samples at room temperature. We find a clear dependence of the magnetic anisotropy on both crystallographic orientation and film thickness. We discuss to which extent this evolution of magnetic anisotropy is linked to epitaxial strain, and compare our results to the literature.

MA 18.18 Tue 15:15 Poster E

An anisotropic Heisenberg model on the trigonal lattice for modelling multiferroic oxides — •Tim Kunze[1,3], Michael Schreiber[1], Carsten Olbrich[2], and Sibylle Gemming[3] — [1]Institut für Physik, Technische Universität, D-09107 Chemnitz, Germany — [2]Jacobs University, D-28725 Bremen, Germany — [3]Forschungszentrum Dresden-Rossendorf, D-01414 Dresden, Germany.

Hexagonal manganites are oxides, in which structural, electronic, and magnetic degrees of freedom are coupled in a complex manner. Therefore, such materials have the potential for novel, nanoscale sensing and switching applications. Manganites are composed of dense-packed hexagonal manganese oxide layers with strong in-plane and weak interlayer coupling, thus the possible spin configurations may be studied with the help of a two-dimensional model Hamiltonian. For this purpose a two-dimensionally periodic trigonal spin system is qualitatively studied with the help of an extended multiparameter Heisenberg model. The temperature dependence of the magnetisation is investigated with the help of a Metropolis-Monte-Carlo algorithm as a function of the anisotropy term and of an external magnetic field. Thermodynamic quantities such as the total energy, the heat capacity and the magnetization are determined by statistical evaluation.

MA 18.19 Tue 15:15 Poster E

Growth and magnetic properties of epitaxial $Fe_{3-x}Zn_xO_4$ thin films — •Deepak Venkateshvaran[1], Andrea Boger[1], Sebastian T. B. Goennenwein[1], Matthias Opel[1], M. S. Ramachandra Rao[2], and Rudolf Gross[1] — [1]Walther-Meissner-Institut, BayerischeAkademie der Wissenschaften, 85748 Garching, Germany — [2]Materials Science Research Centre, Indian Institute of Technology Madras,Chennai-600036, India

Fe_3O_4 is an interesting material for spintronic devices due to its high Curie temperature $T_C \approx 860$ K, and its predicted half metallicity. Doping magnetite with Zn allows to control T_C as well as the carrier concentration without losing mobility of the carriers [1]. In this work,

we investigated the influence of Zn-doping on the magnetic properties, particulary on saturation magnetization, coercivity and remanence.

We have grown epitaxial $Fe_{3-x}Zn_xO_4$ thin films with $x = 0$, 0.1, 0.05 and 0.5 on (001) oriented MgO substrates by pulsed laser deposition. The growth was monitored in situ by reflection high energy electron diffraction (RHEED). The observation of RHEED oscillations proves smooth layer by layer growth. We detected no impurity phases by X-ray diffractometry in combination with a high crystalline quality of the films indicated by a FWHM of the rocking curves of the (004) reflection down to 0.04°. The magnetic properties were investigated by SQUID magnetometry at temperatures between 5 K and 375 K at fields up to 7 T.

[1] J. Takaobushi et al., Appl. Phys. Lett. **89**, 242507 (2006)

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MA 18.20 Tue 15:15 Poster E

Electronic Structure of shandite $Co_3Sn_2S_2$ — •Matthias Holder[1], Yuri S. Dedkov[1], Serguei L. Molodtsov[1], and Helge Rosner[2] — [1]Institut für Festkörperphsik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Max-Planck Institut für Chemische Physik fester Stoffe, 01187 Dresden, Germany

From theoretical calculation within LSDA method the ground state of shandite $Co_3Sn_2S_2$ is predicted to be ferromagnetic with a tiny gap in the minority spin channel. Previous experimental results from magnetic susceptibility, specific heat, and resistivity measurements on powder samples showed a phase transition to a ferromagnetic metallic state at 177 K with a saturation moment of 0.87μB/f.u. Here we present the results of studies of its electronic structure by means of spin- and angle- resolved photoemission on poly- and singlecristalline $Co_3Sn_2S_2$ samples. Experimental results are discussed in the framework of existing spin- resolved band- structure calculations.

MA 18.21 Tue 15:15 Poster E

Soft x-ray resonant magnetic scattering from magnetic multilayers showing a field induced transition from weak to strong ferromagnetic coupling — •Daniel Lengemann[1], Tanja Weis[1], Dieter Engel[1], Arno Ehresmann[1], Feliks Stobiecki[2], Maciej Urbaniak[2], Bogdan Szymanski[2], Janusz Dubowik[2], Piotr Kuswik[2], I. Sevklo[3], and Andrzej Maziewski[3] — [1]Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str.40, D-34132 Kassel — [2]Institute of Molecular Physics, Polish Academy of Sciences, ul. Smoluchowskiego 17, 60-179 Poznan, Poland — [3]Laboratory of Magnetism, Institute of Experimental Physics, University of Bialystok, ul. Lipowa 41, 15-950 Bialystok, Poland

As for sputter deposited multilayers $(Ni_{80}Fe_{20}/Au/Co/Au)_{10}$ with alternating out-of-plane (Co) and in-plane (NiFe) magnetization anisotropy and negligible exchange coupling we found a stripe domain structure in remanence due to a specific magnetostatic coupling.

We present first results of several complementary studies, e.g. element specific soft x-ray resonant magnetic scattering (SXRMS) hysteresis measurements, which indicate, that the reversal of the NiFe magnetization is strongly affected by magnetostatic coupling due to domain stray fields. We will discuss the behaviour of this magnetostatic coupling in dependence of the Co thickness in these multilayers.

MA 18.22 Tue 15:15 Poster E

Dominant role of thermal magnon excitation in the temperature dependence of interlayer exchange coupling — •Kilian Lenz, Sangita S. Kalarickal, Xiaoying Xu, Klaus Baberschke, and Wolfgang Kuch — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Ultrathin Ni/Cu/Co trilayers were deposited on Cu(001) in ultrahigh vacuum (UHV) and the ferromagnetic resonance (FMR) measured *in situ* as a function of both, temperature and out-of-plane angle of the external field. The interlayer exchange coupling J_{inter} can then be unambiguously extracted at various temperatures, entirely from the angular dependence of the resonance field positions [1]. The temperature dependence of $J_{\text{inter}}(T)$ was found to follow an effective power law AT^n, $n \approx 1.5$. Analysis of the scaling parameter A shows an oscillatory behavior with spacer thickness, as does the strength of the coupling at $T = 0$. The results clearly indicate that the dominant contribution to $J_{\text{inter}}(T)$ is due to the excitation of thermal spin waves and that it follows closely recently developed theory [2].

[1] S.S. Kalarickal, X.Y. Xu, K. Lenz, W. Kuch, and K. Baberschke, Phys. Rev. B **75**, 224429 (2007).

[2] S. Schwieger, J. Kienert, K. Lenz, J. Lindner, K. Baberschke, and W. Nolting, Phys. Rev. Lett. **98**, 057205 (2007).

MA 18.23 Tue 15:15 Poster E

Local magnetization study of exchange bias in patterned Co/CoO dots — •Ulrike Wolff[1], Sarah Suck[2], Dominic Givord[2], Jeffrey McCord[1], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Institut Néel, CNRS-UJF, 25 avenue des Martyrs, F-38042 Grenoble, Cedex 9, France

It is well known that exchange-bias (EB) originates from symmetry breaking at the interface between a ferromagnet (FM) and an antiferromagnet (AFM). However, due to the presence of complex disordered structural and magnetic configurations at the FM/AFM interfaces, a clear description of this phenomenon is still missing. The role of structural and magnetic defects is expected to be considerably reduced at the nanosize when the single crystalline and single domain state is entered [1]. Therefore, the present work focuses on the study of the local magnetization process in arrays of small (120 x 360 nm^2) Co/CoO dots by magnetic force microscopy at low temperatures (50 K) and in an applied in-plane field. The dots behave as magnetic dipoles where the magnetization reversal mainly occurs in a single switching event explained by a coherent rotation process modified by the exchange bias. Nevertheless, in some dots multidomain formation is observed upon reversal. This behaviour is compared with global magnetization measurements and with additional Kerr microscopy experiments, which probe the magnetization reversal on an intermediate mesoscopic scale.

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MA 18.24 Tue 15:15 Poster E

Time dependent changes of the exchange bias field in MnIr/CoFe bilayers after ion bombardment with 10keV He ions — •Christoph Schmidt[1], Tanja Weis[1], Dieter Engel[1], Volker Höink[2], Günter Reiss[2], and Arno Ehresmann[2] — [1]Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str.40, D-34132 Kassel — [2]University of Bielefeld, Department of Physics, Nano Device Group, P.O. Box 100131, D-33501 Bielefeld

The strength and direction of the unidirectional anisotropy of thin magnetic layer systems, showing the exchange bias effect, can be tailored by ion bombardment with e.g. He ions. Some of these systems show a drift of the exchange bias field after ion bombardment in an applied magnetic field with time to a finite value. Depending on the ion dose and the direction of the applied magnetic field relative to the direction of the unidirectional anisotropy before ion bombardment this drift could be to positive or negative exchange bias field values. We will present results demonstrating the time dependence of the exchange bias field for MnIr/CoFe bilayers for different ion doses and different CoFe layer thicknesses, as well as the dependence of the exchange bias field drift on the storing conditions between the magnetic characterization measurements.

MA 18.25 Tue 15:15 Poster E

Positive exchange bias in NiFe/IrMn bilayer — •S. K. MISHRA, F. RADU, H. A. DÜRR, and W. EBERHARDT — BESSY GmbH, Albert Einstein Str. 15, D-12489 ,Berlin, Germany

The microscopic origin of the positive exchange bias, i.e. the shift of the ferromagnetic hysteresis in the opposite direction compared to conventional exchange bias, remains elusive.Recently we observed positive exchange bias in a $Ni_{80}Fe_{20}/Ir_{19}Mn_{81}$ polycrystalline thin-film bilayer system. We have employed soft X-ray Resonant Magnetic Scattering (XRMS) to study element specifically the magnetic properties of the bilayer. After field cooling through the Neel temperature (470K) the system exhibits the conventional negative exchange bias. By training, i.e. repeated magnetization reversals, the positive exchange bias is induced starting at about 420K up to the blocking temperature (450K). This indicates that increasing interfacial magnetic disorder might be the microscopic driving force of the positive exchange bias in the bilayer system.

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MA 18.26 Tue 15:15 Poster E

Training and temperature effects of epitaxial and polycrystalline $Ni_{80}Fe_{20}/Fe_{50}Mn_{50}$ exchange biased bilayers — •Marian Fecioru-Morariu[1], Jerzy Wrona[2], Cristian Papusoi[3], and Gernot Güntherodt[1] — [1]Physikalisches Institut (IIA), RWTH Aachen University, 52056 Aachen, Germany — [2]AGH University of Science and Technology, 30-059 Krakow, Poland — [3]SPINTEC, CEA/CNRS, 38054 Grenoble Cedex 9, France

For exchange biased bilayers of $Ni_{80}Fe_{20}/Fe_{50}Mn_{50}$, the effects of crystalline structure on the training effect of the exchange bias field (H_{EB}) and of the coercive field (H_C) have been investigated for (001) and (110) epitaxial as well as polycrystalline thin film samples [1]. The training effect of H_{EB} and H_C at 5 K is strongest for the polycrystalline sample as compared to the (110)-oriented sample. The training effect is found to originate from the hysteresis cycle-number dependence of H_1, the switching field of the descending branch of the hysteresis loop. A very good qualitative agreement is observed between the cycle-number dependence of H_{EB} and of the fraction of uncompensated spins of the AFM. In the temperature range between 5 K and 300 K, H_{EB} and H_C are found to depend strongly on the crystalline structure and orientation of the FM/AFM bilayers. // The financial support through the EU Research Training Network NEXBIAS (HPRN-CT-2002-00296) is gratefully acknowledged. [1] M. Fecioru-Morariu, et al., submitted.

MA 18.27 Tue 15:15 Poster E

Interfacial magnetic domain coupling study in single-cristalline Fe/CoO bilayers — •Jorge Miguel[1], Radu M. Abrudan[1,2], Matthias Bernien[1], Marten Piantek[1], Carsten Tieg[2], Jürgen Kirschner[2], and Wolfgang Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany — [2]Max-Planck-Institut für Mikrostruktur, Weinberg 2, D-06120 Halle, Germany

X-ray absorption spectroscopy and spectromicroscopy were employed to probe the magnetic and electronic properties of Fe/CoO bilayers with elemental selectivity. The use of a photoelectron emission microscope (PEEM) in connection with x-ray magnetic circular and linear dichroisms (XMCD and XMLD) allows the layer-selective imaging of ferromagnetic (FM) and antiferromagnetic (AFM) domains. Absorption spectra taken from bilayers with different Fe thicknesses show only a weak indication for the formation of Fe oxide at the Fe/CoO interface, and a parallel coupling between the Fe magnetization and the CoO spin axis. XMCD- and XMLD-PEEM images were used to laterally probe both magnetic layers. A magnetic coupling between the layers can be deduced by comparing the magnetic domains in Fe and CoO. In addition to the AFM domains in CoO, which are imaged by XMLD, XMCD images at the Co $L_{2,3}$ edges yield a magnetic contrast due to induced magnetic moments. A perfect overlap in the domain walls of the Fe and CoO layers is observed. Furthermore, Fe layers with thicknesses below the onset of ferromagnetism have an effect on the size of the CoO AFM domains.

MA 18.28 Tue 15:15 Poster E

Magnetic properties of rare earth transition metal borides $R_{2-x}Ni_{21}B_6$ (R = Sc, Zr, Lu) and $Lu_{1.65-x}R_xNi_{21-y}M_yB_6$ (R = Y, Zr; M = Cu) — •Roman Gumeniuk, Walter Schnelle, Helge Rosner, Yuri Prots, Igor Veremchuk, Andreas Leithe-Jasper, and Yuri Grin — Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

The crystal structures of the compounds $R_{2-x}Ni_{21}B_6$ (R = Sc, Zr, Lu) have been determined by means of single crystal refinement and belong to the $Cr_{23}C_6$ type. The temperature dependence of the magnetic susceptibility of these compounds is described by a modified Curie-Weiss law. The unexpectedly large paramagnetic moment ($\mu_{\rm eff}$ = 1.49 μ_B/f.u.) for $Lu_{1.65}Ni_{21}B_6$ could indicate that the compound is close to ferromagnetic ordering. LSDA band structure calculations suggest a ferromagnetic ground state where only the Ni atoms at the crystallographic 4a position exhibit a sizable magnetic moment. Experimentally no magnetic order was observed down to 1.8 K. Substitution of Lu by Y or Zr, or Ni by Cu in the crystal structure leads to the suppression of the tendency towards ferromagnetism.

MA 18.29 Tue 15:15 Poster E

Crystal electric field levels in Ho_2PdSi_3 studied by inelastic neutron scattering in magnetic fields — •Fei Tang[1], Matthias Frontzek[1], Michael Loewenhaupt[1], Astrid Schneidewind[1,2], Peter Link[2], Holger Bitterlich[3], and Günter Behr[3] — [1]IFP, TU Dresden, D-01062 Dresden, Germany — [2]FRM-II, TU München, D-85375 Garching, Germany — [3]IFW Dresden, D-01069 Dresden, Germany

The series R_2PdSi_3 (R = rare earth), has been found to exhibit rich magnetic phenomena resulting from the interplay between $RKKY$ interaction, crystal-electric field effects and geometric frustration. Except for the Ho_2PdSi_3 compound the second order crystal electric field parameter dominates the magneto-crystalline anisotropy .

The Ho_2PdSi_3 compound which orders antiferromagnetically at T_N = 7.7K offers therefore the opportunity to study the influence of the higher order crystal electric field parameters. We performed inelastic neutron scattering experiments on a large Ho_2PdSi_3 single crystal in magnetic fields up to 13T at the cold triple axis spectrometer (PANDA, FRM-II). In applied magnetic fields above the critical field for the transition into FM induced state, the crystal electric field levels undergo Zeeman splitting; and the energy shift varies from approx. 0.1meV/T to 0.3meV/T, implying the influence of the higher order crystal field parameters.

In this contribution we will present and discuss the results of the inelastic neutron scattering experiments and give a proposal for the crystal electric field level scheme.

MA 18.30 Tue 15:15 Poster E

Properties of ternary rare earth $REXY$ compounds with 18 valence electrons — •Frederick Casper and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

Ternary rare earth compounds $REXY$, where RE is a lanthanide element, Y a transition element and Z is an sp element, offer a large variety of structure types. Our research focuses on compounds LiGaGe and MgAgAs ($C1_b$) structure which all have 18 valence electrons. Magnetic and resistivity measurements were used to examine some of these compounds. Most of the compounds order antiferromagnetic at low temperatures. While compounds with LiGaGe structure are metallic, many of the compounds with MgAgAs structure are semiconducting. Additionally for some of these compounds a metal-insulator transition was found. The metal - insulator transition temperature depends strongly on the preparation conditions. Both the magnetic ground states and the resistance behavior are in good agreement with electronic band structure calculations.

This work was supported by DFG grant FE633/1-1 within SPP1166.

MA 18.31 Tue 15:15 Poster E

Mößbauer spectroscopy of $Fe_{2-x}Co_{1+x}Si$ Heusler alloys — •Verena Jung, Benjamin Balke, Gerhard H. Fecher, and Claudia Felser — Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz

This work reports about the properties of the solid solutions of $Fe_{2-x}Co_{1+x}Si$ Heusler alloys. Generally the X_2YZ Heusler compounds crystallise in the cubic $L2_1$ structure (space group no. 225: $F\,m\bar{3}m$). The cubic X_2YZ compounds are not only found with the $AlCu_2Mn$ type structure but also with the $CuHg_2Ti$ type structure. This formal $XYXZ$-type structure exhibits T_d symmetry (space group no. 216: $F\bar{4}3m$). In that structure the two X atoms occupy non equivalent positions in contrast to the $L2_1$ structure. This structure is frequently observed if the nuclear charge of the Y element is larger than the one of the X element from the same period, that is $Z(Y) > Z(X)$ for two 3d transition metals. However, the two structures may be hardly distinguishable by X-ray diffraction as both have the general fcc-like symmetry. Therefore, ^{57}Fe Mößbauer spectroscopy was performed to determine the local environment and hyperfine magnetic fields of the iron atoms. Two different hyperfine magnetic fields were clearly detected due to the two different local environments of the Fe atoms in $Fe_{2-x}Co_{1+x}Si$ Heusler alloys crystallising in the $CuHg_2Ti$ type structure.

MA 18.32 Tue 15:15 Poster E

Metallurgical Investigations of the Crystal Growth of $Co_2FeAl_{1-x}Si_x$ Heusler Compounds — •Christian G. F. Blum[1], Benjamin Balke[1], Sabine Wurmehl[2], Gerhard H. Fecher[1], Claudia Felser[1], and Armin Reller[3] — [1]Johannes Gutenberg - Universität, 55099 Mainz — [2]Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands — [3]Universität Augsburg, 86135 Augsburg

The structure of the crystallites of $Co_2FeAl_{1-x}Si_x$ Heusler compounds with $0 \leq x \leq 1$ were investigated. The influence of the annealing process on the crystallisation was studied by annealing the samples for

1-3 weeks at 873-1273 K. Discs were cut from the bulk samples resulting in surfaces with different orientation compared to the direction of the cooling gradient. After polishing, the surfaces of the discs were etched with different acids in order to colour different crystallites differently. The best results were obtained with a solution of 2 mol/L Fe_2Cl_3 in 12% to 8% concentrated HCl. This particular concentrations tinted different crystallites in a different tone while the surface of the sample was not destroyed very deep. Using this approach, different types of crystallites were found: needle-like ones for the Si-rich compounds and block-like for the Al-rich compounds.

The authors gratefully acknowledge financial support by the DFG (Research Unit 559).

MA 18.33 Tue 15:15 Poster E

X-ray Diffraction studies on $RFe_3(BO_3)_4$ — •Jorge Hamann Borrero[1], Martin Philipp[1], Olga Kataeva[2], Rüdiger Klingeler[1], Christian Hess[1], Bernd Büchner[1], Martin von Zimmermann[3], Alexander Vasiliev[4], and Leonard Bezmaternykh[5] — [1]Leibniz Institute for Solid State and Materials Research IFW Dresden, 01171 Dresden — [2]A.E.Arbuzov Institute of Organic and Physical Chemistry of the Russian Academy of Sciences, Arbuzov Str. 8, Kazan, 420088, Russia — [3]HASYLAB@DESY, Notzkestr. 85, 22603 Hamburg — [4]Faculty of Physics, Moscow State University, Moscow, 119992 Russia — [5]Institute of Physics, Siberian Division, Russian Academy of Sciences, Krasnoyarsk, 660036 Russia

Mo X-ray radiation and hard X-rays diffraction experiments, with and without external magnetic field, were made on single crystalline $RFe_3(BO_3)_4$ compounds (R = Tb, Gd, Nd, Dy and Y) in order to elucidate the various interesting crystal structures and phase transitions, with a special focus on $TbFe_3(BO_3)_4$. The crystal structure of this compound is of space group $R32$ at room temperature and undergoes a symmetry reduction at $T < 192K$ to space group $P3_121$ involving slight distortions of the TbO_6 prisms and FeO_6 octahedra. Distinct field dependent structural features were observed on $TbFe_3(BO_3)_4$ when applying a magnetic field parallel to the c axis at T=2K. At fields higher than around 3T, a superstructure peak (0 0 1.5) appears as an indication of a new field induced structure which involves doubling of the unit cell along the c axis. These results are compared with the structures of the other rare earth and Y compounds.

MA 18.34 Tue 15:15 Poster E

Evolution of the crystal structure of $YMn_{2-x}Fe_xO_5$ due to iron doping and DFT calculations for the x=1 compound — •Torsten Weissbach[1], Dmitri Souptel[2], Günter Behr[2], Thomas Führlich[1], Falk Wunderlich[1], Dirk C. Meyer[1] und Sibylle Gemming[3] — [1]Institut für Strukturphysik der TU, Dresden, Germany — [2]Institut für Festkörper-und Werkstoffforschung (IFW), Dresden, Germany — [3]FZ Dresden-Rossendorf, Dresden, Germany

$YMnFeO_5$ is a ferrimagnet below 165 K[1]. Its crystal structure is derived from that of the ferromagnetic and low-temperature ferroelectric YMn_2O_5 by occupation of the Mn position possessing pyramidal oxygen environment with Fe; the other Mn site is coordinated by oxygen in an octahedral manner. Powder samples for x = 0, 0.25, 0.5, 1 [2] were inspected by X-ray powder diffraction and EXAFS, single crystals (x = 0.07, 0.25) by single-crystal X-ray diffraction methods. The structure data show a significant displacement of Fe within the oxygen pyramid, while the Mn position remains nearly constant with respect to the surrounding oxygen atoms. All-electron density-functional calculations in the LSDA+U approximation for the x = 1 compound [3] are in good agreement with the collinear, commensurate ferrimagnetic ordering of the magnetic moments as proposed in [1].

[1] Munoz, A. et al., Chem. Mater. 16, 4087 (2004); [2] all materials prepared by D. Souptel at IFW Dresden; [3] FPLO: Koepernik, K. et al., Phys. Rev. B 59, 1743 (1999)

MA 18.35 Tue 15:15 Poster E

Investigation of the electronic structure of $LuFe_2O_4$ by means of XPS, XAS, XES and calculations — •Michael Raekers[1], Christian Taubitz[1], Karsten Kuepper[2], Stephen J. Blundell[3], Dharmalingam Prabhakaran[3], and Manfred Neumann[1] — [1]Universität Osnabrück, FB Physik, Barbarastr.7, 49069 Osnabrück, Germany — [2]FZ Dresden-Rossendorf, Dresden, Germany — [3]Clarendon Laboratory, University of Oxford, Oxford, UK

The use of magneto electric coupling and multi ferroics in spintronics has led to an intense interest in ferro electric magnets. The spinel $LuFe_2O_4$ is a very promising candidate for such applications because of its giant room temperature magneto dielectric response, which suggests a strong coupling between spin moment and electric dipole. The resulting giant magneto capacitance is due to charge ordering of iron ions. A complex two dimensional ferri magnetism plays an important role for the multi ferroic properties of $LuFe_2O_4$. We determine the electronic structure by means of XPS, XAS and XES. Experimental data is compared with multiplet calculations, which are performed with the TT multiplet program taking into account charge transfer and the crystal field. The comparison with the experiment shows the occupation of tetrahedral and octahedral sites of the crystal.

MA 18.36 Tue 15:15 Poster E

Raman study of FeSi under high pressures up to 15 GPa — •Ivan Jursic, Ana Maria Racu, Dirk Menzel, and Joachim Schoenes — Institut für Physik der Kondensierten Materie, TU Braunschweig, Mendelsohnstr. 3, 38106 Braunschweig, Germany

Single crystals of FeSi which were grown by the Czochralski technique have been investigated by Raman spectroscopy up to pressures of 15 GPa. The measurements were performed at room temperature in a diamond anvil cell (DAC) using Daphne7373 oil as a pressure transmitting medium.

FeSi crystallizes in the B20 structure for which the factor group analysis predicts 9 Raman active modes. Measurements on larger crystals outside of the DAC allowed the assignment of all vibrations.[1] In the DAC only the stronger E-mode vibrations at 182 cm^{-1} and 313 cm^{-1} and the T-mode vibration at 310 cm^{-1} could be observed.

With increasing pressure the frequencies of the vibrations shift to higher wave numbers. For all the observed modes the Grüneisen parameters are calculated and compared to the values from temperature dependent measurements at ambient pressure. The data are discussed in terms of both localized and itinerant models of FeSi.

[1]A.-M. Racu et. al., Phys. Rev. B 76, 115103(2007)

MA 18.37 Tue 15:15 Poster E

Modification of magnetic order in Mn_5Si_3 and Mn_5Ge_3 by C ion implantation — •Christoph Sürgers[1], Niraj Joshi[1], Richard Montbrun[1], Hilbert v. Löhneysen[1,2], Kay Potzger[3], and Wolfhard Möller[3] — [1]Physikalisches Institut and Center for Functional Nanostructures, Universität Karlsruhe, D-76128 Karlsruhe — [2]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe — [3]Institute for Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, Bautzner Landstraße 128, D-01328 Dresden

Antiferromagnetically ordered Mn_5Si_3 can be driven ferromagnetic by incorporation of carbon into the voids of Mn octahedra of the hexagonal structure. While for $Mn_5Si_3C_x$ polycrystals the Curie temperature saturates for $x > 0.22$ at $T_C = 152$ K [1], sputtered $Mn_5Si_3C_{0.8}$ films exhibit a T_C above room temperature [2]. An enhancement of T_C is also found after C doping of the isostructural compound Mn_5Ge_3 which is currently in the focus of possible spintronic applications. In an alternative approach, $Mn_5Si_3C_x$ and $Mn_5Ge_3C_x$ films were prepared by implantation of 45 - 195 keV C^+ ions into Mn_5Si_3 or Mn_5Ge_3 films at elevated temperatures. The carbon-implanted samples exhibit magnetic properties very similar to their respective magnetron-sputtered counterparts as inferred from magnetization and resistivity measurements.

[1] J. P. Sénateur et al., Bull. Soc. Fr. Mineral. Cristallogr. **90**, 537 (1967)

[2] C. Sürgers et al., Phys. Rev. B **68**, 174423 (2003)

MA 18.38 Tue 15:15 Poster E

Local measurement of magnetic anisotropy in (Ga,Mn)As — •Frank Hoffmann, Matthias Sperl, Georg Woltersdorf, Ursula Wurstbauer, and Christian Back — University Regensburg, Germany

The magnetic properties of the ferromagnetic and semi-conducting material (Ga,Mn)As can be accessed by means of static and dynamic experimental approaches (e.g. SQUID, FMR). In contrast to these integrative methods we present a dynamic approach which combines FMR and Kerr microscopy. This local technique enables us to investigate magnetic anisotropies within the laser spot diameter (submicron resolution). Microwaves in the GHz range which are synchronized to the laser probe pulses are used for the excitation of the magnetization. The magnitude of the precessional motion of the magnetization is measured by means of the magneto-optic Kerr effect. By sweeping the magnetic bias field at a fixed excitation frequency both resonance field and linewidth can be obtained. From the angular dependence of

the resonance fields, the anisotropy constants can be determined.

Our results of (Ga,Mn)As on GaAs(001) at low temperatures can be explained by a superposition of several anisotropies: A cubic anisotropy due to the zinc-blende crystal structure, a uniaxial out of plane anisotropy attributed to the compressive strain of (Ga,Mn)As on GaAs and an additional uniaxial in-plane anisotropy in agreement with standard FMR results [1]. At higher temperatures a spin reorientation due to the vanishing of the cubic anisotropy was found.

[1] Liu et al., PRB 67, 205204 (2003)

MA 18.39 Tue 15:15 Poster E

Magnetization measurements of Co-coordinated fullerene-porphyrin dyads under pressure — •Klaus Gieb[1], Konstantin Pethukov[1], Jörg Dannhäuser[2], Andreas Hirsch[2], and Paul Müller[1] — [1]Institut für Physik der Kondensierten Matherie, Universität Erlangen-Nürnberg — [2]Institut für Organische Chemie LS II, Universität Erlangen-Nürnberg

In this report we present the development of a small titanium alloy pressure cell that enables measurements of the magnetic moment under pressure. It can produce a pressure of 0.5 GPa, and is suitable for use in any Quantum-Design SQUID magnetometer. The pressure is established by the solidification of gallium inside the cell. Pressure calibration was established by the shift of the critical temperature of lead. A special background subtraction procedure has been developed. Susceptibility measurements of Co-coordinated fullerene-porphyrin dyads are presented. The samples show a pressure induced shift of the antiferromagnetic ordering temperature.

MA 18.40 Tue 15:15 Poster E

In-situ photoemission and electron microscopy from ferrofluids and nanoparticles dissolved in ionic liquids. — •Siham Ouardi[1], Gerhard H. Fecher[1], Andrei Gloskowskii[1], Lubna Basit[1], Claudia Felser[1], Bert Mallik[2], and Anja Mudring[2] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz — [2]Inorganic Chemistry I, Ruhr - University, 44801 Bochum

This work reports on in-situ electron spectroscopy on fluids. Photo emission spectroscopy from liquids is a challenging task because the experiments have to be carried out in vacuum. It becomes, however, simplified for ionic liquids due to the low vapour pressure. Results are presented for the ferrofluid $[bmim]_4Dy[SCN]_7[H_2O]$ exited by photons of 4.5 keV. Ionic liquids allow to separate ferromagnetic nano particles that otherwise stick together. Results will be presented for magnetic nanoparticles in [bmpyr][OTf] and Pt nanoparticles in the ferrofluid $[bmim]FeCl_4$ investigated by photo emission excited by laboratory sources for X-rays as well as synchrotron radiation. SEM combined with EDX analysis was used to image the nanoparticles dissolved in the liquid.

MA 18.41 Tue 15:15 Poster E

Magnetoresistance and magnetization of magnetically ordered proton irradiated graphite — •Jose Barzola-Quiquia[1], Martin Rothermel[2], Daniel Spemann[2], Tilman Butz[2], Michael Ziese[1], and Pablo Esquinazi[1] — [1]Division of Superconductivity and Magnetism, University of Leipzig, Leipzig, Germany — [2]Division of Nuclear Solid State Physics, University of Leipzig, Leipzig, Germany

Defect induced magnetic order is a new phenomenon in material science that refers to the triggering and manipulation of magnetic order and magnetic moments in nominally non-magnetic materials by lattice defects and/or non-magnetic add atoms. A noticeable example of this effect is the magnetic order produced by proton irradiation of graphite. In this contribution we present SQUID measurements of the magnetization showing a fluence dependent Curie temperature as well as magnetoresistance and Hall effect measurements showing irreversible behavior similar to that found in ferromagnetic films. This indicates the presence of spin/domain reorientation effects in irradiated graphite. The observed magnetoresistance effects and Curie temperatures above room temperature are promising facts that may lead to useful carbon-based devices in the near future.

MA 18.42 Tue 15:15 Poster E

X-ray and Neutron Scattering on a Ni dot array — •Wolfgang Kreuzpaintner, Dieter Lott, Michael Störmer, and Andreas Schreyer — GKSS Forschungszentrum GmbH, Max-Planck-Str. 1, 21502 Geesthacht

Since some time elastic and inelastic neutron scattering on magnetic bulk and thin layer materials has proven as a reliable analysis method and has even allowed for collecting spin wave information from rare earth super lattice samples with multilayer periods below the μm-scale.

However, for on the sub-μm scale laterally structured magnetic samples, these inelastic experimental possibilities are still not that far developed and, consequently, not that well established. Nevertheless, theoretical calculations show, such experiments should be possible and could yield essential information for the further development of higher density magnetic data storage devices and new technologies like magnetic random access memory as not only magnetic switching behavior but also the spin wave dispersion could be probed in regions of the Brillouin zone which by other means are not accessible.

The middle to long term goal of measuring quantized spin waves on magnetic nanostructures by inelastic neutron scattering is an ambitious task and requires the optimization of a variety of parameters of both, instrumental and specimen sides.

We here present recently performed x-ray and neutron test measurements on Ni dots with 200nm diameter arranged in a 2D square lattice array with 700nm periodicity.

MA 18.43 Tue 15:15 Poster E

Magnetic Quantum Dots — •Peter Moraczewski and Daniela Pfannkuche — 1. Intitut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg

In semiconductor quantum dots electrons and holes are confined in all three spatial directions. Their eigenstates can be tailored by the used materials, the size and the shape of the dot and also by applied electric and magnetic fields. When we insert atoms with a large magnetic moment, like Mn, into the quantum dot they interact with the electrons or holes via electric and magnetic interactions. We can now expect to manipulate the alignment of the Mn-spins by changing the states of electrons or holes. In III-V semiconductors such as GaAs the Mn atom is an acceptor, so holes will be the main charge carriers. We calculate the eigenstates of several holes in a quantum dot by k*p-theory-, under the influence of a magnetic field and with many-body interaction. Then we examine the interplay between the hole states and the magnetic impurities and calculate the resulting magnetization of the dot.

MA 18.44 Tue 15:15 Poster E

FMR study of ordered submicronscale permalloy antidot arrays — •Stephan Martens, Kornelius Nielsch, and Detlef Görlitz — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Antidot arrays, consisting of lattices of holes in continuous magnetic films, exhibit periodic demagnetization field distributions, which effect the magnetic structure and properties in these films. Our almost squarely ordered 180 nm period antidot arrays with a mesh aperture of $\sim$ 80 nm have been prepared by vapor deposition of permalloy on porous anodic alumina substrates. We investigate the anisotropy field of our samples by means of ferromagnetic resonance (FMR) measurements, carried out at 9.2 GHz. The magnetic spectra reveal one uniform and multiple spin wave modes depending on the alignment of the film plane relative to the external field. These angle dependencies are compared with those of the coercive fields, previously observed via vibrating sample magnetometry [1].

[1] F. J. Castaño et al., Appl. Phys. Lett. **85**, 2872 (2004)

MA 18.45 Tue 15:15 Poster E

Analytic formulae for multipole moments of general ellipsoids, elliptic cylinders and prisms — •Nikolai Mikuszeit, Matthias Schult, Elena Vedmedenko, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

The multipole moments of different homogeneously polarised/charged geometries are calculated analytically. The general shapes include important limits: spheroid and sphere, cylinder or disc, and cube. It is shown that all multipole moments can be expressed as polynomials. The polynomial functions depend on the particle shape and the aspect ratios. Even the solutions for the general ellipsoid, where hypergeometric functions appear, can be expanded in finite polynomials of the semi-axes [1]. The calculations are valid up to every order of the multipole expansion. Some results are extended to symmetric two-/multidomain states.

The results allow to calculate potentials as well as interaction energies within the framework of multipole expansion. It is therefore

easy to consider important higher order interactions—corrections to dipole-dipole energies—in systems of interacting particles, where the interparticle distance is of the order of the particle size [2].

[1] M. Schult, N. Mikuszeit, E. Y. Vedmedenko, and R. Wiesendanger, 2007, J. Phys. A, *accepted*

[2] E. Y. Vedmedenko, N. Mikuszeit, H. P. Oepen, and R. Wiesendanger, 2005, Phys. Rev. Lett. **95**, 207202

MA 18.46 Tue 15:15 Poster E

Preparation of anti-vortex configurations in Permalloy micromagnets — •Christian Dietrich, Christian Back, and Josef Zweck — Institut für Experimentelle und Angewandte Physik der Universität Regensburg, Germany

Permalloy magnets with lateral dimensions in the micron range or below show several (quasi)-stable magnetic configurations depending on thickness, precise shape and size. The static and dynamic properties of single-domain and vortex configurations are numerously published. On the way to do current-induced anti-vortex excitations we investigate how to experimentally prepare a preferably single anti-vortex. In general anti-vortex configurations in patterned magnetic films are characterised by a local energy minimum and only for specific shapes or dimensions these configurations reach an absolute energy minimum. The energy landscapes were studied by micromagnetic simulations. Rectangles with a particular aspect ratio and thickness show an anti-vortex configuration as most stable state in remanence. Micromagnetic simulations were also used to optimize the shape of the micromagnets to enhance the probability for the creation of an anti-vortex in remanent state for a given direction of the saturating magnetic field. To verify the simulations we investigated Permalloy rectangles with a constant width of 1 micron and different thicknesses and lengths by Lorentz transmission electron microscopy using the Fresnel mode, which allows a fast and simultaneous evaluation of many rectangles. Different magnetic configurations can be observed, with their frequency related to the energy distribution.

MA 18.47 Tue 15:15 Poster E

Hall micromagnetometry of magnetic vortices and single domain walls — •Lena Breitenstein, Peter Lendecke, René Eiselt, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

Hall micromagnetometry is a powerful tool for the investigation of the magnetization of nanostructures. We apply the technique to study magnetic vortices [1] and domain-wall depinning [2] in Permalloy squares and wires. Both sample geometries are investigated in the temperature range between 1.6 and 50 K. In the square elements the vortex core is nucleated and driven through the sample by an external magnetic field. Because of the high sensitivity of the Hall sensor to the local stray fields we identify vortex core nucleation and displacement as well as minor loops. Thus the vortex state can be separated from other micromagnetic configurations. Furthermore we investigate the temperature dependence of the vortex core nucleation and displacement. In the wire geometry we examine the temperature dependence of depinning fields of single domain walls to gain knowledge about the pinning potential. The observations are well described by a model with a single energy barrier. Magnetic-force microscopy and micromagnetic simulations round out the low temperature experiments.

[1] M. Rahm, J. Stahl, W. Wegscheider, and D. Weiss, Appl. Phys. Lett. **85**, 1553 (2004).

[2] P. Lendecke, R. Eiselt, U. Merkt, and G. Meier, submitted.

MA 18.48 Tue 15:15 Poster E

Understanding the behaviour of mesoporous Co3O4 using TRM-IRM curves as fingerprints of magnetic systems — •María José Benítez Romero[1], Oleg Petracic[1], Yuriy Yanson[1], Elena Lorena Salabas[2], Ferdi Schüth[2], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität, Bochum, Germany — [2]Max-Planck Institut für Kohlenforschung, Mülheim an der Ruhr, Germany

Antiferromagnetic mesoporous Co3O4 exhibits interesting magnetic properties at low temperatures: bifurcation of the FC and ZFC susceptibilities at 30 K and shifted hysteresis loops after field cooling. This anomalous behavior originates due to the exchange interaction between the AFM core and the surface spins. To understand the nature of the surface spins in the nanostructured Co3O4 we propose to study the thermoremanent magnetization (TRM) and isothermal remanent magnetization (IRM) curves in this AFM as well as in other magnetic systems. The ordered mesoporous Co3O4 has been synthesized using the nanocasting method. The nanowires were characterized using X-ray diffraction, N2 adsorption-desorption isotherms, transmission electron microscopy and a superconducting quantum interference device magnetometer. We report measurements of thermoremanent moments and isothermal remanent moments in spin glass, exchange bias, superparamagnetic and antiferromagnetic systems. The analysis of thermal and isothermal remanence curves suggest that the mesoporous Co3O4 consists of antiferromagnetically aligned core spins and a spin-glass-like surface layer.

MA 18.49 Tue 15:15 Poster E

XMCD studies of FePt nanocrystals — •Daniela Nolle[1], Eberhard Goering[1], Liberato Manna[2], Albert Figuerola[2], Thomas Tietze[1], Sebastian Brück[1], and Gisela Schütz[1] — [1]Max-Planck-Institute for Metal Research, Heisenbergstr. 3, 70569 Stuttgart, Germany — [2]National Nanotechnology Laboratory of CNR-INFM, Unità di Ricerca IIT, Distretto Tecnologico ISUFI, via per Arnesano km. 5, I-73100 Lecce, Italy

We have investigated bi-magnetic FePt hybrid nanocrystals, prepared in a "one-pot" technique, using X-ray magnetic circular dicroism (XMCD). These hybrid nano crystals consist of a metallic FePt core with fcc structure and an iron oxide shell with inverse spinell crystal structure, which is a mixture of magnetite (Fe3O4) and maghemite (γ-Fe2O3). The investigations were performed both surface-sensitive in total electron yield mode (TEY) and bulk-sensitive in transmission.

These spectra have been analysed in terms of a linear superposition of suitable reference data. So we could determine the radial composition of the nanocrystals and the contributions of the constituents to the overall magnetic moment. A comparison between TEY and transmission measurements shows that the iron oxide shell is mainly maghemite like, while the surface magnetisation has predominantly magnetite character. With decreasing temperature the XMCD transmission results are in perfect agreement to bulk sensitive SQUID-measurements, while the surface exhibits a stronger increased magnetic moment at low temperatures.

MA 18.50 Tue 15:15 Poster E

Structure and magnetic properties of iron-platinum particles with iron oxide shell. — •Lubna Basit[1], Ibrahim Shukoor[1], Vadim Ksenofontov[1], Wolfgang Tremel[1], Gerhard H. Fecher[1], Claudia Felser[1], Sergei A. Nepijko[2], Gerd Schönhense[2], and Michael Klimenkov[3] — [1]Institut of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, 55099 Mainz — [2]Institut of Physics, Johannes Gutenberg - University, 55099 Mainz — [3]Institut of Materials Research I, Forschungszentrum Karlsruhe, 76021 Karlsruhe

Nanoparticles of solid solution Fe_xPt_{1-x}, where $0.25 \geq x \geq 0$ with Fe_2O_3 shell were synthesized and characterized by high-resolution transmission electron microscopy, energy dispersive X-ray analysis, electron energy loss spectroscopy, Mößbauer spectroscopy and magnetometry. The magnetic properties, of such two-phase particles are interesting because their core is antiferromagnetic or paramagnetic (at very small values of x) whereas the shell is ferrimagnetic. The size of the particles was in the range of several nanometers. ^{57}Fe Mößbauer spectroscopy revealed a blocking temperature of about 100 K above which the particles are superparamagnetic. Towards lower temperatures, the magnetic characteristics showed an increase of magnetic rigidity. The saturation magnetization increases by a factor of 1.4 between room temperature and 5 K.

MA 18.51 Tue 15:15 Poster E

Investigations of confined domain walls in nanoscale constrictions — •Jan Rhensius[1,2], Dirk Backes[1,2], Laura Heyderman[1], Christian David[1], Mathias Kläui[2], Christine Schieback[2], Peter Nielaba[2], Friederike Junginger[2,3], Henri Ehrke[2,3], Ulrich Rüdiger[2], Takeshi Kasama[3], and Rafal Dunin-Borkowski[3] — [1]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, Switzerland — [2]FB Physik, Universität Konstanz — [3]Department of Materials Science and Metallurgy, University of Cambridge, UK

Magnetic domain walls in curved-line elements can exhibit a vortex or transverse wall spin structure. A notch forms a constriction, which pins TW inside the constriction and the VW adjacent to the notch [1]. Such elements were fabricated on membranes with constrictions as narrow as 30 nm [2]. Electron holography is used to study the spin-structure around the constriction with a spatial resolution below 5 nm. The shape of the walls depends on the geometry which we characterize systematically. In total three different spin configurations were found,

depending on the size of the constriction and the element width. Symmetric and asymmetric TW were found for narrow constrictions, VW were found for wider constrictions. The width of the domain walls was found to depend on the constriction and decreases with decreasing constriction width super linearly [3]. The experimental data was compared with micromagnetic simulations using a Heisenberg model.

[1] M. Kläui et al., Appl. Phys. Lett. 87, 102509 (2005)
[2] D. Backes et al., Microelectron. Eng. 83, 1726 (2006)
[3] D. Backes et al., Appl. Phys. Lett. 91, 112502 (2007)

MA 18.52 Tue 15:15 Poster E

Structural and magnetic properties of thin CoCrPt-SiO_2 films and their application to patterned media — •Felix Springer[1], Christoph Brombacher[2], Hartmut Rohrmann[3], Marco Sauer[3], and Manfred Albrecht[2] — [1]University of Konstanz, Department of Physics, 78457 Konstanz, Germany — [2]Chemnitz University of Technology, Institute of Physics, 09107 Chemnitz, Germany — [3]OC Oerlikon Balzers AG, 9496 Balzers, Liechtenstein

Thin granular films of CoCrPt-SiO_2 are used as storage layer in perpendicular magnetic recording media. In order to investigate the properties of the storage layer only, we reduced the layer stack of a conventional hard disk to a system consisting of substrate/Ta/Ru/CoCrPt-SiO_2. We studied the properties of this system deposited under various growth conditions and observed a strong relationship between structural and magnetic properties. The formation of small grains in the hcp (0001) oriented Ru intermediate layer supported the formation of hcp (0001) oriented columnar CoPt grains in the magnetic layer. With increasing segregation of SiO_2 and Cr to the grain boundaries the exchange coupling between single CoPt grains was reduced and the coercivity increased. The application of those CoCrPt-SiO_2 films to patterned media might be a promising candidate to achieve areal densities of more than 1Tbit/in^2. Thus we deposited film systems onto arrays of SiO_2 nano spheres. Particles with diameter down to 10nm have been coated by reducing the overall film thickness and adjusting the deposition conditions of the different layers.

MA 18.53 Tue 15:15 Poster E

Magneto-optic investigations on the dynamics of the switching behavior of CoFeB TMR structures — •Georg Wolf, Patrizio Candeloro, Patricia Martin Pimentel, Helmut Schultheiss, Britta Leven, and Burkard Hillebrands — FB Physik and FSP MINAS, TU Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany

For technical applications of TMR structures like magnetic random access memory or magnetic logic devices the dynamics of the switching behavior is of great importance. Optimizing the switching process is a major task in the development of these devices. We report on time-resolved Kerr microscopy investigations on the dynamics of 3 x 6 μm^2 ellipsoidal CoFeB-TMR structures under the influence of two orthogonal magnetic field pulses [1]. The TMR stack has been prepared in collaboration with the group of Guenter Reiss, University of Bielefeld. This study is focused on the dynamic behavior of the free magnetic layer. The field pulses were oriented in 45° geometry with respect to the easy magnetic axis of the system in the so called Savtchenko-geometry [2]. The field response of the different magnetization components is presented and compared with simulations in a macro spin approximation. These simulations yield a good agreement with the measurements. Financial support by the EU-IST Project MAGLOG (510993) is gratefully acknowledged.

[1] P.Martin Pimentel et al, Appl. Phys. Lett., **88**, 122510, (2006).
[2] L. Savtchenko et al. US Patent 6,545,906 B1, Apr. 8 (2003).

MA 18.54 Tue 15:15 Poster E

Magnetic interactions and anisotropies present in ferromagnetic nanotubes of manganites — •Rodolfo D. Sanchez[1,2], Javier Curiale[1], Horacio Troiani[1], Alejandro Butera[1], Ana G. Leyva[3], and Pablo Levy[3] — [1]Centro Atómico Bariloche (CNEA), Av. Bustillo 9500 Bariloche (RN-8400), Argentina — [2]I Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany — [3]Centro Atómico Constituyentes (CNEA), Av. Gral Paz 1499 (B1650KNA), Buenos Aires, Argentina

We present a work about FM manganites with tubular morphology at the nanoscale. Although their FM transition temperatures (Tc) are close to the bulk, the rest of their magnetic properties are notably affected. These tubes have an external diameter of 800nm and their walls are constituted by an assembly of nanoparticles with size of 25nm. The wall thicknesses are 45 nm for LSMO and 60 nm for LCMO. Our previous study[1] shows that each grain is a single magnetic domain, with a thick dead layer on the surface and dipolar magnetic interactions between them. In order to characterize completely the interactions between the magnetic nanograins, we show First-Order Reversal Curves (FORC) diagrams. We also discuss the role of the interaction in the configuration of the magnetic moments. FM resonance results on aligned LSMO nanotubes complete this study, with information about the magnetic anisotropies present in the system.

[1] J. Curiale,et al. Phys. Rev. B 75, 224410 (2007) RDS acknowledges financial support of DFG (via its Leibniz-Program) during his stay in Göttingen.

MA 18.55 Tue 15:15 Poster E

Preparation and characterisation of Ni and Ni/Ag nanowire arrays in alumina — •Gesa Beck and Kerstin Petrikowski — Forschungsinstitut Edelmetalle und Metallchemie, Katharinenstr. 17, 73525 Schwäbisch Gmünd, Germany

Magnetic nanowires, fabricated by various methods, represent an important family of magnetic nanostructures. Imbedding magnetic nanowires in a regular matrix yields systems which are promising candidates for magnetic storage media. One example for such systems are magnetic nanowire arrays in alumina.

Nanoporous alumina with a self-organised hexagonal arrangement of the nanopores can be formed by anodic oxidation of aluminium. In the nanopores metallic nanowires can be electrodeposited, resulting in a nanowire array in alumina.

We prepared alumina with highly ordered nanopores by two-step anodisation and subsequently electrodeposited both Ni and Ni/Ag-layered nanowires in the nanopores. The systems were characterised by X-ray diffraction, high resolution scanning electron microscopy, magnetic hysteresis and magnetoresistance measurements.

MA 18.56 Tue 15:15 Poster E

Growth parameters and transport properties of WC and PdC nanowires prepared in a Dual Beam Microscope — •Detlef Spoddig[1], Kristian Schindler[1], Peter Rödiger[1], Jose Barzola-Quiquia[1], Holger Motzkau[1], Katharina Fritsch[1], Hans Mulders[2], and Pablo Esquinazi[1] — [1]Abteilung für Supraleitung und Magnetismus, Institut für Experimentelle Physik II, Universität Leipzig, Linnéstr. 5, D-04103 Leipzig, Germany — [2]FEI Electron Optics, Achtseweg Noord 5, 5651GG AE Eindhoven, The Netherlands

Here we present investigations on the growth conditions and the electrical transport properties of Tungsten Carbon (WC) and Palladium Carbon (PdC) nanostructures on Si substrates using a focused ion beam and a scanning electron microscope. In-situ energy dispersive x-ray characterizations reveal that electron beam induced WC and PdC nanostructure depositions (EBID) show a lower metal concentration (below 3 at.%) than in ion beam induced deposition (IBID) (above 20). For PdC the growth pattern and the Pd/C content were optimized by adjusting the deposition temperature of the precursor material. In-situ measurements of the resistivity as a function of thickness reveal a minimum at 200 nm. The lowest resistivity obtained for the PdC and WC is two orders of magnitude higher than the bulk values. The EBID samples show a non-metallic behaviour due to the low metal content. The temperature and magnetic field dependence of the IBID structures reveal a behaviour similar to disordered or granular conductors. The upper critical field and current density of the WC structures were measured below the superconducting critical temperature of 5 K.

MA 18.57 Tue 15:15 Poster E

Remagnetization patterns in 2-d arrays of hard magnetic elements embedded in a soft magnetic matrix — •Sven Schnittger[1], Jonas Norpoth[1], Christian Jooss[1], Sybille Sievers[2], and Uwe Siegner[2] — [1]Institut für Materialphysik, Universität Göttingen — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

In a regular array of moderately hard magnetic elements, the stray field coupling between neighbouring elements may become important. In this contribution, the influence of a surrounding soft magnetic matrix on this magnetostatic interaction is investigated [1]. The remagnetization behaviour of 2-d artificial dot arrays is examined by means of Magnetic Force Microscopy (MFM) and Magneto-Optic Indicator Film-Technique (MOIF). (001)-L10 CoPt and Co-ferrite provide regularly arranged elements with different magnetocrystalline anisotropy; the mediating soft magnetic matrix consists of Permalloy. A Permalloy antidot array is investigated as reference sample. Additionally,

straightforward stray field calculations are performed to determine characteristic features of the corresponding stray field distributions.

[1] S. Schnittger, S. Dreyer, Ch. Jooss, S. Sievers, and U. Siegner, APL 90, 042506 (2007)

MA 18.58 Tue 15:15 Poster E

Investigation of permalloy nanowire-based NOT gates in the microwave regime using crossed coplanar waveguides — •Andres Conca, Patricia Martin Pimentel, Britta Leven, and Burkard Hillebrands — FB Physik + FSP MINAS, TU Kaiserslautern, Erwin Schrödinger-Str. 56, 67633 Kaiserslautern, Germany

Serious obstacles must be confronted in order to reduce the dimensions and power consumption of Si-based logic devices. In this context, alternative possibilities exploiting the magnetic properties of materials have triggered a large research effort.

Recently, Allwood *et al.* [1] proved logic operations by domain wall motion at low frequencies (27 Hz) in structures consisting of nanometric permalloy wires under a rotating static magnetic field.

In collaboration with the Imperial College London, similar gates are patterned with focused ion beam on top of a crossed coplanar waveguides (cpw's) scheme previously developed by P. Martín Pimentel [2]. Microwave currents phase-shifted by $\pi/2$ are sent through two cpw's in order to achieve a rotating microwave field. Main aim of this research is the investigation of the behavior of the NOT gates at larger frequencies (20MHz-1GHz) in order to find the maximal operating speed of the devices. For this purpose, a time-resolved Kerr microscope is used. Here, results concerning the magnetic response of the NOT gates in the mentioned frequency range are shown and discussed.

Support by MAGLOG (IST-FET-510993) is acknowledged.

[1]D. A. Allwood *et al*, *J. Appl. Physics*, **95**, 8264 (2004).

[2]P. Martín Pimentel *et al*, *Appl. Phys. Lett.*, **88**, 122510 (2006).

MA 18.59 Tue 15:15 Poster E

Magnetization reversal in a twodimensional two-phase magnet — •Sibylle Sievers[1], Sven Schnittger[2], Sebastian Dreyer[2], Christian Jooss[2], Kai-Felix Braun[1], and Uwe Siegner[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig — [2]Institut für Materialphysik, Universität Göttingen

We characterized the remagnetization behaviour of a two-dimensional two-phase ferromagnet. For the fabrication of the two phase magnet hard magnetic structures (CoPt) were patterned and embedded in a soft magnetic film (Permalloy). The magnetic characterization has been done by a magneto-optical indicator film technique using the Faraday Effect and by magnetic force microscopy. The remagnetization process was investigated at increasing reversal fields. In the soft magnetic matrix a long range ordered symmetry breaking domain pattern was found. Furthermore, a correlation between reversal domains in the hard magnetic structures and the matrix was observed. The mechanisms of the magnetization reversal will be discussed.

MA 18.60 Tue 15:15 Poster E

Direct laser interference patterning of magnetic thin films — •Sebastian Fischer, Philipp Leufke, Stephen Riedel, Manfred Albrecht, Paul Leiderer, and Johannes Boneberg — University of Konstanz, Department of Physics, D-78457 Konstanz, Germany

We report on direct laser interference patterning of magnetic thin films. When exposed to nanosecond laser pulses the films are annealed locally. Thus, the magnetic behaviour is locally altered. The direct laser interference patterning is performed using two, three and four beams of a ns-Nd: YAG laser system at wavelengths of 532 and 266 nm. Different patterns of light intensity can be created by varying the angle of incidence or polarization of the beams. The received magnetic patterns were locally investigated with magnetic force microscopy and compared with the hysteresis loops measured by polar magneto-optical Kerr effect and superconductive quantum interference device magnetometry.

MA 18.61 Tue 15:15 Poster E

Microfluidic Separation System for Magnetic Beads — •Frank Wittbracht, Alexander Weddemann, and Andreas Hütten — Bielefeld University, Universitätsstraße 25, 33615 Bielefeld

Lab-on-a-chip technologies and the μTAS have gained importance in recent years. The ultimate goal is the integration of all functions and components needed for the analysis of a sample on microfluidic chips. Magnetic materials are used widely in these systems for different applications such as magnetohydrodynamic pumps and magnetic valves. Especially in terms of separation and detection of biological samples magnetic materials are suitable.

In this work a microfluidic separation system for magnetic beads was experimentally realized according to theoretical simulations. The separation of magnetic beads is achieved by magnetic gradient fields resulting from conducting lines that are structured on the fluidic chip. Silicon wafers are used as a substrate and enable the integration of XMR sensors into the microfluidic device. Microfluidic structures are built with SU-8 negative photo resist due to its excellent mechanical and chemical stability.

MA 18.62 Tue 15:15 Poster E

Simulation of the magnetization dynamics of ferromagnetic layers on nano-spheres — •Daniel Mutter and Peter Nielaba — Physics Department, University of Konstanz, 78457 Konstanz, Germany

In this work we investigated the magnetization-dynamics of ferromagnetic caps on nano-spheres with computer simulations. These caps are regarded as a promising approach for a further reduction of the magnetic storage density in hard-disks [1]. In our calculations, the magnetic volume was modeled by magnetic moments, arranged on a discrete lattice, which interact with each other due to exchange and dipole-dipole coupling [2]. Additionally, there is an anisotropy in the system, which is directed perpendicular to the surface of the sphere. The dynamics was analyzed by numerical solving of a stochastic extension of the Landau-Lifshitz-Gilbert equation to include temperature effects. We present results concerning hysteresis-effects for different cap- and cell-sizes in the presence of external magnetic fields under various angles. The dynamics of the magnetization reversal at the coercive field strength is analyzed, and a comparison with the behavior of classical Stoner-Wohlfahrt particles shows significant differences in the reversal mechanisms.

[1] M. Albrecht, G. Hu et al., *Magnetic multilayers on nanospheres*, Nature Materials, **4**, 203 (2005).

[2] U. Nowak, *Thermally activated reversal in magnetic nanostructures*, Annual Reviews of Computational Physics, **IX**, 105-151 (2001).

MA 18.63 Tue 15:15 Poster E

Numerical investigation of geometrically confined domain walls and spin torque using the Heisenberg model — •C. Schieback[1], U. Nowak[2], M. Kläui[1], D. Backes[1,3], L. J. Heydermann[3], U. Rüdiger[2], and P. Nielaba[1] — [1]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]Department of Physics, University of York, York YO10 5DD, UK — [3]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, CH-5232 Villingen PSI, Switzerland

Computer simulations are preformed on a classical spin model. Thermal activation of the system is taken into account by numerically solving the Landau-Lifshitz-Gilbert equation with Langevin dynamics.

Using this model, we study systematically the influence of lateral constrictions on the spin structure of transverse domain walls in permalloy nano-structures. The domain wall width is strongly correlated with the constriction width. Reduced constriction width leads to a superlinear scaling of the wall width [1]. Furthermore we calculate the response of a domain wall to a current due to a spin transfer torque resulting in current-induced domain wall motion. We compute the behavior of domain walls in a one dimensional chain when currents are injected using adiabatic and non-adiabatic spin torque terms [2]. Our results are compared to analytical calculations and are found to agree very well for small current density predictions.

[1] D. Backes et al., APL 91, 112502 (2007). [2] C. Schieback et al., EPJ B, DOI:10.1140/epjb/e2007-00062-2

MA 18.64 Tue 15:15 Poster E

Thermodynamically Extended Preisach Modeling of Magnetic Properties of Ni-Nanoparticles in Fullerene Films — •Sven Schubert and Günter Radons — Chemnitz University of Technology, D-09107 Chemnitz

For developing high-density recording memories decreasing the particle size and optimizing their packing is necessary. Therefor, small molecules, e.g. fullerene (C_{60}), are used as a matrix for metallic magnetic nanoparticles. As the scales are shrinking the interaction between particles and the properties of the interface to the surrounding medium are enhanced.

To avoid a complicated surface dependency and gain a more general model a thermodynamically extended Preisach approach is used for modeling the magnetic behavior of Ni nanoparticles embedded in

fullerene matrices.

The achieved results are compared to experimental data [1]. Among other things, it is shown that taking into account small particle hysteresis leads to a better agreement with SQUID measurements than using a standard practice Preisach distribution function. This suggests a physical picture consisting of a large number of small particles with small coercive fields within the matrix.

[1] G. Salvan et al. J. Appl. Phys. submitted.

MA 18.65 Tue 15:15 Poster E

Observation of a spin spiral state in the Mn monolayer on W(001) — Kirsten von Bergmann, Paolo Ferriani, Elena Vedmedenko, •André Kubetzka, Stefan Heinze, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Germany

The magnetism of single atomic layers is a fascinating topic. Due to the reduced symmetry, changed nearest neighbor distances, and hybridization with the substrate the magnetic properties can be quite distinct from the respective bulk systems. A variety of magnetic structures can be observed, ranging from collinear ferro- or antiferromagnetic states to complex non-collinear spin structures. Spin-polarized scanning tunneling microscopy (SP-STM) combines magnetic sensitivity with high lateral resolution and therefore grants access to such complex magnetic order with unit cells on the nanometer scale. Recently, different intricate magnetic structures have been observed in pseudomorphic $3d$ atomic layers on $5d$ transition metal substrates [1,2].

Here we present SP-STM data of the pseudomorphic Mn layer on W(001). We observe a spin spiral with a periodicity on the nanometer-scale. Due to the four-fold symmetry of the surface, two rotational domains are possible. Via spin-orbit interaction the spin-spiral and the rotational domains can also be imaged with non-magnetic probe tips [3].

[1] K. von Bergmann *et al.*, Phys. Rev. Lett. **96**, 167203 (2006).
[2] M. Bode *et al.*, Nature **447**, 190 (2007).
[3] M. Bode *et al.*, Phys. Rev. Lett. **89**, 237205 (2002).

MA 18.66 Tue 15:15 Poster E

Spin-dependent surface electronic structure of Gd(0001) near the Fermi-level: An angle-resolved (I)PE study — •Michael Budke, Alexander Wittkowski, Juliet Correa, and Markus Donath — Physikalisches Institut, WWU Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

A widely accepted picture for the surface electronic structure of Gd(0001) comprises a spin-split surface state (SS) with its mayority part 0.2 eV below E_F and its minority part 0.5 eV above E_F with a finite exchange splitting of 0.4 eV at T_C [1]. The discussion about this SS remains controversially because spin-resolved inverse photoemission identified a SS with both minority and majority components above E_F [2]. The reason for these conflicting results might be found in different sample conditions since the Gd films are usually grown on W(110), a material with considerably different lattice constant than Gd. To overcome this suspicion, we performed both, spin- and angle-resolved direct (PE) and inverse photoemission (IPE) on the same sample preparation of a 30 ML Gd film grown on Y(0001). We were able to identify two SSs with their minority and majority components well separated from E_F. While the occupied SS shows spin-mixing behaviour as observed in other PE experiments, the unoccupied SS exhibits an exchange splitting of 250 meV that vanishes at T_C. To identify the nature of the unexpected SS, we performed angular-resolved IPE measurements that support the interpretation as d-like SS above E_F and reveal a variety of additional spectral features. [1] Getzlaff *et al.*, JMMM **184**, 155 (1998). [2] Donath *et al.* PRL **77**, 5138 (1996).

MA 18.67 Tue 15:15 Poster E

XMCD and Spin-Resolved Photoemission on Ce/Fe Interfaces — •Matthias Holder[1], Yuri S. Dedkov[1], Yuri Kucherenko[2], Mikhail Fonin[3], Sönke Voss[3], Alexei Preobrajenski[4], Serguei L. Molodsov[1], and Clemens Laubschat[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Germany — [2]Institute for Metal Physiscs, National Akademie of Science Ukraine, 03142 Kiev, Ukraine — [3]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [4]MAX-lab, Lund University, 22100 Lund, Schweden

The correlation effects of the Ce $4f$ shell with extended valenz-band electrones are usually described in the framework of the Anderson model. These correlations are the most importend mechanism for description of magnetic properties of Ce- compounds. Here the electronic as well as the magnetic properties of Ce/Fe interface were studied by means of magnetic dicroism and Spin-resolved Photoemission. Obtained experimental results were treated by LSDA calculations and periodic Anderson model.

MA 18.68 Tue 15:15 Poster E

Combined study of topography and electronic structure of Co/Cu(001) — •Tobias Allmers, Michael Budke, and Markus Donath — Physics Institute, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

In this contribution we report on results for fcc Co thin films on Cu(001). Our experimental setup allows the combined study of the topography (via scanning tunneling microscopy) and the spin-dependent electronic structure below and above the Fermi-level (via spin- and angle-resolved direct and inverse photoemission) [1]. The influence of different growth conditions on the topography and the electronic structure was investigated. With the possibility to dose adsorbates onto the surface, we were able to distinguish between surface and bulk contributions to the spectral features. We studied quantum-well states, which show up as well defined spectral features for flat interfaces and therefore serve as a sensor for the quality of interfaces [2], as well as the influence of the topography *and* the adsorbate sensitivity of surface resonance states of Co/Cu(001) [3].

[1] M. Budke, T. Allmers, and M. Donath, Rev. Sci. Instrum., in press (2007)
[2] D.H. Yu, M. Donath, J. Braun, and G. Rangelov, Phys. Rev. B **65**, 155415 (2003)
[3] K. Miyamoto *et al.*, 19th International Colloquium on Magnetic Films and Surfaces (2006)

MA 18.69 Tue 15:15 Poster E

Exchange interaction between magnetic nanowires on stepped and flat Cu surfaces: ab initio study — •Hossein Hashemi[1], Pavel A. Ignatiev[2], Wolfram Hergert[1], and Valeri S. Stepanyuk[2] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, Von-Seckendorff-Platz 1, 06120 Halle — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle

We report on the ab initio study of the indirect exchange interaction between magnetic nanowires on flat and stepped Cu(111) surfaces. Several geometrical arrangements of Fe nanostructures on stepped and flat surfaces are considered. The exchange interaction is found to exhibit an oscillatory behavior and depends on the chain-chain separation. We compare the exchange interaction between magnetic nanowires on stepped and flat Cu surfaces.

MA 18.70 Tue 15:15 Poster E

Investigation of higher-order exchange interactions in magnetic nanostructures — •Samir Lounis, Peter H. Dederichs, and Stefan Blügel — IFF, Forschungszentrum Jülich, D-52425 Jülich, Germany

A realistic description of the complex magnetic phases in nanosystems on the basis of model Hamiltonians requires the exchange interactions beyond the standard Heisenberg term [1]. These are difficult to calculate by common DFT based first-principles methods. To calculate the biquadratic interactions by the Korringa-Kohn-Rostoker Green function (KKR-GF) method, a formula based on the magnetic force theorem is derived. Moreover, the full-potential KKR-GF method for non-collinear magnetism [2,3,4] has been used to investigate the complex magnetic structures of small Mn and Cr clusters of different sizes and shapes on the Cu(111) surface. Here, the importance of these additional interactions will be illustrated and discussed.

[1] Ph. Kurz, G. Bihlmayer, K. Hirai, S. Blügel, Phys. Rev. Lett. **86**, 1106 (2001).
[2] S. Lounis, Ph. Mavropoulos, P. H. Dederichs, S. Blügel, Phys. Rev. B **72**, 224437 (2005).
[3] S. Lounis, Ph. Mavropoulos, R. Zeller, P. H. Dederichs and S. Blügel, Phys. Rev. B **75**, 174436 (2007).
[4] S. Lounis, M. Reif, Ph. Mavropoulos, L. Glaser, P. H. Dederichs, M. Martins, S. Blügel and W. Wurth, cond-mat/0608048.

MA 18.71 Tue 15:15 Poster E

Current induced domain wall motion in perpendicularly magnetized wires — •Johannes Kimling, Olivier Boulle, Mathias Kläui, and Ulrich Rüdiger — Fachbereich Physik, Universität Konstanz, Universitätsstraße 10, 78457 Konstanz, Germany

The recent discovery that a spin polarized current can move a domain wall (DW) through a transfer of spin angular momentum opens a new path to manipulating magnetization without any external magnetic field. So far, current induced DW motion (CIDM) has been experimentally investigated in details for in-plane magnetized wires with a large DW width ($\geq$ 100 nm) where spin transfer is expected to occur in the "adiabatic limit". Here, we will present experiments on $(Pt/Co)_n$ thin films with perpendicular magnetic anisotropy in which a very narrow DW is expected (width $\approx$ 10 nm). This allows the investigation of the non adiabatic part of the spin transfer torque, a key parameter in CIDM, which is expected to be larger for narrower DWs. The CIDM was studied in $(Pt/Co)_n$ films patterned in 200-500 nm wide nanowires. Using the extraordinary Hall effect, we have observed small displacements of a domain wall pinned in the Hall cross induced by current pulses of the order of 10^{11} A/m^2 at low field, in agreement with previous works. In order to correct for the significant temperature rise caused by the Joule heating while injecting current pulses, a systematic study of current induced depinning under various field and temperature has been carried out. By taking into account the role of the Joule heating in CIDM, this allows a true evaluation of the efficiency of the spin transfer in this material.

MA 18.72 Tue 15:15 Poster E

Current-induced domain-wall and vortex motion — •Thomas Kamionka[1], Michael Martens[1], Stellan Bohlens[2], Toru Matsuyama[1], Ulrich Merkt[1], and Guido Meier[1] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiustr. 11, 20355 Hamburg, Germany — [2]I. Institut für Theoretische Physik, Universität Hamburg, Jungiustr. 9, 20355 Hamburg, Germany

The interaction of spin-polarized currents with the magnetization of a ferromagnet opens new opportunities to design magnetic memory and logic devices. We investigate the harmonic excitation of a vortex in a square permalloy thin-film element with spin-polarized currents. A rotation of the vortex around its equilibrium position has been predicted [1]. The experimental challenge is to design a square with a low resonance frequency of the vortex, i.e. a weak confining potential, and to ensure the existence of the vortex state. The low resonance frequency is obtained for a small ratio t/l of thickness t and width l. We analyze the micromagnetic behavior of our permalloy squares by magnetic-force microscopy and the anisotropic magnetoresistance (AMR). Supported by micromagnetic simulations, we can determine possible magnetization patterns. A current induced excitation increases the electrical resistance because of the energy dissipation [2] and should be measurable using a LCR-Tester and scalar network analysis.

[1] B. Krüger et al., Phys. Rev. B accepted.
[2] E. Saitoh et al., Nature **432**, 203 (2004).

MA 18.73 Tue 15:15 Poster E

Experiments and theoretical description of spin precession in lateral all-metall spin valves — •Jeannette Wulfhorst, Andreas Vogel, Alexander van Staa, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstrasse 11, 20355 Hamburg (Germany)

Via transport measurements at low temperatures and with an external magnetic field we examine spin valves which consist of two ferromagnetic permalloy electrodes and a normal metal strip. Due to the shape anisotropy the electrodes are quasi-single domain and can be oriented parallel or antiparallel to each other. To obtain the coercive fields of the electrodes we have measured the anisotropic magnetoresistance of both. The nonlocal spin-valve effect is determined by using the first electrode to inject a spin-polarized current into the normal metal and to detect it with the aid of the other electrode [1]. With an out-of-plane external magnetic field spin precession, i.e. the Hanle-effect, is observed. The measured data is described by spin-dependent transport including spin diffusion, spin relaxation, spin precession, and tunnel barriers at the interfaces between the electrodes and the normal metal strip [1]. We estimate a spin-diffusion length in aluminum of 1034 nm, and a spin-relaxation time of 111 ps. The aluminum oxide tunnel barrier inbetween those films can enlarge the spin polarization of the injected current [2].

[1] A. van Staa, J. Wulfhorst, U. Merkt and G. Meier, submitted
[2] F.J. Jedema et al., Nature **416**, 713 (2002)

MA 18.74 Tue 15:15 Poster E

Interaction of pure diffusive spin currents with magnetic domain walls — •Dennis Ilgaz[1], Lutz Heyne[1], Dirk Backes[1,2], Stephen Krzyk[1], Mathias Kläui[1], Laura J. Heyderman[2], and Ulrich Rüdiger[1] — [1]Universität Konstanz, 78462 Konstanz, Deutschland — [2]Paul Scherrer Institut, 5232 Villigen, Schweiz

Diffusive pure spin currents received increasing attention in the last years, due to their novel physics and possible applications. In the non-local spin valve geometry diffusive spin currents can be locally seperated from charge currents. These spin currents induce no Joule heating. It has been shown that pure spin currents can interact with a second magnetic system, e.g. switch the magnetization of a small magnetic particle [1].

We employ pure diffusive spin currents to support current and field-induced domain wall motion. We present new results on the combined influence of pure diffusive spin currents and magnetic fields on magnetic domain walls studied via magnetic resistance measurements in a cryostat at variable temperature.

References [1] T. Kimura et al., Phys. Rev. Lett. 96, 037201 (2006).

MA 18.75 Tue 15:15 Poster E

Magnetoresistive Effects in Co/Pd Multilayers on Self-assembled Nanospheres — •Judith Moser[1], Hans-Fridtjof Pernau[1], Vojko Kunej[1], Martina Suty[1], Günter Schatz[1], Elke Scheer[1], and Manfred Albrecht[2] — [1]University of Konstanz, Department of Physics, D-78457 Konstanz, Germany — [2]Chemnitz University of Technology , Institute of Physics, D-09107 Chemnitz, Germany

The deposition of Co/Pd multilayers on self-assembled spherical particles provides a system with unique magnetic properties. The magnetic caps on 200nm polystyrene spheres have perpendicular anisotropy, are single-domain, and magnetically decoupled, but in electrical contact. By applying an external magnetic field, the individual caps can be switched separately. This makes the system an interesting candidate for magnetoresistance measurements.

First results on a two dimensional array are reminiscent of GMR behaviour. We believe that the resistivity change is caused by spin dependent scattering in the magnetic caps. For a better understanding of the observed effects we developed a method based on template-assisted self-assembly that provides the possibility to contact a few magnetic caps only.

The system might be of interest for both fundamental aspects and technological application.

MA 18.76 Tue 15:15 Poster E

Noncollinear magnetic order in transition-metal nanowires — •Michael Czerner[1], Bogdan Yu. Yavorsky[1], Laszlo Szunyogh[2], and Ingrid Mertig[1] — [1]Department of Physics, Martin Luther University, Germany — [2]Department of Theoretical Physics, Budapest University of Technology and Economics, Hungary

The progress in nanotechnology during the last two decades stimulated interest in ferromagnetic nanocontacts [1,2]. The transport properties of the nanocontacts depend strongly on the details of the magnetic structure. In particular, in the presence of a domain wall the magnetic configuration becomes noncollinear. On the other hand there are experimental indications [3], that the magnetic anisotropy has considerable effect on the magnetic structure of the nanocontact. A direct measurement of the magnetic configuration is difficult. In this respect first-principle calculations of the magnetic structure of the nanocontact are of primary importance. We present ab initio calculations of ferromagnetic nanowires suspended between two semi-infinite leads of the same material. The system was treated without adjustable parameters. We calculated the electronic and magnetic structure by means of the screened Korringa-Kohn-Rostoker (KKR) Greens function method in the relativistic formulation. We demonstrate that the ground state shows noncollinear magnetic order in Ni, Co and Fe nanowires. The influence of the magnetic anisotropy on the magnetic order is discussed.

[1] M.R. Sullivan et.al. , Phys.Rev.B **71**, 024412 (2005)
[2] H.D. Chopra et.al. , Nat. Mat. **4**, 832 (2005)
[3] M. Viret et.al. , cond-mat/0602298

MA 18.77 Tue 15:15 Poster E

Magnetotransport measurements on epitaxial Fe nanostructures — •Markus Wahle[1], Björn Wilke[1], Saskia F. Fischer[1], Ulrich Kunze[1], Ellen Schuster[2], Werner Keune[2], Dirk Sprungmann[3], and Kurt Westerholt[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Angewandte Physik, Universität Duisburg-Essen, D-47048 Duis-

burg — [3]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

To investigate spin dependent transport in nanoscale ferromagnetic cross-junctions we performed temperature dependent (2 K to 300 K) non-local measurements. The examined structures consist of thin ($\leq$ 50 nm) epitaxial Fe-films grown on intrinsic GaAs and capped by Cr. The growth and film quality has been controlled by means of RHEED images. Nanostructuring was done by e-beam lithography and subsequent Ar-ion etching. The widths of the cross-junctions vary from 200 to 500 nm. Non-local measurements constrain the observed area to the innermost part of the cross-junctions thus giving detailed information on magnetic switching processes/domain wall motion without the contribution of the leads towards resistance changes. Four different geometries of leads providing different domain structures and switching fields have been fabricated. We also present OOMMF simulations showing the switching behavior of such leads. The work is supported by the DFG within the SFB491.

MA 18.78 Tue 15:15 Poster E

Spin-polarized current through organic molecules — •Daungruthai Jarukanont, Samuel Baltazar Rojas, Alan Kalitsov, and Martin E. Garcia — Institut für Physik Universität Kassel

The study of molecular electronics has attracted a lot of interest in recent years. In this field, one attempts to make electronic devices using organic molecules. In order to manipulate such devices, it's very important to have a good understanding of the molecular transport properties. We study the tunneling of spin-polarized electrons through molecules that are weakly coupled to ferromagnetic electrodes.

We model our system by sandwiching molecules in between two magnetic electrodes, where a small bias is applied to see the I-V characteristics. The calculations are based on the non-equilibrium Green's function and the Keldysh formalism. The electronic states are described by the tight-binding model. We have studied a dependence of the tunneling current on the relative orientation of the magnetizations of the electrodes. We hope that these studies will allow us to suggest an appropriate choice for molecules for molecular electronics devices.

MA 18.79 Tue 15:15 Poster E

Tunneling magnetoresistance in all-oxide $La_{0.7}Sr_{0.3}MnO_3$/ MgO/ $La_{0.7}Sr_{0.3}MnO_3$ tunnel junctions — •Stephanie Raabe, Vasily Moshnyaga, Kai Gehrke, and Konrad Samwer — I. Physikalisches Institut der Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen

Half-metallic $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) looks very promising for spintronic applications. We have studied all-oxide structures LSMO(100) / MgO(100) / LSMO(100) prepared by means of Metalorganic Aerosol Deposition (MAD). Epitaxial LSMO films on MgO(100) substrate with T_C=360K and residual resistance $\rho = 16 \cdot 10^{-5} \Omega cm$ were obtained. Additionally we have shown that MgO grows also epitaxially on LSMO, which gave us the opportunity to prepare epitaxial tunneling LSMO/MgO/LSMO trilayers. Results on tunneling magnetoresistive effects will be presented.

MA 18.80 Tue 15:15 Poster E

Magnetic tunnel junctions with TiO barrier — •Zoe Kugler, Andy Thomas, and Günter Reiss — Bielefeld University, Universitätsstraße 25, D-33615 Bielefeled

We investigated magnetic tunnel junctions based on TiO and TiO/AlSiO-composite barriers.

Tunnel junctions with these barriers were prepared by dc- and rf-magnetron sputtering in a vacuum system with a base pressure of $1 \cdot 10^{-7}$ mbar and postoxidation of the barrier materials.

We have investigated the influence of different oxidation times, barrier thickness and annealing temperatures. Futhermore, we will present the results of our measurements for TiO based tunnel junctions with different magnetic electrodes such as CoFeB, CoFe and NiFe.

For the TiO/AlSiO-composite barriers we have investigated the TMR- and the area-resistance ratio with respect to the TiO and AlSiO thickness.

MA 18.81 Tue 15:15 Poster E

Magnetic tunnelling junctions with Co_2MnSi, Co_2MnSn and Cu_2MnAl- Heusler alloy electrodes — •Mohamed Obaida[1,2], Hasan Inam[1], Erik Verdijun[1], Kurt Westerholt[1], and Hartmut Zabel[1] — [1]Institute für Experimentalphysik IV Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]National Research Center, Cairo, Egypt

We fabricated magnetic tunnelling junctions (MTJs) using Heusler half metallics Co_2MnSi, and Co_2MnSn as base electrodes and Al_2O_3 or MgO as barrier material. As the counter electrode we used Co. The Heusler layers were deposited by UHV magnetron sputtering on oxidized SiO_2 substrates, the barriers were prepared by plasma oxidation of Al or direct sputtering of MgO, respectively. For Co_2MnSi we get a tunnelling magnetoresistance (TMR) of 27% at low temperatures, for the case of the Co_2MnSn electrode the maximum value we observed was 12%, however for this junction we could not avoid Neel coupling between the ferromagnetic electrodes so that the antiferromagnetic orientation was not well defined. We have also tried to grow MgO barriers on the Heusler alloy half metallics, however it turned out to be very difficult to get pinhole free barriers on this electrodes by direct sputtering of MgO. We have also started to grow MgO barriers on the Heusler phase Cu_2MnAl, which actually is not half metallic but is perfectly lattice matched to MgO and could serve as a reference material for Heusler MTJs. On this material we get high quality, pinhole free barriers, but the TMR we observed until now is still small.

MA 18.82 Tue 15:15 Poster E

Current induced diffusion in magnetic tunnel junctions with ultra-thin MgO tunnel barriers — •Patryk Krzysteczko[1], Xinli Kou[1,2], Karsten Rott[1], Andy Thomas[1], and Günter Reiss[1] — [1]Bielefeld University, Universitätsstraße 25, D-33615 Bielefeld — [2]Lanzhou University, 73000 Lanzhou, China

We apply high current-pulses ($j \sim 10^6\ A/cm^2$) to thin MgO barriers in a CoFeB/MgO/CoFeB TMR element prepared of magnetron sputtering and subsequent electron beam lithography. The samples are charactarized by a low area resistance ($AR \sim 20\,\Omega\mu m^2$) and a high spin polarization ($TMR \sim 100\,\%$). We observe reversible resistance changes when a critical electrical current is applied. Depending on the current polarity, the resistance decreases monotonically or non-monotonically with one or two distinct relaxation times, respectively. These different relaxation processes suggest independent physical mechanisms acting simultaneously inside the TMR element. The physical origin of these effects is discussed.

MA 18.83 Tue 15:15 Poster E

Interface-dependent sign of tunneling magnetoresistance in CrO_2/MgO/CoFe junctions — •Martin Sperlich[1], Marcel Mathissen[1], Titus Leo[2], Christian Kaiser[3], Hyunsoo Yang[3], Stuart S. P. Parkin[3], David J. Smith[4], and Gernot Güntherodt[1] — [1]II. Physikalisches Institut, RWTH Aachen — [2]School of Materials, Arizona State University, Tempe, USA — [3]IBM Almaden Research Center, San Jose, USA — [4]Department of Physics, Arizona State University, Tempe, USA

Half-metallic ferromagnets (FMs) such as CrO_2 are potentially useful as electrodes in magnetic tunnel junctions (MTJs) because of the possibility for 100% spin polarization near the Fermi energy. We show the tunneling magnetoresistance (TMR) behavior of MTJs using epitaxial CrO_2(100) as one electrode and a counterelectrode containing CoFe, with MgO as the tunnel barrier. When CrO_2 is exposed to air, a few monolayers of the intrinsic surface decompose and negative TMR is observed. Conversely, sample surfaces protected by a thin Mg interlayer show small but positive TMR consistent with intrinsic spin polarization. Thus, the sign of the TMR can be reversed simply by subtle modifications to the CrO_2/MgO interface. High resolution transmission electron microscopy confirms that we can remove the natively decomposed Cr_xO_y layers by gentle Ar-ion sputtering and produce a good quality interface between MgO und CrO_2.
T. Leo et al., APL 2007 (accepted).

MA 18.84 Tue 15:15 Poster E

An investigation of bcc-Co thin-film and bulk properties and their influence on tunneling magnetoresistance — •Marjana Ležaić, Frank Matthes, Phivos Mavropoulos, Stefan Blügel, and Claus M. Schneider — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich, Germany

We report on the electronic band structure modifications of metastable bcc Co films introduced by tetragonal distortion of the lattice along the [001] direction. Density functional calculations were performed to find the equilibrium lattice distortion and the resulting electronic structure, predicting, for individual bands, a shift in binding energy dependent on the sign and size of the tetragonal distortion. Under

certain tetragonalisation, a minority band with Δ_1 symmetry along $\Gamma - X$ shifts to lower energies and intersects the Fermi level. The effect can severely reduce the tunneling magnetoresistance ratio (TMR) of Co/MgO/Co junctions. This is supported by spin-resolved photoemission spectroscopy measurements on bcc-Co thin films stabilized on bcc Fe. We also investigated, both theoretically and experimentally [1], the modification of the electronic structure of Co at the surface and interface to MgO. Furthermore, we calculated the influence of tetragonal distortion on exchange interactions and the Curie temperature of bcc Co, Fe and their alloys [2], as these quantities are related to the temperature stability of TMR in Co- and Fe-based junctions.

[1] L.-N. Tong *et al.*, Phys. Rev. B **73**, 214401 (2006).
[2] M. Ležaić *et al.*, Appl. Phys. Lett. **90**, 082504 (2007).

MA 18.85 Tue 15:15 Poster E

Bias dependence in mesoscopic systems using non-equilibrium Green's functions — •Steven Walczak[1], Christian Heiliger[2,3], Michael Czerner[1], and Ingrid Mertig[1] — [1]Department of Physics, Martin Luther University,D 06099 Halle, Germany — [2]Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD 20899-6202 — [3]Maryland NanoCenter, University of Maryland, College Park, MD, 20742

The understanding of bias dependencies is a key issue in ballistic transport. In particular, the voltage drop within the scattering region depends strongly on the geometry of the system. For example in a tunnel junction one expects a simple linear voltage drop over the barrier but for atomic contacts, nanowires, or molecules the voltage drop is expected to be more complicated. To account for these systems we extend our implementation of the Keldysh formalism in the Korringa-Kohn-Rostoker Green's function method [1]. This extension includes the self-consistent treatment of the system under applied bias using the non-equilibrium density between the chemical potentials of the left and the right lead. The voltage drop within the system is then the difference of the densities with and without an applied voltage. We compare ab initio results of voltage drops in different geometries. This work has been supported in part by the NIST-CNST/UMD-NanoCenter Cooperative Agreement.
[1] C. Heiliger, M. Czerner, B. Yavorsky, I. Mertig, M. Stiles, J. Appl. Phys. (in press), arXiv:0711.2082

MA 19: Spin Dynamics / Spin Torque I

Time: Wednesday 14:00–18:45 Location: EB 301

MA 19.1 Wed 14:00 EB 301

Current-induced magnetization switching of thermally stable nanoislands — •Stefan Krause[1], Gabriela Herzog[1], Roland Wiesendanger[1], and Matthias Bode[2] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Center for Nanoscale Materials, Argonne National Laboratory, USA

Recently is has been shown that spin-polarized scanning tunneling microscopy (SP-STM) serves as a tool to manipulate the switching behavior of uniaxial superparamagnetic nanoislands [1]. Besides its scientific relevance to investigate the details of current-induced magnetization switching (CIMS), this technique opens perspectives for future data storage technologies based on SP-STM. However, for such an application it is essential to switch nanoislands which show a stable magnetization over up to ten years. Hence, the current-induced spin-torque must be the only driving force for reversal, whereas the magnetization of every single data bit has to be stable against thermal agitation.

Iron monolayer nanoislands consisting of 50 to 150 atoms on a W(110) surface exhibit a monodomain magnetization state. In our latest experiments on CIMS at low temperature ($T = 31\,\mathrm{K}$), individual quasistable nanoislands have been addressed and switched using a magnetic SP-STM tip. Using manually initiated pulses of high spin-polarized current we show how SP-STM can be used as a tool to switch the magnetization of quasistable magnetic nanoislands, thereby demonstrating the general capability of SP-STM to manipulate magnetism at ultimate resolution.
[1] S. Krause *et al.*, Science **317**, 1537 (2007).

MA 19.2 Wed 14:15 EB 301

Influence of Fe thickness on spin transfer torque in Fe/MgO/Fe — •Christian Heiliger[1,2] and Mark D. Stiles[1] — [1]Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD 20899-6202 — [2]Maryland NanoCenter, University of Maryland, College Park, MD, 20742

We report calculations of the spin transfer torque in Fe/MgO/Fe tunnel junctions using a non-equilibrium Keldysh formalism implemented in the Korringa-Kohn-Rostoker Green's function method [1]. For the coherent interfaces achievable for this lattice matched system, the Fe layers are half metallic with respect to the Δ_1 states at the Brillouin zone center. This property causes the high tunnelling magnetoresistance measured in Fe/MgO/Fe tunnel junctions [2]. Our calculations show that it also leads to strong localization of the spin transfer torque to the interface. Due to the restriction of the spin transfer torque to the interface, the in-plane torque per current is independent of the Fe layer thickness for more than three monolayers of Fe. This work has been supported in part by the NIST-CNST/UMD-NanoCenter Cooperative Agreement.
[1] C. Heiliger, M. Czerner, B. Yu. Yavorsky, I. Mertig, M. D. Stiles, J. Appl. Phys. (in press); arXiv:0711.2082.
[2] C. Heiliger, P. Zahn, I. Mertig, Materials Today 9, 46 (2006).

MA 19.3 Wed 14:30 EB 301

Spin-torque driven excitations in strongly antiferromagnetically coupled Co/Cu/Co bilayer nanostructures. — •Eva Maynicke[1], Marc Weidenbach[1], Nicolas Müsgens[1], Coen Smits[1], Bernd Beschoten[1], Matthias Bückins[2], Joachim Mayer[2], and Gernot Güntherot[1] — [1]II Physikalisches Institut A, RWTH Aachen, 52056 Aachen, and Virtual Institute for Spinelectronics (VISel) — [2]Gemeinschaftslabor für Elektronenmikroskopie, RWTH Aachen, 52065 Aachen

We investigate the current-induced switching behaviour and high frequency dynamics in MBE grown Co/Cu/Co nanopillars with lateral dimensions below 100 nm by means of transport and microwave probes at room temperature.

In contrast to previous studies we observe a two-step magnetic reversal in field-sweep measurements at low current densities with an intermediate stable state between parallel and antiparallel alignment. The intermediate state is most stable in samples with strong antiferromagnetic coupling between both Co layers as tested by systematic variations of the Cu spacer layer thickness.

Near the critical field for magnetic switching into this intermediate state we observe pronounced dips in the differential resistance at negative currents. In this regime we detect microwave emission with broad spectral features extending from 50 MHz to 4 GHz. Surprisingly, there is no frequency shift with current or magnetic field.

Work supported by DFG through SPP1133.

MA 19.4 Wed 14:45 EB 301

Spin-current induced magnetic excitations in single magnetic layer nanopillars — •Marc Weidenbach[1], Eva Maynicke[1], Nicolas Müsgens[1], Coen Smits[1], Bernd Beschoten[1], Matthias Bückins[2], Joachim Mayer[2], and Gernot Güntherodt[1] — [1]II Physikalisches Institut A, RWTH Aachen, 52056 Aachen, and Virtual Institute for Spinelectronics (VISel) — [2]Gemeinschaftslabor für Elektronenmikroskopie, RWTH Aachen, 52065 Aachen

We investigate current-induced spin-wave excitations in Cu/Co/Cu single magnetic layer nanopillar devices with asymmetric Cu leads by means of transport and microwave probes at room temperature.

The thin film stack is deposited by MBE in prefabricated nanostencil masks with lateral dimensions below 100 nm. At high current densities we observe narrow excitations (bandwidth $\sim$ 100 MHz) and higher harmonics for magnetic fields perpendicular to the layers. The frequency increases with increasing current and magnetic field, which indicates an out-of plane precessional mode as found in bilayer systems (e.g., Kiselev et al., PRL 93, 036601(2004)).

Furthermore we observe frequency jumps as a function of both current and magnetic field, which might originate from transitions between different localized nonlinear spin-wave modes.

Work supported by DFG through SPP1133.

MA 19.5 Wed 15:00 EB 301

Investigation of spin-wave radiation and current controlled three-magnon-scattering in spin-torque nanocontact devices — •Helmut Schultheiss[1], Xavier Janssens[2], Sven Cornelissen[2], Maarten van Kampen[2], Sebastian Hermsdörfer[1], Britta Leven[1], Andrei N. Slavin[3], Liesbet Lagae[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and FSP MINAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]IMEC, Kapeldreef 75, Leuven, Belgium — [3]Oakland University, Rochester, Michigan, USA

The magnetization dynamics of spin torque oscillators are of large interest for the fundamental understanding of the interaction between a spin polarized current and a magnetic thin film. Here we report on Brillouin light scattering microscopy investigations of the magnetization dynamics in spin-torque nanocontacts under the influence of an applied ac and dc current. The spin-wave radiation patterns are studied for several applied microwave frequencies. Strong nonlinear effects are observed and discussed within the framework of three-magnon-scattering. Intriguing is the shift of the power threshold for these nonlinear processes when a dc current is applied. Depending on the dc current direction the threshold and efficiency of the three-magnon-scattering can be strongly enhanced or reduced. This is a clear evidence that the internal damping due to magnon scattering can be tuned by a dc current. Support by the DFG within the SPP 1133 and by the EC-MRTN SPINSWITCH (MRTN-CT-2006-035327) and EC-Dynamax (IST-033749) is acknowledged. MvK acknowledges the IWT Flanders for financial support.

MA 19.6 Wed 15:15 EB 301

Real-time soft X-ray microscopy of current-induced domain-wall oscillations — •Lars Bocklage[1], René Eiselt[1], Markus Bolte[1], Benjamin Krüger[2], Peter Fischer[3], Ulrich Merkt[1], and Guido Meier[1] — [1]Institut für Angewandte Physik, Universität Hamburg — [2]I. Institut für Theoretische Physik, Universität Hamburg — [3]Center for X-Ray Optics, LBNL, USA

Novel concepts for high density and ultrafast magnetic storage devices suggest domain walls (DW) or vortices in nanostructures to store information. Spin-polarized currents exerting a torque on the local magnetization can move these magnetization configurations [1,2]. Magnetic soft X-ray microscopy allows to image changes in the DW structures upon spin current injection with a spatial resolution down to 15 nm [3]. Spin dynamics can be imaged by a stroboscopic pump-probe measurement scheme at a temporal resolution below 100 ps. We have prepared vortex DWs in a restoring potential in permalloy nanostructures and displaced the vortex from its equilibrium position by injecting nanosecond current pulses. The displacement holds while the pulse is applied, afterwards the DW starts a free oscillation with strong damping. The frequency, the damping constant, and the confining potential of our samples is calculated within a harmonic oscillator model.
This work was supported by the DPG via SFB 668 and GRK 1286 as well as by the DOE via Contract No. DE-AC02-05-CH11231.
[1] S. Zhang and Z. Li, Phys. Rev. Lett. 93, 127204 (2004).
[2] G. Meier et al., Phys. Rev. Lett. 98, 187202 (2007).
[3] D. H. Kim et al., J. Appl. Phys. 99, 08H303 (2006).

MA 19.7 Wed 15:30 EB 301

Homodyne Detection of Domain Wall Oscillations — Daniel Bedau[1], Mathias Klaeui[1], Stefan Krzyk[1], •Katarzyna Buchta[1], Ulrich Ruediger[1], G. Faini[2], and L. Vila[2] — [1]Department of Physics, University of Konstanz, Germany — [2]CNRS, Phynano Team, Laboratoire de Photonique et de Nanostructures, Route de Nozay, France

Laterally confined magnetic domain walls behave like quasiparticles moving in an external potential well created by a mechanical constriction or a pinning defect. Spin torque effects allow to displace the domain wall quasiparticle electrically, by injecting an ac current the domain can be excited to resonate inside the potential well. As the domain wall oscillates, the resistance of the magnetic structure is modulated due to the anisotropic magnetoresistance in phase with the domain wall position. If the quasiparticle happens to be excited at the resonance frequency, the varying resistance will rectify the injected high frequency current and a DC voltage is developed across the structure. Using this technique we determined the resonance frequency of the domain wall. At resonance we observed a reduction of the depinning field of the domain wall for currents as low as 2×10^{10} A/m^2, allowing us to determine the resonance frequency by a second method. The domain wall resonance frequency was measured for different external magnetic fields and was found to be proportional to the external field. By measuring the mean value of the resistance during excitation we identified the oscillation of the domain wall to be confined close to the potential minimum without a large-scale displacement.

MA 19.8 Wed 15:45 EB 301

Direct observation of the Walker breakdown process during domain wall (dw) propagation in Permalloy nanowires — •Sascha Glathe and Roland Mattheis — IPHTJena e.V., A.-Einstein-Str.9, D-07745 Jena

The Walker breakdown process determines the field driven dw movement in nanowires above a critical magnetic field Hw. Until now there are only some simulations adressing this process, mainly in ideal structures. An adequate experimental verification is not offered yet.

We explored the dw propagation in 150 nm wide, 15 nm thick permalloy films, which are the sense layer of GMR stacks. The dw movement was examined due to time resolved measurements of GMR stack resistance. During the dw motion we find periods of steady dw movement and periods where the dw stops. These time domains are in the order of some ns and are repeated alternately. We attribute this behaviour of the dw to the Walker breakdown process. Thus we provided a direct experimental evidence of the Walker breakdown process.

MA 19.9 Wed 16:00 EB 301

Spin waves in curved $Ni_{81}Fe_{19}$ nanowires in the presence of domain walls — •Christian W. Sandweg, Sebastian J. Hermsdörfer, Helmut Schultheiss, P.Andreas Beck, Britta Leven, and Burkard Hillebrands — FB Physik and FSP MINAS, TU Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany

We present a study of spin-wave properties in curved $Ni_{81}Fe_{19}$ nanowires in the presence of domain walls. The spin-wave spectra are detected with a lateral resolution of 300 nm employing Brillouin light scattering microscopy. The elements are prepared using a combination of EBL and MBE. The structure dimensions are a radius of 10 μm, a width of 500 nm and a thickness of 10 nm. A protrusion with a radius of 250 nm acts as artificial domain wall pinning site. In the absence of a domain wall we observe typical spin wave quantization effects due to the lateral confinement in radial direction. In contrast, in the presence of a domain wall the quantized wave profile is distorted in the vicinity of the domain wall due to the variation of the internal magnetic field. The domain structure was investigated by Lorentz microscopy in collaboration with the group of John Chapman, Glasgow university. First results on artificially excited spin waves as well as their decay length in $Ni_{81}Fe_{19}$ are presented. Technical support by the Nano+Bio Center of the TU Kaiserslautern and financial support by the DFG within SPP1133, the EU-MRTN SPINSWITCH (MRTN-CT-2006-035327) and the NEDO grant No 2004IT093 is acknowledged.

15 Min. Session Break

MA 19.10 Wed 16:30 EB 301

Nanowires for high DC current applications — •Sebastian Hankemeier, Konrad Sachse, Yuliya Stark, Matthias Scholz, Germar Hoffmann, Robert Frömter, and Hans Peter Oepen — Universität Hamburg, Germany

For a more detailed investigation of current induced domain wall movement in nanowires by spin torque effect, it is essential to have maximum control of the external experimental parameters, i.e. the current density and the wire temperature. Additional, to study the forces that act on the walls, it is desirable to perform experiments with DC currents large enough to move the domain walls.

In this talk we present the realization of Permalloy nanowires which sustain current densities larger $4 \cdot 10^{12} A/m^2$. The wires are made from $20nm$ thick Permalloy, evaporated on diamond, with a width of $1\mu m$ and a length of $25\mu m$. While applying current densities beyond $10^{11} A/m^2$, we observe ohmic heating of the wires, which causes annealing effects. This effect can be used to improve the specific resistance of the wire near to the values of bulk material. The experiments are performed under HV conditions to prevent oxidation and cooling with liquid nitrogen is necessary for heat dissipation. The temperature of the wire, which depends on the applied current, has been evaluated utilizing the change in wire-resistance and estimated by heat transfer calculations.

MA 19.11 Wed 16:45 EB 301

Selective Vortex Core Switching by Applying Rotating Magnetic Fields — Michael Curcic[1], •Bartel Van Waeyenberge[1,2], Kang Wei Chou[1], Arne Vansteenkiste[2], Markus Weigand[1], Vitalij Sackmann[1], Aleksander Puzic[1], Hermann Stoll[1], Georg Woltersdorf[3], Tolek Tylisczak[4], Christian H. Back[3], and Gisela Schütz[1] — [1]Max-Planck-Institut für Metallforschung, Stuttgart, Germany, — [2]Departement of Subatomic and Radiation Physics, Ghent University, Gent, Belgium — [3]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, Germany — [4]Advanced Light Source, LBNL, Berkeley, USA

We report on the experimental observation of the switching of the vortex core polarization in sub-micron sized ferromagnetic Landau structures caused by rotating magnetic fields.

In contrast to linear field pulses which toggle the vortex core from its up to the down position or vice versa, rotating magnetic fields allow for a selective vortex core switching either to its up or to its down position depending on the sense of field rotation.

The experiments were performed on 500 nm wide, 50 nm thick Permalloy Landau structures. They were imaged by time-resolved scanning transmission X-ray microscopy (STXM, BL. 11.0.2, ALS Berkeley). Defined thresholds were observed for the field amplitudes needed to switch the vortex core. Surprisingly, the threshold for the CW rotating field and CCW rotating field differed significantly. Possible explanations for this 'symmetry breaking' will be discussed.

MA 19.12 Wed 17:00 EB 301

The influence of non centric holes on the magnetization dynamics of Landau structures — •Sebastian Wintz[1], Karsten Kuepper[1], Matthias Buess[2], Joerg Raabe[2], Christoph Quitmann[2], Chavkat Akhmadaliev[1], Lothar Bischoff[1], and Juergen Fassbender[1] — [1]FZ Dresden-Rossendorf, Bautzner Landstr. 128, D-01328 Dresden, Germany — [2]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, Switzerland

Magnetic vortex cores are attracted and can be trapped by artificial defects. If more than one of such defects are created a switching between different vortex core trapped states, which might serve as discrete levels in a multivalent memory device, can be achieved. Up to now a number of studies of circular vortex structures comprising holes has been reported, e. g. [1,2,3]. We report the imaging of the magnetic excitation spectrum in presence of holes, fabricated by focussed ion beam milling, in the magnetic domains and domain walls of Landau structures by means of x-ray magnetic circular dichroism photoemission electron microscopy (XMCD-PEEM). Due to the very high lateral and temporal resolution the magnetization dynamics and the corresponding Eigen modes, which are characteristic for the vortex-hole interaction, are investigated in detail. The experimental results are compared to micromagnetic simulations.

[1] M. Rahm et al., Appl. Phys. Lett. **85**, 1553 (2004).
[2] T. Uhlig et al., Phys. Rev. Lett. **95**, 237205 (2005).
[3] F. Hoffmann et al., Phys. Rev. B **76**, 014416 (2007).

MA 19.13 Wed 17:15 EB 301

Harmonic oscillator model for current and field-driven vortices and antivortices — •Benjamin Krüger[1], André Drews[2], Markus Bolte[2], Ulrich Merkt[2], Daniela Pfannkuche[1], and Guido Meier[2] — [1]1. Institut für Theoretische Physik, Universität Hamburg, 20355 Hamburg, Germany — [2]Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

We investigate the gyroscopic motion of current- and field-driven magnetic vortices and antivortices in micro- or nanostructured thin-film elements by analytical calculations and by micromagnetic simulations [1]. Starting from micromagnetic equations of motion we derive an analytical expression for the current- and Oersted-field driven trajectory of the vortex and antivortex. For small harmonic excitations the vortex and antivortex cores perform an elliptical rotation around their equilibrium positions. Our analytical model allows to calculate the amplitude and the phase of the current- and Oersted-field driven gyration. The global phase of the rotation and the ratio between the semi-axes are determined by the frequency and the amplitudes of the field and the spin torque. The accordance between analytical and numerical approaches is very good. Even though the influence of the Oersted field on the trajectories of a vortex or antivortex is small, the phase of the rotation is significantly changed. Thus, the model can give an estimate of the Oersted-field's contribution in spin-torque experiments.

[1] B. Krüger, A. Drews, M. Bolte, U. Merkt, D. Pfannkuche, and G. Meier, Phys. Rev. B, accepted.

MA 19.14 Wed 17:30 EB 301

Amplification and suppression of magnetic antivortex motion — •André Drews[1], Stellan Bohlens[2], Benjamin Krüger[2], Markus Bolte[1], and Guido Meier[1] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg — [2]I. Institut für Theoretische Physik, Universität Hamburg

We investigate numerically the response of an antivortex to excitation by alternating currents and magnetic fields using micromagnetic simulations. The phase between antivortex deflection and excitation in case of an electrical current depends on the polarization and in case of magnetic field additionally on the chirality. The chirality of an antivortex can be changed by a rotation of the sample with respect to the driving force. The dynamical characteristics of antivortices can be identified with a harmonic oscillator model as it has been recently shown for the vortex state theoretically as well as experimentally. Excitation in a superposition of an electrical current and a magnetic field can lead to an enhancement or to an entire suppression of the amplitude of the antivortex gyration. For example, for an antivortex with positive polarization an angle of 0 or π occurs between magnetic field and current excitation with chiralities $c = 0$ and $c = 2$, respectively. This leads in case of $c = 0$ to an enhancement and in case of $c = 2$ to a quenching of the gyration. In experiments this chirality-dependent amplitude of the gyration can be used to distinguish between current and Oersted field driven antivortex core motion.

MA 19.15 Wed 17:45 EB 301

Dynamic Vortex-Antivortex Interaction in a Single Cross-Tie Wall — •Karsten Kuepper[1], Matthias Buess[2], Joerg Raabe[2], Christoph Quitmann[2], and Juergen Fassbender[1] — [1]FZ Dresden-Rossendorf, Bautzner Landstr. 128, 01328 Dresden, Germany — [2]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, Switzerland

In a rectangular permalloy platelet one can find a stable micromagnetic configuration comprising two vortices and an antivortex, a so called single cross-tie wall. Such a single cross-tie wall can be understood as being a coupled micromagnetic system with three static solitons. Here we report on its magnetization dynamics including the vortex-antivortex interactions [1]. The spectrum of eigenmodes is investigated as well as the effect of different vortex core orientations. These are important for the magnetization dynamics because they determine the sense of rotation for the gyrotropic motion. Since three cores are present in total $2^3 = 8$ configurations are possible. We find that different types of configurations lead to completely different dynamic behaviors. The origin is the dynamic coupling of the cores which is mediated by the exchange coupling through the adjacent domain walls. This coupling is significant and introduces unexpected effects, such as the quenching of gyrotropic motion for the antivortex in certain core configurations. The vortex dynamics can be used to identify the core configuration, which is not directly accessible to x-ray microscopy because of its limited spatial resolution.

[1] K. Kuepper et al., Phys. Rev. Lett. **99**, 167202 (2007)

MA 19.16 Wed 18:00 EB 301

Dynamic Properties of Patterned Ferromagnetic Thin Films — •Roman Adam, Riccardo Hertel, and Claus M. Schneider — Institute of Solid State Research, Research Center Jülich, D-52425 Jülich, Germany

We studied dynamic response of ferromagnetic thin film bars to magnetic pulse excitations employing both time-resolved magneto-optic Kerr effect (TR-MOKE) measurements and micromagnetic simulations. The bars with rectangular and hexagonal geometries were patterned on top of coplanar waveguides and oriented with their long axis either parallel, perpendicular or 45° with respect to the external magnetic field. The bars were inserted into weak magnetic field and excited with 10 ps magnetic pulse generated by a photoconducting switch. The time evolution of the magnetization was recorded employing TR-MOKE and compared with micromagnetic simulations. Fourier analysis of the time-resolved signal reveals the presence of oscillatory modes associated with the dynamics in the central part and at the borders of ferromagnetic bars. The observed initial gradual increase of the oscillation amplitude is attributed to the excitation of multiple modes inside the sampled region. A strongly nonlinear dependence of the relaxation time on the static field suggests an even

more complex response due to mode interactions.

MA 19.17 Wed 18:15 EB 301

Adjusting ferromagnetic precessional modes in magnetic thin film structures — •Jeffrey McCord[1], Rainer Kaltofen[1], Manfred Wolf[1], Ingolf Mönch[1], Eckhardt Quandt[2], Rudolf Schäfer[1], and Ludwig Schultz[1] — [1]IFW Dresden — [2]CAU Kiel

By controlled adjustment of the magnetic ground state in square ferromagnetic elements a coupled micromagnetic system with coupled precessional oscillations is generated. The occurrence of the coupled system is associated with domain branching at the element's edges. Dynamic mode-to-mode energy transfer results in a precessional decay time exceeding the natural ferromagnetic material's relaxation time. This reduction in the effective magnetic damping parameter is in contradiction to the consensus that magnetic domain formation leads to a decrease in precessional relaxation time.

MA 19.18 Wed 18:30 EB 301

The role of bandstructure on the ultrafast magnetization dynamics — •Tobias Roth, Daniel Steil, Mirko Cinchetti, and Martin Aeschlimann — TU Kaiserslautern, Erwin-Schrödinger Str. 46, 67663 Kaiserslautern

Herein we report on the effect of the electronic bandstructure on the spin dynamics. In a comparative study the 3d ferromagnet Co and the Heusler alloy Co_2MgSi, both with strongly deviating bandstructures, were investigated by means of the time resolved MOKE. The focus was put on the ultrafast magnetization dynamics following an optical excitation with a high intensive femtosecond laser pulse. The behaviour of the first ultrafast demagnetization step is similar for both materials. In contrast, the process of thermalization between the participating subsystems is delayed in the case of the Heusler alloy. We ascribe this as a distinct signature of a blocked Elliot-Yafet like scattering due to the bandgap in Co_2MgSi.

MA 20: Multiferroics

Time: Wednesday 14:00–18:15 Location: EB 202

MA 20.1 Wed 14:00 EB 202

Observation of ferrotoroidic order in $LiCoPO_4$ — •Manfred Fiebig[1,2], Bas B. Van Aken[1,2], Jean-Pierre Rivera[3], and Hans Schmid[3] — [1]HISKP, Universität Bonn, Nussallee 14–16, 53115 Bonn, Germany — [2]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany — [3]Department of Chemistry, University of Geneva, 30 quai Ernest-Ansermet, 1211 Geneva 4, Switzerland

Domains are an essential property of any ferroic material. Three forms of ferroic order (ferromagnetism, ferroelectricity, ferroelasticity) are widely known. It is currently debated whether to include an ordered arrangement of magnetic vortices as fourth form of ferroic order termed ferrotoroidicity [1]. Although there are reasons to do this from the point of view of thermodynamics a crucial hallmark of the ferroic state, *i.e.*, ferrotoroidic domains, has never been observed. Here ferrotoroidic domains are spatially resolved by optical second harmonic generation in $LiCoPO_4$ where they coexist with independent antiferromagnetic domains [2]. The origin of ferrotoroidicity in $LiCoPO_4$ is discussed. Their space- and time asymmetric nature relates ferrotoroidics to multiferroics with magnetoelectric phase control and other systems in which space and time asymmetry leads to exciting possibilities for future application. — Work supported by the SFB 608 of the DFG.

[1] C. Ederer, N.A. Spaldin, arXiv:0706.1974v1 [cond-mat.str-el], Phys. Rev. B, in press (2007)

[2] B.B. Van Aken, J.P. Rivera, H. Schmid, M. Fiebig, Nature **449**, 702 (2007)

MA 20.2 Wed 14:15 EB 202

Towards a microscopic theory of toroidal moments in periodic crystals — •Claude Ederer[1] and Nicola A. Spaldin[2] — [1]School of Physics, Trinity College Dublin, Dublin 2, Ireland — [2]Materials Department, University of California, Santa Barbara, CA 93106, USA

A toroidal moment breaks both time- and space-inversion symmetries simultaneously, and thus facilitates coupling between magnetization and electric polarization in magnetoelectric multiferroics. Furthermore, the recent observation of toroidic domains suggests that "ferrotoroidicity"represents a fundamental form of ferroic order, in addition to ferromagnetism, ferroelectricity, and ferroelasticity [1].

Here we review the basic definitions of toroidal moments and illustrate the difficulties in evaluating the toroidal moment of an infinite periodic system. We show that periodic boundary conditions give rise to a multivaluedness of the toroidal moment per unit cell, in close analogy to the case of the electric polarization in bulk periodic crystals. We then evaluate the toroidal moments of several multiferroic and magnetoelectric materials ($BaNiF_4$, $LiCoPO_4$, $GaFeO_3$, and $BiFeO_3$) in the "localized dipole limit", where the toroidal moment is caused by a time and space reversal symmetry-breaking arrangement of localized magnetic moments [2].

[1] B. B. Van Aken, J. P. Rivera, H. Schmid, and M. Fiebig, Nature 449, 702 (2007).

[2] C. Ederer and N. A. Spaldin, arXiv:0706.1974v1 [cond-mat.str.el], Phys. Rev. B, in press (2007).

MA 20.3 Wed 14:30 EB 202

Pyroxenes: a new class of multiferroics — •Sven Jodlauk[1], Petra Becker[1], John Mydosh[2], Daniel Khomskii[2], Thomas Lorenz[2], Sergej Streltsov[2], and Ladislav Bohatý[1] — [1]Inst. f. Kristallographie, Universität Köln — [2]II. Physikalisches Institut, Universität Köln

We present the results of our dielectric and magnetic investigations on pyroxenes with the general formula $AMSi_2O_6$ (A = mono- or divalent metal, M = di- or trivalent metal). They are shown to be a new class of multiferroic materials. In particular, we have found so far that $NaFeSi_2O_6$ becomes ferroelectric in a magnetically ordered state below ≈ 6 K. Similarly, magnetically driven ferroelectricity is also detected in the Li homologues, $LiFeSi_2O_6$ ($T_C \approx 18$ K) and $LiCrSi_2O_6$ ($T_C \approx 11$ K). In all these monoclinic systems the electric polarization can be strongly modified by magnetic fields. We present measurements of magnetic susceptibility, pyroelectric current and dielectric constants performed in various magnetic fields using a natural crystal of aegirine ($NaFeSi_2O_6$) and synthetic crystals of $LiFeSi_2O_6$ and $LiCrSi_2O_6$ grown from melt solution. For $NaFeSi_2O_6$ we propose a temperature versus magnetic field phase diagram. The possibility of a spiral magnetic structure caused by frustration to be the origin of the multiferroic behaviour taking into account computed exchange constants is discussed. We propose that other pyroxenes may also be multiferroic, and that the versatility of this family offers an exceptional opportunity to study general conditions for and mechanisms of magnetically driven ferroelectricity. This work was supported by the DFG via SFB 608.

Reference: J. Phys.: Condens. Matter **19** (2007) 432201

MA 20.4 Wed 14:45 EB 202

(Sr,Mn)TiO_3 - a magnetoelectric multiglass — •Subhankar Bedanta[1], Vladimir Shvartsman[1], Pavel Borisov[1], Wolfgang Kleemann[1], Alexander Tkach[2], and Paula Vilarinho[2] — [1]Angewandte Physik, Universität Duisburg-Essen, D-47048 Duisburg, Germany — [2]Department of Ceramics and Glass Engineering, CICECO, University of Aveiro, 3810-193 Aveiro, Portugal

In recent years there has been a growing interest in studies of multiferroic materials, in which two or more ferroically ordered states - usually long-range polar and magnetic order - exist simultaneously. In this work we extend this frame onto the simultaneous occurrence of two different glassy states, hence, looking for a "multiglass"scenario rather than for a multiferroic one. This is realized in $Sr_{0.98}Mn_{0.02}TiO_3$ ceramics [1] where the Mn^{2+} dopand ions are at the origin of both a polar cluster and a magnetic spin glass. Both the temperature dependencies of the magnetization, $M(T)$, and of the magnetic susceptibility, $\chi(T)$, show an anomaly around 38 K [2]. On the other hand, this temperature corresponds to the polar glass transition, indicating a correlation between magnetic and polar order. Both glassy states are unambiguously and independently evidenced by their specific aging and memory effects. In addition, higher order magnetoelectric coupling between the polar and magnetic degrees of freedom is observed [2].

[1] A. Tkach et al., Appl. Phys. Lett. **86**, 172902 (2005).

[2] S. Bedanta et al., in press

MA 20.5 Wed 15:00 EB 202

Relaxation dynamics of multiferroic rare-earth manganites — •Florian Schrettle[1], Peter Lunkenheimer[1], Joachim Hemberger[2], and Alois Loidl[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany — [2]Institute of Physics II, University of Cologne, 50937 Cologne, Germany

In recent years, multiferroic compounds attracted an enormous scientific and technological interest [1]. This rare class of materials combines ferroelectricity with (anti-)ferromagnetism in a single phase. In rare cases both order parameters are strongly coupled, leading to pronounced magnetocapacitive effects. Prominent examples for such systems are rare-earth manganites like, e.g., $TbMnO_3$. In these compounds partial frustration of the Mn-spins leads to spiral magnetic structures, which allow for a finite ferroelectric polarization. Besides the transition to the multiferroic phases, dielectric spectroscopy reveals a relaxation along the c-direction in these materials. We provide the results of a detailed investigation of the relaxation dynamics in several rare-earth manganites ($GdMnO_3$, Eu:$YMnO_3$, $TbMnO_3$, $DyMnO_3$). This dynamics seems to play an important role for the magnetocapacitive properties of these compounds.

[1] T. Kimura *et al.*, Nature **426**, 55 (2003); T. Lottermoser *et al.*, Nature **430**, 541 (2004); T. Goto *et al.*, Phys. Rev. Lett. **92**, 257201 (2004).

MA 20.6 Wed 15:15 EB 202

Magnetoelectric coupling in $La_{2/3}Ca_{1/3}MnO_3$-$BaTiO_3$ superlattices — •Kai Gehrke[1], Vasily Moshnyaga[1], Konrad Samwer[1], and Alexandr Belenchuk[2] — [1]I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Institute of Applied Physics, Academieis 5, MD-2028 Chisinau, Moldova

Artificial composites of ferromagnetic and ferroelectric phases are promising for the study of magnetoelectric phenomena. We have prepared LCMO-BTO superlattices on MgO substrates, using the metalorganic aerosol deposition technique. Very high values of magnetocapacitance, $MC = [C(7T) - C(0)]/C(0) = 800\%$, were observed. The treatment in terms of an equivalent circuit shows that the majority of this effect originates from the colossal magneto resistance (CMR), present in the LCMO-layers. Considering the resistance of LCMO, one can separate the "CMR-part"from the "coupling-part"of the MC. The analysis shows that the coupling is present in the ferromagnetic state only and results in a linear dependence of the BTO-layer capacitance on magnetic field ($C_{BTO} = C_0 + \alpha|H|$). This MC is as large as MC=16% at T=TMI, and MC=5% at low temperature.

The work was supported by the Deutsche Forschungsgemeinschaft via SFB 602, project A2.

MA 20.7 Wed 15:30 EB 202

Characterization of multiferroic $HoMnO_3$ films by second harmonic generation — •Tobias Kordel[1], Christian Wehrenfennig[1], Dennis Meier[1], Thomas Lottermoser[1], Catherine Dubourdieu[2], Isabelle Gelard[2], Kathrin Dörr[3], Jong-Woo Kim[3], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn, Germany — [2]LMPG, Grenoble, France — [3]IFW, Dresden, Germany

The magnetic and electric properties of hexagonal $HoMnO_3$ films were investigated by optical second harmonic generation (SHG). Symmetry arguments relate different polarized SH contributions uniquely to either the electric or magnetic properties of $HoMnO_3$.

Epitaxial hexagonal $HoMnO_3$ and $YMnO_3$ films with 50-1000nm thickness were grown by PLD and MOCVD on YSZ(111) substrates. The "nonmagnetic"SHG signal in the films is similar to that of bulk $HoMnO_3$ pointing to the presence of ferroelectric ordering. However, a "magnetic"SHG signal has not been observed. At present, this can be explained by two models: (i) The film has anitferromagnetic domains with lateral dimensions much smaller than the wavelength of the light, so that the magnetic signal cancels out by interference; (ii) the film is in a ferroelectric single domain state. This induces ferromagnetic ordering of the Ho^{3+} spins and a Mn^{3+} spin configuration for which no SHG signal is observable. The latter model is supported by the observation of misaligned crystallites in the film with a preferred direction of polarisation.

MA 20.8 Wed 15:45 EB 202

Spindynamics of multiferroic $HoMnO_3$ — •Tim Hoffmann[1], Tim Günter[1], Takuya Satoh[2], Thomas Lottermoser[1], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn, Nussallee 14-16, 53115 Bonn, Germany — [2]Department of Basic Science, The University of Tokyo, Komaba, Meguro-ku, Tokyo 153-8902, Japan

$HoMnO_3$ is a promising multiferroic because of the unusually pronounced coupling of electric and magnetic order manifesting as giant magnetoelectric effect. Static measurements have shown that the mangetic state of the Ho spins can be controlled by an external electric field [1]. We have investigated the dynamical properties of the magnetoelectric coupling of hexagonal $HoMnO_3$ using optical pump-probe experiments with 130 fs time resolution. Around 37 K a reorientation of the Mn spins is induced by competition of Ho-order, Mn-order and ferroelectric distortion, thus reflecting the multiferroic coupling. The reorientation is triggered by a pump pulse at 1.55 eV and probed time-resolved by optical second harmonic generation. Results point to an optically induced reorientation of Mn spins within a few hundreds of picoseconds. Is is superimposed by an oscillation with a 10 ns period around the new orientation. Possible explanations of these effects will be discussed.

[1] T. Lottermoser et al., Nature 430, 541 (2004)

15 Min Session Break

MA 20.9 Wed 16:15 EB 202

Electromagnons in rare earth multiferroics $DyMnO_3$ and $TbMnO_3$ — •Alexey Shuvaev[1], Alexander Mukhin[2], Anatoli Balbashov[3], Alois Loidl[4], and Andrei Pimenov[1] — [1]Experimentelle Physik IV, Universität Würzburg, 94074 Würzburg, Germany — [2]General Physics Institute of the Russian Academy of Sciences, 119991 Moscow, Russia — [3]Moscow Power Engineering Institute, 111250 Moscow, Russia — [4]Experimentalphysik V, EKM, Universität Augsburg, 86135 Augsburg, Germany

Dielectric permittivity spectra of rare earth multiferroic manganites $DyMnO_3$ and $TbMnO_3$ have been investigated in the terahertz frequency range. Similar to other multiferroics well-defined magnetoelectric excitations (electromagnons) are observed in the incommensurate magnetic phases below T = 40 K. Electromagnons are excitations of the incommensurate magnetic structure and, contrary to magnons, can be excited solely by electric component of the electromagnetic wave. Application of external magnetic fields strongly modifies the permittivity spectra in both compositions leading to magnetoelectric effects down to zero frequencies. In $TbMnO_3$ and in moderate fields additional structure appears close to $\nu \sim 10$ cm^{-1} and is suppressed again for magnetic fields above 5 T. Manifestations of different magnetic phase boundaries in the spectra of the dielectric permittivity are discussed.

MA 20.10 Wed 16:30 EB 202

Nonlinear optics on multiferroic tricolor superlattices — •Thomas Lottermoser[1,2], Hiroyuki Yamada[3], Jobu Matsuno[2], Takahisa Arima[2,4], Masashi Kawasaki[3,5], Manfred Fiebig[1], and Yoshinori Tokura[2,3,6] — [1]HISKP, Universität Bonn, 53115 Bonn, Germany — [2]ERATO, Multiferroics Project, JST, Tokyo 113-8656, Japan — [3]CERC, AIST, Tsukuba 305-8562, Japan — [4]IMRAM, Tohoku University, Sendai 980-8577, Japan — [5]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan — [6]Department of Applied Physics, University of Tokyo, Tokyo 113-8656, Japan

While multiferroics propose new physical phenomena and technical applications, materials exhibiting pronounced magnetoelectric coupling are still rare. Here, a new concept based on tricolor superlattices composed of repeated sequences of the transition-metal oxides $SrMnO_3$, $LaMnO_3$ and $LaAlO_3$ is used. Electron transfer at the interfaces of the antiferromagetic insulators $SrMnO_3$ and $LaMnO_3$ leads to a modification of their magnetic and electronic behavior. The electronic state near the interface is modified to be a ferromagnetic metal like (La, Sr)MnO_3. In addition, the charge transfer produces electric dipole moments along the stacking direction that do not cancel out in the ABCABC stack. Therefor the tricolor superlattices are polar ferromagnets. The artificial symmetry breaking allows (non-)magnetic contributions to optical second harmonic generation (SHG) which we used to probe directly the magnetic properties of the superlattice interfaces. The dependence on layer thickness and stress induced by different kinds of substrates is reported.

MA 20.11 Wed 16:45 EB 202

Magnetic field dependent structural modulations in $RFe_3(BO_3)_4$ — •Martin Philipp[1], Olga Kataeva[1,2], Christian

Hess[1], Jorge E. Hamann-Borrero[1], Rüdiger Klingeler[1], Natalia Tristan[1], Bernd Büchner[1], Martin von Zimmermann[3], Alexander Vasiliev[4], Elena Popova[4], and Leonard N. Bezmaternykh[5] — [1]Leibniz-Institute for Solid State and Materials Research, IFW-Dresden, 01171 Dresden, Germany — [2]A.E.Arbuzov Institute, Russian Academy of Sciences, Arbuzov Str. 8, 420088 Kazan, Russia — [3]HASYLAB@DESY, Notkestr. 85, 22603 Hamburg, Germany — [4]Physics Faculty, Moscow State University, 119992 Moscow, Russia — [5]L.V.Kirensky Institute of Physics, Siberian Branch of RAS, 660036 Krasnoyarsk, Russia

Recently, rare earth iron borates $RFe_3(BO_3)_4$ (R: Rare Earth) attracted attention as candidates for possible multiferroic behavior. Most of the $RFe_3(BO_3)_4$ crystals exhibit antiferromagnetic order below $\sim$ 40 K. In this ordered phase several magnetic transitions are taking place, in dependence of temperature and magnetic field.
We have studied these magnetic transition by means of hard x-ray diffraction ($h\nu$ = 100 keV) for the compounds $TbFe_3(BO_3)_4$, $GdFe_3(BO_3)_4$ and $YFe_3(BO_3)_4$. Several superlattice reflections could be observed, which indicate commensurate stuctural modulations along *a*- and *c*-axis. We compare the field and temperature dependence of these superlattice reflections with results from thermodynamics and transport measurements.

MA 20.12 Wed 17:00 EB 202

Magnetization density in $TbMnO_3$ single crystals — •de Groot Joost[1], Kentzinger Emmanuel[1], Goukassov Arsène[2], Gillon Beatrice[2], and Möchel Anne[1] — [1]Forschungszentrum Jülich Gmbh D52425 Jülich IFF-4: Streumethoden — [2]Laboratoire Léon Brillouin (LLB), CEA-CNRS, CE Saclay, F-91191 Gif-sur-Yvette Cedex, France

$TbMnO_3$ belongs to a class of rare earth manganites showing multiferroic behaviour. While neutron diffraction [1] gives evidence for 4f Tb magnetization below the ferroelectric phase transition temperature 26K, hard x-ray resonance exchange scattering [2] clearly shows a magnetic polarization in the Tb 5d states below T_N=41K. In [2] it is argued that a strong coupling exists between the Mn magnetic order and the Tb magnetization. In order to evidence this coupling and to search for induced magnetization on the Oxygen atoms, we performed polarized neutron diffraction using the spin flip method in an external field on a $TbMnO_3$ single crystal. These experiments were performed on the diffractometer 5C1 at the LLB. We detected a clear antiferromagnetic coupling between the field induced magnetization at the Tb and Mn sites in the paramagnetic phase. We will discuss these results compared to resonant x-ray scattering.
[1] M. Kenzelmann et al.,PRL 95, 087206 (2005)
[2] J. Voigt, J. Persson, J. W. Kim, G. Bihlmayer, Th. Brückel; Phys. Rev. B, 76 (2007), 104431-1

MA 20.13 Wed 17:15 EB 202

Coexistence of ferroelectric and long-wavelength magnetic ordering in $MnWO_4$ — •Dennis Meier[1], Michael Maringer[1], Thomas Lottermoser[1], Gouliang Yuan[1], Petra Becker[2], Ladislav Bohatý[2], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn — [2]Institut für Kristallographie, Universität zu Köln

The strong interest in magnetoelectric multiferroics is due to their potential concerning the design of novel multifunctional devices, as well as to their unusual physical properties. Among these, $TbMnO_3$, $Ni_3V_2O_8$, and $MnWO_4$ form a particularly challenging group: The key factor for ferroelectricity lies in the long-wavelength magnetic order. However, the nature of the ferroelectric (FE) state in such a *spiral magnet* and its relation to the magnetic ordering is largely unclear. Here we report about the spatial distribution of FE domains in $MnWO_4$, revealed by optical second harmonic generation (SHG). Although the spontaneous polarization in this ferroelectric is magnetically induced, 180° domains as in a conventional ferroelectric are observed. This work was supported by the DFG through SFB 608

MA 20.14 Wed 17:30 EB 202

Polarization-dependent X-Ray Absorption Spectroscopy of $MnWO_4$ — •Nils Hollmann[1], Zhiwei Hu[1], Ladislav Bohaty[2], Petra Becker-Bohaty[2], Arata Tanaka[3], and Liu Hao Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Kristallographisches Institut, Universität zu Köln — [3]Department of Quantum Matter, Hiroshima University

Multiferroic materials which combine magnetism and ferroelectricity currently attract considerable attention. One of the recently discovered multiferroic materials is $MnWO_4$ (Hübnerite). It belongs to the group of multiferroics where a spontaneous electric polarization is caused by a spiral magnetic structure with a spin rotation axis not coinciding with the propagation vector.
To investigate the details of this astonishing combination of electronic and magnetic properties, we look at the electronic structure with the use of polarization-dependent X-ray absorption spectroscopy on single crystals of $MnWO_4$. The analysis of the experimental data on the *L*-edge of Mn is done by a configuration interaction calculation and will be discussed during the talk.

MA 20.15 Wed 17:45 EB 202

Growth and Characterization of $La_{0.67}Ca_{0.33}MnO_3$ and $BaTiO_3$ multilayers using PLD with in-situ RHEED — •Alexander Hirsch, Heiko Fasold, Ralf Koppert, Christian Wille, Frank Ludwig, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik,

One way to design multiferroics, i.e., materials with ferroelectric and ferromagnetic properties, for new sensor applications is to grow superlattices with alternating ferromagnetic and ferroelectric layers.

Using pulsed laser deposition (PLD) $La_{0.67}Ca_{0.33}MnO_3$ (LCMO) and $BaTiO_3$ (BTO) multilayers are grown on $SrTiO_3$ (100) substrates. To obtain atomically flat and single terminated substrate surfaces a chemical and subsequent annealing treatment is applied. All targets were prepared by standard ceramic synthesis. The growth of the films is monitored by in-situ reflection high energy electron diffraction (RHEED), which is a powerful tool for optimizing thin films with the objective of superlattice growth. In addition, the thin films are characterized by X-ray diffraction and atomic force microscopy.

Superlattices with alternating LCMO and BTO layers are grown, with BTO layer thicknesses ranging from 4 u.c. to 16 u.c. and LCMO layer thicknesses of 5 u.c.. RHEED intensity oscillations are used to control the thickness of the multilayers. Superlattices up to thicknesses of approx. 825 nm were grown. The influence of the BTO layer and the superlattice thickness, respectively, on the properties is analyzed.

MA 20.16 Wed 18:00 EB 202

Superconducting quantum interference device (SQUID) setup for magnetoelectric measurements — •Pavel Borisov, Andreas Hochstrat, Vladimir V. Shvartsman, and Wolfgang Kleemann — Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

The magnetoelectric (ME) effect in its original sense refers to the intrinsic property of some material to react on an electric field by establishing a magnetic moment, and vice versa, to generate an electric polarization by applying a magnetic field. The best investigated ME material is Cr_2O_3, where Astrov measured the linear ME effect for the first time [1]. In Astrov's setup, the magnetic *ac* response signal, which was induced by an external electric field, was detected. Our method of the ME measurements is mainly based on Astrov's approach, but at the same time takes advantage of modern SQUID magnetometry [2]. We modified a commercial SQUID setup (MPMS 5S from Quantum Design), equipped with a magnetic *ac* susceptibility option, for measurements of the linear ME effect and tested it on a Cr_2O_3(111) single crystal. The results are in excellent agreement with previously reported data. The main advantage is the high sensitivity of the SQUID magnetometer combined with lock-in measuring technique. In addition, investigation of field-induced and higher order ME effects is possible.

[1] D. N. Astrov, Sov. Phys. JETP **11**, 780 (1960); **13**, 729 (1961)
[2] P. Borisov *et al.*, Rev. Sci. Instr. **78**, 106105 (2007)

MA 21: Magnetic Thin Films II

Time: Wednesday 14:00–18:45 Location: H 1012

MA 21.1 Wed 14:00 H 1012

Exchange interactions and critical temperature of ultrathin films MnSi/Si(001) — •Mahbube Hortamani[1,2], Leonid Sandratski[1], Peter Kratzer[3], Ingrid Mertig[1,2], and Matthias Scheffler[4] — [1]MPI für Mikrostrukturphysik Halle — [2]Martin-Luther-Universität Halle-Wittenberg — [3]Universitaet Duisburg-Essen — [4]FHI der MPG Berlin

Epitaxial growth of Mn on Si(001) has been recently studied in the context of spintronics, in order to investigate spin injection through a metal-semiconductor interface. Requirement for an efficient spin injection is to have a high spin polarization of carriers at the Fermi level which retains at room or higher temperature.

Earlier, we had shown that a well ordered layered structure of MnSi can be grown epitaxially on Si(001) substrate under Mn-rich conditions. These films were found to be ferromagnetic with the B2-type lattice structure. The spin moment of interfacial Mn atoms and the spin polarization at the Fermi level are considerable. In order to determine whether or not the thin films remain ferromagnetic above room temperature, we calculate the Curie temperature of ultrathin films MnSi/Si(001).

The Curie temperature is estimated within the multiple sublattice Heisenberg model, applying (i) a mean-field model and (ii) the random-phase approximation. The exchange coupling is obtained from energy differences of various collinear spin configurations. The calculations are performed using DFT with the GGA-PBE functional and the FP-APW+lo method, as implemented in the WIEN2k package.

MA 21.2 Wed 14:15 H 1012

Pulsed laser deposition of epitaxial $Co_2Mn_{1-x}Fe_xSi$ films — •Horst Schneider and Gerhard Jakob — Institut für Physik, Johannes Gutenberg-Universität Mainz

The Heusler compound Co_2MnSi has been predicted to be half-metallic, and recent experiments show a tunneling spin polarization of more than 90% at low temperatures. However, this value decreases rapidly at higher temperatures. It has been shown theoretically that replacing Mn with Fe will shift the Fermi energy of the compound away from the valence band into the center of the half metallic energy gap. This might reduce the temperature dependence of the spin polarization. We report the successful pulsed laser deposition of thin $Co_2Mn_{1-x}Fe_xSi$ films over the whole stoichiometry range $0 \leq x \leq 1$. The films were grown on MgO (100) with and without Cr buffer layer under UHV conditions. The investigated films grow epitaxially and possess the fully ordered $L2_1$ Heusler structure. Furthermore, we present results of bulk magnetometry experiments as well as investigations of the electronic transport of these samples. We discuss these results with respect to the electronic structure of the alloys.

MA 21.3 Wed 14:30 H 1012

Characterization and nanopatterning of Ni_2MnIn Heusler films — •Jan M. Scholtyssek, Jeannette Wulfhorst, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

The Heusler alloy Ni_2MnIn is a promising material as spin injector because of its predicted half-metallicity at the interface to InAs. We grow thin films of this Heusler alloy by thermal coevaporation of Nickel and the alloy MnIn. The alloy is grown on Si_3N_4 membranes and amorphous carbon films for transmission-electron microscopy (TEM) as well as on Si and InAs. The degree of the transport spin polarization of the films grown on Si(100), InAs(100) and in-situ cleaved (110) surfaces of InAs is determined by point-contact Andreev reflection spectroscopy (PCAR) [1]. The almost perfect lattice match between InAs and Ni_2MnIn supports highly oriented growth, as we have proven by electron diffraction under grazing incidence [2]. Lateral spin valves with Heusler electrodes are lithographically defined. In view of the temperature-sensitivity of the optical and electron-beam resists, the samples are grown at substrate temperatures of 50 °C and annealed up to 400 °C afterwards. The post-growth annealing process is investigated in situ in the TEM using transmission-electron diffraction on structured samples grown on Si_3N_4 membranes.

[1] L. Bocklage, J.M. Scholtyssek, U. Merkt, and G. Meier, J. Appl. Phys. **101** 09J512 (2007). [2] J.M. Scholtyssek, L. Bocklage, R. Anton, U. Merkt, and G. Meier, J. Magn. Magn. Mat. **316**, e923 (2007).

MA 21.4 Wed 14:45 H 1012

Temperature Dependence of Magnetic Order in Fe/(Ga,Mn)As studied by Monte Carlo Simulations — •Svitlana Polesya[1], Jan Minar[1], Hubert Ebert[1], and Christian Back[2] — [1]LMU München, Dept. Chemie und Biochemie/Phys. Chemie, Butenandtstrasse 11, D-81377 München, Deutschland — [2]Institut für Experimentelle Physik, Univ. Regensburg, Deutschland

The magnetic order of the heterogeneous interface system (GaMn)As/Fe at finite temperatures has been studied by Monte Carlo simulations. The ground state magnetic properties were determined within ab initio electronic structure calculations using the SPR-TB-KKR Green's function method. All calculations have been performed for the semi-infinite system of (GaMn)As with 5 % Mn covered by a 7 ML Fe film. The temperature dependent properties of this system (with and without external magnetic field) have been studied using MC simulation. The exchange coupling within the Fe and (GaMn)As subsystems were found to be dominantly long-range ferromagnetic whereas the coupling of Fe and Mn moments close to the interface is strongly antiferromagnetic. The Monte Carlo simulations lead to a Curie temperature of about 1000 K for the Fe film. Within the (GaMn)As subsystem due to the polarisation induced by the Fe film the average magnetisation at room temperature is still about 70 % of its $T = 0$ value for several layers close to the interface. These results are in full agreement with recent experimental findings.

MA 21.5 Wed 15:00 H 1012

Interface magnetic properties of Al/Heusler films investigated by XAS and XMCD — •Michael Kallmayer[1], Kerstin Hild[1], Tobias Eichhorn[1], Horst Schneider[1], Gerhard Jakob[1], Andres Conca[1], Martin Jourdan[1], Hans-Joachim Elmers[1], Andrei Gloskovskii[2], Stefan Schuppler[3], and Peter Nagel[3] — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik, D-55099 Mainz — [2]Johannes Gutenberg-Universität Mainz, Institut für Anorganische und Analytische Chemie, D-55099 Mainz — [3]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe

The magnetic interface properties of Heusler alloys often deviate from bulk properties, but they greatly determine the functionality of Heusler films in devices. We have investigated magnetic interface properties of $Co_2Cr_{0.6}Fe_{0.4}Al$, Co_2FeSi and Ni_2MnGa films that are capped by an Al layer. X-ray absorption spectroscopy (XAS) reveals a considerable interdiffusion of Al into the Heusler film at elevated temperatures and even at rough interfaces at 320 K. This explains a decreased interface magnetization as observed by x-ray magnetic circular dichroism (XMCD) [1]. Microspectroscopy using photoemission electron microscopy reveals that the reaction proceeds inhomogeneously with reaction nuclei separated on a micron length scale [2].

[1] M.Kallmayer et al., J.Phys.D: Appl.Phys. 40 (2007) 1552.
[2] M.Kallmayer et al., Appl.Phys.Lett. 91 (2007) 192501.

MA 21.6 Wed 15:15 H 1012

Mößbauer study of epitaxial $Co_2Cr_{0.6}Fe_{0.4}Al$ thin films. — •Vadim Ksenofontov[1], Christian Herbort[2], Martin Jourdan[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

Epitaxial thin films of the promising for spintronic applications Heusler half-metallic compound $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA) were investigated using conversion electron Mößssbauer spectroscopy (CEMS) in order to get insight into the structural and magnetic properties. Thin films of 100 nm thickness were deposited by rf magnetron sputtering on MgO substrates without and with 10 nm Fe buffer layer. We discuss a correlation between the annealing temperature and the structural disorder and hyperfine fields on Fe atoms measured by Mößbauer spectroscopy. Samples prepared at the optimum annealing temperature as determined by tunneling magnetoresistance measurements show the optimum degree of order on the Fe sites as determined by CEMS. Additionally, we observed evidence for a diffusion of Cr atoms from the CCFA thin film into the Fe buffer layer and the related diffusion of Fe atoms from the buffer into the CCFA film. Thus the thermal treat-

ment changes the Fe to Cr ratio of the Heusler compound additional to influencing the degree of disorder on the Fe/Cr sites.

The authors gratefully acknowledge financial support by the DfG (Research Unit 559).

MA 21.7 Wed 15:30 H 1012

Magnetic and Transport Properties of doped EuO Thin Films — •S. Altendorf[1], R. Sutarto[1], M. Moretti[2], T. Haupricht[1], and L. H. Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Germany — [2]Dipartimento di Fisica, Politecnico di Milano, Italy

Europiumoxide (EuO) is a ferromagnetic semiconductor with a bandgap of 1.12 eV at room temperature and a Curie temperature of 69 K. In slightly Eu-rich EuO, the magnetic transition is accompanied by a metal-insulator transition with an unprecedented large change in resistivity up to 13 orders of magnitude. Spin-polarized electron spectroscopies revealed that the charge cariers are moving in an essentially fully spin-polarized band [1]. Eu-rich EuO also exhibits an increase of T_C up to 150 K [2]. Similarly, in Gd-doped EuO thin films, T_C can be enhanced up to 170 K with Gd concentration of about 4 % [3]. However, as to whether a MIT occurs in Gd-doped EuO is still an open question [2,4].
We report our results of *in situ* measurements of the magnetic and transport properties of EuO thin films prepared by means of molecular beam epitaxy technique in a distillation method [1,3] which allows a precise control and tuning of the stoichiometry. The connection between the magnetic order and metal-insulator transition of Eu-rich and Gd-doped EuO thin films was investigated.
[1] P. G. Steeneken *et al.*, Phys. Rev Lett. **88** 047201 (2002) [2] T. Matsumoto, *et al.*, J. Phys.: Condens. Matter **16**, 6017 (2004) [3] H. Ott, *et al.*, Phys. Rev. B **73**, 094407 (2006) [4] J. Schoenes *et al.*, Phys. Rev B **9**. 3097 (1974)

MA 21.8 Wed 15:45 H 1012

Temperature dependent anisotropy in epitaxial $PrCo_7$ films — •Ajit Patra[1], Michael Eisterer[2], Steffen Wirth[3], Konstantin Nenkov[1], Sebastian Fähler[1], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Atomic Institute of the Austrian Universities, Stadionallee 2, A-1020 Vienna, Austria — [3]MPI for Chemical Physics of Solids, Nöthnitzer Straße 40, 01187, Germany

Research on RE-Co magnets with a $TbCu_7$ structure has been intensified in recent years because of their potential as permanent magnets for high temperature applications. $RECo_7$ magnets display a unique combination of intrinsic properties such as a high saturation polarization, a high Curie temperature and a room temperature uniaxial anisotropy. In order to tailor the extrinsic properties of these magnets, a better understanding of the intrinsic properties is necessary. In this work, the temperature dependence of the anisotropy constants for an epitaxial $PrCo_7$ film is investigated. Magnetization curves have been measured with field applied along different angles with respect to the easy axis (which is the crystallographic c-axis) at various temperatures. A full range fitting procedure to simulated magnetization loops leads to the determination of the first and second uniaxial anisotropy constants (K_1 and K_2) as a function of the temperature. The spin reorientation transition from uniaxial anisotropy to an easy cone anisotropy is described as a sign reversal of K_1 and the spin reorientation angle is determined.

MA 21.9 Wed 16:00 H 1012

Nanocrystalline epitaxial $SmCo_5$ films with perpendicular anisotropy — •Marietta Seifert, Volker Neu, and Ludwig Schultz — IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany

Hard magnetic thin films find important applications in nano and micro electromagnetic systems (NEMS, MEMS) and magnetic recording. $SmCo_5$ is a material with a high uniaxial magnetic anisotropy and therefore has the potential to be used as a high density recording media. Thus, in the last years, research focusses on the preparation of Sm-Co films with perpendicular anisotropy. Based on our experience on epitaxial growth of high anisotropic $SmCo_5$ with in-plane texture we developed epitaxial $SmCo_5$ films with strong perpendicular anisotropy by pulsed laser deposition on Ru buffered $Al_2O_3(0001)$ substrates. The deposition temperature was systematically varied in a range between 550°C and 800°C. X-ray diffractometry shows that the $SmCo_5$ phase develops at 550°C and is best formed at 700°C. Texture measurements of the (10-11) $SmCo_5$ pole prove the perpendicular orientation of the c-axis and reveal the epitaxial growth with two different in plane orientations of the hexagonal unit cell. VSM measurements demonstrate the magnetic anisotropy with the easy axis out of plane. The sample prepared at 700°C possesses a square shaped hysteresis loop (squareness = 0.81) with a coercivity of $\mu_0 H_c = 1.0$ T. All films grow in a granular fashion with grain sizes of 100 to 300 nm. The nanocrystalline microstructure together with the local epitaxy provides the combination of highly anisotropic and well textured $SmCo_5$ grains with good coercivity.

15 Min. Session Break

MA 21.10 Wed 16:30 H 1012

Uniaxial magnetic anisotropy of $Fe_{1-x}Co_x$(110) /GaAs(110) and $Fe_{1-x}Co_x$(001)/GaAs(001) — •Björn Muermann, Florian Nitsch, and Günther Bayreuther — Universität Regensburg, Germany

The tailoring of the magnetic properties of ferromagnets on semiconductors is of prime importance to the field of spintronics. In this contribution we have compared the magnetic anisotropy of epitaxial $Fe_{1-x}Co_x(110)$ and $Fe_{1-x}Co_x(001)$ ($0 \leq x \leq 0.8$) films grown by MBE on GaAs. The samples were studied by means of AGM and FMR spectroscopy. The angular dependent energy density observed can be explained by two main contributions to the magnetic anisotropy: an effective fourth order anisotropy, $K_1^{\text{eff}}(t)$, and an effective second order anisotropy, $K_U^{\text{eff}}(t)$. The fourth order term originates from the cubic symmetry of the bcc FeCo lattice. The thickness dependence of K_1 is in good agreement with the prediction for the sign reversal according to Néel's pair energy model [1].

The uniaxial anisotropy of FeCo alloys on GaAs(001) has been found to be independent of composition and to be a pure interface phenomenon arising from the bonding mechanism of the Fe/Co atoms to the As atoms [2]. For (110)-oriented films one observes an opposite sign of K_U for Fe-rich and Co-rich alloys exactly as for K_1. It is concluded that for (110)-oriented FeCo films the uniaxial anisotropy is mainly of magneto elastic origin.

[1] G. Bayreuther et al., J. Appl. Phys. 93 (2003) 8230,
[2] M. Dumm et al., J. Appl. Phys. 91 (2002) 8763

MA 21.11 Wed 16:45 H 1012

Magnetic Excitations in Gd/Y and Dy/Y superlattices investigated with Inelastic Neutron Scattering — •Alexander Grünwald[1,2], Elena Tartakovskaya[3], Andrew Wildes[2], Wolfgang Schmidt[4], Katharina Theis-Bröhl[5], Peter Link[6], Roger Ward[7], and Andreas Schreyer[1] — [1]GKSS-Research Centre Geesthacht, Germany — [2]Institut Laue-Langevin, France — [3]Institute for Magnetism, Ukraine — [4]Jülich Centre for Neutron Science, Germany — [5]Ruhr-Universität Bochum, Germany — [6]TU München, Germany — [7]University of Oxford, UK

Investigations of spin waves in magnetic superlattices are of great interest to understand fundamental properties of magnetism in confined structures. Inelastic neutron scattering is the most versatile technique to study magnetic excitations. The theory predicts discrete energy levels and Brillouin zone folding effects for spin waves propagating along the surface normal in rare earth superlattices. To compare with these calculations, we have investigated a number of Gd/Y and Dy/Y superlattices. Here we present inelastic neutron scattering measurements of low energy excitations. Clear dispersive modes from magnetic excitations and indications on discrete energy levels have been found in both superlattice compounds. The modes have a marked field dependence, particularly for the Gd/Y samples in which a spin wave gap is observed in moderate fields. The observations are in broad agreement with the theory.

MA 21.12 Wed 17:00 H 1012

A Neutron Scattering Study on the Antiferromagnet in an exchange biased systems — •Danica Solina[1], Dieter Lott[1], Wolfgang Schmidt[2], Yu-Chang Wu[3], Jochen Fenske[1], Chih-Huang Lai[3], and Andreas Schreyer[1] — [1]Institute of Materials Research, GKSS Research Centre, Geesthacht, Germany — [2]Institut-Laue-Langevin, Grenoble, France — [3]Department of Materials Science and Engineering, National Tsing Hua University, HsinChu, Taiwan

The magnetic structure of single crystal antiferromagnetic PtMn that biases CoFe has been studied using neutron scattering. Polarized neutron reflection (PNR) was used to determine the switching behaviour of the ferromagnetic layer and polarized neutron diffraction (PND) to probe the magnetic configuration of the anti-ferromagnetic layer. PNR suggests a combination of rotation and domain formation. Changes

were observed in the PND patterns taken at points around the hysteresis loop. The diffraction data has been simulated with a 'twisting' of part of the anti-ferromagnetic layer as the ferromagnetic layer changes.

MA 21.13 Wed 17:15 H 1012

Influence of argon-ion milling on perpendicular anisotropy of Co/Pt multilayer — •Norbert Franz, Matthias Jacobi, Leonid Lichtenstein, Hendrik Spahr, Hannes Zechlin, Holger Stillrich, and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr.11, 20355 Hamburg, Germany

For the fabrication of magnetic nanodots we use self- assembling masks built from micelles, which are copied into a ferromagnetic multilayer via ion milling. A prerequisite to successfully perfom these experiments is the investigation of the influence of sputtering on the magnetic properties of the films. Co/Pt multilayers (uncovered) with an easy perpendicular axis are made via magnetron/ion sputtering techniques. When bombarding the multilayers with 2 keV Ar^+ we find a spin reorientation at small doses. For 500 eV ions, however, the multilayers stay vertical as long as they exhibit remanence. The magnetic anisotropy decreases almost instantly on bombardment with 500 eV Ar^+ while the saturation signal stays constant. In the talk we will present the detailed evaluation of the saturation signal and the magnetic anisotropy as function of ion dose for 500 eV Ar^+. We will discuss and compare results for a single and double Co/Pt bilayer.

MA 21.14 Wed 17:30 H 1012

Spin reorientation transistion and canted magnetization of Co/Pt multilayers — •Holger Stillrich and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The spin reorientation transition of Co/Pt multilayers from perpendicular easy axis to easy plane is analyzed. The spin reorientation is driven by the thickness of either the cobalt or the platinum layer. The behavior of $(Co/Pt)_8$ multilayers and single cobalt layers on platinum will be discussed. The films are grown by magnetron sputter deposition and the magnetic properties are investigated via the magneto-optic Kerr effect.

The spin reorientation occurs via a state of canted magnetization. In the spin reorientation transition the polar Kerr hysteresis exhibits a shape which is associated with a domain decay [1]. The in-plane magnetization shows a partial switching of the magnetization which is explained by the switching between canted states with opposite in-plane magnetization components. The uniaxial anisotropy constants in first and second order approximation are examined in the whole thickness range of Co and Pt layers. In the thickness range of spin reorientation a negative first and positive second order uniaxial anisotropy constant K_1 and K_2 are found, indicating canting. We find a similar behavior for both $(Co/Pt)_8$ multilayers and single cobalt layers.

[1] W. B. Zeper et al, J. Appl. Phys. **65**, 4971 (1989); J. E. Davies et al, Phys. Rev. B **70**, 224434 (2004).

MA 21.15 Wed 17:45 H 1012

Direct observation of field and temperature induced domain replication in dipolar coupled perpendicular anisotropy films — Thomas Hauet[1], •Christian M Günther[2], Bastian Pfau[2], Stefan Eisebitt[2], Peter Fischer[3], Ramon L Rick[4,5], Jan-Ullrich Thiele[1], Bruce Terris[1], and Olav Hellwig[1] — [1]Hitachi GST, San Jose, CA 95135, USA — [2]BESSY, 12489 Berlin, Germany — [3]CXRO, LBNL, Berkeley CA 94720, USA — [4]Applied Physics, Stanford University, Stanford CA 94305-4090, USA — [5]SSRL, SLAC, Menlo Park CA 94295, USA

Studies on the dipolar interactions in magnetic multilayers with perpendicular anisotropy have recently attracted increasing attention in order to improve the reliability of magneto-electronic devices [1] and for applications in multilevel magnetic recording [2]. Particularly, replication of non-uniform magnetic configurations such as domains or bit-patterns in hard/soft bilayers induced by stray fields has been investigated. Combining magnetometry and dichroism in soft X-ray microscopy [3] and holography [4], we directly reveal dipolar interactions in a hard/soft [Co/Pd]_n/Pd/[CoNi/Pd]_m bilayer system. With sub 100 nm resolution, we image domain replication from the hard to the soft magnetic layer. In addition, by tuning the Curie temperature Tc in the CoNi/Pd multilayers, we demonstrate thermally activated domain replication at room temperature in remanence. [1] B. Rodmacq, et al., Phys. Rev. B 73, 92405 (2006). [2] T. Ohta, et al., J. Magn. Magn. Mater. 242, 108 (2002). [3] D.-H. Kim, et al., J. Appl. Phys. 99, 08H303 (2006). [4] S. Eisebitt et al., Nature, 432, 885 (2004).

MA 21.16 Wed 18:00 H 1012

Study of the correlation between nanostructures and nanomagnetism in bcc Co thinfilms on Au(001) investigated by XMCD/STM — •toshio miyamachi[1], shin imada[1], takeshi kawagoe[2], masanori tsunekawa[1], hidenori fujiwara[1], fan-hsiu chang[3], hong-ji lin[3], c.t chen[3], keiki fukumoto[4], hitoshi osawa[4], tetsuya nakamura[4], and shigemasa suga[1] — [1]Graduate School of Engineering Science,Osaka University Osaka 560-8531, Japan — [2]Division of Natural Science, Osaka Kyoiku University Osaka 582-8582, Japan — [3]NSRRC Hsinchu 30076, Taiwan — [4]SPring-8 Hyogo 679-5198, Japan

Development in MBE techniques enables one to fabricate magnetic bits whose size can be down to nm scale. To realize much higher data density for information storage and understand the magnetism of bits, careful consideration of a relationship between nanostructures and nanomagnetism is essential. We performed STM/STS and XMCD measurements of bcc Co ultrathinfilms. From STM/STS measurements, it is found that Co nanostructures are formed by post-annealing without alloying. Furthermore, by applying XMCD sum rule to obtained XMCD data, orbital magnetic moments turned out to increase as the size of nanostructures decrease for post-annealed bcc Co films. We conclude that this result is due to the increase of the ratio of edge atoms, which play an important role for out-of-plane magnetization likewise the case of Co/Pt(111).[1]

[1] S. Rusponi et al.,Nature Mater.,546 (2003)

MA 21.17 Wed 18:15 H 1012

Influence of ligand states on the relationship between orbital moment and magneto-crystalline anisotropy — Cecilia Andersson[1], Biplab Sanyal[1], Olle Eriksson[1], Lars Nordstrom[1], Olof Karis[1], •Dimitri Arvanitis[1], Takehisa Konishi[2], Elizabeta Holub-Krappe[3], and Jonathan Hunter Dunn[4] — [1]Uppsala University, Uppsala, Sweden — [2]Chiba University, Chiba, Japan — [3]Hahn-Meitner Institut, Berlin, Germany — [4]MAX-lab, Lund University, Lund, Sweden

We investigate the spin reorientation in Au/Co/Au trilayers, grown on a W(110) single crystal, using X-ray magnetic circular dichroism (XMCD) in situ. We investigate also an ex situ grown Au/Co/Au sample where the spin reorientation is induced upon cooling. The spin and orbital moments of these Au/Co/Au trilayers are obtained by means of the XMCD sum rules both for an in- and an out-of-plane magnetization. Our findings suggest that the orbital moment of Co does not obtain a maximum value along the easy axis, in contrast to previous experience. This is attributed to the large spin-orbit interaction within the Au caps. Both second order perturbation theory and first principles calculations show that the magneto-crystalline anisotropy (MCA) is influenced by this effect, and that this can lead to that the orbital moment anisotropy is not proportional to the MCA [1]. [1] C. Andersson *et al.*, Phys. Rev. Lett. **99**, 177207 (2007).

MA 21.18 Wed 18:30 H 1012

Co L-edge EXAFS analysis of Au/Co/Au/W(110) magnetic thin films — •Masako Sakamaki[1], Cecilia Andersson[2], Takehisa Konishi[1], Takashi Fujikawa[1], Elizabeta Holub-Krappe[3], Hermann Rossner[3], Olof Karis[2], Andreas Persson[2], and Dimitri Arvanitis[2] — [1]Chiba University, Chiba, Japan — [2]Uppsala University, Uppsala, Sweden — [3]Hahn-Meitner Institut, Berlin, Germany

Ultrathin Au/Co/Au is known as a prototypical system which shows perpendicular magnetic anisotropy. Our recent XMCD study of in-situ prepared Au/Co/Au/W(110) showed that, contrary to the widely accepted picture, there is no increase of the Co perpendicular orbital moment that accompanies the in-plane to out-of-plane spin reorientaton transition(SRT)[1]. We performed an in-situ Co L-edge Extended X-ray Absorption Fine Structure (EXAFS) study of the local structure on the same samples whose magnetic properties were characterized using XMCD and X-ray resonant reflectivity. We applied the Bayes-Turchin approach developed by Krappe and Rossner[2, 3] in analyzing the EXAFS spectra. From this analysis, we obtain quantitative information about the structural strain and disorder of the Co layers. We discuss the role of the local structural modifications among the mechanisms responsible for the occurence of the SRT. [1] C. Andersson *et al.*, Phys. Rev. Lett. **99**, 177207 (2007). [2] H. J. Krappe and H. H. Rossner, Phys. Rev. B **70**, 104102 (2004). [3] H. H. Rossner, D. Schmitz, P. Imperia, H. J. Krappe, J. J. Rehr, Phys. Rev. B **74**, 134107(2006).

MA 22: Magnetic Particles / Clusters II

Time: Wednesday 14:00–16:30 Location: H 1028

MA 22.1 Wed 14:00 H 1028

Magnetism in homonuclear 3d transition metal dimers — •Daniel Fritsch, Klaus Koepernik, Manuel Richter, and Helmut Eschrig — Leibniz Institute for Solid State and Materials Research IFW Dresden, PO Box 270116, D-01171 Dresden, Germany

We have investigated the structural and electronic properties of the 3d transition-metal dimers utilising the full-potential local-orbital program package FPLO [1] for the solution of the Kohn-Sham equations using the local spin density approximation (LSDA). Special emphasis has been laid on the magnetic properties of the transition-metal dimers which are obtained from spin polarised relativistic calculations. Since orbital moments are usually underestimated in these calculations we have additionally studied the influence of orbital polarisation corrections (OPC) on the orbital moments. Such corrections have been suggested by Eriksson *et al.* [2] and later in slightly modified form by Eschrig *et al.* [3]. The results will be compared with available experimental data and other theoretical investigations available in the literature.

[1] K. Koepernik and H. Eschrig, Phys. Rev. B **59**, 1743 (1999); http://www.fplo.de.

[2] O. Eriksson, M. S. S. Brooks, and B. Johansson, Phys. Rev. B **41**, 7311 (1990).

[3] H. Eschrig, M. Sargolzaei, K. Koepernik, and M. Richter, Europhys. Lett. **72** 611 (2005).

MA 22.2 Wed 14:15 H 1028

Chemical ordering and magnetic properties in bimetallic transition metal clusters — •Sanjubala Sahoo, Georg Rollmann, Alfred Hucht, and Peter Entel — Physics Department, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany

Ground state properties of binary Co-Mn icosahedral clusters are studied using the density functional theory. The structural and magnetic properties are studied with respect to various compositions of the constituents. Recent experimental observation of increase in the average magnetic moment of Co-Mn clusters with increase in Mn concentration is clearly reproduced in present studies and is related to the fact that for the smaller Co-Mn clusters with a total number of atoms, N $\leq$ 147, the Mn atoms are preferably embedded on the surface of clusters. In addition, results on Co-Fe, Co-Ni and Fe-Mn clusters will also be presented.

MA 22.3 Wed 14:30 H 1028

Tuning the magnetic properties of deposited transition metal clusters by decoration — •Jan Minar[1], S. Bornemann[1], H. Ebert[1], J.B. Staunton[2], S. Rusponi[3], and H. Brune[3] — [1]Dep. Chemie, LMU, Butenandtstr. 5-13, 81377 M\"unchen, Germany — [2]Department of Physics, University of Warwick, UK — [3]EPF Lausanne, Switzerland

Using the fully relativistic version of the KKR-method for electronic structure calculations within local spin density functional theory (LSDA) the magnetic properties of Fe, Co and Ni clusters deposited on the Pt(111) surface have been investigated. Of central interest are the role of spin-orbit coupling as it influences the spontaneous formation and orientation of magnetic moments and gives rise amongst others to the occurrence of orbital magnetic moments, the magnetic anisotropy energy (MAE) and magnetic circular dichroism in X-ray absorption (XMCD). Our systematic investigations of different clusters and nanostructures aim to reveal the mutual relationship among their spin-orbit induced properties. In addition they show how their various magnetic properties depend on the structural properties and chemical composition of the studied system. For large two-dimensional clusters we focussed especially on the dependency of the MAE on decoration with another transition metal. Our results are in qualitative agreement with recent experimental findings. We resolved the MAE contributions for inequivalent cluster atoms and will discuss the effect of the induced MAE within the Pt substrate.

MA 22.4 Wed 14:45 H 1028

Synthesis and Characterization of Magnetic Nanoparticles — •Sabrina Disch, Wiebke Sager, Raphaël Hermann, Günter Goerigk, and Thomas Brückel — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH; 52425 Jülich

Magnetic nanoparticles are the object of intensive research both because of their possible applications *e.g.* in information storage, catalysis, medical imaging and owing to the interest in fundamental understanding of their magnetic properties. Magnetic nanoparticles, as compared to bulk materials, show unique physical properties such as superparamagnetism or enhanced anisotropy constants. Very little is known about the magnetization distribution within a single particle and magnetic correlations in ordered arrangements of such nanoparticles. In order to investigate such phenomena using scattering techniques, samples of highly monodisperse nanoparticles are required.

We developed a synthesis route for the preparation of cobalt nanoparticles with diameters below 10 nm, originally based on the reduction of $Co(AOT)_2$ in water-in-oil microemulsions [1]. Our water-free synthesis route yields nanoparticle dispersions that are stable against oxidation for weeks if stored in nitrogen atmosphere. Here, we report on the progress made in synthesis optimization as well as magnetic characterization of the as-synthesized particles. We will also present results from scattering experiments performed on cobalt nanoparticles and on highly monodisperse iron oxide nanoparticles [2].

[1] C.Petit, A.Taleb, M.Pileni; *J. Phys. Chem. B*, **1999**, *103*, 1805.
[2] J. Park, T. Hyeon; *Nat. Mat.*, **2004**, *3*, 891.

MA 22.5 Wed 15:00 H 1028

Synthese von Au-core/Co-shell Nanopartikeln — •Britta Vogel[1], Carsten Waltenberg[2], Inga Ennen[1], Harald Rösner[3], Peter Jutzi[2] und Andreas Hütten[1] — [1]Department of Physics, University of Bielefeld, D-33615 Bielefeld, Germany — [2]Department of Chemistry, University of Bielefeld, D-33615 Bielefeld, Germany — [3]Institute of Nanotechnology, Forschungszentrum Karlsruhe GmbH, D-76021 Karlsruhe, Germany

Eine interessante Anwendungsmöglichkeit von magnetischen Nanopartikeln besteht im Einsatz in lebenden Zellen. Dazu ist es notwendig, die Nanopartikel mit einer biokompatiblen und oxidationshemmenden Hülle zu versehen. Eine Möglichkeit dafür bietet die Umhüllung mit Gold. [1][2]

Es wurden Cobalt-Nanopartikel durch thermische Zersetzung von Co-Precursoren synthetisiert, auf denen Gold durch Zersetzung eines Au-Precursors abgeschieden wurde. Untersuchungen der Partikel mittels HRTEM, EDX und EFTEM ergaben, dass bei dieser Synthese zunächst legierte Co/Au-Partikel als Zwischenprodukt entstehen. Es konnte experimentell durch Auslagerungsuntersuchungen gezeigt werden, dass das metastabile Zwischenprodukt in ein Au-core/Co-shell Partikel im Gleichgewichtszustand übergeht. Zudem werden magnetische Eigenschaften dieser Partikel diskutiert.

[1] R.Shenhar, V.M. Rotello, Acc. Chem. Res. 2003, 36, 549. [2] M. Ch. Daniel, D. Astruc, Chem. Rev. 2004, 104, 293.

MA 22.6 Wed 15:15 H 1028

Influence of biaxial stress on the magnetic properties of cobalt nanoparticles — •Srinivasa Saranu[1], Ulf Wiedwald[2], Paul Ziemann[2], and Ulrich Herr[1] — [1]Institut für Mikro- und Nanomaterialien, Universität Ulm, 89081 Ulm — [2]Institut für Festkörperphysik, Universität Ulm, 89069 Ulm

Co nanoparticles with an average diameter of 25nm have been produced using an inert gas condensation technique. The particles were deposited on Si substrates and covered in situ with a 20nm Cu film. When the substrate coverage exceeds 5 %, the remanent magnetization along the in-plane direction was larger than that along the out-of-plane direction which is attributed to the dipolar interaction between the particles. For Co particles on Ta substrates, the effect of stress on the magnetic properties of isolated particles was studied. A thin film of phospholipids (DOPC) on the Ta substrate was used to avoid the agglomeration of the particles during deposition. The lipid layer was removed in an oxygen plasma, afterwards the particles were reduced to metallic Co again using a hydrogen plasma and subsequently covered with 20nm of SiOx. The effect of stress on the magnetic properties of these particles was studied by loading the Ta substrate with hydrogen. For 0.6% of strain in the Ta substrate, out-of-plane magnetization measurements showed an increase of the saturation field Hs and a reduction of the remanent magnetization. This indicates that 25nm cobalt nanoparticles have a positive magnetostriction. Support

by the Landesstiftung Baden-Württemberg is greatfully acknowledged.

MA 22.7 Wed 15:30 H 1028

Analysis of the ultra-fast in-flight heating of FePt nanoparticles. — •Elias Mohn, Darius Pohl, Ute Queitsch, Franziska Schäffel, Ludwig Schultz, and Bernd Rellinghaus — IFW Dresden, P.O. Box 270116, D-01171 Dresden,

FePt nanoparticles within a size range of 4-6 nm are prepared by DC magnetron sputtering in an inert gas atmosphere and subsequently ejected into high vacuum via differential pumping. The particles are subjected to a heat treatment in high vacuum (HV) prior to there deposition onto substrates. In contrast to earlier experiments at somewhat elevated pressures [1], the in-flight annealing of the particles is done optically, since conventional convective heating is not possible under HV conditions.

In order to determine the experimentally hardly accessible temperature of the particles, the thermal history of the particles is rather calculated from the interaction with the electromagnetic field along the flight path through the light furnace used for the in-flight annealing. The results obtained for the particle temperature are corroborated by experimental findings on the sintering of agglomerated particles.

The experiments reveal that the effect of the thermal treatment on both the structural and magnetic properties of the FePt nanoparticles strongly depends on the particles' crystal structure before the annealing.

[1] S. Stappert et al., J. Crystal Growth 252 (2003) 440.

MA 22.8 Wed 15:45 H 1028

Magnetic Anisotropy as Function of Particle Diameter in FePt Alloy Particles — Ulf Wiedwald[1], Luyang Han[1], Andreas Klimmer[1], Balati Kurbanjan[1], Lianchen Shan[1], Hans-Gerd Boyen[1], Kai Fauth[2], and •Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, Germany — [2]Max-Planck-Institut für Metallforschung, Stuttgart, Germany

FePt alloy nanoparticles show huge magnetic anisotropy energy (MAE) in the chemically ordered $L1_0$ phase. The ordered phase is typically reached by annealing above 900 K starting from chemically disordered FePt nanoparticles [1]. The plasma-induced nucleation of metal salt loaded reverse micelles allows the formation of self-assembled regular arrays on top of various substrates. Employing the micellar preparation route, the particle separation can be tuned between 20-100 nm and, thus, agglomeration during annealing is fully suppressed [2]. We investigated the formation of the $L1_0$ phase as functions of annealing temperature and time for 3-10 nm FePt particles. The phase transformation is tracked by hysteresis loops at 11 K and 300 K. 9 nm particles are ferromagnetic at 300 K and a MAE of $1-2\cdot10^6 \mathrm{J/m^3}$ is found after annealing at T = 1000 K. Despite an increasing MAE as a function of annealing temperature is observed for particles smaller than 6 nm, those, however, remain superparamagnetic at 300 K.

[1] U. Wiedwald et al., Appl. Phys. Lett. **90**, 062508 (2007)
[2] A. Ethirajan et al., Adv. Mater. **19**, 406 (2007)

*New address: H.-G. Boyen, University of Hasselt, Belgium

MA 22.9 Wed 16:00 H 1028

Chemical trends in structure and magnetism of binary multiply twinned nanoparticles — •Markus Ernst Gruner, Antje Dannenberg, and Peter Entel — Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Arrays of $L1_0$ ordered nanoparticles of near-stoichiometric FePt and CoPt with diameters down to 4 nm are considered as promising material for future ultra-high density recording media. However, with decreasing particle size, also multiply twinned structures like decahedra and icosahedra are frequently encountered in experiment (e. g., [1]). These structures, however, will not posses the required hard magnetic properties due to the different crystallographic orientations of the individual twins. Recent large scale ab initio calculations of FePt clusters with up to 2.5 nm in diameter [2] show that ordered multiply twinned structures are energetically preferred over $L1_0$ cuboctahedra. Within this contribution, we discuss from the electronic structure point of view the influence of chemical trends on the structural stability of the $L1_0$ phase obtained by variation of the $3d$ and the $5d$ element.

[1] Z. R. Dai *et al.*, Surf. Sci. **505**, 325 (2002); D. Sudfeld *et al.*, Mater. Res. Soc. Symp. Proc. **998E**, 0998-J01-06 (2007)
[2] M. E. Gruner, G. Rollmann, P. Entel, M. Farle (submitted)

MA 22.10 Wed 16:15 H 1028

The effect of topology, charge and magnetic field on the arrangement of FePt nanomagnets on bacterial S-layers — •Ute Queitsch[1], Anja Blüher[2], Michael Mertig[2], Ludwig Schultz[1], and Bernd Rellinghaus[1] — [1]IFW Dresden, P.O. Box 270116 D-01171, Germany — [2]MBZ, University of Technology Dresden, Budapesterstr. 27, Dresden, D-01069, Germany

Gas phase preparation has proven to allow for the preparation of $L1_0$-ordered FePt nanoparticles by in-flight annealing prior to the particle deposition. The regular arrangement of the statistically arriving particles has been shown to be accomplished by depositing onto bacterial surface layers (S-layers) of Bacillus sphaericus NCTC 9602 exhibiting p4 symmetry and a lattice constant of 12.5nm. Aiming at improving the regularity of the particle arrangement we have explored the nature of the interaction between the particles and their affinity sites on the S-layers. Therefore, we have systematically varied both the particle size and charge. Upon adapting the particle size to the size of the template features we observe a pronounced improvement of the regularity. Varying the particle charge resulted only in a minor effect. Hence apparently, the observed affinity originates from topographical effects rather than from electrostatical interactions. In addition, the degree of agglomeration becomes important at high particle densities. Here, applying an in-plane magnetic field during the particle deposition is observed to result in a pronounced decrease of agglomeration and subsequently in an improvement of the regularity at high particle densities.

MA 23: Spinelectronics/ Spininjection in Heterostructures

Time: Wednesday 16:45–18:45 Location: H 1028

MA 23.1 Wed 16:45 H 1028

First-principles calculations of the spin-orbit effects in a Fe/GaAs interface — •Martin Gmitra[1], Alex Matos-Abiague[1], Claudia Ambrosch-Draxl[2], and Jaroslav Fabian[1] — [1]University of Regensburg, 93040 Regensburg, Germany — [2]University of Leoben, A-8700 Leoben, Austria

The recently discovered tunneling anisotropic magnetoresistance(TAMR) effect in semiconductor heterostructures containing a single ferromagnetic layer is potentially useful for spintronics devices. TAMR essentially means that the tunneling current depends on the direction of the magnetization of the ferromagnet; if strong enough, this anisotropy can give a nice spin-valve-like signal. Important, TAMR has recently been observed in a metallic system, namely, in Fe/GaAs/Au junctions. Surprisingly, while all the bulk components of the system are cubic, the observed anisotropy is twofold, of the C2v class. This suggests that rather than coming from the bulk anisotropy of the density of states, the effect arises from the interface that indeed has a reduced symmetry. A phenomenological model reflecting this symmetry in the form of the Bychkov-Rashba and the Dresselhaus spin-orbit coupling was proposed, giving a quantitative fit to the experiment. Here we report on comprehensive ab initio calculations of the spin-orbit effects stemming from the interface anisotropy, providing strong support to the phenomenological theory. In particular, we have performed FLAPW density functional calculations of an Fe/GaAs slab to extract quantitative information about the proposed model as well as to provide guidance to future experiments.

MA 23.2 Wed 17:00 H 1028

Electrical spin injection from Fe into Si(001): ab-initio calculations — •Phivos Mavropoulos and Stefan Blügel — IFF, Forschungszentrum Jülich, D-52425 Jülich, Germany

Electrical spin injection is highly important for novel spintronics devices. Recent experiments [1] have demonstrated efficient spin injection from Fe into Si with very large spin coherence length of the injected current. In the present contribution we seek a theoretical upper limit for the injection efficiency in Fe/Si(001) junctions. Our calculations

of the electronic structure and spin-dependent transport are based on the Korringa-Kohn-Rostoker Green function method [2] within local density functional theory. We show that use of slightly strained Si [3] along the growth axis lifts the degeneracy of the Si conduction band, so that only symmetry-selected Δ_1 states at the center of the surface Brillouin zone carry current. States of such symmetry are absent from the minority-spin bands of Fe at the Fermi level. As a result, the interface allows only spin-selective transmission, allowing in for a high current polarization. We discuss complications arising from interface resonances formed in the minority-spin bands, which reduce the transmission efficiency by resonant tunneling through the Schottky barrier, and we address the problem of reduction of the Fe interface moment when it is strained to match the Si lattice parameter.

[1] B.T. Jonker et at., Nature Physics **3**, 542 (2007).
[2] P. Mavropoulos, N. Papanikolaou, and P.H. Dederichs, Phys. Rev. B **69**, 125104 (2004).
[3] D. Buca et al., Appl. Phys. Lett. **90**, 032108 (2007).

MA 23.3 Wed 17:15 H 1028

Study of spin-injection in the organic semiconductor CuPc by means of spin-resolved two-photon photoemission — •Mirko Cinchetti[1], Kathrin Heimer[1], Oleksiy Andreyev[2], Michael Bauer[2], Huanjun Ding[3], Yongli Gao[3], Stefan Lach[1], Christiane Ziegler[1], and Martin Aeschlimann[1] — [1]Dpartment of Physics, University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institut fuer Experimentelle und Angewandte Physik, Universitaet Kiel, 24098 Kiel, Germany — [3]Deparment of Physics and Astronomy, University of Rochester, Rochester, NY 14267, USA

Spin injection from a ferromagnetic electrode into thin films of organic semiconductors (OSC) is a fundamental prerequisite for the implementation of OSC-based spintronics devices. All experimental studies done so far to demonstrate the feasibility of spin injection into OSC are based on magnetoresistance or electroluminescence measurements, which result in a spin-dependent signal integrated over the whole spintronics device. Great care has to be taken in the search of spin injection in such experiments, since stray fields may mimic the spin effects. We propose spin-resolved two-photon photoemission as an alternative method allowing to collect direct experimental information about the efficiency of spin injection. As a model system for OSC-based spintronics devices, we have studied the heterojunction between a Cobalt thin film and Copper phthalocyanine (CuPc). We will discuss the crucial role played by the specific interface properties (such as the surface topography of the ferromagnetic electrode and the related growth of the OSC) on the efficiency of spin injection.

MA 23.4 Wed 17:30 H 1028

Magnetic characterization of injector/collector contacts for silicon spintronics — •Daniel Schwarz[1], Theodoros Dimopoulos[1], Thomas Uhrmann[1], Vlado Lazarov[2], Amit Kohn[2], Sascha Weyers[3], Uwe Paschen[3], and Hubert Brückl[1] — [1]Austrian Research Centers GmbH - ARC, Nano System Technologies, Donau-City-Str. 1, 1220 Wien, Austria — [2]Department of Materials, University of Oxford, Parks Road, OX1 3PH, U.K. — [3]Fraunhofer Gesellschaft, Finkenstr. 61, 45057 Duisburg, Germany

Electrical spin-polarized current injection in Si promises a breakthrough in future spintronic devices. Its efficiency depends strongly on the magnetic properties of the ferromagnetic (FM) contacts used for current injection and detection, commonly including a tunneling barrier between the FM metal and Si. We sputter-deposited rectangular, sub-μm FM contacts, embedded into holes in SiO_2 dielectric prepatterned by optical lithography. As a tunneling barrier we used MgO of thickness between 0 and 2.5nm and a $Co_{70}Fe_{30}$(2nm)/$Ni_{80}Fe_{20}$(8nm) bilayer. The antiparallel magnetic state between injector and collector is achieved by tailoring the shape anisotropy. For this, the aspect ratio is varied between 3 and 10. Using magneto-optical Kerr effect, we have studied the dependence of the switching field and its distribution, as a function of the MgO thickness and the aspect ratio, supported by micro-magnetic simulations. Domain structure information is provided by magnetic force microscopy measurements as a function of the magnetic field. The effect of annealing up to 400°C is also discussed. We acknowledge support from the EU project EMAC-Strep 017412.

MA 23.5 Wed 17:45 H 1028

Spin-polarized spin-orbit-split quantum-well states in a metal film — •Andrei Varykhalov[1], Jaime Sánchez-Barriga[1], Alexander M. Shikin[2], Wolfgang Gudat[1], Wolfgang Eberhardt[1], and Oliver Rader[1] — [1]BESSY Berlin — [2]St. Petersburg State University

Elements with high atomic number Z lead to a large spin-orbit coupling. Such materials can be used to create spin-polarized electronic states without the presence of a ferromagnet or an external magnetic field if the solid exhibits an inversion asymmetry. We create large spin-orbit splittings using a tungsten crystal as substrate and break the structural inversion symmetry through deposition of a gold quantum film. Using spin- and angle-resolved photoelectron spectroscopy, it is demonstrated that quantum-well states forming in the gold film are spin-orbit split and spin polarized up to a thickness of at least 10 atomic layers. This is a considerable progress as compared to the current literature which reports spin-orbit split states at metal surfaces which are either pure or covered by at most a monoatomic layer of adsorbates.

MA 23.6 Wed 18:00 H 1028

Room temperature operation of a magnetic tunnel transistor with an epitaxial spin valve base — Alexander Spitzer, •Julien Vigroux, Juergen Moser, and Guenther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, 93040, Germany

We present a magnetic tunnel transistor (MTT) with room temperature operation. The performance of MTTs is usually limited to temperatures far below 300K due to strongly temperature dependent leakage currents of the Schottky barrier. These leakage currents originate from defects created by Ar-sputtering processes during patterning of the MTT. The leakage currents dominate the collector current IC and therewith reduce the magneto current ratio (MCR) which is the normalized difference in IC for parallel and antiparallel alignment of the ferromagnetic layers in the MTT. To overcome this hurdle, two approaches are possible: The use of either wet chemical etching to remove those defects or film deposition through shadow masks. We show that both lead to a strong reduction of the leakage current. As a base contact for our MTT we use a fully epitaxial FeCo/Au/FeCo spin valve grown on n-GaAs(001). A Ta emitter grown on an Al2O3 tunnel barrier provides the hot electron emitter current IE. Depending on the thickness of the magnetic layers our MTTs show MCRs over 1000 % at 11K. Support by Deutsche Forschungsgemeinschaft (SFB 689) and Marie Curie RTN "ultrasmooth" is gratefully acknowledged.

MA 23.7 Wed 18:15 H 1028

Transport properties of embedded MgO-based ferromagnetic MIS diodes for silicon spintronics — •Thomas Uhrmann[1], Theodoros Dimopoulos[1], Daniel Schwarz[1], Vlado Lazarov[2], Amit Kohn[2], Sascha Weyers[3], Uwe Paschen[3], and Hubert Brückl[1] — [1]Austrian Research Centers GmbH - ARC, Nano System Technologies, Donau-City-Str. 1, 1220 Wien, Austria — [2]Department of Materials, University of Oxford, Parks Road, OX1 3PH, U.K. — [3]Fraunhofer Gesellschaft, Finkenstr. 61, 45057 Duisburg, Germany

The major challenges in the field of semiconductor spin-electronics is the efficient electrical injection of spin polarized carriers into the semiconductor, their manipulation and subsequent detection.

Here we will focus on the electrical characterization of embedded sub-μm MIS tunneling diodes dedicated for spin injection and detection in silicon, using MgO as tunneling barrier. The conductivity mismatch theory predicts, that only within a narrow window of resistance values optimized spin injection efficiency is obtained. With respect to this, we report the influence of the tunneling barrier thickness (varied between 0.5 and 2.5 nm) and of the n- and p-doping density (from 10^{15} to 10^{18} cm^{-3}) on the electrical transport properties of isolated cells and injector-collector pairs. For this we used current-voltage measurements as a function of the temperature and of the magnetic field. The effect of the annealing, up to 400^{o}C, on the transport and structural properties of the diodes is also discussed.

We acknowledge support from the EU project EMAC-Strep 017412.

MA 23.8 Wed 18:30 H 1028

Role of interface short range order in of CoFeB/MgO/CoFeB magnetic tunnel junctions — •Gerrit Eilers[1], Marvin Walter[1], Kai Ubben[1], Michael Seibt[1], Talaat Al-Kassab[2], Volker Drewello[3], Andy Thomas[3], Günter Reiss[3], and Markus Münzenberg[1] — [1]IV. Phys. Inst., Universität Göttingen — [2]Institut für Materialphysik, Universität Göttingen — [3]Fakultät für Physik, Universität Bielefeld

Magnetic tunnel junctions consisting of CoFeB/MgO/CoFeB trilayers have been of great interest in research just recently. Due to their high

magneto resistance they are a promising candidate for the fabrication of spin torque MRAM devices. For future writing concepts like current induced magnetic switching magnetic tunnel junctions (MTJs) with thin barriers are necessary to provide sufficient high current densities. In such elements the TMR is strongly dependent on the electron transmission at the metal / oxide interfaces. Therefore the quality of the interfaces is of great significance and should be optimized on the nano-scale. With the objective to correlate electrical transport properties (I/V characteristics, TMR) with the geometrical and chemical interface roughness, the structural analysis was made by cross-sectional TEM, energy dispersive X-ray spectroscopy (EDX) and Atom Probe Tomography (APT). The distribution of the layer elements, especially the Boron, through the layer stack is of particular interest and an up to now unsolved mystery.

Research was funded by SFB 602

MA 24: FV Internal Symposium in honour of Nobelprice 2007 to Peter Grünberg and Albert Fert

Time: Thursday 9:30–11:30 Location: EB 301

Invited Talk MA 24.1 Thu 9:30 EB 301
Physics and applications of tunneling magnetoresistance effect — •Shinji Yuasa — National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki 305-8568, Japan

A magnetic tunnel junctions (MTJ), which consists of an ultra-thin insulator (a tunnel barrier) sandwiched by two ferromagnetic electrode layers, exhibits tunneling magnetoresistance (TMR) effect due to spin-dependent electron tunneling. Since the discovery of room-temperature TMR effect in 1995, MTJs with an amorphous Al-O tunnel barrier have been extensively studied and are currently used in magnetoresistive random-access-memory (MRAM) and read head of hard disk drive (HDD). These conventional MTJs show magnetoresistance (MR) ratios of up to about 70% at room temperature. However, MTJs with much higher magnetoresistance are desired for next-generation MRAM and HDD. In 2001, first-principle theories predicted the MR ratios above 1,000% in epitaxial Fe(001)/MgO(001)/Fe(001) MTJs with a crystalline MgO(001) tunnel barrier as a result of coherent spin-dependent tunneling. In 2004, giant MR ratios of about 200% at room temperature (RT) were experimentally achieved in fully epitaxial MgO-based MTJs and (001)-oriented poly-crystalline (textured) MgO-based MTJs. Novel CoFeB/MgO(001)/CoFeB MTJ structure, which is highly compatible with mass-manufacturing processes of MRAM and HDD read head, was also developed, and giant MR ratios above 200% up to 500% at RT have been achieved. Giant TMR effect in MgO-based MTJs is of great importance not only for developing various spintronic devices but also for clarifying the physics of spin-dependent tunneling.

Invited Talk MA 24.2 Thu 10:00 EB 301
From giant magnetoresistance to current-induced magnetic switching: theoretical aspects — •Jozef Barnas — Department of Physics, Adam Mickiewicz University, Poznań, Poland

The presence of two well-defined and strongly spin-dependent transport channels in ferromagnetic metals leads to the phenomenon of giant magnetoresistance (GMR) in magnetic layered structures. The discovery and successful applications of GMR led to a new branch of mesoscopic electronics, called spin electronics or briefly spintronics. Some basic theoretical aspects related to the GMR in magnetic multilayers as well as those related to semiconductor and molecular spintronics will be briefly discussed. Another consequence of the presence of two spin channels for electronic transport (and also of the discovery of GMR) is the phenomenon of current-induced magnetic switching (CIMS) due to spin torque. The latter is a consequence of spin transfer from conduction electrons to local magnetic moments. The spin torque can generate transitions between different local (quasi)equilibrium states. At some conditions, however, the spin-transfer torque may cause transition to dynamical states of microwave frequency, where the energy is pumped from a voltage source to the magnetic system. Of particular interest are structures, in which the microwave precessional states can be induced in the absence of external magnetic field.

Invited Talk MA 24.3 Thu 10:30 EB 301
Magnetoresistive Sensors and Magnetic Nanoparticles for Biotechnology — •Günter Reiss, Andreas Hütten, Inga Ennen, Alexander Weddemann, Andy Thomas, and Jan Schmalhorst — Bielefeld University, Physics Department, P.O. Box 100131, 33501 Bielefeld, Germany

Detection as well as manipulation of biomolecules on one technological platform is important for both basic research as well as for numerous applications. The discovery of the Giant Magnetoresistance enabled the vision of a magnetoresistive Biochip: The detection of small magnetic carriers1 with tailored magnetoresistive sensors can create a completely electronic (bio-) chip capable of detecting antibodies or DNA fragments2. Moreover, this system would be compatibel with important developments in microelectronics, namely read heads and MRAM. Different configurations are discussed and the results for GMR sensors are compared to an analysis of the same systems marked with fluorescence dyes. This shows, that down to a low concentration of, e.g., DNA molecules, the magnetoresistive technique is competitive to nowadays standard analysis methods. The capability of the Tunneling Magnetoresistance sensors to detect even single markers as well as on chip manipulation of the carriers are additionally demonstrated.

1 G. Reiss, A. Hütten, Nature Materials News and Views, 4 (2005) 725

2 W. Schepper et.al., Physica B-Condens. Mat. 372 (2006) 337

Invited Talk MA 24.4 Thu 11:00 EB 301
Status and Future of Magnetic Recording — •Dieter Weller — Seagate Technology, 47010 Kato Rd, Fremont, CA 94538

The areal density in magnetic recording continues to grow at 40% per year. This growth is fueled by advancements in recording heads and media as well as improvements in the systems architecture and channels electronics. Perpendicular magnetic recording (PMR) was introduced in 2005 at 130 Gbit/in^2 and is now deployed across all product lines at densities up to 250 Gbit/in^2. Laboratory demos show that 520 Gbit/in^2 in PMR and 602 Gbit/in^2 in Discrete Track Recording (DTR) [Western Digital and TDK in October, 2007] are possible. Component technologies are tunneling magneto-resistance (TMR) heads and granular CoCrPt based perpendicular media with soft underlayers. Discrete tracks help to reduce the adjacent-track erasure effect and allow for higher track density. It is expected that a combination of PMR and DTR will enable Tbit/in^2 densities by 2010. At that point major changes in the heads and media are needed to support further extensions. The two vital options are (1) to scale the media to smaller grain size but use harder magnetic materials, which require write assist to allow recording in Heat Assisted Magnetic Recording (HAMR) and (2) to lithographically make thermally stable islands and record one bit on each one of them in Bit Patterned Media (BPM).

MA 25: Invited Talks Woltersdorf / Meier / Rasing

Time: Thursday 12:00–13:30 Location: EB 301

Invited Talk MA 25.1 Thu 12:00 EB 301
Magnetization dynamics due to pure spin currents — •Georg Woltersdorf[1], Olexandr Mosendz[2], Christian H. Back[1], and Bret Heinrich[2] — [1]Physik, Universität Regesburg, Universitätsstraße 31, 93040 Regensbug, Germany — [2]Physics Department, Simon Fraser University, 8888 University Drive, V5A 1S6 Burnaby, B.C., Canada

The magnetization dynamics in magnetic double layers is affected by spin-pump and spin-sink effects. So far, only the spin-pumping and its effect on the magnetic damping was studied. However, due to conser-

vation of angular momentum this spin current also leads to magnetic excitation of the layer dissipating this angular momentum (spin-sink). We use the time resolved magneto-optic Kerr effect to directly show the excitation due to the pure spin current. In particular, we observe magnetization dynamics due to the transfer of spin angular momentum in magnetic double layers. In contrast to other experiments where a spin polarized charge current is passed through a nanomagnet this effect is based on pure spin currents without net transfer of electric charge.

In addition it is shown that this effect can be used to estimate the spin diffusion length of the non-magnetic spacer material.

Invited Talk MA 25.2 Thu 12:30 EB 301

Time-Resolved Imaging of Domain-Wall and Vortex Motion Driven by Spin-Polarized Currents — •Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

Transmission x-ray microscopy can directly visualize the influence of a spin-polarized current on the magnetization of micro- and nanostructures. We investigate the stochastic motion of domain walls in curved wires and the motion of vortices in squares. To observe domain-wall motion pulses of nanosecond duration and high current density are send through permalloy wires and either move or deform the domain wall. Repetitive pulse measurements reveal the stochastic nature of current induced domain-wall motion. Via a micromagnetic code based on OOMMF including the spin-torque transfer model of Zhang and Li experiments are compared to theory. The simulations support the interpretation of the experimental results.
Sinusoidal high-density currents are applied to micrometer-sized permalloy squares containing ferromagnetic vortices. Spin-torque induced vortex gyration on the nanosecond timescale is observed. The phase of the gyration in structures with different chirality are compared to an analytical model and micromagnetic simulations, considering both alternating spin-polarized currents and the current's Oersted fields. This analysis reveals that spin-torque is the main source of motion.
Supported by the DFG via SFB 508, SFB 668, and GK 1286 as well as by the U.S. DOE Contract No. DE-AC02-05-CH11231.

Invited Talk MA 25.3 Thu 13:00 EB 301

Controlling Magnetism by light — •Theo Rasing — Institute for Molecules and Materials, Radboud University Nijmegen, The Netherlands

The interaction of light with magnetic matter is well known: magneto optical Faraday or Kerr effects are frequently used to probe the magnetic state of materials. or manipulate the polarisation of light.

The inverse effects are less known but certainly as fascinating: with light one can manipulate matter, for example orient their spins. Using femtosecond laser pulses we have recently demonstrated that one can thus generate ultrashort and very strong (˜Teslas) magnetic field pulses that provide unprecedented means for the generation, manipulation and coherent control of magnetic order on very short time scales.

In this talk the basic ideas will be discussed and illustrated with recent results.

References

A.V.Kimel, A.Kirilyuk, P.A.Usachev, R.V.Pisarev, A.M.Balbashov and Th.Rasing,Ultrafast nonthermal control of magnetization by instantaneous photomagnetic pulses, Nature 435 (2005), 655-657

C.D.Stanciu, F.Hansteen, A.V.Kimel, A.Kirilyuk, A.Tsukamoto, A.Itoh and Th.Rasing, All-optical Magnetic Recording with Circularly polarized Light, Phys.Rev.Lett.99, 047601 (2007)

MA 26: Spin Dynamics / Spin -Torque II

Time: Thursday 14:30–18:45 Location: EB 301

MA 26.1 Thu 14:30 EB 301

Relationship between the asymmetry of inelastic magnon excitation and the spin polarization — Nicolai Urban[1], Tobias Schuh[1], Albert F. Takacs[1], Timofey Balashov[1], Markus Däne[2], Arthur Ernst[2], Patrick Bruno[2], and •Wulf Wulfhekel[1] — [1]Physikalisches Instiut, Universität Karlsruhe (TH), Wolfgang - Gaede Str. 1, 76131 Karlsruhe — [2]MPI für Mikrostukturphysik, Weinweg 2, 06108 Halle

Electrons tunneling between the non-magnetic tip of a scanning tunneling microscope and a ferromagnetic sample can scatter inelastically, creating spin waves in the ferromagnet [1]. These excitations can be created for both tunneling directions, i.e. by hot electrons or holes. We observe a strong asymmetry between these two processes. From the selection rules of the conservation of angular momentum follows that in the forward direction only tunneling minority electrons create spin waves, while in the backward direction only tunneling majority electrons create spin waves. Thus, the probability of spin wave creation for forward/backward tunneling is proportional to the local density of states (LDOS) of minority/majority electrons in the investigated magnetic material.

We examined the excitation asymmetry in bulk Fe(100), and thin Co films on Cu(111) and Cu(100). The experimental results of the asymmetry agree well with theoretical calculations of the spin polarization of the LDOS.

[1] T. Balashov, A. Takács, W. Wulfhekel, J. Kirschner, *Phys. Rev. Lett.* **97** 187201 (2006)

MA 26.2 Thu 14:45 EB 301

Excitation of standing spin waves in antiferromagnetic thin films using hot electrons — •Chunlei Gao[1], Wulf Wulfhekel[1,2], Arthur Ernst[1], Guntram Fischer[3], Wolfram Hergert[3], Patrick Bruno[1], and Jürgen Kirschner[1] — [1]MPI für Mikrostrukturphysik, 06120 Halle — [2]Physikalisches Institut, Universität Karlsruhe, 07131 Karlsruhe — [3]Martin-Luther-Universität Halle-Wittenberg, Fachbereich Physik, 06099 Halle

Standing spin waves confined in face centered tetragonal antiferromagnetic Mn thin films were locally excited by hot electron injection with a STM tip. The dispersion of the spin waves was obtained through measurements of the excitation energies in films of various thicknesses. The damping of the spin waves was extracted from the width of the excitation peaks. Both the experimental dispersion and the damping agree well with neutron scattering results of Ni doped γ-Mn. Further, abinitio calculations of the spin wave dispersion confirm the experimental results.

MA 26.3 Thu 15:00 EB 301

Direct observation of the excitation phase of microwave excited spin waves — •Thomas Schneider[1], Alexander A. Serga[1], Timo Neumann[1], Burkard Hillebrands[1], and Mikhail P. Kostylev[2] — [1]Fachbereich Physik und Forschungsschwerpunkt Minas, TU Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany — [2]School of Physics, M013, University of Western Australia, 35 Stirling Highway, Crawle, WA 6009, Australia

We report on phase resolved Brillouin light scattering spectroscopy investigations of the excitation of spin waves by microwave pulses. We observed the phase difference between two counterpropagating waves with antiparallel wavevectors excited by the same microwave current flowing through a microstrip spin-wave antenna (the so called "excitation phase"). Theory predicts that for the backward volume mode (spin-wave propagation parallel to the applied bias field) this excitation phase should be equal to π since they are excited by the out-of-plane component of the microwave field. By measuring the phase accumulation (i.e. the change of phase with propagation distance) we were able to experimentally confirm that value. If one changes the propagation direction to perpendicular to the applied field (Damon-Eshbach mode) while the amplitude of the two waves becomes drastically unsymmetrical our experiments show that the phase becomes symmetrical (excitation phase equals zero). Theoretical analysis confirms this effect.

Financial support by the DFG, the Graduiertenkolleg 792 and the Australian Research Council is gratefully acknowledged.

MA 26.4 Thu 15:15 EB 301

Wave-vector Resolved Brillouin Light Scattering Observation of Parametrically Generated Excitations in a Magnon Gas — •Timo Neumann, Aleksandr Serga, and Burkard Hillebrands — Fachbereich Physik, TU Kaiserslautern, Kaiserslautern, Germany

The parametric pumping technique is a very powerful tool to selectively control the density of a magnon gas.

Here we report on the identification of the wave vectors of parametrically generated magnons in a ferrite film.

Using Brillouin Light Scattering (BLS) spectroscopy with wave vector resolution we have studied the process of parametric interaction between an electromagnetic field and the spin wave subsystem of an yttrium iron garnet film in order to unambiguously identify the spectral positions of the generated groups of magnons. Moreover, the process of energy transfer from the overheated areas was investigated.

To achieve this, the possibility to retrieve information about the wave vectors was implemented in an existing BLS-setup by means of spatial selection of the scattered light. Advantages and shortcomings of different methods of such a selection procedure are discussed.

Financial support by the MATCOR Graduate Program is acknowledged gratefully.

MA 26.5 Thu 15:30 EB 301

Non-resonant parametric restoration of microwave spin-wave signals in YIG films — •Sebastian Schäfer, Andrii V. Chumak, Alexander A. Serga, and Burkard Hillebrands — FB Physik and FSP MINAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

We report on the storage and restoration of spin-wave pulses in a thin Yttrium-iron-garnet (YIG) film. A Damon-Eshbach (DE) type spin-wave pulse is irradiated by a microstrip antenna and excites perpendicular standing spin-wave modes (PSSW), existing due to the finite thickness of the film. Those modes are excited, where the crossing of DE and PSSW dispersions leads to a hybridization of both groups of magnons. After the DE pulse has left the area of interest, energy is provided to the magnonic system with the means of parallel parametric pumping. Here we focus on the dependence of the characteristics of recovered traveling spin-wave pulses on the intensity of the input microwave spin-wave signal for the non-resonant case where the pumping frequency does not match exactly twice the carrier frequency of the original DE mode. This enables the investigation of spectral characteristics of the input microwave spin-wave signal and is a basic step in order to understand the influence of the thermal bath and increasing of the thermal noise for the interaction between the magnon system and a parametric pumping field. Financial Support by the DFG within the SFB/TRR 49 is gratefully acknowledged.

MA 26.6 Thu 15:45 EB 301

Storage and parametrically stimulated recovery of microwave signal using standing spin-wave modes of a magnetic film — •Alexander Serga[1], Andrii Chumak[1,2], Alexander André[1], Gennadiy Melkov[2], Andrei Slavin[3], Sergej Demokritov[4], and Burkard Hillebrands[1] — [1]FB Physik and FSP MINAS, TU Kaiserslautern, Germany — [2]Taras Shevchenko University of Kiev, Ukraine — [3]Oakland University, Rochester, MI, USA — [4]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Germany

Microwave signals stored for a long time in the form of standing spin-wave (SW) modes of the ferrite film were recovered by parametric pumping. The experiment was performed on an in-plane magnetized yttrium-iron-garnet film. The microwave signal was carried by a packet of surface spin waves that propagate transversely to the bias magnetic field. Near the points of hybridization between the lowest SW mode and the higher-order exchange-dominated SW modes this packet partially transforms into standing thickness modes of the film. A pumping pulse having a carrier frequency close to twice the frequency of one of the standing modes recovers the packet of propagated waves. The time of recovery, duration, and power of the recovered pulse signal were controlled by the pumping power. We propose a theory of non-stationary parametric amplification of the standing modes on the background of the thermal magnon bath, which provides a good qualitative explanation of the experimental results. The work was supported by the DFG, by the Ukrainian Fund for Fundamental Research, by the U.S. Army Research Office, and by the Oakland University Foundation.

MA 26.7 Thu 16:00 EB 301

Propagation, Dispersion and Interference of Spin Waves in Ferromagnetic Thin Films — Korbinian Perzlmaier, •Wolfgang Scheibenzuber, Frank Hoffmann, Georg Woltersdorf, and Christian H. Back — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstr. 31, 93040 Regensburg

The propagation and interference of spin waves has been observed in 20 nm thick $Ni_{80}Fe_{20}$ films by time and space resolved scanning Kerr microscopy. The sample is a continuous thin film with a CPS (coplanar stripline) patterned along one edge of the sample. Using cw (continuous wave) or pulsed microwave excitation, the phase velocities, group velocities, and dispersion relations have been determined in two geometries of an externally applied magnetic in plane bias field, namely the DE (Damon Eshbach) and MSBV (Magneto Static Backward Volume) geometries. Analytical calculations based on the linearized LLG (Landau Lifshitz Gilbert) equation reproduce the experimental findings.

Further on, we report on the interference of propagating spin waves in continuous ferromagnetic films.

MA 26.8 Thu 16:15 EB 301

Crosstalk of dipolar spin-wave modes in thin Nickel films — •Benjamin Lenk, Marija Djordjevic, Jakob Walowski, Gerrit Eilers, and Markus Münzenberg — IV. Physikalisches Institut, Universität Göttingen

The relaxation mechanisms in thin Nickel films are investigated with all optical pump-probe experiments. Laser pulses with a duration of $60fs$ from a Ti:Sa mode-coupled laser system are used for optical excitation (pump pulse) as well as observation of the subsequent magnetic relaxation taking place in the pico- and nanosecond regime (probe pulse). The relaxation spectra, i.e. the time dependent magnetization curves $M(t)$, are recorded using the time-resolved magneto-optical Kerr effect (TRMOKE). Numerical analysis yields the relaxation frequencies for all layer thicknesses ranging from $40nm$ to $220nm$ on a wedge sample.

Different modes are observed that can be attributed to i) uniform precession of the spins ii) exchange-dominated perpendicular standing spin waves as well as iii) dipole-dominated surface modes. By applying an external field $0mT \leq \mu_0 H \leq 150mT$ dispersion relations $\omega(H)$ are determined for the different modes at each layer thickness. The experimental results are compared to theoretical equations derived from the Landau-Lifschitz-Gilbert equation of motion. Good agreement is seen with partly strong deviations at points of mode crossing.

Research is supported by *DFG Schwerpunkt SPP 1133: "Ultrafast magnetization processes"*.

15 Min. Session Break

MA 26.9 Thu 16:45 EB 301

Determination of the magnon dispersion of ferromagnets on the nanometer scale — •Nicolai Urban, Timofey Balashov, Albert F. Takacs, and Wulf Wulfhekel — Physikalisches Institut, Universität Karlsruhe (TH), Wolfgang Gaede Str. 1, 76131 Karlsruhe

We studied the dispersion of magnons in thin ferromagnetic Co films on Cu(100) using inelastic tunneling spectroscopy at 4K. By an interaction between the tunneling electrons and the spin-polarized electron sea of the films, magnons can be excited. Due to the finite thickness of the films, a series of standing magnons quantized perpendicular to the plane evolves. From the film thickness and the order of the standing mode, the magnon momenta can be determined while the energy is given by the position of the extrema in the inelastic tunneling spectra. The obtained dispersion curve agrees well with neutron scattering data and with ab-initio calculations within the whole Brillouin zone [1]. This experimental method allows to determine excitation energies and magnon dispersions of magnetic materials on the nanometer scale.

[1] M. Pajda et al., Phys. Rev. B. **64**, 174402 (2001).

MA 26.10 Thu 17:00 EB 301

Femtosecond magnetization dynamics of iron films after laser excitation — •Stefan Polei, Xuan Truong Nguyen, Armin Kleibert, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

In 1996 Beaurepaire et al. [1] demonstrated a femtosecond demagnetization of a ferromagnetic sample after excitation with ultrashort laser pulses. The observed time scale was approx. 100 times shorter than expected from theory of magnetization dynamics. Thus, this pioneering experiment has attracted much attention by researchers worldwide. Despite its enormous potential for applications, a full microscopic understanding is still lacking. Thus, great efforts are made to get insight into the fundamental physical processes which lead to a rapid loss followed by a slower recovery of the magnetization within the first picoseconds.

In this contribution we present recent pump-probe experiments on thin iron films. Our setup relies on a Ti-Saphire-laser followed by a multipath amplifier providing pulses of 35fs with up to 2.5mJ at 800nm

and a repetition rate of 1kHz. The magnetization dynamics is investigated observing the magneto-optical Kerr-rotation in the longitudinal geometry. Time-dependent hysteresis loops obtained by varying the pump-probe delay give insight into the magnetization dynamics.

[1] Beaurepaire et al., PRL **76**, 4250 (1996)

MA 26.11 Thu 17:15 EB 301

Spatio-temporal magnetic imaging with a femtosecond laser Kerr microscope — •Thomas Eimüller, Jie Li, Min-Sang Lee, Wei He, and Björn Redeker — Nachwuchsgruppe Magnetische Mikroskopie, Ruhr-Universität Bochum, D-44780 Bochum

We report on first results obtained with our new femtosecond laser scanning Kerr microscope. The abilities of the instrument to study magnetization dynamics with a temporal resolution below 100 fs and a lateral resolution in the sub-micrometer regime is demonstrated in all-optical two-colour pump-probe experiments. In a wedged Fe/Gd sample we record the dynamic polar MOKE signal both as a function of the film thickness gradient and as a function the delay time. The resulting spatio-temporal images reveal how the demagnetization process and the induced spin precession change as a function of the film thickness. The high lateral resolution is furthermore used to study the the reversal and magnetization dynamics of lithographically structured Co/Pt systems as a function of different geometrical shapes and different sizes of the elements.

Financial support by the DFG via project SFB491-N1 is gratefully acknowledged.

MA 26.12 Thu 17:30 EB 301

Ultrafast magnetization dynamics in Gd studied by time-resolved XMCD — •Marko Wietstruk[1], Torsten Kachel[1], Niko Pontius[1], Christian Stamm[1], Hermann A. Dürr[1], Wolfgang Eberhardt[1], Alexey Melnikov[2], Uwe Bovensiepen[2], Cornelius Gahl[3], and Martin Weinelt[2,3] — [1]BESSY GmbH, Berlin — [2]FU Berlin, FB Physik — [3]MBI Berlin

In order to improve heat assisted magnetic recording techniques, the understanding of ultrafast magnetization processes especially the flow of energy and angular momentum is essential. The demagnetization of a thin gadolinium film has been investigated in the .1 to 100 ps regime after excitation of the 5d6s valence electrons by a 100 fs IR laser pulse.

The measurements were done at the fs-slicing facility at BESSY in low-α and slicing mode. Using circularly polarized synchrotron radiation we measured X-ray magnetic circular dichroism (XMCD) at the Gd $M_{4,5}$ absorption edges, a method which provides access to the 4f spin and orbital momentum.

The measurements show that the demagnetization process is divided into two steps. First, a 'fast' demagnetization occurs with a reduction of the sample magnetization by 20% within the first ps after excitation. This is followed by a further magnetization decrease within 100ps. While the latter time scale corroborates earlier observations [1] and is assigned to spin-lattice relaxation, the sub-ps component suggests ultrafast demagnetization via the exchange interaction between the 5d6s valence and the 4f core electrons.

[1] A. Vaterlaus *et.al.*, Phys. Rev. Lett. 67, 3314 - 3317 (1991)

MA 26.13 Thu 17:45 EB 301

Ultrafast dynamics in optically excited nickel nanodiscs — •Georg Müller[1], Gerrit Eilers[1], Zhao Wang[1], Malte Scherff[1], Ran Ji[2], Kornelius Nielsch[2], and Markus Münzenberg[1] — [1]IV. Phys. Institute, Georg-August-University, Friedrich-Hund-Platz 1, D-37077 Göttingen — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle

The temporal change in the Kerr angle of an in-plane magnetized nano patterned nickel wedge structure as the response to a fs laser pulse is investigated. The examined structure consists of an array of discs with a diameter of 185 nm and a separation of 280 nm, whose thickness is varied from 4 to 40 nm, and is prepared by optical interference lithography. The traced Kerr signal dynamics comprises a wealth of different modes which can be mostly attributed to reflectivity changes of the film due to the generation of surface acoustic waves or even magnetoelastic coupling. Nevertheless, one mode is clearly identified to be of pure magnetic origin. The theoretical mode spectrum of a single nanodisc obtained by micromagnetic simulations shows that the experimentally excited mode is of end mode type. A comparison between the theoretically and experimentally determined dependence of the frequency on the structure thickness allows to derive an approximate expression for the dipole interaction between the discs in the patterned film.

Research is supported by the DFG priority program 1133 'Ultrafast Magnetization Processes'.

MA 26.14 Thu 18:00 EB 301

Laser-Induced Magnetization Dynamics of Holmium-Doped Permalloy Thin Films — •Ilie Radu[1,4], Matthias Kiessling[1], Georg Woltersdorf[1], Alexey Melnikov[2], Uwe Bowensiepen[2], Jan Thiele[3], Martin Wolf[2], and Christian Back[1] — [1]Institut für Experimentelle Physik, Universität Regensburg — [2]Fachbereich Physik, Freie Universität Berlin — [3]Hitachi GST, San Jose Research Center, USA — [4]BESSY GmbH, Berlin

The magnetization response of holmium-doped permalloy thin films after femtosecond laser excitation is studied by time-resolved magneto-optical Kerr effect (TR-MOKE). The investigated system consists of 10 nm Permalloy (Py) films doped with Holmium (Ho) at concentrations ranging from 1% to 8%. Consequently, the magnetization damping parameter changes from 0.008 (pure Py) to 0.2, as deduced from ferromagnetic resonance measurements. Thus, we can investigate the contribution of the impurity-assisted spin-flip scattering to the photo-induced demagnetization process. From the TR-MOKE data we observe: (i) a drop in the transient MOKE signal that evolves within the first hundreds of femtoseconds after optical excitation (ii) a gradual shift to longer pump-probe delays of the minimum position of the transient MOKE signal as the Ho impurity content increases. The results will be discussed along the lines of a recent theoretical model [1] which propose a laser-induced demagnetization mechanism determined by impurity- or/and phonon-mediated spin-flip scattering processes.

[1] B. Koopmans et al., PRL 95, 267207 (2005)

MA 26.15 Thu 18:15 EB 301

Photo-Induced Magnetization Dynamics of FeRh Thin Films Investigated by Time-Resolved X-ray Magnetic Circular Dichroism — •Ilie Radu[1,2], Christian Stamm[2], Torsten Kachel[2], Niko Pontius[2], Paul Ramm[1], Jan Thiele[3], Hermann Dürr[2], and Christian Back[1] — [1]Institut für Experimentelle Physik, Universität Regensburg — [2]BESSY GmbH, Berlin — [3]Hitachi GST, San Jose Research Center, USA

For close to equiatomic composition the FeRh alloy undergoes a first-order phase transition from the antiferromagnetic (AFM) to ferromagnetic (FM) state upon heating above room temperature. We trigger the magnetic phase transition by femtosecond laser excitation and study the subsequent dynamics of the Fe and Rh magnetic moments in an element specific manner using X-ray magnetic circular dichroism (XMCD) as a probing tool. For both elements we observe a gradual growth of ferromagnetic ordering that takes place on a ˜200 ps time scale after optical excitation. On the other hand, once in the FM state, FeRh can be demagnetized on a few picoseconds time interval, the observed dynamics being limited by the width of the X-ray probing pulse (here ˜10 ps). By comparison to the demagnetization dynamics measured on Ni under similar conditions, we retrieve the lower limit of the demagnetization process that evolves on a sub-picosecond time scale. Hence, the AFM-FM phase transition in conjunction with time-resolved XMCD allow us to study at a microscopic level the elementary processes involved in the magnetization growth, demagnetization and re-magnetization phenomena.

MA 26.16 Thu 18:30 EB 301

First-principles study of ultrafast magneto-optical swithing in nickel oxide: Phononic contributions. — •Georgios Lefkidis and Wolfgang Hübner — Dept. of Physics, Kaiserslautern University of Technology, Box 3049, 67653 Kaiserslautern, Germany.

NiO is a good candidate for ultrafast magnetic swiching because of its large spin density, antiferromagnetic order, and clearly separated intragap states. In order to detect and monitor the switching dynamics, we develop a systematic approach to study optical second harmonic generation in NiO, both at the (001) surface and in the bulk [1-2].

We model NiO as a doubly embedded cluster and obtain all intragap *d*-states of the bulk and the (001) surface with highly correlational quantum chemistry. Then we propagated the states in time under the influence of a static magnetic field and a laser pulse. Switching can be best achieved with linearly polarized light. We also show the importance of including an external magnetic field in order to distinguish spin-up and spin-down states and the necessity of including magnetic-dipole transitions in order to realize the Λ-process in the centrosymmetric bulk [3]. Having already shown the effects of phonons in SHG for the bulk within the frozen phonon approximation [4], we discuss their role as a symmetry-lowering mechanism in the switching scenario and investigate the electronic and lattice temperature effects.

[1] R. Gómez-Abal *et al.*, PRL **92**, 227402 (2004)
[2] G. Lefkidis and W. Hübner, PRL **95**, 077401 (2005)
[3] G. Lefkidis and W. Hübner, PRB **76**, 014418 (2007)
[4] G. Lefkidis and W. Hübner, PRB **74**, 155106 (2006)

MA 27: Bio- and Molecular Magnetism

Time: Thursday 14:30–18:00 Location: EB 202

MA 27.1 Thu 14:30 EB 202

Can large magnetic anisotropy and high spin really coexist? — Eliseo Ruiz[1], Jordi Cirera[1], Joan Cano[1,2], Santiago Alvarez[1], •Claudia Loose[3], and Jens Kortus[3] — [1]Departament de Quimica Inorgánica and Institut de Recerca de Quimica Teórica i Computacional, Universitat de Barcelona, Diagonal 647,08028 Barcelona, Spain — [2]Institució Catalana de Recera i Estudis Avancats, Spain — [3]Institut für Theoretische Physik, TU Bergakademie Freiberg, Leipziger Str. 23, D-09599 Freiberg, Germany

This theoretical study discusses the interplay of the magnetic anisotropy and magnetic exchange interaction of two Mn_6 complexes. Our results for two polynuclear Mn_6 complexes show a very strong dependence of the D value on the spin of the ground state while the energy barriers are practically constant. Thus, complex 2 with a large spin (S = 12) favoured by ferromagnetic interactions has a small D value, while the lower spin complex 1 (S = 4) has a large D value. Therefor we suggest, that a large magnetic anisotropy is not favoured by a high spin state of the ground state.

MA 27.2 Thu 14:45 EB 202

Inelastic neutron scattering on an antiferromagnetic tetrahedral Ni_4 molecule — •Joscha Nehrkorn[1], Oliver Waldmann[1], and Hannu Mutka[2] — [1]Physikalisches Institut, Universität Freiburg, D-79104 Freiburg, Germany — [2]Institut Laue Langevin, BP 156-38042, Grenoble Cedex 9, France

We study the magnetic excitations in a tetrahedral Ni_4 molecule by inelastic neutron scattering (INS). The Ni_4 cluster consists of four antiferromagnetically coupled spin-1 Ni^{2+} ions in an almost perfect tetrahedral arrangement. The antiferromagnetic Heisenberg coupling should lead to a $S = 0$ ground state with higher-lying $S = 1$ and $S = 2$ levels. In our INS measurements we see peaks at transition energies in accord with the Heisenberg spectrum, but which violate the INS selection rule $\Delta S = 0, \pm 1$. That is, we observe not only the peaks which would correspond to the $S = 0 \rightarrow S = 1$ and $S = 1 \rightarrow S = 2$ transitions, but also a peak which would have to be assigned as a $S = 0 \rightarrow S = 2$ transition. However, Ni^{2+} ions are known to exhibit single-ion anisotropies as large as several 10 K, which hence, apparently, should not be neglected. Therefore, the effects of a single-ion anisotropy in a tetrahedral symmetry on the INS spectrum is explored by exact numerical calculations.

MA 27.3 Thu 15:00 EB 202

Multiple nearest-neighbor exchange constants in the frustrated magnetic molecules $\{Mo_{72}Fe_{30}\}$ and $\{Mo_{72}Cr_{30}\}$ — •Christian Schröder[1,2], Ruslan Prozarov[2], Hiroyuki Nojiri[3], and Marshall Luban[2] — [1]University of Applied Sciences, Bielefeld, Germany — [2]Ames Laboratory & Iowa State University, Ames, Iowa, USA — [3]Tohoku University, Sendai, Japan

Our measurements of the differential susceptibility $\partial M/\partial H$ of the frustrated Keplerate magnetic molecules $\{Mo_{72}Fe_{30}\}$ and $\{Mo_{72}Cr_{30}\}$ reveal a pronounced dependence on magnetic field (H) and temperature (T) in the low H – low T regime, contrary to the predictions of existing models. Excellent agreement with experiment is achieved upon formulating a nearest-neighbor classical Heisenberg model where the 60 nearest-neighbor exchange interactions in each molecule, rather than being identical as has been assumed heretofore, are described by a two-parameter probability distribution of values of the exchange constant. We suggest that the probability distribution provides a convenient theoretical platform for summarizing the combined effects of multiple microscopic mechanisms that disrupt the idealized picture of a Heisenberg model based on a single value of the nearest-neighbor exchange constant.

MA 27.4 Thu 15:15 EB 202

Pulsed W-Band ESR studies on Cr_7Ni — •Christoph Schlegel[1], Joris van Slageren[1,2], Hans-Jürgen Kümmerer[3], Gert Denninger[3], Richard E. P. Winpenny[4], and Martin Dressel[1] — [1]1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]School of Chemistry, University of Nottingham, Nottingham NG7 2RD, United Kingdom — [3]2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [4]Department of Chemistry, University of Manchester, Oxford Road, Manchester, M13 9PL, United Kingdom

For quantum information processing sufficiently long coherence times of the employed system are necessary. Molecular magnets are potential systems for the realization of quantum bits. Both spin-lattice and spin-spin relaxation times of $Cr_7NiF_8Piv_16$ were measured with a pulsed W-Band spectrometer. The measurements were performed on diluted frozen solutions, because in Cr_7Ni crystals dipolar interactions lead to very short coherence times. At 5 K and a concentration of 0.2 mg/ml, T_1 was determined to be 2300 ns, while T_2 was measured to be 357 ns, which is comparable to literature values. [1] To improve the coherence times, it is necessary to understand the decoherence mechanism. One of the decoherence pathways is through coupling with the nuclear spins. With pulsed ENDOR the hyperfine coupling of the electron spin to the nuclear spin of the protons could be quantified to -0.8 MHz in a 1 mg/ml solution. Surprisingly, no coupling to the nuclear spin of fluorine could be found.
[1] A. Ardavan et al., Phys. Rev. Lett. **98**, 057201 (2007)

MA 27.5 Thu 15:30 EB 202

High-frequency ESR and frequency domain magnetic resonance spectroscopic studies of single molecule magnets in frozen solution — •Fadi El Hallak[1], Joris van Slageren[1], Martin Dressel[1], Jordi Gómez-Segura[2], and Daniel Ruiz-Molina[2] — [1]1.Physikalsiches Institut, Universität Stuttgart, Stuttgart, Germany — [2]Institut de Ciència de Materials de Barcelona, Bellaterra, Spain

Frozen solutions of the single molecule magnet Mn12-Pivalate (or trimethylacetate) are studied by magnetization and magnetic resonance investigations. AC magnetic susceptibility measurements show that the system is stable in solution. Interestingly, the barrier and prefactor for the thermally activated magnetization relaxation are the same as in the solid state. This means that this system is not influenced by its surroundings,in contrast to other Mn12 derivatives. The zero-field-splitting spin Hamiltonian parameters of Mn12Piv in solution are determined by magnetic resonance spectroscopy methods to be very similar to those in the solid state. By these methods, it is also possible to distinguish between truly dissolved and precipitated species, which is not possible by magnetization measurements.

MA 27.6 Thu 15:45 EB 202

Electronic Spin Dynamics and Static Order in Coupled Magnetic Keplerates $Fe_{30}Mo_{72}$ — •F.J. Litterst[1], H.-H. Klauss[1,2], T. Dellman[1,2], J. Schnack[3], R. Klingeler[4], and A. Müller[5] — [1]IPKM, TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig — [2]IFP, TU Dresden, Zellesche Weg 16, 01069 Dresden — [3]Fakultät für Physik, Univ. Bielefeld, 33501 Bielefeld — [4]IFW-Dresden, Helmholtzstr. 20, 01171 Dresden — [5]Anorganische Chemie I, Univ. Bielefeld, 33501 Bielefeld

In the polyoxomolybdate nanomolecule $Fe_{30}Mo_{72}$ 30 S=5/2 FeIII ions are located on the vertices of an icosidodecahedron coupled via nearest-neighbor antiferromagnetic interactions J [1]. In the paramagnetic molecules the electronic ground state and excitations are governed by the strong magnetic frustration on the Kagomé-like surface [2]. A modified system with much stronger inter-molecular exchange interaction [3] shows several anomalies in the magnetic susceptibility below 5 K.

We performed ^{57}Fe-Mössbauer spectroscopy on the isolated and magnetically interacting molecules. Around 4.45 K (broad maximum in $\chi(T)$) dynamic magnetic hyperfine spectra with magnetically inequivalent sites appear. Around 2.45 K a drop in $\chi(T)$ is accompanied by a slowing down of hyperfine dynamics and indicates antiferromagnetic order.

[1] A. Müller et al., Angew. Chem. Int. Ed. Engl. 38 (1999) 3238. [2] V.O. Garlea et al., Phys. Rev. B 73 (2006) 024414. [3] A. Müller

et al., Angew. Chem. Int. Ed. Engl. 39 (2000) 1612.

MA 27.7 Thu 16:00 EB 202

Broadband electron paramagnetic resonance of single-molecule magnets at millikelvin temperatures. — •Konstantin Petukhov[1], Klaus Gieb[1], Thorsten Glaser[2], Wolfgang Hansen[3], and Paul Müller[1] — [1]Institut für Physik der Kondensierten Materie, Universität Erlangen-Nürnberg — [2]Lehrstuhl für Anorganische Chemie I, Universität Bielefeld — [3]Institut für Angewandte Physik, Universität Hamburg

We present a technique which combines Hall-bar magnetometry of single-molecule magnets (SMMs) with broadband microwave absorption measurements. This electron paramagnetic resonance-like spectroscopy can be performed at millikelvin temperatures and enables the use of short-pulsed microwave radiation. Thus, the spin dynamics of SMMs can be studied. We present measurements on novel Mn_6Mn and Mn_6Cr single-molecule magnets.

MA 27.8 Thu 16:15 EB 202

Spin-dynamics of ferric wheels in high magnetic fields — •Lars Schnelzer and Bernd Pilawa — Physikalisches Institut, Universität Karlsruhe (TH), D-76131 Karlsruhe

The dynamic properties of the antiferromagnetic cyclic hexanuclear iron(III) complexes $^{23}Na/^{7}Li@Fe_6(tea)_6$ have been studied by means of nuclear magnetic resonance. We analyzed the longitudinal relaxation rate T_1^{-1} of the central alkali ions ^{23}Na and ^{7}Li in the magnetic field range up to 20 T at a temperature of 2 K. The T_1^{-1} measurements reveal the influence of the levelcrossing between the S=0 and S=1 states by an enhanced relaxation rate, as well as a strong decrease of the relaxation rate at characteristic fields between level crossings. In comparison with the calculated fluctuation spectrum of the electronic spins this suppression of the T_1-rate indicates an extremely reduced line width of the electronic resonance around ω=0 (the so called ω_0-resonance).

MA 27.9 Thu 16:30 EB 202

Coordination geometry induced changes on magnetic parameters of Cu(II) complexes — •Björn Bräuer[1], Tobias Rüffer[1], Dante Gatteschi[2], Maria Fittipaldi[2], Andrea Caneschi[2], Florian Weigend[3], and Georgeta Salvan[1] — [1]Chemnitz University of Technology, Department of Physics, Reichenhainer Straße 70, D-09126 Chemnitz — [2]University of Florence, Department of Chemistry, Via della Lastruccia 3, I-50019 Florence — [3]Forschungszentrum Karlsruhe, Institute for Nanotechnology, Postfach 3640, D-76021 Karlsruhe

Cu(II)-bis(oxamato) complexes are prominent representatives for basic research studies of magnetic exchange phenomena [1]. We have used Electron Paramagnetic Resonance (EPR) spectroscopy to study the dependence of the hyperfine coupling constants A and the spin density distribution on the structural parameters of mono-nuclear complexes. Furthermore, the influence of such variations on the super exchange coupling parameter J of the respective tri-nuclear complexes was investigated. It was shown that deviations from the square planar coordination geometry decrease the delocalisation of spins leading to a smaller J value, i. e. a smaller antiferromagnetic interaction. The obtained parameters were also calculated by means of Density Functional Theory (DFT). The J parameters were determined using the broken symmetry approach and the influence of packing effects, counter ions, and bridging ligands were investigated. The COnductor like Screening Field MOdel (COSMO) was found to be a suitable model for reliable predictions of experimental trends. [1] O. Kahn, Molecular Magnetism, VCH Weinheim, 1993.

MA 27.10 Thu 16:45 EB 202

Enhanced magnetocaloric effect in frustrated magnetic molecules with icosahedral symmetry — •Jürgen Schnack[1] and Johannes Richter[2] — [1]Universität Bielefeld, Fakultät für Physik, PF 100131, D-33501 Bielefeld — [2]Universität Magdeburg, Institut für Theoretische Physik, PF 4120, D-39016 Magdeburg

We investigate the magnetocaloric properties of certain antiferromagnetic spin systems that have already been or very likely can be synthesized as magnetic molecules. It turns out that the special geometric frustration which is present in antiferromagnets that consist of corner-sharing triangles leads to an enhanced magnetocaloric effect with high cooling rates in the vicinity of the saturation field. These findings are compared with the behavior of a simple unfrustrated spin ring as well as with the properties of the icosahedron. To our surprise, also for the icosahedron large cooling rates can be achieved but due to a different kind of geometric frustration. [J. Schnack, R. Schmidt, J. Richter, Phys. Rev. B **76** (2007) 054413]

MA 27.11 Thu 17:00 EB 202

Electronic structure of phthalocyanines — •Predrag Lazic, Nicolae Atodiresei, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich, Germany

The coupling between the π-delocalized electrons of the phthalocyanine with the *d*-localized electrons of a metal yields to a class of organometallic molecules with interesting physical properties. We have performed the *ab-initio* calculations on the gas phase of metal-phthalocyanine molecules as well as their adsorption on a Cu(111) surface precovered with a monolayer of sodium chloride. In order to describe accurately the molecule-substrate interaction we have used the seamless approach to include the long range correlation effects (i.e. van der Waals interaction) which are not properly described in the present DFT codes using LDA or GGA exchange-correlation functionals.

MA 27.12 Thu 17:15 EB 202

Approximate spectra for magnetic molecules with sublattice structure — •Roman Schnalle[1] and Jürgen Schnack[2] — [1]Universität Osnabrück, Fachbereich Physik, D-49069 Osnabrück — [2]Universität Bielefeld, Fakultät für Physik, PF 100131, D-33501 Bielefeld

A lot of interesting magnetic molecules cannot be treated with numerically exact diagonalization routines because of the huge dimensions of the Hilbert spaces. Therefore approximate numerical techniques are highly desirable to obtain information about the energy spectra of the investigated systems. In a recent work we developed a perturbation theory that is guided by an approximate Hamiltonian for spin systems with sublattice structure, the rotational band Hamiltonian [1]. Within this perturbative approach an increasing number of states is taken into account. These states are chosen to be those with low-lying energies in the spectrum of the rotational band Hamiltonian [2].

[1] J. Schnack, M. Luban, Phys. Rev. B **63**, 014418 (2000)
[2] O. Waldmann, Phys. Rev. B **75**, 012415 (2007)

MA 27.13 Thu 17:30 EB 202

Electronic and Magnetic Properties of Mn_{12} Single-Molecule Magnets on the Au(111) Surface — •Sönke Voss[1], Michael Burgert[1], Mikhail Fonin[1], Christian Michaelis[2], Ivan Brihuega[2], Yury S. Dedkov[3], Ulrich Groth[1], Klaus Kern[2], and Ulrich Rüdiger[1] — [1]Universität Konstanz, 78457 Konstanz — [2]Max-Planck-Institut für Festkörperforschung, 70569 Stuttgart — [3]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden

The paramount interest in single-molecule magnets (SMMs) like Mn_{12}-acetate and its derivatives was inspired by numerous experimental and theoretical insights indicating the feasibility of addressing quantum effects of magnetism on a molecular scale. Due to its relatively high blocking temperature (∼3K) combined with the ability to identify well-defined spin states, Mn_{12} still remains the most favoured SMM possibly allowing the detection of magnetic fingerprints in transport properties of a single molecule.

In this work, the electronic properties of Mn_{12} molecules chemically grafted on Au(111) surfaces have been studied by means of low temperature as well as room temperature scanning tunneling microscopy and spectroscopy (STS), x-ray absorption spectroscopy and photoelectron spectroscopy. The results revealed signatures from most probably intact Mn_{12} molecules while STS measurements in magnetic fields indicate the possibility to identify magnetic fingerprints in scanning tunneling spectra. The results will be discussed with respect to previous attempts to perform transport measurements on Mn_{12} SMMs.

MA 27.14 Thu 17:45 EB 202

Fe-porphyrin monolayers on ferromagnetic substrates: Electronic structure and magnetic coupling strength — •Matthias Bernien[1], Xiaoying Xu[1], Jorge Miguel[1], Marten Piantek[1], Philipp Eckhold[1], Jun Luo[1], Julia Kurde[1], Klaus Baberschke[1], Wolfgang Kuch[1], Heiko Wende[2], and Pankaj Srivastava[2] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany — [2]Fachbereich Physik, Experimentalphysik - AG Wende, Universität Duisburg-Essen, Lotharstrasse 1, D-47048 Duisburg, Germany

Paramagnetic Fe-porphyrin molecules are promising candidates for applications in molecular nano-electronics. A fundamental understanding of the interaction of these molecules with ferromagnetic substrates is essential to realize future functional devices. Here we present systematic x-ray absorption and x-ray magnetic circular dichroism (XMCD) studies on octaethylporphyrin-Fe(III) chloride molecules sublimated onto epitaxially grown Ni and Co films on Cu(100). The fine structures observed in the absorption and dichroic spectra of the Fe-$L_{2,3}$ edges are explained in terms of different Fe 3*d* orbitals probed in angular-dependent measurements. The coverage of Fe-porphyrin molecules is varied from submonolayer to 1.5 monolayer, and measurements were carried out at room as well as at low temperatures. From the temperature dependence of the Fe-XMCD signal, a weaker coupling strength between the Fe atom and the Ni substrate is found as compared to the Co case.

MA 28: Magnetic Thin Films III

Time: Thursday 14:30–17:30 Location: H 1012

MA 28.1 Thu 14:30 H 1012

Structural and magnetic properties Nickel/rubrene(peroxide) bilayers — •Wen Li[1], Felix Springer[2], Manfred Albrecht[1], Dietrich R.T. Zahn[1], and Georgeta Salvan[1] — [1]Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]University of Konstanz, Department of Physics,D-78457 Konstanz,Germany

Bilayers of nickel/rubrene were obtained by sequential deposition of rubrene and Ni onto Si(111) substrate under ultra-high vacuum conditions. Ex situ AFM studies show that the growth mode of Ni is significantly influenced by the thickness of the underlying rubrene layer. When deposited onto a 14nm rubrene layer Ni forms large islands, hundreds of nanometers in lateral dimension, with large voids between them. On thicker rubrene layers the Ni islands are much smaller forming an almost continuous film.

The hysteresis curves recorded ex situ by magneto-optical Kerr effect (MOKE) measurements in polar geometry show that the magnetic properties change according to the different growth modes. The hysteresis behavior of Ni(7nm)/rubrene peroxide(14nm) shows a combination of ferromagnetic and superparamagnetic behaviour. When the thickness of the rubrene underlayer increases the system behaves ferromagnetically.

The spectroscopic MOKE measurements show that the signal intensity and the energetic position of the spectral features are strongly influenced by the rubrene thickness. Compared to the single Ni(7nm) layer deposited on Si, the MOKE signal of bilayers can be enhanced by about a factor of three.

MA 28.2 Thu 14:45 H 1012

An ab-initio description of the magnetic shape anisotropy — •Sven Bornemann and Hubert Ebert — Department Chemie und Biochemie, LMU München, Germany

For magnetic transition metal systems with reduced dimensionality and low symmetry the shape anisotropy becomes a significant contribution to the magnetic anisotropy. In fact, it can reach the same order of magnitude as the spin-orbit induced anisotropy. So far, the shape anisotropy has been always treated as a classical interaction between magnetic dipoles while the spin-orbit anisotropy has been determined by relativistic band structure calculations. It is uncertain, however, whether such an inconsistent treatment of the two anisotropy contributions is still valid for low dimensional nano structures such as magnetic thin films, wires or clusters where the magnetic easy axis can depend strongly on the interplay between these two contributions.

As an alternative to the standard approach an ab-initio description of the shape anisotropy has been developed. This is achived by including the Breit interaction, which is the natural cause of the shape anisotropy, in the Dirac-equation set up within the framework of spin density functional theory. We have implemented this approach using the fully relativistic KKR band structure scheme. We will present the details of our implementation and show first results for the shape anisotropy of thin films in comparison with the classical treatment.

MA 28.3 Thu 15:00 H 1012

Magnetism of 3*d*-transition metals on Rh(100) — •Ali Al-Zubi, Gustav Bihlmayer, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

Motivated by recent publications [1,2] reporting on unexpected magnetic properties of ultrathin magnetic films on 4*d* and 5*d* metal substrates, we employ DFT in conjunction with the full-potential linearized augmented plane wave (FLAPW) method implemented in the `FLEUR` code to study systematically the magnetic properties of the 3*d* transition-metal (V, Cr, Mn, Fe, Co and Ni) monolayers on the Rh(100) surface. Including relaxations, we predict a ferromagnetic (FM) ground state for V, Co and Ni, while Cr, Mn and Fe favor the $c(2\times2)$ antiferromagnetic (AFM) state. The unexpected $c(2\times2)$ AFM for Fe encouraged more detailed investigations of this system such as e.g. the row-wise AFM $p(1\times2)$ order. The role of the hybridization between the monolayers and the Rh substrate is analyzed by comparing the results to those of 3*d* monolayers on Ag(100) and Pd(100).

[1] P. Ferriani *et al.*, Phys. Rev. Lett. **99**, 187203 ('07)
[2] P. Ferriani *et al.*, Phys. Rev. B **72**, 024452 ('05)

MA 28.4 Thu 15:15 H 1012

Iron and its native oxide: From chemical structure to magnetic ordering — •Sebastien Couet[1], Kai Schlage[1], Karel Saksl[2], and Ralf Röhslberger[1] — [1]Hamburger Synchrotron Strahlungslabor (HASYLAB) at Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg — [2]IMR, Slovak Academy of Sciences Watsonova, 4704353 Kosice, Slovak republic

It has been demonstrated recently that a strong non collinear magnetic coupling appears between metallic iron layers separated by nanolayer of native iron oxide[1]. Although the microscopic coupling mechanism is not fully understood, theoretical models suggest that it is due to an antiferromagnetic (AFM) order of the oxide layer. As the different oxide phases of iron appear in different magnetic states, it is crucial to resolve the chemical structure of the native oxide to understand the underlying magnetic properties. We therefore investigated the oxidation process in-situ by X-ray absorption spectroscopy. This technique allows us to get quantitative information about the chemistry and the local order in the layer. The study shows that the native oxide at saturation is composed of a mixture of iron oxide phases with a predominance of Fe^{3+} iron species. Upon coverage by a thin iron layer, the oxide is completely reduced and only an FeO like phase remains. This quantitative study shows that it is possible to control the thickness and structure of those native oxide and open the possibility to tailor the magnetic coupling of the system.

[1] Th. Diederich, S. Couet, R. Röhlsberger, Phys. Rev. B **76**, 54401 (2007).

MA 28.5 Thu 15:30 H 1012

Investigation of ferromagnetism in oxygen deficient Hafnium oxide thin films — •Erwin Hildebrandt[1], Jose Kurian[1], Yoshiharu Krockenberger[1], Andreas Suter[2], Fabrice Wilhelm[3], Andrei Rogalev[3], and Lambert Alff[1] — [1]Institut für Materialwissenschaft, TU Darmstadt — [2]PSI, Villingen, Schweiz — [3]ESRF, Grenoble, Frankreich

Oxygen deficient thin films of hafnium oxide were grown on single crystal *r*-cut and *c*-cut sapphire by reactive molecular beam epitaxy. RF-activated oxygen was used for the in situ oxidation of hafnium oxide thin films. Oxidation conditions were varied substantially in order to create oxygen deficiency in hafnium oxide films intentionally. The films were characterized by x-ray and magnetic measurements. X-ray diffraction studies show an increase in lattice parameter with increasing oxygen deficiency. Oxygen deficient hafnium oxide thin films also showed a decreasing bandgap with increase in oxygen deficiency. The magnetisation studies carried out with SQUID did not show any sign of ferromagnetism in the whole oxygen deficiency range. X-ray magnetic circular dichroism measurements also confirmed the absence of ferromagnetism in oxygen deficient hafnium oxide thin films.

MA 28.6 Thu 15:45 H 1012

Preparation and magnetization reversal of exchange bias structured thin films — •Christine Hamann, Jeffrey McCord,

Ingolf Mönch, Rainer Kaltofen, Thomas Gemming, Rudolf Schäfer, and Ludwig Schultz — Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstr. 20, 01069 Dresden

Magnetically patterned thin films of NiFe/IrMn/Ta − NiFe/$IrMnO_x$ with laterally modulated unidirectional anisotropy were prepared by local oxidation of the antiferromagnetic IrMn layer. Varying the lateral dimensions and orientation with respect to the anisotropy modulation, the films exhibit different magnetization reversal behaviors. While stripes aligned parallel to the unidirectional anisotropy direction display a spin valve-like two step hysteresis loop, perpendicular orientation lead to a single step shifted hysteresis loop. Magnetic domain observation reveals separate switching of the stripes for the parallel alignment and simultaneous reversal for the perpendicular orientation. By decreasing the lateral dimensions, quasi-domain states have been observed. The presented magnetic data of the exchange biased-pattered films show that we did succeed in creating an alternative method for the preparation of materials with new hybrid properties.

MA 28.7 Thu 16:00 H 1012

Thermal stability of GMR stack systems: Parameter variation of the artificial antiferromagnet — •Matthias Hawraneck[1,2], Wolfgang Raberg[1], Jürgen Zimmer[1], Klemens Prügl[1], Thomas Bever[1], and Lambert Alff[2] — [1]Infineon Technologies AG, Am Campeon 1-12, 85579 Neubiberg — [2]Institut für Materialwissenschaft, TU Darmstadt, Petersenstr. 23, 64287 Darmstadt

After the discovery of the GMR effect in 1988 by Peter Grünberg and Albert Fert, this effect has gained a huge interest, because of its application potential. A very important attribute of GMR stacks system used in applications, e.g. read heads or automotive sensors, is their thermal stability, due to the lifetime and the temperature profiles in these applications. In high volume production of thin layers, like in GMR stacks, a certain variation of the thicknesses and the compositions of different layers have to be anticipated. Besides the resulting differences in performance, the influence of these variations on the stability is very important. Therefore we focus in our studies on the influence of process variations of the artificial antiferromagnet on the thermal stability.

MA 28.8 Thu 16:15 H 1012

AMR-induced microwave photoresistance and photovoltage in ferromagnetic films — •Nikolai Mecking[1,2], Yongsheng Gui[1], and Can-Ming Hu[1] — [1]Dep. of Physics, University of Manitoba, Winnipeg, Canada — [2]IAP, Uni Hamburg, Jungiusstr. 11, 20355 Hamburg

We have investigated the microwave photoresistance (PR) and photovoltage (PV) of photolithographically stripe shaped ferromagnetic $Ni_{80}Fe_{20}$-films [1-3]. Along these we find maximal AMR with parallel magnetization M and minimal AMR with perpendicular M. However, excited to precess M shifts and the AMR decreases in the parallel case (negative PR) and increases in the perpendicular case (positive PR) [1]. Additionally M precession causes an AMR oscillation that partially rectifies the microwave current I (PV). M can be excited through FMR [1], standing exchange spin waves [2] or magnetostatic modes [3]. These are very sensitively detected during magnetic field sweeps and show a linear combination of dispersive and Lorentz line shape whose ratio is determined by the phase difference between M and I [1]. So, while the PR shows only Lorentz line shape, the PV gives us an insight into the phase of M. Moreover, due to the ferromagnetic susceptibility anisotropy we can distinguish the PV portions arising from the different spatial components of the exciting microwave magnetic field and resolve their phase [1] what is interesting for magnetic field sensing. We acknowledge support from BMBF 01BM461, SFB 508 and the DAAD.

[1] N. Mecking, Y.S. Gui, and C.-M. Hu, ArXiv/cond-mat 0710.1974.
[2] Y.S. Gui, N. Mecking *et al.*, PRL **98**, 107602 (2007).
[3] Y.S. Gui, N. Mecking, and C.-M. Hu, PRL **98**, 217603 (2007).

MA 28.9 Thu 16:30 H 1012

Transition from TMR to AMR in ultrathin magnetic films — •Alexander von Schmidsfeld, Stephen Krzyk, Mathias Kläui, and Ulrich Rüdiger — Fachbereich Physik, Universität Konstanz, 78457 Konstanz

We report on the transition from tunneling magnetoresistance (TMR) to anisotropic magnetoresistance (AMR) in ultrathin magnetic films grown on insulating substrates at low temperature. In situ magnetotransport measurements were carried out in a UHV MBE chamber during film growth. The magnetotransport characteristics changed from a TMR regime towards AMR with increasing film thickness. This transition occurs at thicknesses of several monolayers, indicating island growth. By further increasing the fim thickness above 10 ML, AMR dominates, indicating a transition from islands to a continuous film. This transition zone around the percolation threshold was investigated with high thickness resolution for different materials.

MA 28.10 Thu 16:45 H 1012

A new magnetic octupole setup for in situ investigations on magnetic nanostructures — •Norman Wilken, Stefan Polei, Nagamony Ponpandian, Armin Kleibert, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Magnetic clusters and nanostructures are highly interesting candidates for many applications as ,e.g., magnetic mass storage devices. Thus, strong efforts have been undertaken in the past in order to prepare and study the properties of nanosized magnets. In particular techniques based on magneto-optics in the visible as well as in the soft x-ray regime [for instance the resonant x-ray magnetic circular dichroism (XMCD)] have been successfully applied in many investigations, see e.g. Ref.1. In this contribution we will present a new experimental setup enabling for sophisticated studies on magnetic nanostructures. The main part of the setup is a magnetic octupole consisting of eight resistive magnets, equally spaced on the corners of a cube. This configuration provides an omnidirectional field vector with a magnitude of up to 1 Tesla. A sample preparation chamber as well as the arc cluster ion source (ACIS) being attached to the magnet chamber allow for full in situ preparation and investigation on a broad variety of magnetic nanostructures [2]. Recent experiments on magnetic thin film samples carried out at BESSY reveal the capabilities for transmission, reflection and absorption experiments in the soft x-ray regime.

[1] J. Bansmann et al., Surf. Sci. Reports **56**, 189 (2005)
[2] A. Kleibert et al., J. Appl. Phys. **101**, 114318 (2007)

MA 28.11 Thu 17:00 H 1012

Scanning Tunneling Microscopy and Spectroscopy Measurements on a $(La_{1-0.375}Pr_{0.375})_{0.7}Ca_{0.3}MnO_3$ Thin Film — •Christin Kalkert, Lakshmana Sudheendra, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I.Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

One of the main goals of manganite physics is to reach an understanding of the metal-insulator transition and associated colossal magnetoresistance effect (CMR). Scanning tunneling microscopy (STM) and spectroscopy (STS) measurements may play an important role in explaining these phenomena since they resolve the spatial distribution and evolution of electronic states across the transition temperature.We have studied a $(La_{1-0.375}Pr_{0.375})_{0.7}Ca_{0.3}MnO_3$ thin film epitaxially grown by metalorganic aerosol deposition on MgO substrate. STS measurements show a homogeneous insulating behavior at room temperature and high resolution STM measurements lead to the assumption that we are dealing with a charge ordered state. STM and STS measurements at temperatures below T_C yield an electronically phase-separated state with an insulating state showing the same conductivity as the homogeneous high temperature state coexisting with a metallic state. Close to T_C we have also observed phase separation. Here we see the high temperature state but also a phase with an intermediate conductivity. This work is supported by DGF via SFB 602 TPA2 and the Leibniz program.

MA 28.12 Thu 17:15 H 1012

Skyrmion states in confined condensed matter systems with intrinsic or surface-induced chirality — •Andrei A. Leonov[1,2], Igor E. Dragunov[2], Christian Pfleiderer[3], Ulrich K. Rössler[1], and Alexei N. Bogdanov[1,2] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology — [3]Physik Department E21, TU München

Chiral interactions stabilize smooth "Skyrmion" textures in ordered condensed matter systems. Unconventional Skyrmion states may be observable in magnetic nanostructures, where the chiral Dzyaloshinskii-Moriya exchange arises owing to reduced dimensionality and modified electronic properties of surfaces [1]. Similar surface effects exist also in ferroelectric layers and in confined liquid crystals. We develop a phenomenological theory for modulated and localized states in films of noncentrosymmetric ferromagnets and chiral liquid crystals with strong surface anisotropy or anchoring. Skyrmions with convex shape exist as localized and topologically stable excitations in collinearly ordered states of such films. The solutions for these two-

dimensional "Baby-Skyrmions" are related to spherulitic domains in chiral nematic films. The theory describes Skyrmions with variable shapes. This variety is determined by the nature of the chiral coupling, which may arise due to broken inversion symmetry at surfaces or noncentrosymmetric crystal structures as in the chiral magnet MnSi [2].

[1] C. Pfleiderer, U.K. Rößler, Nature 447 (2007) 157; [2] U.K. Rößler, A. N. Bogdanov, C. Pfleiderer, Nature 442 (2006) 797.

MA 29: Spin Structures / Magnetic Phase Transitions

Time: Thursday 17:45–19:00 Location: H 1012

MA 29.1 Thu 17:45 H 1012

XAFS investigation of the light and thermally induced low-spin to high-spin transition in metallo-supramolecular assemblies — •Bahia Arezki[1], Yves Bodenthin[2], Ronald Frahm[3], Ralph Wagner[3], Dirk Lützenkirchen-Hechta[3], and Ullrich Pietsch[1] — [1]Fachbereich 7- Physik- Universität Siegen, Walter-Flex-Straße 3, 57072 Siegen, Germany — [2]) Paul Scherrer Institut, CH-5232 Villigen, Switzerland — [3]Fachbereich C - Physik, Bergische Universität Wuppertal, Gaußstr. 20, 42097 Wuppertal, Germany

We have investigated the structural changes associated with the low spin to high spin transition (ST) of Metallo-supramolecular polyelectrolyte-amphiphile-complexes (PAC) induced by temperature and light. For this purpose, X-ray absorption near the edge (XANES)has been used to probe the structural changes in the local FeN6 octahedra, before and after a temperature induced ST. The PACs contain 2 (PAC6E16_12) and 6 (PAC6E16_16) amphiphiles per metal ion and are composed by Fe and Ni ions in order to identify any structural changes solely induced by the magnetic process. Our results clearly show changes in the profiles of both spin states indicating a structural modification during the ST. In next experiment, we will investigate if the same structural changes can be induced by light (LIESST-Light-Induced-Excited-Spin-State-Trapping). In case of success, this experiment, will be the first proof of LIESST in a metallo-polyelectrolyte embedded into an amphiphilic matrix. It will answer the question how the coordination shell of the Fe2+ ions looks after light irradiation.

MA 29.2 Thu 18:00 H 1012

Magnetic Structure of $GdMnO_3$ — •Anne Möchel[1], Jörg Voigt[1], Martin Meven[2], Jong-Woo Kim[3], and Thomas Brückel[1] — [1]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Technische Universität München, ZWE FRM II, 85748 Garching, Germany — [3]Ames Laboratory, Ames, Iowa 50011, USA

We present the results of a combined neutron diffraction and X-ray resonance exchange scattering study of a $GdMnO_3$ single crystal carried out in order to clarify the magnetic structure. Below the Néel-Temperature T_N=41.6K, we find an incommensurate structure with a spin polarisation aligned parallel to the c-direction. At low temperatures (T≈15K) we have a step-like change of the propagation vector τ to an near commensurate τ=0.245 associated with a strong increase in intensity.
The onset of magnetic order is reflected by a λ anomaly in the specific heat, which shows no anomaly at 15K, where the propagation vector shows the sudden change. The magnetic susceptibility reveals a reduced paramagnetic effective moment as compared to the moments expected for free Gd^{3+} and Mn^{3+}. A possible model for the magnetic structure is proposed based on the above observations.

MA 29.3 Thu 18:15 H 1012

Direct Experimental Observation of Fermi-Surface Nesting in Tb and Dy Metal — •Kristian Döbrich[1], Aaron Bostwick[2], Kai Rossnagel[2], Jessica McChesney[2], Eli Rotenberg[2], and Günter Kaindl[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Germany — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, UC Berkeley, USA

Some of the lanthanide metals develop antiferromagnetic phases with a helical arrangement of the localized $4f$ electron spins. The magnetic coupling is mediated by the valence electrons (RKKY interaction). The commonly accepted nesting hypothesis links the formation of helical ordering to the existence of parallel sheets of the Fermi surfaces (FS), the so-called FS nesting. For Y and Y-Gd alloys, FS nesting was observed with positron annihilation. However, for a pure lanthanide metal, nesting had not been observed prior to this work.

Angle-resolved photoemission as performed at beamline 7.0.1 of the Advanced Light Source, Lawrence Berkeley National Laboratory, USA, gives access to the occupied part of the electronic structure over a wide region of momentum space, covering several Brillouin zones. We studied Gd metal that orders ferromagnetically as well as the two metals Tb and Dy, which exhibit helically-ordered antiferromagnetic phases. The photoemission data on Gd presented here confirm the absence of FS nesting in this metal, while our data on Tb and Dy give clear evidence of FS nesting in these two metals. The present results therefore provide strong support for the correctness of the nesting hypothesis.

This work was supported by the DFG project No. STA 413/3-1.

MA 29.4 Thu 18:30 H 1012

Quantum Phase Transition of a Magnet in a Spin-bath — •Conradin Kraemer[1,2], Henrik M. Ronnow[1], Joel Mesot[2], Peter Link[3], Astrid Schneidewind[4], Tobias Unruh[3], Thomas F. Rosenbaum[5], Gabriel Aeppli[6], and Jens Jensen[7] — [1]Laboratory for Quantum Magnetism EPFL, CH-1015 Lausanne — [2]Laboratory for Neutron Scattering ETHZ PSI, CH-5232 Villigen — [3]Forschungsneutronenquelle FRM II, D-85747 Garching — [4]Institut für Festkoerperphysik, TU Dresden, D-01062 Dresden — [5]Department of Physics, University of Chicago, Chicago, IL 60637 — [6]London Centre for Nanotechnology, UCL, London WC1E 6BT — [7]Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen

As a physical realisation of the ferromagnetic Ising model with a quantum phase transition in a transverse field of 5T, $LiHoF_4$ is a widely celebrated model system with a thoroughly characterized Hamiltonian. However, the innocently weak hyperfine coupling to the nuclear spins dramatically influence the quantum critical point. Below 600 mK the critical field is extended slightly upwards. More spectacularly, is softening of the principal electronic excitation - the hall mark of a quantum phase transition - forestalled by hybridization, which transfers true softening to the mixed nuclear electronic states at much lower energies. The electronic system thus remain sub-critical with finite quantum coherence. We report the counterintuitive observation that maximum electronic quantum criticality is achieved not as expected at T=0 K but rather at a finite intermediate temperature $0 < T < T_c$.

MA 29.5 Thu 18:45 H 1012

Antiferromagnet — ferromagnet transition in Fe islands on Cu(111) — •Timofey Balashov[1], Albert F. Takacs[1], Markus Däne[2], Arthur Ernst[2], Patrick Bruno[2], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Universität Karlsruhe, Wolfgang-Gaede Strasse 1, 76131 Karlsruhe, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

Fe is known for its martensitic phase transition between fcc and bcc configurations. Recently, it has been shown that 2ML Fe islands on Cu(111) show both configurations, an fcc core and a bcc outer rim [1]. We investigated the electronic structure of the Fe islands by scanning tunneling spectroscopy at 4K. By comparison to the local density of states obtained from ab-initio calculations, we were able to show that the core is antiferromagnetic while the rim of the island is ferromagnetic. Hand in hand with this phase change, Fe adopts different out of plane lattice constants as determined by topographic and spectroscopic STM investigations.

Most interestingly, we discovered that the Fe structure can be switched hysteretically between the two states by the presence of the STM tip. The transition occurs at nano Ampere currents and is also visible in topographical data, due to lattice transitions.

[1] A. Biedermann, W. Rupp, M. Schmid and P. Varga, Phys. Rev. B **73**, 165418 (2006)

MA 30: Electron Theory

Time: Thursday 14:30–18:30 Location: H 1028

MA 30.1 Thu 14:30 H 1028

Predicting the formation of long chains in break junctions — •Alexander Thiess[1,2], Yuriy Mokrousov[1], and Stefan Heinze[1] — [1]Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

We introduce a simple model of chain formation in break junctions by formulating separate criteria for the stability and producibility of suspended monoatomic chains based on total energy arguments. Using the full-potential linearized augmented plane wave method [1] within the density-functional theory, we apply our model to break junctions of 5*d* transition-metals (TMs) and Au including the effect of spin-orbit coupling. Thereby, we can explain the physical reason of the experimentally observed trend of increasing probability for the creation of long suspended chains in break junctions for 5*d*-TMs at the end of the series [2]. Moreover, we predict that the probability of chain elongation can be greatly enhanced by the presence of oxygen in experiments with Au and Ag. Our model also allows us to make predictions on the ballistic transport properties of suspended chains.

[1] Y. Mokrousov *et al.*, Phys. Rev. B **72**, 045402 (2005)
[2] R. H. M. Smit *et al.*, Phys. Rev. Lett. **96**, 266102 (2001)

MA 30.2 Thu 14:45 H 1028

Relativistic optimized potential method for open-shell systems — D Ködderitzsch[1], •H Ebert[1], and E Engel[2] — [1]Ludwig-Maximilians-Universität München, Department Chemie und Biochemie, Physikalische Chemie, Butenandtstraße 11, D-81377 München, Germany — [2]Institut für Theoretische Physik, J. W. Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, D-60438 Frankfurt/Main, Germany

A formulation of the relativistic optimized potential method (ROPM) within spin-density functional theory is presented.[1] Various forms of the corresponding ROPM equations are given that allow to determine the spin-averaged and spin-dependent exchange correlation potentials. For a implementation numerical of the scheme we use the exact exchange (EXX). Results are presented for a number of free atoms that demonstrate the implication of the fully relativistic approach as well as the impact of making use of the KLI (Krieger-Li-Iafarate) approximation.

[1] D. Ködderitzsch, H. Ebert, E. Engel, Phys. Rev. **B**, accepted

MA 30.3 Thu 15:00 H 1028

An improved s-d model for the dissipative domain wall dynamics — •Lorenzo De Angeli and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, 70569 Stuttgart, Germany

The dissipative dynamics of domain walls induced by an external magnetic field or by spin-polarized transport currents is often described within the framework of the s-d model [1]. Thereby the magnetization is subdivided into a localized part $\mathbf{M}_d(\mathbf{r},t)$ arising from the d electrons and a part $\mathbf{m}(\mathbf{r},t)$ due to the conduction s and p electrons, and the dynamics of $\mathbf{M}_d(\mathbf{r},t)$ is influenced by the torques exerted on the localized magnetization by $\mathbf{m}(\mathbf{r},t)$. A basic assumption of the conventional s-d model is that in a static situation the atomic moments arising from $\mathbf{M}_d$ and $\mathbf{m}$ are collinear. It has been shown that for strongly noncollinear situations (e.g., narrow domain walls, vortex cores, etc.) this assumption is not correct [2]. We have extended the s-d model by taking into account a possible noncollinearity between the d magnetization and the conduction electron magnetization, leading to various new torques. By extending the Walker model for the dynamics of domain walls [3] the influence of such torques on the initial and final velocity of a Neel wall is investigated.

[1] S. Zhang and Z. Li, Phys. Rev. Lett. 93, 127204 (2004).
[2] M. Fähnle, R. Singer and D. Steiauf, Phys. Rev. B 73, 172408 (2006).
[3] N.L. Schryer and L.R. Walker, J. Appl. Phys. 45, 5406 (1974).

MA 30.4 Thu 15:15 H 1028

Ab-initio calculations of adiabatic magnon spectra using the atomic-sphere-approximation for the spin direction — Reinhard Singer, •Frank Dietermann, Daniel Steiauf, and Manfred Fähnle — Max-Planck-Institute für Metallforschung, Heisenbergstrasse 3, D-70569 Stuttgart, Germany

The frozen-magnon calculations of the adiabatic spin-wave spectra, which are often based on the atomic-sphere approximation (spin-ASA), are revisited. There are two complications arising from the spin-ASA: The atomic magnetic moments are not necessarily parallel to the local spin-quantization axes of the spin-ASA, and there may be additional torques acting on the magnetic moments. It is shown that the spin-wave energies obtained from spin-ASA calculations are very similar to those of full-spin calculations if these two complications are taken into account properly.[1]

[1] R.Singer, F.Dietermann, D.Steiauf and M. Fähnle, Phys.Rev.B 76, 052403

MA 30.5 Thu 15:30 H 1028

Wannier-function approach to spin-wave excitations in transition metals — •Ersoy Sasioglu, Arno Schindlmayr, Christoph Friedrich, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

We develop a computational scheme based on many-body perturbation theory to study excitation spectra of magnetic materials from first principles using Wannier functions. The main quantity of interest is the spin-spin correlation function (or dynamical spin susceptibility), from which magnetic excitations, including single-particle spin-flip Stoner excitations and collective spin-wave modes as well as their lifetimes can be obtained. In order to describe collective spin-wave excitations we include appropriate vertex corrections in the form of a multiple-scattering T-matrix, which describes the coupling of electrons and holes with different spin. To reduce the numerical cost for the calculation of the four-point T-matrix we exploit a transformation to maximally localized Wannier functions that takes advantage of the short spatial range of electronic correlation in the partially filled *d* or *f* orbitals of magnetic materials. Our implementation is based on the all-electron full-potential linearized augmented plane-wave (FLAPW) method. As a first step, we calculate the dynamical spin susceptibility of the non-interacting Kohn-Sham electrons and the matrix elements of the Coulomb potential in the Wannier basis. The obtained values for the latter are in good agreement with previous calculations. This work was funded in part by the EU's Sixth Framework Programme through the Nanoquanta Network of Excellence (NMP-4-CT-2004-500198).

MA 30.6 Thu 15:45 H 1028

Modification of the magnetocrystalline anisotropy of transition metal films by external electric fields: density functional calculations — •Hongbin Zhang, Ferenc Tasnadi, Ingo Opahle, and Manuel Richter — IFW Dresden, Dresden, Germany

Recent experiments verified a modification of the Magnetocrystalline anisotropy (MA) of FePt and FePd films by electrochemical charging [1]. We have carried out density functional calculations for such slabs, using the relativistic version of the full-potential local-orbital (FPLO) code. The electric field is simulated by virtual crystal approximation (VCA) applied to the surface atoms. Good agreement between the calculated dependence of the MA on the external field with the experimental data is achieved. It is demonstrated, that the variation of MA is a surface effect. However, correct finite size scaling is important for the quantitative results. We predict that the electric field dependence of MA is even stronger for CoPt films than for FePt films.

[1] M. Weisheit et al., Science 315 (2007) 349.

MA 30.7 Thu 16:00 H 1028

Electronic and magnetic properties of the nitrometalathes $\mathbf{A_3[M^{III}N_3]}$ — •Julia Wildeboer, Joanna Katarzyna Bendyna, Peter Höhn, Walter Schnelle, and Helge Rosner — Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Strasse 40, D-01187 Dresden

In solid state physics, geometrically frustated systems enjoy a steadily growing interest. The nitrometalathe compounds $A_3[M^{III}N_3]$ have recently been synthesized. They crystallize in a hexagonal structure containing the planar complex $[M^{III}N_3]^{6-}$ and form a frustated lattice of magnetically active transition metal ions.

We present an comparative experimental and theoretical study of the electronic and magnetic properties of these systems based on thermo-

dynamical measurements; e.g. magnetic susceptibility and electrical resistivity, and density functional theory (DFT) calculations.

The DFT-based results support the experimental data: the compound Sr_3CrN_3 have a non-magnetic ground state whereas all other systems exhibit antiferromagnetic long ranged order.

Similarities and differences with respect to chemical bonding and exchange interaction will be discussed. The influence of strong coulomb repulsion on the transition metal sites will be investigated.

MA 30.8 Thu 16:15 H 1028

Electronic and magnetic properties of Fe_3O_4 in the electronic ground state and in a constrained excited state — •Christos Kostoglou, Reinhard Singer, and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

Below the Verwey temperature T_V magnetite (Fe_3O_4) exhibits an insulating, ordered phase with a special type of charge, spin and orbital order [1,2] due to an ordered arrangement of two types of atoms Fe(B,1) and Fe(B,2) on the Fe(B) sublattice. For an interpretation of experiments on the electronic conductivity and on the magnetic aftereffect at finite temperatures below T_V it is generally assumed [3] that there are thermally-activated electronic transitions involving pairs of exchanged Fe(B,1) and Fe(B,2) atoms as intermediate configuration. The energy difference between the perfectly ordered state and the state containing such a defect is calculated by the LDA+U method and the augmented spherical wave method.

[1] I. Leonov, A.N. Yaresko, V.N. Antonov, M.A. Korotin, and V.I. Anisimov, Phys. Rev. Lett. 93, 146404 (2004)
[2] Horng-Tay Jeng, G.Y. Guo, and D.J. Huang, Phys. Rev. Lett. 93, 156403 (2004)
[3] F. Walz, J. Phys.: Condens. Matter 14, R285 (2002), M. Fähnle, H. Kronmüller, F. Walz, Physica B 369, 177-180 (2005)

15 Min. Sessoin Break

MA 30.9 Thu 16:45 H 1028

Spin-wave excitations from time-dependent density-functional theory — •Manfred Niesert, Arno Schindlmayr, Christoph Friedrich, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

Spin waves constitute an important class of low-energy excitations in magnetic solids with a characteristic material-specific dispersion and a direct relation to magnetization dynamics. Until now most theoretical studies were based on the Heisenberg model of localized spins or on the frozen-magnon method, but neither is applicable to investigate the dynamics of spin waves in metallic systems with itinerant electrons. As a possible solution, time-dependent density-functional theory gives access to the full frequency-dependent transverse spin susceptibility, from which not only the spin-wave dispersion but also the corresponding excitation lifetimes and other spectral information can be extracted. We have developed a practical scheme to calculate spin-wave spectra from first principles within this framework and illustrate its performance by applications to prototype ferromagnetic transition metals. Our implementation uses the full-potential linearized augmented plane-wave method, and dynamic exchange-correlation effects are in the first instance described by the adiabatic local-density approximation.

MA 30.10 Thu 17:00 H 1028

Towards a linear-scaling algorithm for density-functional calculation for metallic systems — •Rudolf Zeller — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich

Linear-scaling algorithms for electronic structure calculations are usually based on a truncation of the density matrix, which decays exponentially in band gap systems. For metallic systems, however, it is not yet well understood whether the decay is fast enough or can be made so by introducing finite temperatures. These questions were investigated with the tight-binding (screened) Korringa-Kohn-Rostoker Green-function method. In calculations for large Cu and Pd supercells with fcc geometry, a spatial truncation of the Green function was applied and the dependence of total energy error on the truncation radius was determined. For reasonable electronic temperatures it was found that the error was bounded by about 2 meV per atom if a few thousand atoms are contained in the truncation range. It is shown that a fixed truncation radius leads to a computational effort per atom, which is independent of the number of atoms in the system, if the sparse matrix equations, which arise because of the tight-binding (screening) transformation, are solved iteratively. This linear-scaling feature and a straightforward parallelization strategy over the atoms opens the way to calculate the electronic and magnetic structure of large metallic systems on massively parallel computers.

MA 30.11 Thu 17:15 H 1028

Collapse of strong ferromagnetism in YCo_5 under pressure - a magnetically driven electronic topological transition evidenced by XMCD — •Helge Rosner[1], Angela Trapananti[2], Miriam Schmitt[1], Ulrich Schwarz[1], and Manuel Richter[3] — [1]MPI CPfS Dresden, Nöthnitzer Straße 40, 01187 Dresden — [2]ESRF, BP220, 38043 Grenoble, France — [3]IFW Dresden , PF 270116, 01171 Dresden

Isomorphic lattice collapse under pressure is a rare phenomenon, usually related to a change of chemical valence. The most famous examples are SmS and Ce metal, collapsing isomorphically under pressure with about 15% volume reduction. In SmS the electronic transition is ascribed to a change of valence, in Ce it is connected with altering contributions of the $4f$-electrons to the chemical bonding. In contrast, the investigated YCo5 obviously is a compound with a stable valence. An entirely new type of isomorphic electronic transition under hydrostatic pressure has been reported recently using ab-initio electronic structure calculation and high-pressure x-ray diffraction.[1,2] The volume collapse is characterized as a first-order Lifshitz or electronic topological transition (ETT) and assigned to magnetic exchange interactions. This mechanism is now directly evidenced by a combination of high pressure XMCD measurements and DFT band structure calculations, both revealing a substantial drop of the magnetic moment related to the phase transition.

[1] H. Rosner et al., Nature Physics **2**, 469, (2006).
[2] D. Koudela et al., Phys. Rev. B. (submitted)

MA 30.12 Thu 17:30 H 1028

Temperature dependent magnetic exchange interactions in the paramagnetic state of hcp Gd. — •Khmelevskyi Sergii, Khmelevska Tetyana, Ruban Andrei, and Mohn Peter — Center for Computational Materials Science, Vienna University of Technology, Gumpendorferstrasse 1, Vienna, Austria, A-1060

We use the first-principles magnetic force theorem embodied in the Korringa-Kohn-Rostoker method to calculate pair magnetic exchange interactions in pure hcp Gd metal in the ferromagnetic as well as in the paramagnetic state with disordered local 4f-moments. It is found that the exchange interactions between the localized 4f-moments, in particular also distant ones, depend on the state of magnetic disorder. Such a dependence is a consequence of the electronic structure changes of the conduction band that mediates the interaction between the local moments. The magnetic ordering temperature has been calculated using a Monte-Carlo simulation technique and the results are compared with mean-field based studies. It is also shown that most important interactions between of nearest neighbors Gd 4f moments is essentially non RKKY in character.

MA 30.13 Thu 17:45 H 1028

Electron theory of dissipative spin dynamics — •Jonas Seib, Daniel Steiauf, and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

Within the breathing Fermi surface model the damping of the magnetization dynamics is related to the change of the Fermi surface with changing magnetic configuration, given by the orientations of the atomic magnetic moments: This change requires a scattering of the electrons among the single-electron states in reciprocal space, and this in turn requires time. The theory yields a Gilbert-type equation of motion for the magnetization with the damping scalar of the original Gilbert equation replaced by a damping matrix. This damping matrix depends on a relaxation time describing the scattering, and on the change of single-electron energies when the directions of the atomic magnetic moments are changing. These derivatives of single-electron energies can be calculated within electron theory. For collinear configurations the breathing of the Fermi surface is caused by spin-orbit coupling, and the derivatives can been calculated with a torque-operator method [1]. For noncollinear situations, also interatomic exchange interaction is the origin of a breathing Fermi surface, and a new Harris-Foulkes approach [2] can be used to calculate the change of single-electron energies. Numerical results for the damping matrix in collinear configurations as obtained by the two methods are compared. A preview on damping in noncollinear situations is given.

[1] D. Steiauf and M. Fähnle, Phys. Rev. B **72**, 064450 (2005).
[2] P. Bruno, Phys. Rev. Lett. **90**, 087205 (2003).

MA 30.14 Thu 18:00 H 1028

Parametrization of the adiabatic magnetic energy on the atomic level: spin-cluster expansion technique vs. Heisenberg modeling — •Reinhard Singer, Frank Dietermann, and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

A widely adopted analytic representation of the adiabatic magnetic energy on the atomic level is the family of Heisenberg models. There the basic configurational dependence of the adiabatic magnetic energy is assumed to be a sum of pair interactions, $\mathbf{e}_i \cdot \mathbf{e}_j$, with $\mathbf{e}_i$ being the unit vector of the atomic magnetic moment located at site i. The recently introduced spin-cluster expansion (SCE) [1] breaks this limitation and takes account of all possible multi-site spin clusters and of a complete set of site basis functions $Y_{lm}(\mathbf{e}_i)$ which are the spherical harmonics. Under the symmetry restrictions of the Heisenberg model, i.e., time-reversal and rotational invariance, a complete set of SCE basis functions were obtained [2] which contain the Heisenberg interactions as a subset. Practically the interaction parameters of a truncated SCE are obtained by fitting to energies calculated with the ab-initio electron theory for a set of reference configurations. We show how the SCE is constructed and how it offers a more efficient and flexible way of parametrizing the complex adiabatic magnetic energy landscape of fcc-Fe and fcc-Ni. Furthermore we present how the SCE helps to identify new magnetic groundstate candidates in fcc-Fe.

[1] R. Drautz and M. Fähnle, Phys. Rev. B 69, 104404 (2004).
[2] R. Singer and M. Fähnle, J. Math. Phys. 47, 113503 (2006).

MA 30.15 Thu 18:15 H 1028

Spin-mixing in noncollinear ferromagnetic metals as basis of femtosecond magnetization dynamics — •Daniel Steiauf and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

A simple phenomenological model for the ultrafast demagnetization of a system after laser pulse irradiation is presented. The basic ideas are very similar to those of the Elliott-Yafet mechanism. If the spinor-field wavefunctions of the electrons are mixtures of spin-up and spin-down states depending on the wave vector, the transitions between states with different wave vectors due to scattering at defects or phonons change the spin polarization of the electrons, whereby angular momentum is transferred to the lattice via spin-orbit coupling. In collinear magnetic configurations the spin-mixing arises exclusively from spin-orbit coupling and thus it is very small, requiring very many scattering events for a considerable change of the magnetic moment of the system. In noncollinear magnetic systems there is an additional and much stronger spin-mixing arising from the much larger exchange couplings. For systems like Ni which are ferromagnetic in the ground state a noncollinearity arises at nonzero temperatures due to thermal disordering. The degree of spin-mixing due to spin-orbit coupling on the one hand and due to the noncollinearity on the other hand is calculated quantitatively by the ab-initio density functional electron theory.

MA 31: ThyssenKrupp Electrical Steel Dissertationspreis der 2008 der AG Magnetismus

Time: Friday 9:30–11:10 Location: EB 301

MA 31.1 Fri 9:30 EB 301

In-plane Anisotropy of the Spin-Excitation Spectrum in Twin-free $YBa_2Cu_3O_{6-x}$ — •Vladimir Hinkov — MPI Festkörperforschung, Stuttgart

5 min. Discussion

MA 31.2 Fri 9:55 EB 301

Ab initio Simultationen eisenhaltiger Systeme: Vom Festkörper zum Cluster — •Georg Rollmann — Theor. Physik, Uni Duisburg-Essen

5 min. Discussion

MA 31.3 Fri 10:20 EB 301

Theory of Magnetic Transition Metal Nanoclusters on Surfaces — •Samir Lounis — IFF Theorie 1, FZ Jülich

5 min. Discussion

MA 31.4 Fri 10:45 EB 301

Magentische Eigenschaften des Legierungssystems Fe-Pt-Volumenmaterial und Nanopartikel — •Caroline Antoniak — Exp. Physik, Uni Duisburg-Essen

5 min. Discussion

MA 32: Postersession II: Spinstruct./Phase Trans. (1-10); Spinelectronics (11-15); Thin Films (16 - 36); Particles/Clusters (37-45); Multiferroics (46-54); Spindynamics/Spin Torque (55 - 76); Post Deadlines (77-79)

Time: Friday 11:15–14:00 Location: Poster E

MA 32.1 Fri 11:15 Poster E

Neutron scattering studies on frustrated $s = 1/2$ spin chain cuprates — •W. Lorenz[1,2], W.-D. Stein[2], A. Schneidewind[3], T. Unruh[3], B. Pedersen[3], C. L. Zhang[4], S.-W. Cheong[4], O. Volkova[5], A. Vasiliev[5], S.-L. Drechsler[1], C. Hess[1], R. Klingeler[1], B. Büchner[1], and M. Loewenhaupt[2] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]IFP (Institut für Festkörperphysik), TU Dresden, 01062 Dresden, Germany — [3]Forschungsneutronenquelle Heinz Maier-Leibnitz , D-85748 Garching, Germany — [4]Rutgers University, Piscataway, New Jersey 08854, USA — [5]Moscow State University, 119992 Moscow, Russia

We report on neutron scattering studies on the frustrated $s = 1/2$ spin chain cuprates $LiCu_2O_2$ and Li_2ZrCuO_4 and discuss these results against the background of their macroscopic properties. In both compounds, the interplay between nearest and next-nearest neigbor interactions yields a helical ground state. For $LiCu_2O_2$, results on the nuclear as well as on the magnetic structure have been determined, as well as preliminary data on the magnetic excitations. We will also present magnetic excitation spectra measured on Li_2ZrCuO_4 which is a new spin chain compound close to the critical frustration between helical and ferromagnetic in-chain order.

MA 32.2 Fri 11:15 Poster E

Magnetic properties of the $(Co_xMn_{1-x})_4Nb_2O_9$ solid solution series. — •Björn Schwarz[1], Daniel Kraft[2], Ralf Theissmann[3], and Helmut Ehrenberg[1] — [1]Institute for Complex Materials, IFW Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany — [2]Institute for Materials Science, Darmstadt University of Technology, Petersenstrasse 23, D-64287 Darmstadt, Germany — [3]Institute for Nano Structures and Technology (NST), University of Duisburg-Essen, Bismarckstr. 81, D-47057 Duisburg, Germany

α-Fe_2O_3 (Hematite) is an antiferromagnetic material below the Morin transition at 260 K, and a canted antiferromagnet or weakly ferromagnetic above the Morin transition and below its Néel temperature at 948 K, above which it is paramagnetic. $(Co,Mn)_4Nb_2O_9$ crystallizes isostructural to α-Fe_2O_3 and the end members order collinear anti-

ferromagentically, whereas the results of magnetization measurements (powder samples and single crystals) and powder neutron diffraction experiments for samples of the solid solution series indicate the realization of weak ferromagnetism, too. A Morin transition induced by a change in cation composition in this system would have presented a qualitatively new approach for understanding the fundamentals of the Morin-transition. Comparative experiments performed on samples of the $(Co,Mn)_4Nb_2O_9$ solid solution series that were prepared by arc melting instead of subsolidus reaction reveal, however, that the experiments performed on samples prepared by the latter method, even on single crystals, were decisively affected by additional $(Co,Mn)_3O_4$ phases possessing complex magnetic properties.

MA 32.3 Fri 11:15 Poster E

Spin-strain coupling in $NiCl_2$-4SC$(NH_2)_2$ — •O. Chiatti[1], A. Sytcheva[1], J. Wosnitza[1], S. Zherlitsyn[1], V. S. Zapf[2], M. Jaime[2], and A. Paduan-Filho[3] — [1]Forschungszentrum Dresden-Rossendorf, Hochfeld-Magnetlabor Dresden (HLD), 01314 Dresden, Germany — [2]National High Magnetic Field Laboratory, Los Alamos National Lab, Los Alamos, NM — [3]Instituto de Fisica, Universidade de São Paulo, Brazil

We report results of sound-velocity and sound-attenuation measurements in the quantum $S = 1$ spin-chain magnet $NiCl_2$-4SC$(NH_2)_2$, in magnetic fields up to 18 T. This material is discussed in the context of Bose-Einstein condensation of magnons. The longitudinal c_{33} acoustic mode, which has a propagation direction along the spin chains, shows pronounced spin-lattice effects. This mode demonstrates a softening in the vicinity of the field-induced antiferromagnetic ordering (below $T = 1.2$ K), accompanied by an energy dissipation in the acoustic wave. A broad maximum has been observed in the temperature dependence of the sound velocity at 44 K. The low-temperature sound-velocity and sound-attenuation behavior is subject to fluctuations of Ni spin degrees of freedom resulting in frequency-dependent effects. The $B - T$ phase diagram obtained from the ultrasonic measurements is compared with results extracted from other experimental investigations. The ultrasonic results are analyzed with a theory based on exchange-striction spin-phonon coupling.

MA 32.4 Fri 11:15 Poster E

Study of iron spin states in the low dimensional polymeric system PAC by ESR and static magnetometry — •A. Alfonsov[1], Ch. Golze[1], V. Kataev[1], U. Pietsch[2], Y. Bodenthin[3], G. Schwarz[4], D. G. Kurth[4], and B. Büchner[1] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden — [2]University of Siegen — [3]PSI Villingen, Switzerland — [4]MPI-KG Potsdam

Tunable high-field Electron Spin Resonance (ESR) and magnetization measurements were used to determine the presence and the properties of the spin-crossover effect in the iron based polyelectrolyte - amphiphile complex (PAC). This metallosupramolecular complex is the result of a self-assembling process of Fe(II), 1,4-bis(2,2':6',2"-terpyridin-4'-yl)benzene with dihexadecyl phosphate. The magnetically active ion, Fe(II), is sixfold coordinated by nitrogen ions. This pseudo octahedral ligand crystal field (CF) affects the splitting of the 3d-levels of the iron ion. Depending on the strength of the CF, the splitting may give rise to a low spin (LS, S=0) or a high spin (HS, S=2) ground state of Fe. Transitions from LS to HS have been produced by a heat treatment of PAC which is detected by magnetization and ESR measurements of the polycrystalline samples. The transition temperature (380K) was determined by magnetization measurements. Furthermore, in the absorption spectrum of the powder sample a splitting of the main ESR signal into two separate ESR lines has been observed at high frequencies (> 80 GHz), which indicates g-factor anisotropy. We discuss a relationship between the structural transformation and magnetic properties occurring in Fe-PAC samples.

MA 32.5 Fri 11:15 Poster E

Crystal growth and properties of $Nd_{2-x}Ca_{2+x}Cu_5O_{10}$ and $Y_{2-x}Ca_{2+x}Cu_5O_{10}$ — •Nadja Wizent[1], Günter Behr[1], Wolfgang Löser[1], Mircea Apostu[2], and Bernd Büchner[1] — [1]IFW Dresden, Institute for Solid State Research, Germany — [2]Al.I. Cuza University, Iasi, Romania

The copper oxide-based compounds are known for interesting properties like superconductivity, spin and charge ordering. Single crystals of cuprates with Nd/Y and different Ca-doping were grown by a Floating Zone method under air and elevated oxygen pressure.

Because single crystalline samples of $Y_{2-x}Ca_{2+x}Cu_5O_{10}$ have not been available for a long time the structure has not been solved until recently [1,2]. The compound is also interesting because of its change from antiferromagnetic ordering through spin glass to a spin gap state at higher Ca-doping ($1.4 \leq x \leq 1.67$) [3].

Further investigations by neutron diffraction and magnetic measurements on doped samples of $Y_{2-x}Ca_{2+x}Cu_5O_{10}$ and $Nd_{2-x}Ca_{2+x}Cu_5O_{10}$ are under way.

[1] J. Thar: Diploma Thesis, Aachen (2005)
[2] Y. Gotoh et al.: J. Alloys & Comp. 408 (2006)
[3] K. Kudo et al.: Phys. Rev. B 71 (2005) 104413

MA 32.6 Fri 11:15 Poster E

Longitudinal fluctuations in itinerant-electron systems — •Leonid Sandratskii — Max Planck Institute of Microstructure Physics, Halle, Germany

The recent successes in the understanding of the thermodynamics of the itinerant-electron systems are to a large extent related to the so-called adiabatic treatment of the atomic moments. This concept allows to introduce disorder of the atomic moments within the itinerant-electron picture and solves the problems of the Stoner model. A most used mathematical approach is the mapping of the itinerant-electron system on a Heisenberg-type Hamiltonian with subsequent application of a statistical-mechanics scheme to evaluate the temperature dependence of the magnetization and the Curie temperature.

Despite important successes with respect to the Stoner theory it becomes increasingly clear that many physical effects in the itinerant magnets cannot be described, even on the qualitative level, without taking into account the longitudinal fluctuations of the atomic moments in addition to the transversal fluctuations described by the Heisenberg-type Hamiltonians. The examples of such effects are the short range magnetic order in Ni above the Curie temperature or metamagnetic order-order phase transition in FeRh. Another important physical problem is the relation between longitudinal magnetic fluctuations and half-metalicity.

In this presentation we will report on recent studies of the role of the longitudinal fluctuations in itinerant-electron systems.

MA 32.7 Fri 11:15 Poster E

Importance of magnetism for the thermal expansion of transition metals: an ab initio study — •Fritz Körmann, Alexey Dick, Blazej Grabowski, Tilmann Hickel, and Jörg Neugebauer — Max-Planck-Institut für Eisenforschung GmbH, Postfach 140444, 40074 Düsseldorf, Germany

Recently, extensive efforts have been made to combine density functional theory with thermodynamic concepts. For this purpose the Gibbs free energy has conventionally been calculated employing the quasiharmonic approximation. This method allowed to perform ab initio predictions on, e.g., the thermal expansion of the nonmagnetic system and yielded an excellent agreement with experiment [1]. In magnetic materials the ab initio analysis has also to take into account magnetic excitations and their interplay with the vibronic degrees of freedom. However, most studies treat the magnetic and lattice excitations separately. We therefore performed a systematic investigation of the influence of magnetic configurations on the vibronic degrees of freedom. The calculations have been performed for elementary Fe and Ni in the bcc and the fcc phase. Based on these results, we derived the dependence of the temperature induced magnetic disorder and the change of local magnetic moments on thermodynamic quantities of Fe and Ni, with emphasis on thermal expansion and heat capacities.

[1] B. Grabowski, T. Hickel, and J. Neugebauer, Phys. Rev. B **76**, 024309 (2007).

MA 32.8 Fri 11:15 Poster E

Study of $EuCu_2(Ge_{1-x}Si_x)_2$ across a quantum critical point — •Mahmoud A. Ahmida[1], Dirk Johrendt[2], Zakir Hossain[3], Christoph Geibel[4], and Mohsen M. Abd-Elmeguid[1] — [1]II Physikalisches Institut, Universität zu Köln, Köln, Germany — [2]Department Chemie and Biochemie der Ludwig-Maximilians-Universität München, München, Germany — [3]Department of Physics, Indian Institute of Technology, Kanpur, India — [4]Max Planck Institut für Chemische Physik fester Stoffe, Dresden, Germany

The intermetallic series $EuCu_2(Ge_{1-x}Si_x)_2$ crystallizing in the tetragonal $ThCr_2Si_2$-type structure combines the antiferromagnetic (AF) compound $EuCu_2Ge_2$ (T_N=14 K) with the homogenous intermediate valent (IV) compound $EuCu_2Si_2$. Therefore, the system offers the opportunity to investigate the crossover from a magnetically ordered state to a nonmagnetic IV state through a quantum critical point (QCP) at x ≈ 0.65. To gain a microscopic insight into the change of

the magnetic and valence states and their competition at the QCP, we have performed systematic ^{151}Eu Mössbauer effect measurements on $EuCu_2(Ge_{1-x}Si_x)_2$ as a function of concentration ($0 \leq x \leq 1$) at different temperatures (300 to 4 K). The analysis of the results shows that the collapse of AF ordering for x > 0.50 is associated with a simultaneous sharp increase of the valence state of Eu towards the Eu^{+3}state. It is shown that the simultaneous valence /magnetic phase transition across the QCP is of first-order.

MA 32.9 Fri 11:15 Poster E

Crystal structure and magnetic fluctuations in $La_{1-x}A_xCoO_3$ (A = Ca, Sr, Ba) — •Thomas Finger[1], Marco Reuther[1], Daniel Senff[1], Matthias Cwik[1], Thomas Lorenz[1], Markus Braden[1], Klaudia Hradil[2], Anatoliy Senychyn[3], and Yvan Sidis[4] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Georg-August Universität Göttingen / FRM2 Munich — [3]Technische Universität Darmstadt / FRM2 Munich — [4]LLB, Saclay

The phase diagram of perovskite cobaltites is closely related to those of the CMR-manganites as they both show ferromagnetism and metallic behaviour at intermediate doping. We have studied the crystal structure of the series with Ca and Ba doping and will discuss the corresponding phase diagrams. Furthermore, magnetic excitations were studied by inelastic neutron scattering for A = Sr at different doping levels. We report on the magnetic correlations in the ferromagnetic and in the spin-glass phase and present the magnon dispersions which are remarkably different. In the metallic compound we find a very steep ferromagnetic dispersion, with a stiffness constant twice higher than that in $La_{0.7}Sr_{0.3}MnO_3$ and a small anisotropy gap, without any evidence for a splitting of the magnon branches. In contrast the magnetic excitations in the spin-glass phase exhibit a sizeable spin gap and a much more complex low-energy magnetic excitation spectrum. This is the first clear evidence that the spin-glass phase cannot be considered as a short-range analogue of the ferromagnetic phase.

MA 32.10 Fri 11:15 Poster E

Ordered orbital momentum in antiferromagnets from sum rules in soft x-ray resonant diffraction — •Marcel Buchholz[1], Chun Fu Chang[1], Maurits W. Haverkort[1], Christian Schüssler-Langeheine[1], Matthias Cwik[1], Hsueh-Hung Wu[1,2], Thomas Willers[1], Zhiwei Hu[1], Arata Tanaka[3], Enrico Schierle[4], Detlef Schmitz[4], and L. Hao Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]NSRRC, Taiwan — [3]ADSM, Hiroshima University, Japan — [4]HMI c/o Bessy

Using sum rules applied to x-ray magnetic circular dichroism (XMCD) is a well established technique to extract, e.g., the orbital contribution to the magnetic moment in ferromagnets. For antiferromagnets (AF) such an extraction is a more difficult task because XMCD, which requires a net magnetic moment of the sample, cannot be applied here. A novel experimental approach particularly well suited for AF is the use of the sum rules valid for resonant soft x-ray magnetic diffraction. These rules allow to determine the ordered orbital momentum directly from the energy dependence of a magnetic diffraction peak near an electronic resonance [1]. The potential of this method for $3d$ and $4f$ systems is explored by application of sum rules to magnetic diffraction data from $La_{1.5}Sr_{0.5}CoO_4$ and metallic Ho. The results are compared to those obtained by a microscopic modeling of the resonance spectra. Supported by the DFG through SFB 608 and by the BMBF.

[1] M. W. Haverkort, C. Schüßler-Langeheine, A. Tanaka, to be published

MA 32.11 Fri 11:15 Poster E

Ab initio investigations of Fe/GaAs(110) interfaces with respect to electronic transport — •Anna Grünebohm, Heike C. Herper, and Peter Entel — Fachbereich Physik, Universität Duisburg-Essen, Duisburg

Fe/GaAs is a candidate for spintronic devices because of the high Curie temperature of iron, the optical properties of GaAs and the small lattice mismatch (< 2%). However, measured spin injection varies widely between 1% and 30% depending on growth conditions and temperature. Though the structural properties of Fe/GaAs(100) have been intensively studied, detailed transport calculations are lacking. We investigate different interface configurations of GaAs and Fe using VASP within the projector augmented wave method thereby the GGA/PBE has been adopted for the exchange correlation potentials [1]. Spatial relaxations are performed and the relaxed structures are taken as input for transport calculations. Therefore, we make use of the Green's Function technique [2] and the Kubo-Greenwood equation. Here, we focus on systems grown in (110) direction, which seem to be of particular interest for spin injection and have been less investigated than the (110) direction.

[1] VASP, G.Kresse, J.Furthmüller, Phys. Rev. B **54**, 11169 (1996)
[2] H.Akai, Machikaneyama2002

MA 32.12 Fri 11:15 Poster E

Transport properties of CoFeB/MgO/CoFeB magnetic tunnel junctions — •Marvin Walter, Kai Ubben, Gerrit Eilers, and Markus Münzenberg — IV. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen

Magnetic tunnel junctions showing a high tunnel magneto resistance are important for the fabrication of MRAM devices when combined with current induced switching.

Here we present our investigations on CoFeB/MgO/CoFeB magnetic tunnel junctions. The junctions are prepared by means of magnetron sputtering of CoFeB and e-beam evaporation of stoichiometric MgO. Structuring of the multilayer is done using a photolithography process and Argon ion-milling.

We characterize the tunnel junctions by $R(H)$ measurements, I/V-spectroscopy and magneto-optical Kerr effect measurements. Our investigations include the switching properties of the two CoFeB layers depending on their thickness, since no antiferromagnetic layer is used to pin one of the electrodes through the exchange bias effect. Furthermore, a comparison between two different electrode compositions will be made and the dependence on MgO barrier thickness and annealing temperature will be shown.

In the future, we plan to do further downscaling of the size of the magnetic tunnel junctions to achieve sufficient high current densities to observe and investigate current induced switching in this system.

Research is supported by DFG SFB 602.

MA 32.13 Fri 11:15 Poster E

Ion bombardment induced magnetic patterning of reference electrodes in magnetic tunnel junctions with MgO barrier — Volker Höink[1], Xinli Kou[1], •Jan Schmalhorst[1], Günter Reiss[1], Tanja Weis[2], Daniel Lengemann[2], and Arno Ehresmann[2] — [1]Thin Films and Physics of Nanostructures, Department of Physics, University of Bielefeld, P.O. Box 100131, 33501 Bielefeld, Germany — [2]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Kassel University, Heinrich-Plett-Str.40, 34132 Kassel, Germany

For some applications as, e.g., a special type of reconfigurable magnetic logic [1] it is necessary to manipulate the direction of the exchange bias coupling of the reference layer in a magnetic tunnel junction (MTJ). It has been shown in the past that a magnetic patterning of reference layers is possible without a significant loss of tunnel magnetoresistance (TMR) in MTJs with alumina barrier [2,3]. Recently, high TMR amplitudes of up to 500% have been reported for CoFeB / MgO / CoFeB based MTJs [4]. Here, the influence of the ion bombardment on the TMR amplitude, the resistance, and inelastic electron tunnelling spectra of two types of CoFeB / MgO / CoFeB based MTJs is investigated.

[1] Appl. Phys. Lett. 91 (2007) 162505
[2] J. Appl. Phys. 94 (2003) 5556
[3] Appl. Phys. Lett. 86 (2005) 152102
[4] Appl. Phys. Lett. 90 (2007) 212507

MA 32.14 Fri 11:15 Poster E

Reconfigurable magnetic logic for all basic logic functions produced by ion bombardment induced magnetic patterning — •Volker Höink[1], Dirk Meyners[1], Jan Schmalhorst[1], Günter Reiss[1], Dörte Jung[3], Dieter Engel[2], and Arno Ehresmann[2] — [1]Thin Films and Physics of Nanostructures, Department of Physics, University of Bielefeld, P.O. Box 100131, 33501 Bielefeld, Germany — [2]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Kassel University, Heinrich-Plett-Str.40, 34132 Kassel, Germany — [3]now at: Universität des Saarlandes, P.O. Box 15 11 50, D-66041 Saarbrücken, Germany

In most common logic gates based on transistors, different logic functions have to be realized by applying a large number of logic gates, which are capable of performing only one function. A promising approach to overcome this obstacle with the additional advantage of a nonvolatile output is a reconfigurable logic based on small arrays of magnetic tunnel junctions. Here, an approach utilizing an ion bombardment induced patterning of the reference layer is proposed where the same logic unit consisting of only two magnetic tunnel junctions can be used for the AND, OR, NAND, NOR, and X(N)OR, functions.

MA 32.15 Fri 11:15 Poster E

On the influence of bandstructure on transport properties of magnetic tunnel junctions with $Co_2Mn_{1-x}Fe_xSi$ single and multilayer electrode — Jan Schmalhorst[1], •Daniel Ebke[1], Alexander Weddemann[1], Andreas Hütten[1], Andy Thomas[1], Günter Reiss[1], Andrej Turchanin[2], Armin Gölzhäuser[2], Benjamin Balke[3], and Claudia Felser[3] — [1]Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [3]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg Universität, 55099 Mainz, Germany

The transport properties of magnetic tunnel junctions with different (110)-textured Heusler alloy electrode such as Co_2MnSi, Co_2FeSi or $Co_2Mn_{0.5}Fe_{0.5}Si$, AlO_x barrier and Co-Fe counter electrode are investigated. The bandstructure of $Co_2Mn_{1-x}Fe_xSi$ is predicted to show a systematic shift of the position of the Fermi energy E_F through the gap in the minority density of states, while the composition changes from Co_2MnSi towards Co_2FeSi. Although, this shift is indirectly observed by X-ray photo emission spectroscopy, all junctions show a large spin polarization of around 70% at the Heusler alloy / Al-O interface and are characterized by a very similar temperature and bias voltage dependence of the tunnel magnetoresistance. This suggests, that the transport properties of all junctions are dominated by inelastic excitations and not by the electronic bandstructure.

MA 32.16 Fri 11:15 Poster E

Structural and magnetic properties of Co– and Mn–doped ZnO thin films — •Gillian Mayer[1], Sönke Voss[1], Mikhail Fonin[1], Ulrich Rüdiger[1], Reinhard Schneider[2], Dagmar Gerthsen[2], and Eberhard Goering[3] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz — [2]Laboratorium für Elektronenmikroskopie, Universität Karlsruhe, 76128 Karlsruhe — [3]Max Planck–Institut für Metallforschung, 70569 Stuttgart

Diluted magnetic oxides have attracted much attention because of their possible application in spintronic devices. Especially d–metal doped ZnO is a promising candidate as proposed by Dietl et al. [1]. Structural and magnetic properties of Co– and Mn–doped ZnO thin films prepared by rf magnetron sputtering from composite Zn/Co and Zn/Mn targets have been studied. X–ray absorption measurements at the Co and Mn $L_{2,3}$ absorption edges indicate that Co^{2+} and Mn^{2+} are incorporated at Zn sites in ZnO. In SQUID investigations, as prepared Co–doped samples show pure paramagnetism, while vaccum–annealed samples and some of the Mn–doped samples show a ferromagnetic behavior. A detailed X–ray magnetic circular dichroism study of Co–doped ZnO at different temperatures reveales that Co contributes only paramagnetically to the magnetism in vacuum–annealed samples. Transmission electron microscopy investigation of Co–doped ZnO shows that postannealing of the samples leads to the formation of Co–rich clusters that however do not contribute to ferromagnetism. The possible contribution of the substrate to the ferromagnetic behavior is also discussed. [1] Dietl *et al.*, Science **287**, 1019 (2000).

MA 32.17 Fri 11:15 Poster E

Magnetoresistive effects in ultrathin magnetic films — •Stephen Krzyk, Alexander von Schmidsfeld, Mathias Kläui, and Ulrich Rüdiger — Fachbereich Physik, Universität Konstanz, 78457 Konstanz

Inspired by the successful industrial application of the giant magnetoresistance effect (GMR), magnetoresistance properties of nanoscale structures are the subject of intense research. Recent experiments [1] have shown that decreasing the cross section of a nanocontact leads to a significantly increased magnitude of the anisotropic magnetoresistance.

A possible approach to small contact sizes are ultrathin films near the percolation threshold. We investigate magnetotransport through permalloy ($Ni_{80}Fe_{20}$) and iron films grown on isolating substrates such as MgO. Deposition of films in the monolayer range was carried out in an MBE chamber designed for in situ magnetoresistance measurement during film growth. Magnetic fields of up to 100 mT can be applied in the sample plane, and the resistances between fixed sample locations can be measured during growth. The field angle and strength is varied for the purpose of distinguishing between TMR and AMR effects. The measurements can be carried out by increasing the thickness with sub-monolayer resolution.

[1] K. I. Bolotin et al., Phys. Rev. Lett. 97, 127202 (2006)

MA 32.18 Fri 11:15 Poster E

Modulated magnetization depth profile in dipolarly coupled $Co_{80}Fe_{20}/Al_2O_3$ multilayers — •Subhankar Bedanta[1], Emmanuel Kentzinger[2], Oleg Petracic[1,3], Jan Rhensius[1], Wolfgang Kleemann[1], Theo Kleinefeld[1], Amitesh Paul[2], Thomas Brückel[2], Ulrich Rücker[2], Susana Cardoso[4], and Paulo Freitas[4] — [1]Angewandte Physik, Universität Duisburg-Essen, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, Germany — [3]Institut für Experimentalphysik IV, Ruhr-Universität Bochum, Germany — [4]INESC, Rua Alves Redol 9-1, Lisbon, Portugal

Polarized neutron reflectivity (PNR), magnetometry, and magneto-optic Kerr microscopy studies have been performed on two metal-insulator multilayers (MIMs) $[Co_{80}Fe_{20}(t_n)/Al_2O_3(3nm)]_9$ with t_n = 1.6 and 1.8 nm. MIMs exhibit dominant dipolar coupling between the ferromagnetic CoFe layers. Our PNR measurements at the coercive field reveal a novel and unexpected magnetization state of the sample exhibiting an oscillating magnetization depth profile from CoFe layer to layer with a periodicity of five and eight bilayers along the multilayer stack for the t_n = 1.6 and 1.8 nm samples, respectively [1]. Domain imaging by Kerr microscopy reveals different grey scales which evidence the heterogeneity of layer-by-layer magnetization in the multilayer stack [2]. With the help of micromagnetic simulations we demonstrate that competition between long and short-ranged dipolar interactions apparently gives rise to this unusual phenomenon [1].

[1] S. Bedanta et al., Phys. Rev. B **74**, 054426 (2006).
[2] S. Bedanta et al., Physica B **397**, 65 (2007).

MA 32.19 Fri 11:15 Poster E

Simulation of a nano-scale magnetic switch — •Volker Pankoke and Sibylle Gemming — Forschungszentrum Dresden-Rossendorf, Germany

We used ab-initio methods in the LDA with pseudo potentials and a plane wave basis to simulate the growth of thin palladium films on the piezo electric oxide PMN ($Pb(Mg/Nb)O_3$). It is known that the palladium ground state is similar to the ground state of ferromagnetic nickel. A magnetic switch of nano-scale dimension might be possible if the palladium ground-state can be forced to get also ferromagnetic. The piezo electric property of PMN oxides can be used to achieve this by an expansion of the lattice constant. First calculations on bulk-Pd with all-electron and pseudo-potential methods lead to differing results with respect to the magnetic ground state, but it seems, that the projector augmented wave method PAW describes the magnetism correctly. In PAW calculations pure fcc-palladium films remain non-magnetic during expansion, but a doping with cobalt can help to induce a magnetic state.

MA 32.20 Fri 11:15 Poster E

2-Dimensional-Magnetism of Fe-Monolayers in Pd — •Daniel Schumacher, Ulrich Rücker, and Thomas Brückel — IFF-Streumethoden, Forschungszentrum Jülich, 52425 Jülich

Pd almost fulfils the Stoner-criterion to be ferromagnetic. The aim of the work reported here is to explore in detail, how an ultrathin ferromagnetic layer inside a Pd thin film polarizes the surrounding Pd layer. As a function of the thickness of the Fe layer, we investigate the transition from 3d to 2d behaviour inside a Pd matrix.

Samples have been grown by molecular beam epitaxy (MBE) on GaAs substrates using an Ag buffer layer. The epitaxial growth and the surface qualities have been characterized by in-situ LEED and AUGER analysis to optimize the parameters of the preparation process. In addition, the surface quality has been analysed by X-ray-reflectometry. After that some wedge patterned Fe layers in Pd were produced. Thus different layer thicknesses have been obtained all grown at constant parameters (e.g. temperature, pressure, growth rate). The first step to explore the magnetic properties of these samples was done by MOKE measurements.

Polarized neutron scattering under grazing incidence is the method of choice to investigate the magnetization density profile as well as lateral magnetic correlations. By using neutron reflectometry magnetic correlations can be determined as a function of applied field, external temperature and dimensionality.

MA 32.21 Fri 11:15 Poster E

Das Wechselspiel elektrischer und magnetischer Felder in den kolossalen Widerstandseffekten von Ca-dotierten PrMnO3 — •Jörg Hoffmann, Peter Moschkau und Christian Jooss — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, D 37077 Göttingen

Das Ca-dotierte PrMnO3 (PCMO) gehört zu der Klasse von Manganaten, die über den gesamten Temperaturbereich ein elektrisch isolierendes Verhalten zeigen. Dabei führen elektrische und magnetische Felder bei hinreichend tiefen Temperaturen zu kolossalen Widerstandseffekten. Diese Phänomene sind eng mit einer Phasenseparation zwischen strukturell ähnlichen Phasen verbunden, die sich bzgl. der Spin-, Orbital- und Ladungsordnung unterscheiden.

In diesem Beitrag vergleichen wir die elektrisch und magnetisch induzierten Widerstandsänderungen in polykristallinen Proben. Bestimmt wurde die temperatur- und frequenzabhängige Leitfähigkeit in magnetischen Feldern bis zu 9 T. Begleitet wurde dies durch Untersuchungen zur elektrisch induzierten Strukturänderung in einem analytischen Transmissionselektronenmikroskop.

Bei hinreichend hohen Temperaturen überwiegt die elektronisch ungeordnete Phase und die Transporteigenschaften sind durch kleine Holstein-Polaronen bestimmt. Magnetische Felder führen in der polaronen-geordneten Tieftemperaturphase zu einer hohen Leitfähigkeit (CMR). Diese Delokalisierung der Ladungsträger steht in Konkurrenz zu einer rein elektrisch induzierten Mobilisierung (CER), die keine langreichweitige Ordnung erfordert.

MA 32.22 Fri 11:15 Poster E

Magneto-optical Kerr effect measurements of $Fe_{3-x}Zn_xO_4$ thin films — •Matthias Pelkner, Deepak Venkateshvaran, Andrea Boger, Andreas Brandlmaier, Matthias Opel, Sebastian T. B. Goennenwein, and Rudolf Gross — Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meissner-Str. 8, 85748 Garching

Magnetite (Fe_3O_4) is a very attractive candidate regarding spintronic devices, since it has a very high Curie temperature ($T_C = 860$ K) and is considered a half metallic ferrimagnet. To tune its electronic and magnetic properties (carrier concentration and Curie temperature) it is attractive to replace a fraction of the Fe atoms by nonmagnetic ions, e.g. Zn.

We have prepared $Fe_{3-x}Zn_xO_4$ thin films on MgO (100) single crystal substrates using pulsed laser deposition with different Zn concentration ($x = 0$, 0.05, 0.1 and 0.5). The films were grown in Ar atmosphere at a pressure of 3.7×10^{-3} mbar and a substrate temperature of 320°C. The crystalline quality of the films was checked with x-ray diffraction, and the magnetic properties were investigated by means of magneto-optical Kerr effect measurements at room temperature and SQUID magnetometry. We present a comparison of the magnetic properties of the films with different Zn content x, grown under identical conditions, and critically compare our findings with the properties of bulk Zinc ferrite spinels reported in the literature.

This work is supported by the DFG via SPP 1285.

MA 32.23 Fri 11:15 Poster E

Growth and Characterization of $La_{1-x}Ca_xMnO_3$ thin films with different Ca concentrations using PLD with in-situ RHEED — •Alexander Hirsch, Heiko Fasold, Ralf Koppert, Frank Ludwig, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Straße 66, D-38106 Braunschweig, Germany

The growth of doped perovskite manganites is interesting for both basic research and potential applications. These materials, which show the colossal magnetoresistance effect, have promise for new sensor applications, in particular as layers in multiferroic superlattices.

Using pulsed laser deposition (PLD), $La_{1-x}Ca_xMnO_3$ (LCMO) thin films were grown. All targets were prepared by standard ceramic synthesis. As substrates $SrTiO_3$ (100) and $NdGaO_3$ (110) are used. The surface of the $SrTiO_3$ substrates is atomically flat and TiO_2 terminated after chemical and subsequent annealing treatment. To obtain atomically flat and single terminated $NdGaO_3$ surfaces an annealing treatment is applied. The growth of the films is monitored by in-situ reflection high energy electron diffraction (RHEED). The characterization is supplemented by X-ray diffraction and atomic force microscopy.

The LCMO films were grown with five different Ca concentrations between 33 % and 50 %. Optimal growth conditions lead to high quality crystalline magnetic films with rms roughnesses below 1nm for layer thicknesses up to 500 nm. The influence of the Ca concentration, the substrate and the film thickness on the properties of the thin films is analyzed.

MA 32.24 Fri 11:15 Poster E

Characterization of hybrid amorphous-partially crystalline thin films — •Norbert Martin[1], Christine Hamann[1], Jeffrey McCord[1], Jürgen Fassbender[2], Eckhard Quandt[3], Andreas Gerber[4], Nadja Bigall[5], Alexander Eychmüller[5], and Ludwig Schultz[1] — [1]IFW Dresden, Dresden, Deutschland — [2]FZD, Dresden, Deutschland — [3]CAU Kiel, Kiel, Deutschland — [4]Caesar, Bonn, Deutschland — [5]PC2 TU Dresden, Dresden, Deutschland

Amorphous FeCoBSi thin films with uniaxial anisotropy have been laterally structured by Co ion implantation into stripe arrays. The resulting multiphase samples were investigated regarding the magnetic properties. Hysteresis measurements revealed a large increase in coercivity of the implanted areas. By means of TEM investigations this could be attributed to formed crystallites in the amorphous matrix. Magneto-optical imaging was used to correlate the domain structure to the magnetic hysteresis. It is demonstrated that stripe orientation with respect to the magnetic easy axis governs the coupling between implanted and non implanted areas.

MA 32.25 Fri 11:15 Poster E

Magnetic properties of FeCo(110) on GaAs (110) cleaved edges — •Florian Nitsch, Björn Muermann, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

By cleaving a (001)-oriented GaAs wafer in UHV atomically flat and chemically clean GaAs(110) surfaces can be produced. To investigate a possible influence of surface roughness on the magnetic anisotropy of bcc $Fe_{1-x}Co_x(110)$ films, layers grown by molecular beam epitaxy on such cleaved edges and on (110)-oriented GaAs wafers were investigated by alternating gradient magnetometry, magneto-optic Kerr effect and ferromagnetic resonance. Film thickness varied between 10 and 80 ML (monolayers) for compositions of x = 0.30 and x = 0.66. RHEED patterns showed a much lower step density of the cleaved edges compared to the GaAs(110) wafer surfaces prepared by UHV-annealing and Ar^+ etching. The superposition of the cubic anisotropy (constant K_1) and a uniaxial anisotropy (K_U) is observed. Both anisotropy constants show a systematic thickness dependence resulting from the superposition of volume and interface contributions. A comparison with films grown on GaAs(001) indicates that in (110)-oriented films the uniaxial component is mainly of magneto-elastic origin. Both K_1 and K_U have about the same values for films grown on (110) wafers and on cleaved edges. It is concluded that for a thickness up to 80 ML the lattice relaxation due to the formation of misfit dislocations is not affected by the surface roughness of the substrates used in the present work.

MA 32.26 Fri 11:15 Poster E

Investigation of the magnetic phase transition in thin $Fe_{50}Pt_{50-x}Rh_x$ films by neutron diffraction — •Jochen Fenske[1], Dieter Lott[1], Gary J. Mankey[2], Wolfgang Schmidt[3], Karin Schmalzl[3], and Andreas Schreyer[1] — [1]GKSS Research Centre, Geesthacht — [2]MINT Center, The University of Alabama, Tuscaloosa, AL, USA — [3]JCNS, Jülich, Germany

In the last years perpendicular recording plays a major role in the development of novel magnetic data storage. Here, materials with high anisotropy are used which delivers good thermal stability. However in order to write the bits a high magnetic field is necessary. By the use of soft underlayers the write field can be significant reduced. $Fe_{50}Pt_{50-x}Rh_x$ is a promising candidate for such an underlayer. Magnetization measurements of the bulk samples for x=10 refer to a antiferromagnetic (AF)/ferromagnetic (FM) phase transition at about 150K when heated. Additional magnetostriction measurements indicate that the phase transition could also be induced by applying a magnetic field [2]. The FM state lowers the high anisotropy and therefore the high write field. The AF state helps to stabilize the recording media via exchange interaction. For technical applications the use of thin films are essential to save space and costs for the next generation of magnetic storage devices. Here we present results on several thin $Fe_{50}Pt_{50-x}Rh_x$ films with different concentration of Rh. The films were examined by polarized and unpolarized neutron diffraction in dependence of temperature and magnetic field. [2] P.A. Algarabel, et. al, J.Appl. Phys. 79 (8), 1996

MA 32.27 Fri 11:15 Poster E

Magnetic phase transitions at interfaces studied by resonant magnetic soft x-ray scattering — •Enrico Schierle[1], Detlef Schmitz[1], Gunther Springholz[2], and Eugen Weschke[1] — [1]Hahn-Meitner-Institut , Berlin, Germany — [2]Institut für Halbleiterphysik, Johannes Kepler University, Linz, Austria

Properties of magnetic thin films are strongly influenced by the near-

interface regions, where modifications of bulk magnetic order [1] and roughness occur. Using resonant magnetic soft x-ray scattering at the Eu-M_5 resonance, we studied the temperature-dependent magnetization of the individual layers in monocrystalline films of the magnetic semiconductor EuSe with thicknesses of 20 and 40 monolayers. These films exhibit AFM, ferri- (FiM) and FM phases depending on temperature and applied magnetic field [2]. Due to the high magnetic sensitivity at resonance [3], very intense AFM and FiM Bragg peaks could be recorded that are characterized by pronounced Laue oscillations over a large range of momentum transfer. These permit a detailed characterization of temperature-dependent interface-induced disorder for different types of magnetic structures (AFM, FiM) in a single material. Preliminary analyses point to a much stronger influence of the interface on the FiM structure than on AFM order.

[1] K. Binder, P. C. Hohenberg, Phys. Rev. B 9, 2194 (1974)
[2] R. T. Lechner et al., Phys. Rev. Lett. 94, 157201 (2005)
[3] E. Weschke et al., Phys. Rev. Lett. 93, 157204 (2004)

MA 32.28 Fri 11:15 Poster E

Magnetic properties of epitaxial Fe/GaAs(110) — •Igor Barsukov, Cihan Tomaz, Ralf Meckenstock, Jürgen Lindner, and Michael Farle — Fachbereich Physik and Center for Nanointegration (CeNIDE) Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

Epitaxial Fe films in a thickness range from 15 to 30 monolayers (ML) were grown by in-situ molecular beam epitaxy on GaAs(110) at room temperature. The growth and structure of the films were characterized by Auger spectroscopy, low energy electron diffraction (LEED) and IV-LEED. In-situ angular dependent ferromagnetic resonance measurements (FMR) were performed to obtain a full set of anisotropy parameters. Beside the well known film thickness dependent magnetic reorientation transition [1], the investigation shows a characteristic change of anisotropies due to thermal tempering, by direct heating or by covering with flash-evaporated Ag atoms. The comparison of the two characteristic FMR angular dependences reveals that the magnetic transition is driven by a 90° rotation of uniaxial anisotropy axis; the higher order parameters being unchanged. A morphologic explanation of this phenomenon is discussed. This work was supported by DFG, SFB491.

[1] J. Appl. Phys. 89, 11, 7136-7138

MA 32.29 Fri 11:15 Poster E

Effects of wet-chemical etching on MnAs/GaAs hybride structures probed by HX-PES — •Benjamin Schmid[1], Sebastian Engelbrecht[1], Michael Sing[1], Jan Wenisch[2], Charles Gould[2], Karl Brunner[2], Lorenz Molenkamp[2], Wolfgang Drube[3], and Ralph Claessen[1] — [1]Experimentelle Physik IV, Universität Würzburg, Würzburg, Germany — [2]Experimentelle Physik III, Universität Würzburg, Würzburg, Germany — [3]HASYLAB, DESY, Hamburg

Ferromagnet-semiconductor hybride structures represent a promising approach to spintronic applications. Utilizing not only the charge but also the spin degree of freedom would lead to a new generation of computing devices. One promising candidate for spin-injectors or aligners compatible with conventional semiconductors is MnAs. It provides a high Curie temperature of 317 K and a compatibility to GaAs. Moreover, thin films of MnAs can be grown epitaxially on GaAs by MBE with monolayer accuracy.

In order to fabricate tailor-made spintronic devices it is essential to test established surface preparation methods. Obtaining clean surfaces during the fabrication process of heterostructures by wet-chemical etching is a standard method in today's semiconductor industry. We investigated the effects of etching with either HCl or H_2SO_4 on MnAs thin films using photoemission spectroscopy in the hard X-ray regime (HX-PES). HCl removes contaminations such as oxygen and carbon. After etching the surface appears to be covered with an As layer. In contrast, H_2SO_4 leads to a complete destruction of the MnAs thin film.

MA 32.30 Fri 11:15 Poster E

Recovery of the metal-insulator transition in electron-doped $La_{0.7}Ce_{0.3}MnO_{3-\delta}$ films by photoexcitation — •Andreas Thiessen[1], Elke Beyreuther[1], Stefan Grafström[1], Kathrin Dörr[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, TechnischeUniversität Dresden, D-01062 Dresden — [2]Institut für Metallische Werkstoffe, IFW Dresden,Postfach 270116, D-01171 Dresden

The question whether electron-doped mixed-valence manganites, such as $La_{0.7}Ce_{0.3}MnO_3$, can be synthesized as single-phase compounds has been under debate for a decade. Meanwhile it has become clear that electron doping can indeed be achieved in epitaxial thin films [Mitra et al., JAP 89 (2001) 524]. However, as-prepared films often suffer from overoxygenation and concomitant hole doping, which can be overcome by deoxygenation through a post-deposition annealing procedure. Disappointingly, those reduced samples do not exhibit the typical metal-insulator transition (MIT) any longer [Wang et al., PRB 73 (2006) 144403].

In the present work, we show that the MIT of $La_{0.7}Ce_{0.3}MnO_{3-\delta}$ films can be recovered by exposition to visible light. Our films turn out to be highly photoconductive: Laser illumination at 514 nm with a power of 400 mW gave rise to a dramatic resistance drop of around seven orders of magnitude at 100 K as compared to the dark state, while illumination had no impact on the conductivity of an as-prepared reference film.

MA 32.31 Fri 11:15 Poster E

Epitaxial strain and magnetic anisotropy in $LaCoO_3$ thin films — •Erhan Arac[1,2], Dirk Fuchs[1], and Rudolf Schneider[1] — [1]1 Forschungszentrum Karlsruhe, Institut für Festkörperphysik, — [2]Physikalisches Institut, Universität Karlsruhe

$LaCoO_3$ (LCO) thin films do show a strain induced ferromagnetic phase transition below 85K. In order to elucidate the coupling between strain and magnetization, we have grown epitaxial LCO thin films on (001), (111) and (110) oriented $(LaAlO_3)_{0.3}(Sr_2AlTaO_6)_{0.7}$ single crystal substrate with different film thickness. The films were grown by pulsed laser depositions and are differently strained because of the grown direction. The magnetization reversal loops were recorded by light modulated magneto-optical Kerr effect (MOKE) magnetometry whereas strain characterization was carried out by reciprocal space mapping on a four-circle x-ray diffractometer. The magnetic anisotropy as a function of strain is studied . Preliminary results will be presented.

MA 32.32 Fri 11:15 Poster E

Scanning tunneling spectroscopy on $La_{0.75}Ca_{0.25}MnO_3$ thin film in external magnetic fields — •Thomas Mildner, Sigrun Köster, Bernd Damaschke, Vasily Moshnyaga, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Manganite thin films show a colossal magnetoresistance effect (CMR) combined with a metal-insulator transition (MIT). The MIT is observed not only as a function of temperature but also in an external magnetic field. The transition may be discussed in terms of an electronic phase separation with possible contributions of polaronic ordering.

In this work an A-site ordered $La_{0.75}Ca_{0.25}MnO_3$ thin film was grown by metalorganic aerosol deposition (MAD) technique on a MgO substrat. The scanning tunneling spectroscopy measurements were performed in UHV at various temperatures in the vicinity of the MIT and external magnetic fields. Regions with different tunneling conductivity at the Fermi level increases with external magnetic fields leading to a CMR-like effect also in the tunneling conductivity.

The work is supported by the DFG via SFB 602, TP A2

MA 32.33 Fri 11:15 Poster E

Exchange shift of stripe domains in antiferromagnetically coupled superlattices — Nikolay S. Kiselev[1,2], Igor E. Dragunov[2], •Ulrich K. Rössler[1], and Alexei N. Bogdanov[1,2] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology

Recently synthesized antiferromagnetically coupled superlattices with perpendicular anisotropy display qualitatively new physical properties. Competition between the weak interlayer exchange and dipolar coupling yields unusual domain structures and magnetization processes. Understanding and control of these properties may lead to new applications of such perpendicular multilayers. Within a general phenomenological approach we calculate the existence regions and the geometrical parameters of equilibrium stripe and bubble domains, and their evolution in a bias field. A *shifted* phase characterized by a redistribution of magnetization between adjacent magnetic layers exists in a broad range depending on the ratio of magnetic and nonmagnetic layer thicknesses and strengths of interlayer coupling [1]. The transition from the antiferromagnetic monodomain state to the *shifted* phase and coexistence of metastable states was observed in recent experiments [2]. Qualita-

tive and quantitative methods have been developed [3] for the analysis of magnetic force microscopy (MFM) images from this novel class of nanomagnetic systems.

[1] N.S. Kiselev, I. E. Dragunov, U. K. Rößler, A. N. Bogdanov, Appl. Phys. Lett. 91 (2007) 132507; [2] O. Hellwig et al. J. Magn. Magn. Mater. 319 (2007) 13; [3] N.S. Kiselev, I. E. Dragunov, V. Neu, U. K. Rößler, A. N. Bogdanov, J. Appl. Phys. submitted.

MA 32.34 Fri 11:15 Poster E

Thermal stability of GMR stack systems: Influence of the cap layer — •Matthias Hawraneck[1,2], Jürgen Zimmer[1], Wolfgang Raberg[1], Klemens Prügl[1], Thomas Bever[1], Stefan Flege[2], and Lambert Alff[2] — [1]Infineon Technologies AG, Am Campeon 1-12, 85579 Neubiberg — [2]Institut für Materialwissenschaft, TU Darmstadt, Petersenstr. 23, 64287 Darmstadt

In a wide range of applications GMR stack systems can be used as magnetic field sensors. For these applications, like angle und speed sensing, a stable magnetic behavior is a crucial criterion. For unstructured GMR stacks two degradation effects can be considered: First interlayer diffusion within the stack, and second the influence of the environment on the stack. To evaluate the impact of the environment on the GMR stack, especially bottom-pinned spin-valves (SV), we focused on the influence of the cap layer on the thermal stability. From our studies, we conclude that a TaN cap layer acts as an effective diffusion barrier for oxygen, which means it is preventing effectively the GMR stack from being oxidized.

MA 32.35 Fri 11:15 Poster E

Low temperature ion bombardment combined with in-situ ac-susceptibility measurements — •Moritz Trautvetter, Ulf Wiedwald, and Paul Ziemann — Universität Ulm

As has been demonstrated previously, ion bombardment of magnetic films at optimized temperatures allows fine tuning of various magnetic properties like Curie-temperature, hysteretic behavior, exchange bias fields as well as magnetically relevant structural phase transitions. In many cases, it is desirable to find a relation between certain types of defects or of disorder and corresponding changes of a specific magnetic property. For this purpose, a new low temperature (T > 6K) ac-susceptometer was developed and combined with the beam-line of a 300 keV ion accelerator. The design of this system will be introduced and its performance demonstrated by first measurements on FePt films and nanoparticles.

MA 32.36 Fri 11:15 Poster E

Epitaktische PCMO Schichten auf (001) orientierten und vizinalen STO Substraten: — •Peter Moschkau, Jörg Hoffmann, Julia Fladerer und Christian Jooss — Materialphysik Universität Göttingen, Göttingen, Germany

PCMO zeigt im elektronischen Transportverhalten einen ausgeprägten kolossalen magnetoresistiven Effekt (CMR). Dieser wird zusätzlich, je nach Ordnungsgrad, durch die für die Messung benötigten elektrischen Ströme beeinflusst. Dies soll anhand von Strom-Spannungs-Kennlinien als Funktion der Temperatur und des Magnetfeldes diskutiert werden. Die Transporteigenschaften sind in weiten Bereichen durch das Model thermisch aktivierter Polaronen (TAP) deutbar. Der metallische Zustand in hohen Magnetfeldern wird als Übergang zu bandartigen leichten Polaronen interpretiert. Des Weiteren spielen, wie TEM-Ergebnisse zeigen, Defekte eine große Rolle für die Ausbildung einer Polaron-geordneten Phase. Untersuchungen an herstellungsbedingten Defekten (gepulste Laserdeposition, quenched disorder) sowie künstlichen periodischen Defekten (Verwendung vizinaler Substrate) und ihrer Ausheilung durch nachträgliche Auslagerung wurden durchgeführt. Es soll der Zusammenhang zwischen Struktur und elektrischen Transporteigenschaften sowie der Ordnung der Polaronen diskutiert werden.

MA 32.37 Fri 11:15 Poster E

An ab initio study of the surface energy of Fe, Co, Pt and their alloys — •Antje Dannenberg, Markus Ernst Gruner, and Peter Entel — Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

$L1_0$ ordered FePt and CoPt are considered as promising materials for ultra- high density magnetic recording applications due to their extraordinarily high magnetocrystalline anisotropy energy in the bulk phase. For nanoparticles this quantity is influenced by the shape and the structure of the cluster. Since the energies of surfaces and internal interfaces play an important role in determining the equilibrium shape of the particles, their analysis is of fundamental interest. Beginning with the elemental components Fe, Co and Pt, we present as a first step a systematic study of surface energies and electronic structure of low-indexed surfaces, which we extend to the binary alloys FePt and CoPt. The energies are calculated within density functional theory using the VASP code employing the PAW approximation and the GGA exchange-correlation potential. The surfaces were modeled within the slab approach using up to 16 layers whereby the periodic images were separated by a vacuum region corresponding to 8 layers.

MA 32.38 Fri 11:15 Poster E

Temperature dependent fast switching of magnetic nanoparticles — •Alexander Sukhov[1,2] and Jamal Berakdar[2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle/Saale, Deutschland — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Heinrich-Damerow-Straße 4, D-06120 Halle/Saale, Deutschland

We study the temperature-dependent spin dynamics of single-domain magnetic nanoparticles in the presence of a time-dependent magnetic field [1, 2] and/or spin-polarized currents [3, 4]. Our aim is to determine the conditions under which a fast magnetization switching is achievable with weak external drivings. Our work is based on the numerical and analytical solutions of the Landau-Lifshitz-Gilbert equation with temperature effects being implemented on the level of the Langevin dynamics.

[1] C. Thirion *et al.*, Nat. Mater. **2**, 524-527 (2003).
[2] A. Sukhov, J. Berakdar, Phys. Rev. B, submitted.
[3] J. C. Slonczewski, J. Magn. Magn. Mater. **159**, L1-L7 (1996).
[4] L. Berger, Phys. Rev. B **54**, 9353-9358 (1996).

MA 32.39 Fri 11:15 Poster E

Surface anisotropy and vortex states in ferromagnetic nanowires and nanotubes — •Andrei A. Leonov[1,2], Ulrich K. Rössler[1], and Alexei N. Bogdanov[1,2] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology

In ferromagnetic nanowires and nanotubes magnetic couplings induced by lateral surfaces can overcome the stray-field forces and stabilize inhomogeneous states where the magnetization vector rotates along or perpendicular to radial directions as Néel or Bloch vortex, respectively [1]. Depending on the surface anisotropy constants vortices are formed by a continuous rotation of the magnetization vector away from the homogeneous state with collinear longitudinal magnetization. Depending on the material and geometrical parameters different types of Néel and Bloch vortices can exist in nanowires and nanotubes. The phase diagram of the solutions includes stability regions of different vortex states and homogeneous phases with longitudinal or transverse magnetization separated by first- or second-order transition lines. Signatures of vortex states are discussed in relation to experimental observations on magnetization processes in magnetic nanowires. In particular, vortex states may be responsible for certain features of the magnetoresistance in nanowires. For nanotubes solutions for twisted states exist similar to the inhomogeneous phases in ferromagnetic nanolayers [2].

[1] U.K. Rößler, A. N. Bogdanov, K.-H. Müller, IEEE Trans. Magn. 38 (2002) 2586; [2] A. N. Bogdanov, U.K. Rößler, K.-H. Müller, J. Magn. Magn. Mat. 238 (2002) 155.

MA 32.40 Fri 11:15 Poster E

The oxidation behavior of FePt nanoparticles in $A1$ and $L1_0$ phase — •Luyang Han, Kuerbanjiang Balati, Ulf Wiedwald, Lianchen Shan und Paul Ziemann — Institut für Festkörperphysik, Universität Ulm, A.-Einstein-Allee 11, 89081 Ulm, Germany

Self-assembled arrays of FePt nanoparticles attract great attention due to their potential application as magnetic data storage media[1]. For an application the chemical stability of metallic nanoparticles against environmental conditions is critical. To prepare FePt nanoparticles, a micellar method is used, with which the composition and size of the particles can be well controlled[2,3]. The oxidation behavior of the nanoparticles is investigated using X-ray photoelectron and X-ray absorption spectroscopy. The 8 nm chemically disordered $A1$ FePt nanoparticles show surface passivation after exposure to ambient condition for a few hours and possibly a core-shell structure is formed. After annealling at $T > 600°C$ the metallic particles can be transformed partially to the chemically ordered $L1_0$ state, which exhibits increased resistance to oxidation.

[1]S. Sun, *Adv. Mater.*, **18**, 393, (2006)
[2]A. Ethirajan et al., *Adv. Mater.*, **19**, 406, (2007)
[3]U. Wiedwald et al., *Appl. Phys. Lett.*, **90**, 062508, (2007)

MA 32.41 Fri 11:15 Poster E

X-ray Absorption Fine Structure analysis of magnetite nanoparticles — •Masataka Kitagami[1], Masako Sakamaki[1], Takuma Kaneko[1], Takehisa Konishi[1], Takashi Fujikawa[1], Lin Lin[2], Jauyn Grace Lin[3], and Dimitri Arvanitis[4] — [1]Chiba University, Chiba, Japan — [2]National Changhua University of Education, Changhua, Taiwan — [3]National Taiwan University, Taipei, Taiwan — [4]Uppsala University, Uppsala, Sweden

Magnetite (Fe_3O_4) is an important magnetic material for applications, in particular for medicine and biology. The structural, electronic and magnetic state of the near surface region of magnetite nano-particles (of order 2-10 nm) is particularly important in this context. The magnetite nano-particles were characterized in particular, among other techniques, by means of X-ray diffraction, and magnetic susceptometry[1]. Here we present a X-ray Absorption Fine Structure (XAFS) characterization using both soft and hard X-rays at synchrotron radiation laboratories. Soft X-rays allow in particular to assess the nano-particle cleanness and stoichiometry. L-edge Fe XAFS indicates a different electronic state for the Fe atoms in the near surface region for small nanoparticle sizes. The results of the structural hard X-ray XAFS analysis are indicating a different local structure for the nanoparticles versus the bulk. In particular Fe K-edge XAFS indicates a octahedrally coordinated Fe atom rich nano-particle surface, in agreement with the Fe L-edge results. [1] K. H. Hsu *et al.*, J. Appl. Phys. **97**, 114322 (2005)

MA 32.42 Fri 11:15 Poster E

Quantitative Lorentz transmission electron microscopy of structured thin permalloy films — •Sergej Nepijko[1], Gerd Schönhense[1], and Josef Zweck[2] — [1]Institute of Physics, University Mainz, Staudingerweg 7, 5518 Mainz, Germany — [2]Institute of Experimental and Applied Physics, University Regensburg, 93040 Regensburd, Germany

Defocusing of the image, during of investigation of ferromagnetic particles with transmission electron microscope (Lorentz microscopy), gives the ability to determine the distribution of the magnetic field of the specimen, quantitatively. Measurements were done on permalloy disk-shaped particles with diameter of 50 nm and squares 70x70 nm2 and thickness of 10 nm. Disk-shaped particles exhibit a vortex structure, which was characterized with magnetic induction of 1.1 T. Square particles contained four domains, which produce a Landau-Lifshitz flux-closure structure. Value of magnetic induction of domain was also 1.1 T and the width of the 90 degrees Néel boundary between them was 4.5 nm. Stray field in edges of square particle reached 0.35 T.

MA 32.43 Fri 11:15 Poster E

On the magnetic properties of composites containing $CoFe_2O_4$ nano-particles — Béatrice Hallouet, •Carsten Volz, and Rolf Pelster — Universität des Saarlandes, Fachrichtung 7.2 Experimentalphysik, Campus E 2.6 , D-66123 Saarbrücken, Germany

We investigate ferrofluids consisting of nanoscaled single-domain magnetic particles ($CoFe_2O_4$, diameter 5-10nm) in an ethandiole matrix. These are characterized by means of temperature-dependent broadband magnetic spectroscopy up to 6 GHz. We focus on the behavior of the magnetic resonances, especially on the question how these depend on the microstructure, i. e. on the spatial distribution and the orientation of the particles. Non-random systems are obtained by applying a static magnetic field during sample preparation.

MA 32.44 Fri 11:15 Poster E

Fabrications and Detections of Biosensors Based on Giant Magneto-Resistance — •Ning-Ning Liu, Karsten Rott, Alexander Weddemann, Inga Ennen, Günter Reiss, and Andreas Hütten — Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany

Giant magneto-resistance (GMR) materials, which are widely used for read-heads and are good candidates for sensors, attracted more and more peoples. The objective of this contribution is to present a biosensor chip for single molecule detection. In this work, the fabrications of Copper/Permalloy and Copper/Cobalt multilayered GMR-sensors-chips employing e-beam lithography have been reported. 1μm sized Dynal MyOne beads have been used for the first detection. The design of the GMR sensor as well as the resulting GMR characteristics have shown and discussed.

Controlling bead coverage on the GMR sensors a calibration curve GMR versus relative coverage of Co nanoparticle has been determined. The sensor output signal linearly depends on the number of beads and single molecule detection could be demonstrated. We will show the characteristics of this biosensor chip for detecting relatively small magnetic nanoparticles, e.g., 5 to 15 nm sized Cobalt nanoparticles.

Physical aspect and possibilities related to the integration of this biosensor into the fluidic environment will be discussed in detail as well.

MA 32.45 Fri 11:15 Poster E

Interactions of magnetic particles in a rotational magnetic field and applications for particle manipulation — •Alexander Weddemann, Ahmed El-Gendy, and Simone Herth — Universität Bielefeld

Magnetic nanoparticles have a growing number of different applications in many different physical, chemical or medical fields. Nevertheless, in many cases several difficulties have to be overcome: Depending on the way of fabrication, the size distribution of the particles is often unknown making it not easy to make proper predictions on the particle behaviour within a physical or biological system. Particle-particle interactions are very strong at short distances leading to agglomerations of the particles. Such clustering of beads can result in a vanishing total magnetic moment, making them useless for certain applications. We introduce a new method to overcome such problems applying time dependent rotational or alternating magnetic fields to particle distributions. The behaviour has been analysed by simulations and in experiments in respect to frequency leading to different characteristic areas of particle behaviour. The influence of the particle diameter on particle movement is discussed as well. Applications of these studies include the avoidance of particle agglomeration, the alignment of elongated macromolecules by loading with magnetic particles, and a new way to determine particle size distributions.

MA 32.46 Fri 11:15 Poster E

Trends in spin exchange interactions and ferroelectric polarization in the orthorhombic $R\mathbf{MnO_3}$ series — Kunihiko Yamauchi[1], Frank Freimuth[2], Stefan Bluegel[2], Biplab Sanyal[3], Ivan Sergienko[4], Elbio Dagotto[4], and •Silvia Picozzi[1] — [1]CNR-INFM, L'Aquila (Italy) — [2]IFF, Forschungzentrum Jülich, Germany — [3]Uppsala Univ., Sweden — [4]Oak Ridge Natl. Lab. and Univ. Tennessee, TN (USA)

Recently, magnetic ferroelectricity induced by Heisenberg-type interactions has been theoretically predicted in E-type antiferromagnetic (AFM) $HoMnO_3$ [1]. In order to fully clarify this unconventional microscopic mechanism, we've studied the structural, magnetic and ferroelectric properties for the entire family of orthorhombic $R\mathrm{MnO_3}$ (R= rare earth ions), based on first-principles density functional calculations. The ferromagnetic exchange interaction between nearest-neighbor Mn sites decreases with the ionic radius of R (concomitantly with the in-plane Mn-O-Mn bond angle), whereas the antiferromagnetic next-nearest neighbor interaction stays rather constant in the series. The competition of these exchange interactions results in a complicated magnetic phase diagram. The decrease in the Mn-O-Mn angle also affects the hopping integrals between Mn ions (as determined from Wannier functions), so that the calculated electric polarization in E-type AFM $R\mathrm{MnO_3}$ is remarkably reduced throughout the rare earth series.

[1] S. Picozzi et al., Phys. Rev. Lett. (in press).

MA 32.47 Fri 11:15 Poster E

Magnetic and thermodynamic studies of $\mathbf{R(Mn,Fe,Co)_2O_5}$, $\mathbf{(Bi,Sm)MnO_3}$ and $\mathbf{Bi(Fe,Ni)O_3}$ — •Norman Leps[1], Nadja Wizent[1], Dmitri Souptel[1], Rüdiger Klingeler[1], Christian Hess[1], Natalia Tristan[1], Günter Behr[1], Matthias Lutz[1], Sang Wook Cheong[2], and Bernd Büchner[1] — [1]IFW-Dresden, P.O. Box 270116, D-01171 Dresden — [2]Department of Physics and Astronomy, Rutgers, The State University of New Jersey, 136 Frelinghuysen Road, Piscataway, NJ 08854-8019 USA

The simultaneous appearance of magnetic and electric ordering in frustrated spin systems offers the potential for novel electromagnetic building blocks. Among the frustrated spin systems rare earth manganates RMn_2O_3 (R=Y, Tb, Ho) and the perovskites $BiMnO_3$ and $BiFeO_3$ exhibit multiferroic properties. The magneto-electric coupling, however, is very small in all cases and the frustrated antiferromagnetism delimits the achievable tuning of the magnetization via an external electrical field, or vice versa, the spontaneous polarization via a magnetic field. We hence have systematically studied the effect of different doping on both the magnetic and the A-sites of the respective materials. To

be specific, the influence of the cations was investigated by partially substituting Mn by Fe or Co in RMn_2O_5 and Ni in $BiMnO_3$, respectively. The role of the electronic subsystem was investigated by partial substitution of Bi by Sm in $BiFeO_3$. Our magnetization and specific heat measurements of the doped materials provide the phase diagrams which are discussed with respect to the multiferroic properties.

MA 32.48 Fri 11:15 Poster E

Resonant soft x-ray scattering from $DyMnO_3$ — •Enrico Schierle, Victor Soltwisch, Detlef Schmitz, Ralf Feyerherm, Dimitri Argyriou, and Eugen Weschke — Hahn-Meitner-Institut, Berlin, Germany

The multiferroic compound $DyMnO_3$ was studied by resonant x-ray scattering at the Dy-M_5 and Mn-L_2 resonances in the temperature range between 5 K and 50 K. The element-selective resonant method permits to study ordering of the Dy-4f and Mn-3d moments seperately, revealing noticeable differences in the character of the ordered moments in the sinusoidal and the helical ferroelectric phase. From the energy dependence of the scattering cross section across the resonances details about ordering of magnetic moments and orbital wave functions can be inferred.

MA 32.49 Fri 11:15 Poster E

Multiferroic effect in epitaxial $TbMnO_3$ films — •Joost de Groot[1], Emmanuel Kentzinger[1], Jürgen Schubert[2], Stefan Mattauch[1], and Thomas Brückel[1] — [1]Forschungszentrum Jülich Gmbh D52425 Jülich IFF-4: Streumethoden — [2]Forschungszentrum Jülich Gmbh D52425 Jülich IBN 1-IT

$TbMnO_3$ belongs to a class of rare earth manganites showing multiferroic behaviour. The strong magnetoelectric effect is expected to depend on the dimensionality of the system and on epitaxial strain in thin films. We have grown epitaxial $TbMnO_3$ films of different thicknesses (5-100nm) using Pulsed Laser Deposition on $LaAlO_3$ and $SrTiO_3$ substrates. We analysed the films by x-ray diffraction on a four-circle diffractometer and determined the twinings effects quantitatively. We will report on the thickness dependence of magnetization and electrical polarization as well as on scattering experiments using soft x-ray resonant magnetic scattering and polarized neutron reflectometry.

MA 32.50 Fri 11:15 Poster E

Atomic Layer Deposition and Characterization of $BiFeO_3$ Thin Films — •Philipp Leufke[1], Jens Ellrich[1], and Horst Hahn[1,2] — [1]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [2]Fachbereich Material- und Geowissenschaften, Petersenstrasse 23, TU Darmstadt, 64287 Darmstadt, Germany

We report on the deposition of multiferroic thin films of bismuth ferrite ($BiFeO_3$) [1] by ALD (atomic layer deposition) using different Fe and Bi precursors at various deposition conditions.

Surface morphology and crystal structure of the prepared thin films are investigated by means of scanning electron microscopy and X-ray diffraction. Energy-dispersive X-ray spectroscopy is employed for chemical analysis.

The magnetic properties are explored via superconductive quantum interference device magnetometry, measurement of the magnetooptical Kerr effect and depth selective conversion electron Mößbauer spectroscopy, with regard to the disagreements raised by former studies on pulsed laser deposited $BiFeO_3$ thin films [2].

[1] W. Eerenstein et al., *Nature* **442**, 759-765 (2006)
[2] (a) J. Wang et al., *Science* **299**, 1719-1722 (2003); (b) W. Eerenstein et al., *Science* **307**, 1203a- (2005); (c) J. Wang et al., *Science* **307**, 1203b- (2005)

MA 32.51 Fri 11:15 Poster E

Coupling of structure and magnetism in multiferroic $RFe_3(BO_3)_4$: Magnetostriction and thermodynamic studies — •Liran Wang[1,2], Rüdiger Klingeler[1], Natalia Tristan[1], Christian Hess[1], Bernd Büchner[1], Martin Philipp[1], Leschner Janet[1], Norman Leps[1], Olga Kataeva[1,3], Elena Popova[4], Alexander Vasiliev[4], and L.N Bezmaternykh[5] — [1]Leibniz-Institute for Solid State and Materials Research IFW Dresden,Dresden,Germany — [2]IMPRS,Dynamical Processes in Atoms Molecules and Solids,Nöthnitzer Str.38,Dresden,Germany — [3]A.E.Arbuzov Institute, Russian Academy of Science,Arbuzov Str.8,Kazan,Russia — [4]Physics Faculty,Moscow State University,Moscow,Russia — [5]L.V.Kirensky Institute of Physics,Siberian Branch of RAS, Kransnoyarsk, Russia

Rare earth ferroborates exhibit a rich phase diagram owing to the interplay 3d- and 4f-electrons. This interplay gives rise to an interesting structural and magnetic properties and it was found recently that at least two compounds of this series, i.e. R = Gd, Nd, exhibit multiferroism at low temperatures. Here, we present magnetostriction, thermodynamic and dielectric measurements on $TbFe_3(BO_3)_4$, $DyFe_3(BO_3)_4$ and $NdFe_3(BO_3)_4$ single crystals. The data show that, in the antiferromagnetically Fe-spin ordered phase below T_N at nearly 40K, there is a field induced spin-flop of the Fe spins superimposed by a spin-flip of the rare earth moments. This transition is accompanied by significant structural changes. The results are discussed in terms of a mean-field coupling model between the 3d- and the 4f-subsystem.

MA 32.52 Fri 11:15 Poster E

Investigation of multiferroic properties in $MnWO_4$ by SHG-spectroscopy — •Michael Maringer[1], Dennis Meier[1], Thomas Lottermoser[1], Gouliang Yuan[1], Petra Becker[2], Ladislav Bohatý[2], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn — [2]Institut für Kristallographie, Universität zu Köln

Magnetoelectric multiferroics, i.e. compounds displaying magnetic and ferroelectric order in the same phase, attract considerable attention from the point of view of potential device application as well as fundamental physics. In the so-called spin-spiral compounds the interaction is particularly pronounced. Here we introduce optical second harmonic generation (SHG) as a powerful tool for the study of magnetic and eletronic properties and their magnetoelectric interaction in spin-spiral compounds, taking $MnWO_4$ as an example. SHG gives detailed information about the symmetry of crystalline phases and about symmetry changes caused by phase transitions. In particular, in $MnWO_4$ the (anti)ferromagnetic incommensurate phase and the magnetically induced ferroelectric, state are investigated. Although the magnetically induced spontaneous polarization is about four orders of magnitude weaker than in a conventional ferroelectric, a pronounced SHG signal is obtained.

This work was supported by the DFG through SFB 608

MA 32.53 Fri 11:15 Poster E

Magnetoelastic coupling of $La_{0.7}Sr_{0.3}MnO_3$ films near the structural phase transition in $SrTiO_3$ — •Michael Ziese[1], Annette Setzer[1], Pablo Esquinazi[1], Ionela Vrejoiu[2], and Dietrich Hesse[2] — [1]Division of Superconductivity and Magnetism, University of Leipzig, Leipzig, Germany — [2]Max Planck Institute of Microstructure Physics, Halle, Germany

$La_{0.7}Sr_{0.3}MnO_3$ (LSMO) films were grown on vicinal (miscut angle 0.1°) $SrTiO_3$ (100) substrates by pulsed laser deposition at an oxygen partial pressure of 200 mTorr and a substrate temperature of 600°C. XRD and TEM cross-sectional investigations showed heteroepitaxial growth with excellent structural quality of the LSMO layer. Three films with thickness of 40, 15 and 5 nm, respectively, were selected for further magnetic characterization by SQUID magnetometry and ac susceptometry. In agreement with the high structural quality the films were found to be magnetically very soft with coercive fields below 1 mT near 100 K. These low coercivities enabled a detailed study of the coupling between the magnetic properties of the LSMO films and structural distortions that occur below the structural transition in the $SrTiO_3$ substrates. Below 105 K the development of a two-step transition in the magnetic response is clearly observed. This is discussed in terms of the formation of two different types of magnetic domains with different coercivities in the LSMO film as a response to twinning in the $SrTiO_3$ substrate.

MA 32.54 Fri 11:15 Poster E

Structure and magnetism of multiferroic hexagonal $HoMnO_3$ — •Jong-Woo Kim[1], Kathrin Dörr[1], Konstantin Nenkov[1], Ludwig Schultz[1], Bas B. van Aken[2], and Manfred Fiebig[2] — [1]Institute for Metallic Materials, IFW, Dresden, Germany — [2]HISKP, Universität Bonn, Germany

Multiferroics which show more than two ferroic orders simultaneously in the same phase have got considerable attention recently due to their academic and industrial significance. Among the candidates, hexagonal $HoMnO_3$ has been revealed as most promising single-phase multiferroics for its strong magnetoelectric effect [1,2]. We have grown twin-free epitaxial $HoMnO_3$ films of thicknesses from 25 nm to 1 μm on (111) Y:ZrO_2 (YSZ) substrates by pulsed laser deposition (PLD). Mag-

netization measurements reveal several anomalies related with magnetic Ho ordering in the magnetic field vs temperature phase diagram. These anomalies differ in details from those of single crystals, possibly due to the effect of epitaxial strain. We depict a rough phase diagram of both a $HoMnO_3$ film and a single crystal. With non-linear optics (second harmonic generation), the ferroelectric polar order of the films has been observed [3]. For the investigation of magnetoelectric properties, trilayer capacitor structures using an epitaxial Pt bottom electrode have been prepared. The electric polarization measurements show ferroelectric switching at 300 K.

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[2] T. Lottermoser, et al., Nature 430, 541 (2004)
[3] J.-W. Kim et al., Appl. Phys. Lett. 90, 012502 (2007)

MA 32.55 Fri 11:15 Poster E

Current and Field Induced Domain-Wall Motion in Permalloy Nanowires — •Gesche Nahrwold, Lars Bocklage, Hannah Ziehlke, Toru Matsuyama, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg

Magnetic domain walls in nanowires have attracted a lot of interest because of their possible application in logic and memory devices. A novel concept is based on electric currents that push magnetic domain walls along nanowires. This motion can be detected by measuring the anisotropic magnetoresistance (AMR)[1]. We present results obtained in curved permalloy wires where domain walls are pushed by current pulses with durations in the nanosecond range. By an externally applied magnetic field the domain wall is induced at a well defined position in the curved region of the wire. Measurements of the AMR verify the presence of the walls. The resistance values before and after a current pulse indicate whether the domain wall has been depinned and moved out of the wire or not. We observe a strong dependence of the depinning efficiency on the pulse length with a threshold of 1 ns. We found indications that deposition at elevated substrate temperatures is promising to attain a higher quality of the permalloy which is essential to avoid unwanted pinning centres for domain walls. Films sputtered at 400 °C have a dramatically smaller specific resistance compared with those sputtered at room temperature. [1] L. Thomas, M. Hayashi, X. Jiang, R. Moriya, C. Rettner, and S. S. P. Parkin, Nature 443, 197 (2006).

MA 32.56 Fri 11:15 Poster E

Current induced switching in MgO-based MTJs with applied bias fields — •Markus Schäfers, Andy Thomas, Karsten Rott, and Günter Reiss — Bielefeld University, Universitätsstraße 25, D-33615 Bielefeld, Germany

The spin-torque effect in magnetic tunnel junctions can be used in future MRAM applications to minimize the size of the memory cell. To provide high read and write performance of such an MRAM modul the switching behaviour of the free layer in the magnetic tunnel junction must be well understood.

We prepared sub-μm-sized MTJs based on CoFeB/MgO/CoFeB by e-beam lithography and argon ion beam etching. The dependence of critical current density for switching the free layer on the applied bias field was investigated.

MA 32.57 Fri 11:15 Poster E

Magnetization dynamics triggered by THz magnetic field pulses — •Jakob Walowski[1], Zhao Wang[1], Benjamin Lenk[1], Malte Scherff[1], Markus Münzenberg[1], Mihail I. Lepsa[2], and Arno Förster[3] — [1]IV. Physikalisches Institut, Universität Göttingen, Germany — [2]Forschungszentrum Jülich (IBN-1) — [3]Fachhochschule Aachen

A gapped Al strip line structured on low temperature GaAs delivers a metal-semiconductor-metal contact, which acts as a fast photo conductive switch. Using ultrashort light pulses (~ 60 fs) from a Ti:Sapphire laser (pump beam), excites the carriers of the semiconductor (GaAs) and induces short electric pulses. A short magnetic pulse ($1-5$ ps, ~ 400 mT, ~ 20 mA depending on the gap shape) is generated during the current. This pulse triggers the magnetization dynamics of a thin film structured on top of the Al strip line. Changing the path length of the laser pump beam one can probe the magnetization dynamics by recording the Kerr rotation up to 1 ns after excitation (TRMOKE).

Increasing the area of the contact, by structuring the strip line interruption in a finger like shape, increases the current pulse and therewith the field pulse strength and delivers shorter pulses. A sub 10 ps response of the magnetic film is shown.

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MA 32.58 Fri 11:15 Poster E

Femtosecond laser Kerr microscopy — •Jie Li, Min-Sang Lee, Wei He, Björn Redeker, and Thomas Eimüller — Junior Research Group Magnetic Microscopy, Ruhr-University Bochum, D-44780 Bochum, Germany

We present a new femtosecond laser Kerr microscope which has both scanning and full-field imaging capabilities. This instrument combines a lateral resolution in the sub-micrometer regime with a temporal resolution of better than 100 fs. The magnetic sample is thermally pumped by the fundamental beam and probed by the frequency-doubled beam via the magneto-optical Kerr effect (MOKE) in polar or longitudinal geometry. Double lock-in technique using a photo-elastic modulator (50 kHz) and an optical chopper (80 Hz) leads to very high sensitivity. In the scanning mode a three-axis piezo stage with a sub-nanometer resolution and 400 μm scan range in all directions is used. Full-field Kerr microscopy is possible by destroying the lateral coherence of the laser light with a rotating disc and detecting the image with a CCD camera. A cryostat allows measurements in the temperature range from 3.5 to 450 K. Instrument controlling software, developed on Visual Studio .Net, enables multi-dimensional scans, e.g., the MOKE signal can be recorded for arbitrary combination of six parameters (sample position, magnetic field, pump-probe delay time, and temperature). First time-resolved studies on Fe/Gd, Co/Ni and Co/Pt multilayer systems will be presented.

Financial support by the DFG via project SFB491-N1 is gratefully acknowledged.

MA 32.59 Fri 11:15 Poster E

Layer resolved magnetization dynamics in coupled ferromagnetic bilayers using time resolved X-ray magnetic circular dichroism — •Tobias Martin[1], Georg Woltersdorf[1], Christian Stamm[2], Hermann Dürr[2], Roland Mattheis[3], Christian Back[1], and Günther Bayreuther[1] — [1]Universität Regensburg, 93040 Regensburg — [2]Bessy, 12489 Berlin — [3]IPHT Jena e. V., 07745 Jena

Two ferromagnetic layers antiferromagnetically coupled by interlayer exchange, usually called a synthetic antiferromagnet, evolve to important layer systems for storage applications, e.g. as free layer in toggle-switching magnetic random access memory or as storage medium in hard disk drives. Because of the growing operation speed of such devices, the investigation of the magnetization dynamics in interlayer exchange coupled magnetic bilayers with layer resolution is of interest.

Here, interlayer exchange coupled $Co_{90}Fe_{10}/Ru/Ni_{81}Fe_{19}$ bilayers are investigated using time resolved X-ray magnetic circular dichroism in transmission. By detecting the dichroic signal at the Ni or Co L_3 absorption edge with time resolution, the magnetization dynamics of the individual magnetic layers is observed separately. Two different waveguide stack geometries allow for in-phase and anti-phase excitation of both layers using both, pulsed and continuous wave (cw) excitation. Using cw-excitation the layer resolution allows the direct observation of in-phase or anti-phase precession for acoustical and optical mode, respectively. With pulsed excitation we were able to observe a phase shift of the precessional signal due to coupling.

MA 32.60 Fri 11:15 Poster E

Spin dynamics in permalloy antidot lattices: Experiment and simulation — •Sebastian Neusser[1], Bernhard Botters[1], Jesko Topp[2], Jan Podbielski[2], Detlef Heitmann[2], and Dirk Grundler[1] — [1]Fakultaet fuer Physik E10, Technische Universitaet Muenchen, D-85748 Garching, Germany — [2]Institut fuer angewandte Physik, Universitaet Hamburg, Jungiusstr. 11, D-20355 Hamburg, Germany

Spin wave modes in a submicron antidot lattice structured into a polycrystalline Ni80Fe20 thin film are being investigated with both a broadband ferromagnetic resonance (FMR) technique in a coplanar waveguide setup [1] and time-dependent micromagnetic simulations. Comparison between experiment and simulations allows us to correlate FMR absorption lines with the spatio-temporal evolution of spin dynamics and magnon interference phenomena [1]. In our study we focus on the expected magnon mode splitting [2] in a periodic lattice. The authors thank the DFG for financial support via SFB668 and the "Nanosystems Initiative Munich (NIM)" funded within the German Excellence Initiative.

[1]J. Podbielski, F. Giesen, and D. Grundler, Phys. Rev. Lett. 96, 167207 (2006)
[2]J. Podbielski, D. Heitmann, and D. Grundler, unpublished.

MA 32.61 Fri 11:15 Poster E

Brillouin light scattering observation of the spin wave dynamics in magnonic crystals — •Andrii Chumak, Alexander Serga, and Burkard Hillebrands — FB Physik and FSP MINAS, TU Kaiserslautern, Germany

Artificial media based on periodic magnetic structures, so-called magnonic crystals, offer wide tunability of their electromagnetic parameters and are an excellent object for the investigation of linear and nonlinear spin-wave dynamics. We report on the design and test of one-dimensional yttrium-iron-garnet (YIG) film-based magnonic crystals. The periodical structure of grooves on the film surface was produced using photolithography and chemical etching techniques. The grooves were perpendicularly oriented with respect to the spin-wave propagation direction. The microwave spectra were measured for different crystal geometrical parameters and, in particular, for different depth of the grooves. Spectrum rejection bands were clearly observed. The bands width and deepness increase with increasing grooves depth. This can be explained by an increase of the interaction of the "pure" magnonic crystal (groove structure on the YIG film surface) with the underlaying uniform magnetic film. The reflection of spin wave packets, compression and localization (storage) in the magnonic crystal area were detected using the space- and time-resolved Brillouin light scattering technique.

MA 32.62 Fri 11:15 Poster E

Very fast domain wall (dw) propagation in permalloy nanowires under the influence of strong transversal fields — •Sascha Glathe and Roland Mattheis — IPHTJena e.V., A.-Einstein-Str.9, D-07745 Jena

The field driven dw movement was explored in 150 nm wide, 15 nm thick and 45000 nm long permalloy films, which are the sense layer of GMR-stacks. In addition to the usually applied longitudinal fields parallel to the wire axis we applied strong fields orthogonal to the wire axis. Under the influence of a transversal field of Ht = 50 kA/m we observed very high dw velocities of about 7000 m/s. This is about 4-5 times the maximum field driven velocity puplished in the literature [1]. We explain this fast dw propagation with the influence of the transversal field on the dw.

MA 32.63 Fri 11:15 Poster E

Non-linear influences of inhomogeneous current distribution on vortex dynamics — •Stellan Bohlens and Daniela Pfannkuche — I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg

For the development of new memory devices it is important to investigate the mechanisms of coupling between magnetization and electrical current. The orientation of the local magnetization influences the current flow via the anisotropic magneto resistance (AMR). Vice versa the current influences the magnetization via its Oersted field and the spin-transfer-torque. We investigate the effect of inhomogeneous current distributions on different magnetization patterns by micromagnetic simulations. The mutual influence of inhomogeneous current distribution and magnetization pattern causes non-linear effects. Taking these effects into account interesting deviations occur compared to the homogeneous case. A vortex pattern excited by a homogeneous alternating current performs harmonic oscillations. If inhomogeneous current paths are taken into account the amplitude of the oscillation is strongly enhanced and deviations from the ellipsoidal orbit occur.

MA 32.64 Fri 11:15 Poster E

Brillouin light scattering microscopy on magnetization dynamics in spin torque nanocontacts — •Sebastian Hermsdörfer[1], Xavier Janssens[2], Sven Cornelissen[2], Maarten van Kampen[2], Helmut Schultheiss[1], Britta Leven[1], Andrei N. Slavin[3], Liesbet Lagae[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and FSP MINAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]IMEC, Kapeldreef 75, Leuven, Belgium — [3]Oakland University, Rochester, Michigan, USA

Here we report on investigations of the magnetization dynamics in spin-torque nanocontacts under the influence of an applied ac and dc current. The magnetic resonances are determined with Brillouin light scattering microscopy for different externally applied magnetic fields. For the observed resonance frequencies the spin-wave radiation patterns are studied with high spatial resolution. Furthermore, nonlinear effects are observed and can be explained by three-magnon-scattering. A shift of the power threshold for these nonlinear processes is observed when a dc current is applied in addition to the ac current. We demonstrate that the threshold and efficiency of the three-magnon-scattering can be strongly enhanced or reduced depending on the direction of the dc current. This is clear evidence that internal damping due to magnon scattering can be tuned by a dc current. Support by the DFG within the SPP 1133 and by the EC-MRTN SPINSWITCH (MRTN-CT-2006-035327) and EC-Dynamax (IST-033749) is acknowledged. MvK acknowledges the IWT Flanders for financial support.

MA 32.65 Fri 11:15 Poster E

Ferromagnetic resonance study of interlayer exchange-coupled NiFe/Ru/NiFe films. — Mohamed Belmeguenai[1], •Tobias Martin[1], Georg Woltersdorf[1], Vincent Baltz[2], Anna Suszka[2], Bryan Hickey[2], and Günther Bayreuther[1] — [1]Institut f. Exper. und Angew. Physik, Universität Regensburg, 93040 Regensburg — [2]University of Leeds, Leeds, UK

Vector network analyzer ferromagnetic resonance spectroscopy (VNA-FMR) was used to study the different excited modes of sputtered symmetric [NiFe(30nm)/Ru(d_{Ru})/NiFe(30nm)] and asymmetric [NiFe(13.6nm)/Ru(d_{Ru})/NiFe(27.2nm)] exchange-coupled Permalloy films with variable Ru thicknesses, d_{Ru}. Always an optic and an acoustic precessional mode is observed. For the conventional geometry with dc bias field and rf field perpendicular to each other the optic mode was only observed over a limited field range. This restriction was overcome by orienting the bias and rf field parallel to each other. The variation of the mode frequencies with the dc field was directly related to the different magnetic states of the two NiFe layers. Interestingly, in asymmetric trilayers characteristic jumps were observed for the resonance field as a function of the dc bias field. This "anti-crossing"behavior is well reproduced by numerical simulations, as well as the effect of the biquadratic coupling on the mode frequency.

MA 32.66 Fri 11:15 Poster E

Femtosecond X-ray Spectroscopy on Ni — •Niko Pontius, Christian Stamm, Torsten Kachel, Marko Wietstruk, Hermann A. Dürr, and Wolfgang Eberhardt — BESSY m.b.H., Albert-Einstein-Str. 15, 12489 Berlin, Germany

We use fs x-ray pulses as a probe to investigate spin and electron dynamics of a thin Ni film that is excited by a fs laser pulse. Spin and orbital magnetic moments can be determined individually using sum rules of the x-ray magnetic circular dichroism (XMCD). In our pump-probe experiment, we unambiguously find that fs laser excitation is causing an ultrafast quenching of the spin moment, which is not compensated by a corresponding increase of orbital moment. As angular moment is conserved, we conclude that the quenched spin moment is transferred to the lattice on the fs time scale.

The experiments were performed at the BESSY Femtoslicing source. It is capable of generating x-ray pulses of about 100 fs duration with linear as well as circular polarization. The photon energies range from 400-1200 eV, allowing for x-ray absorption measurements of the 3d transition and rare-earth elements.

MA 32.67 Fri 11:15 Poster E

Bias dependence of the spin transfer torque in Fe/MgO/Fe — •Christian Heiliger[1,2], Paul M. Haney[1], and Mark D. Stiles[1] — [1]Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD 20899-6202 — [2]Maryland NanoCenter, University of Maryland, College Park, MD, 20742

Recent experiments [1,2] have reached contradictory conclusions regarding the out-of-plane component of the spin transfer torque in Fe/MgO/Fe tunnel junctions. We use ab initio calculations as well as model calculations to investigate the bias dependence of the spin transfer torque in tunnel junctions. We use the non-equilibrium Keldysh formalism implemented in a Korringa-Kohn-Rostoker method to calculate the spin transfer torque [3]. We find that under certain circumstances one can estimate the bias dependence of the spin transfer torque at small biases in terms of the non-equilibrium torques at the Fermi level for zero bias. In ideal Fe/MgO/Fe junctions we find a small linear dependence of the out-of-plane torque on voltage. However, this torque oscillates rapidly with layer thicknesses and should cancel in samples with realistic roughness. This work has been supported in part by the NIST-CNST/UMD-NanoCenter Cooperative Agreement.

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[2] J. C. Sankey et al., Phys. Rev. Lett. 96, 227601 (2006).
[3] C. Heiliger et al., J. Appl. Phys. (in press); arXiv:0711.2082.

MA 32.68 Fri 11:15 Poster E

Current-Induced Excitations in ferromagnetic Tri-Layer Nanopillars — •Malte Scherff, Markus Münzenberg, Anne Parge, Tore Niermann, and Michael Seibt — IV.Phys. Inst., Georg-August-Universität Göttingen

In this work we would like to present the results of angular momentum transfer studies of ferromagnet/ normal metal/ ferromagnet trilayer junctions with high magnetic fields. Magnetic field sweeps at different temperatures and orientations will be shown and compared with GMR-measurements for consistence.

All experiments have been performed on nanopillars with a diameter of ˜100 nm,which are fabricated in a simplified one step process: Holes are created into a thin PMMA film by e-beam lithography and filled with different metal layers by evaporation.

To improve the preparation parameters, structural analysis has been done by simple cross sectional views as well as accurate TEM measurements of lamella-samples prepared by focused ion beam.

The transport properties were obtained in a four point measurement configuration, where the differential resistance dV/dI was measured by a lock-in technique in an external magnetic field. For sufficiently large DC current densities anomaly changes of resistance were observed(up to 20%). The dynamic and static changes of resistances at fields up to 5T suggest the existence of strong current driven inhomogenious magnetisation with vortex states in the layer system.

Also electrical aging effects of pillars during longer measurement periods are discussed. This work was supported by DFG, SPP 1133.

MA 32.69 Fri 11:15 Poster E

Spin tunneling in molecular magnets on a dissipative environment — •juan manuel florez, patricio vargas, and alvaro nuñez — Physics Department, Universidad Técnica Federico Santa María, P.O.Box 110-V,Valparaíso, Chile

We report on our latest progress on the theoretical study of dissipative effects on the tunneling properties of the spin degree of freedom in molecular magnets. Starting from a simple microscopic model of the interaction between the molecule and an environment we characterize generic consequences of the dissipative effects on the tunneling process. The dynamic changes of the spin degree of freedom are evaluated within a suitable generalized instanton approximation in order to characterize the sensitivity of the tunneling variables to the degrees of freedom of the thermal environment. In particular the tunneling rates and their field dependence are described in detail.

MA 32.70 Fri 11:15 Poster E

Unusual NMR linebroadening and spin lattice relaxation in the Ca-doped S=1/2 spin chain compound $SrCuO_2$ — •Franziska Hammerath, Hans-Joachim Grafe, Anja Wolter, Vladislav Kataev, Patrick Ribeiro, Christian Hess, and Bernd Büchner — IFW Dresden, Institut für Festkörperforschung, Postfach 270116, 01171 Dresden

We present ^{63,65}Cu Nuclear Magnetic Resonance (NMR) measurements on undoped $SrCuO_2$ and Ca doped $Sr_{0.9}Ca_{0.1}CuO_2$ single crystals. The crystal structure contains one dimensional CuO_2 double chains that are magnetically decoupled. The system orders magnetically only below 1.5 K. Nevertheless, the Cu NMR spectra broaden already at temperatures below 100 K and show an anomalous two peak structure at low temperatures. For the Ca doped sample, this broadening is reduced. The reason for this unusual broadening is not known, but a similar broadening has been reported for the single chain compound Sr_2CuO_3. The spin lattice relaxation rate, $1/T_1$, is temperature independent. This is typical for spin chains and has also been reported for Sr_2CuO_3. Surprisingly, non-magnetic Ca induces a gap like behaviour in $1/T_1$.

MA 32.71 Fri 11:15 Poster E

Spin diffusion in metals: ab initio treatment of impurity scattering — •Peter Zahn, Martin Gradhand, Dmitry Fedorov, and Ingrid Mertig — Dept. of Physics, Martin Luther University Halle-Wittenberg, D-06099 Halle, Germany

One of the main issues of spintronics is the spin relaxation, which determines the spatial extension of spin accumulation in Spin Hall experiments, and the spin diffusion length in spin injection experiments. We consider the Elliott-Yafet mechanism caused by the scattering at point defects. The electronic structure of the metallic host and the perturbation of the potential in the vicinity of the defects is calculated in the framework of density-functional theory using a multiple scattering Green's function Korringa-Kohn-Rostoker scheme. The spin-orbit coupling is treated as a perturbation in first order of the Born series expansion of the transition matrix. In the first implementation of the formalism its action is restricted to the impurity site. Our calculations give the momentum and spin relaxation time of conduction electrons in Cu containing different types of impurities in good agreement with residual resistivity measurements and CESR results. The situation is less satisfying for the case of Al and Mg hosts with defects of comparable core charge. In these cases a relativistic treatment is necessary to obtain the so-called spin hot spots on the Fermi surface correctly. These states with a strong spin-mixed character cause a strong spin relaxation due to the chemical potential scattering by the defects. First results are discussed.

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Rabi Oscillations in a Mn doped Quantum Dot — •Doris E. Reiter[1], Svea Sauer[1], Vollrath Martin Axt[2], and Tilmann Kuhn[1] — [1]Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str.10, 48149 Münster — [2]Institut für Theoretische Physik III, Universität Bayreuth, 95440 Bayreuth

The understanding of spin flips in diluted magnetic semicondutors is of fundamental interest for the application to quantum technologies. Recent experimental results prove the fabrication of a single semiconductor quantum dot with a single Mn atom. When an exciton is present in this system the PL line splits up, clearly showing the influence of the Mn spin. We analyze the ultrafast dynamics of exciton and Mn spin after optical excitation in the presence of the Mn-exciton exchange interaction. The temporal behavior of both exciton state and Mn state exhibits a spin flip, which can also be described by Rabi oscillations between a bright and a dark exciton state accompanied by oscillations in the spin orientation of the Mn atom. By means of ultrashort laser pulses the Mn spin can thus be raised or lowered by one on a time scale of a few picoseconds.

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Investigation of multiferroics with ultrafast nonlinear optics — •Tim Günter[1], Tim Hoffmann[1], Takuya Satoh[2], Thomas Lottermoser[1], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn, Germany — [2]Institute of Industrial Science, University of Tokyo, Japan

The dynamic properties of multiferroics and thin multiferroic films (except $BiFeO_3$) have been rarely studied so far. Here, a femtosecond laser setup is introduced that allows us to investigate both aspects. High time resolution is required for the investigation of dynamical properties and high peak intensities are needed for obtaining detectable SHG signal from thin films. In our fs-laser setup we use an amplified 130 fs Ti:Sapphire laser with 2,5 mJ pulse energy for operating two independent workplaces. Each branch is supplied with an optical parametric amplifier covering a wavelength range from 520 nm to 2600 nm. In the first branch, we use a pump-and-probe setup where optical second harmonic generation (SHG) is employed as probe process because many multiferroics are antiferromagnetic. Delays of up to 12 ns are set by use of a four-pass delay line. By setting different polarization configurations for each delay time, both the amplitude and the phase of the SHG signal are determined with high accuracy. In the second branch, the domain topography of thin multiferroic films is investigated. For this purpose, a transmission and reflection SHG setup with a CCD camera as detector is used. First experiments on the magnetization dynamics of magnetoelectric Cr_2O_3 and the magnetic properties of multiferroic $HoMnO_3$ films are reported.

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The role of bandstructure on the ultrafast magnetization dynamics — •Daniel Steil, Tobias Roth, Mirko Cinchetti, and Martin Aeschlimann — TU Kaiserslautern, Erwin-Schrödinger Str. 46, 67663 Kaiserslautern

Herein we report on the effect of the electronic bandstructure on the spin dynamics. In a comparative study the 3d ferromagnet Co and the Heusler alloy Co_2MgSi, both with strongly deviating bandstructures, were investigated by means of the time resolved MOKE. The focus was put on the ultrafast magnetization dynamics following an optical excitation with a high intensive femtosecond laser pulse. The behaviour of the first ultrafast demagnetization step is similar for both materials. In contrast, the process of thermalization between the participating subsystems is delayed in the case of the Heusler alloy. We ascribe this as a distinct signature of a blocked Elliot-Yafet like scattering due to

the bandgap in Co_2MgSi.

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Investigating the Spin Dynamics in Nanostructures at Finite Temperature — David Bauer, Samir Lounis, Phivos Mavropoulos, and •Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich

Reading and writing magnetic information on the nanometer scale is one of the key issues in magnetism for information technology. We investigate the dynamics of the magnetization in nanoscale systems on the basis of a classical spin model including e.g. Heisenberg exchange, magnetic anisotropy and an external magnetic field. The spin-system is coupled to a heat-bath through a stochastic force within the Langevin approach [1]. This requires the solution of the stochastic Landau-Lifschitz equations. The pairwise exchange interaction parameters entering our atomistic model are extracted from density functional theory (DFT) calculations. We present preliminary results on the spin dynamics of different nano-objects like monoatomic chains and small islands and investigate the relaxation of the spin-system upon different external parameters such as change of temperature or external magnetic field. Moreover, the thermodynamical properties are shown to be in excellent agreement to those obtained by Monte Carlo simulations. We gratefully acknowledge financial support from ESF project Self-Assembled Nanoscale Magnetic Networks.
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Current-induced effects in exchange-biased layers — •Alina M. Deac[2,1], Yuichi Otani[1], Takekazu Yamane[2], Akio Fukushima[1], Hitoshi Kubota[1], Shinji Yuasa[1], and Yoshishige Suzuki[1,2] — [1]Nanoelectronics Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan — [2]Graduate School of Engineering Science, Osaka University, Osaka, Japan

Exchange-biasing a magnetic layer might improve the peak-shape of microwave signals induced by a spin-polarized current. FM/AFM bilayers also constitute systems which may provide experimental proof of spin-transfer induced effects in AFM layers. We analyzed spin-transfer effects in two types of pillars: (A) IrMn5/CoFe5/Cu4/CoFe3/IrMn5 and (B) IrMn5/CoFe5/Cu4/CoFe3/Cu3/IrMn5 (thickness in nm) [3]. For structure A, both CoFe layers are pinned; for B, the exchange bias between the top CoFe and IrMn layers is cancelled by inserting the 3 nm Cu layer, so the top CoFe layer is free. The top IrMn layer was kept in B (reference) to insure that the current polarization throughout the pillar remains the same as for A samples, and the measured magnetoresistance is similar. While B pillars exhibit the typical trends of current-induced effects in free layers, the behavior of A samples is consistently different. By applying enough current, both exchanged-biased layers can be switched, partially or completely. Above a given current threshold, these effects become irreversible, indicating that an area of the antiferromagnetic layer has changed orientation. The initial state can be recovered by field re-annealing the samples.

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Exchange coupling in Fe/NiO bilayers grown on vicinal Ag(001) surface — Yizheng Wu[1,2], Jia Li[1,2], Xiuli Fu[1], Fikret Yildiz[1], Xiaodong Ma[1], •Marek Przybylski[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Department of Physics, Fudan University, Shanghai, China

Exchange bias is known as a magnetic coupling phenomenon at ferromagnetic (FM) - antiferromagnetic (AFM) interfaces with strong implications for magnetic field sensor applications, read heads, and modern approaches to spintronics. For complete understanding of the physical origin of the exchange bias, it requires the capability to measure and manipulate the anisotropy of the AFM spins. For example, different out-of-plane anisotropy is reported for AFM films grown on different substrates. We found that the in-plane anisotropy can be tailored by atomic steps if growing the AFM films on a stepped surface. We report on the exchange coupling in Fe/NiO bilayers grown on a Ag(10,1,1) surface with 8^o vicinal angle. The step induced anisotropy in the NiO film was confirmed by XMLD technique. MOKE measurements show that there is perpendicular coupling between Fe and NiO spins. The magnetic anisotropy in the NiO film makes the exchange bias strongly dependent on the cooling field direction. The magnetization of Fe films tilts by a small angle out of the surface plane when the film is grown on a Ag vicinal surface. Placing an antiferromagnetic NiO layer between the Fe film and the Ag(10,1,1) substrate further forces the Fe spins to be oriented away from the surface plane.

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Spin structure in PLD-grown Fe films on Cu(001) in- and out-of-plane magnetic profile from soft x-ray resonant magnetic reflectivity — J.-M. Tonnerre[1], Y. Gabi[1], H. C. N. Tolentino[1], H. L. Meyerheim[2], F. Yildiz[2], X. L. Fu[2], •M. Przybylski[2], A. Ramos[3], E. Bontempi[3], U. Staub[4], and J. Kirschner[2] — [1]Institut Neel, CNRS and Universite Joseph Fourier, B.P 166, 38042 Grenoble, France — [2]Max-Plank-Institut für Mikrostrukturphysik, 06120 Halle, Germany — [3]Universita di Brescia, via Branze, 25123 Brescia, Italy — [4]Swiss Light Source, Paul Scherrer Institut, 5232 Villigen, Switzerland

X-ray resonant magnetic reflectivity in the soft x-ray range (SXRMR) allows the investigation of the magnetic profile in thin films with chemical and orbital selectivity. We investigated the spin reorientation transition in pulsed laser deposited (PLD) Fe films on Cu(001). Three samples were prepared (4, 6 and 8 monolayers (ML) thick) capped by 3 nm of Au. From magneto-optic Kerr effect (MOKE) measurements it is known that at 160 K the 4 ML sample exhibits an in-plane easy magnetization axis while out-of-plane easy axis is found for 8 ML. At 6 ML coverage both in-plane and out-of-plane hysteresis loops are found. The SXRMR experiments were carried out at the Swiss Light Source (SLS). The photon energy dependent dichroic difference $I^+ - I^-$ and the asymmetry ratio $R = (I^+ - I^-)/(I^+ + I^-)$ were collected in the vicinity of the Fe $L_{2,3}$ edges either by reversing the helicity of the light or the applied magnetic field. While for the 4 ML film in-plane ferromagnetic order is derived, the spectra for the 6 and 8 ML films can be interpreted by a noncollinear spin structure.

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Strong perpendicular anisotropy in $Fe_{1-x}Co_x$ alloy films grown on Pd(001), Ir(001) and Rh(001) — •Fikret Yildiz, Feng Luo, Xiaodong Ma, Aimo Winkelmann, Marek Przybylski, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

The orbital magnetic moment and magnetic anisotropy can be increased due to a tetragonal distortion in a system with bulk-like coordination. A model system is provided by $Fe_{1-x}Co_x$ alloy films which are distorted due to their pseudomorphic growth on substrates of mismatching lattice constant like Pd, Ir or Rh. We have shown that the $Fe_{1-x}Co_x$ alloy films of the composition around $x = 0.5$ show a maximum perpendicular anisotropy when their cubic lattice is tetragonally distorted. With increasing film thickness the well ordered tetragonally distorted film fraction contributes less to the film volume causing the easy magnetization axis to be oriented in the film plane. Moreover, anisotropy depends strongly on the temperature. In the case of the $Fe_{1-x}Co_x$ films grown on Pd(001) it results in the easy magnetization axis oriented out-of-plane only at low temperatures even for the 15 ML thick films. Only the films grown on Rh(001) show out-of-plane easy magnetization axis at room temperature in a broad thickness and composition range. This allows studying how the orbital moment and the magnetic anisotropy develop with increasing film thickness and with varying temperature of the sample.