

MAGNETISMUS (MA)

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ÜBERSICHT DER HAUPTVORTRÄGE UND FACHSITZUNGEN
 (Hörsäle TU H1012, TU H1028, TU EMH225, TU A060)

Hauptvorträge

- MA 1.1 Fr 09:45 (TU H1028) **Modifying magnetic films by focused ion beams**, John Chapman
 MA 6.1 Fr 14:00 (TU H1028) **Sub-ns Time-Resolved Magnetic Transmission X-Ray Microscopy**, Hermann Stoll
 MA 6.2 Fr 14:30 (TU H1028) **Ultraschnelle Magnetisierungsdynamik von Antiferromagneten**, M. Fiebig, N.P. Duong, T. Satoh

FV-internes Symposium "Heusler-Legierungen" (Organizers: B. Hillebrands, H. Zabel)

- MA 9.1 Fr 15:15 (TU EMH225) **Halfmetallic Alloys: Electronic Structure, Magnetism, and Spin Polarisation**, Peter H. Dederichs, Iosif Galanakis, Phivos Mavropoulos
 MA 9.2 Fr 15:45 (TU EMH225) **The properties of $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ Heusler compounds**, Claudia Felser, Gerhard H. Fecher, Sabine Wurmehl, Thomas Block
 MA 9.3 Fr 16:15 (TU EMH225) **Elementspecific electronic properties of the Heusler alloys investigated by X-ray absorption spectroscopy**, Hans-Joachim Elmers
 MA 9.4 Fr 16:45 (TU EMH225) **Interplay of defects and temperature in NiMnSb**, Robert A. de Groot, Jisk Attema, Liviu Chioncel, Changming Fang, Gilles A. de Wijs, Alex I. Lichtenstein
 MA 9.5 Fr 17:15 (TU EMH225) **Magnetism of $[\text{Co}_2\text{MnGe}/\text{Au}]_n$ and $[\text{Co}_2\text{MnGe}/\text{V}]_n$ multilayers**, K. Westerholt, A. Bergmann, J. Grabis, E. Verduijn, A. Nefetov, H. Zabel
 MA 9.6 Fr 17:45 (TU EMH225) **Magnetic tunnel junctions with Heusler alloy electrode: Interface structure and magnetism in the shine of soft X-rays**, Jan Schmalhorst
 MA 9.7 Fr 18:15 (TU EMH225) **Anomalous electronic and vibrational effects in magnetic shape memory alloys**, Peter Entel, Alexey T. Zayak, Waheed A. Adeagbo

FV-internes Symposium "Molecular Magnetism" (Organizer: H.J. Krüger)

- MA 10.1 Sa 09:00 (TU H1012) **The Molecular Approach to Nanomagnetism**, Roberta Sessoli
 MA 10.2 Sa 09:30 (TU H1012) **Minimum single-molecule magnets**, P. Müller, H. Rupp, R.W. Saalfrank, M. Ruben
 MA 10.3 Sa 10:00 (TU H1012) **Frustration effects in magnetic molecules**, Jürgen Schnack
 MA 10.4 Sa 10:30 (TU H1012) **Frequency Domain Magnetic Resonance Spectroscopy on Molecular Magnets**, Joris van Slageren, Nadeschda Kirchner, Suriyakan Vongtragool, Marc Duran, Fadi El Hallak, Alexander Mukhin, Boris Gorshunov, Martin Dressel

MA 10.5	Sa	11:00	(TU H1012)	Synthetic approaches to oxygen-bridged molecular magnets, <u>Annie Powell</u>
MA 10.6	Sa	11:30	(TU H1012)	Rational Design of Single-Molecule Magnets, <u>Thorsten Glaser</u>
MA 10.7	Sa	12:00	(TU H1012)	Switchable Molecules, <u>Philipp Gütlich</u>

FV-internes Symposium "Applied Magnetism" (Organizers: R. Hilzinger, H. Huneus, J. Wecker)

MA11.1	Sa	09:00	(TU H1028)	Magneto-resistive biochips and magnetic field assisted hybridization, <u>Paulo P. Freitas</u>
MA 11.2	Sa	09:30	(TU H1028)	Magneto-resistive Sensoren: Applikationen, Technologien und industrielle Umsetzung, <u>Jan Marien</u>
MA 11.3	Sa	10:00	(TU H1028)	Genauer statt Power ! Permanentmagnete in Sensoranwendungen, <u>Martin Grönefeld</u>
MA 11.4	Sa	10:30	(TU H1028)	Magnetic tunnel junctions with different barriers for magnetoelectronic applications, <u>Theodoros Dimopoulos</u> , Günter Gieres, Nils Wiese, Joachim Wecker, Juansu Luo, Konrad Samwer
MA 11.5	Sa	11:00	(TU H1028)	Elektrische Grossmaschinen mit Permanentmagneterregung, <u>Axel Möhle</u>
MA 11.6	Sa	11:30	(TU H1028)	Eigenschaften und Anwendungen weichmagnetischer nanokristalliner Werkstoffe, <u>Rainer Hilzinger</u>
MA 11.7	Sa	12:00	(TU H1028)	The Goss texture formation in silicon steels: Oriented nucleation or growth selection?, <u>Stefan Zaeferrer</u> , Nan Chen, Dorothee Dorner, Ludger Lahn, Klaus Günther, Dierk Raabe

Hauptvorträge

MA 16.1	Mo	09:45	(TU H1028)	Magnetic domain structure and magnetization reversal in perpendicular AF coupled films, <u>Olav Hellwig</u> , Andreas Berger, Eric E. Fullerton
MA 21.1	Di	09:45	(TU H1028)	Lattice strain and disorder effects in magnetotransport of manganite films, <u>Vasily Moshnyaga</u>
MA 26.1	Di	14:00	(TU H1028)	A spectroscopic look at small particle magnetism from the atom to nanoscale solids, <u>Kai Fauth</u>
MA 26.2	Di	14:30	(TU H1028)	Magnetic instabilities in Fe₃C (cementite) particles observed with Fe K-edge x-ray circular dichroism under pressure, <u>Mehmet Acet</u>
MA 30.1	Mi	09:45	(TU H1028)	Proteine und Patienten - Neue Anwendungen der höchstempfindlichen Magnetfeldsensorik , <u>Meinhard Schilling</u>
MA 30.2	Mi	10:15	(TU H1028)	Theorie der magnetischen Strukturbildung in Nanoteilchen und Nanoarrays, <u>E.Y. Vedmedenko</u>

Fachsitzungen

MA 1	Hauptvortrag Chapman	Fr	09:45–10:15	TU H1028	MA 1.1–1.1
MA 2	Magnetische dünne Schichten I	Fr	10:30–13:00	TU H1012	MA 2.1–2.10
MA 3	Magnetische Abbildungsverfahren	Fr	10:30–12:00	TU H1028	MA 3.1–3.6
MA 4	Mikromagnetismus / Computational Magnetism	Fr	12:00–12:45	TU H1028	MA 4.1–4.3
MA 5	Spinstrukturen und magnetische Phasenübergänge	Fr	10:30–13:15	TU EMH225	MA 5.1–5.11
MA 6	Hauptvorträge Stoll / Fiebig	Fr	14:00–15:00	TU H1028	MA 6.1–6.2
MA 7	Magnetische dünne Schichten II	Fr	15:15–18:30	TU H1012	MA 7.1–7.13
MA 8	Spindynamik I	Fr	15:15–18:30	TU H1028	MA 8.1–8.13
MA 9	FV-internes Symposium "Heusler-Legierungen"	Fr	15:15–18:45	TU EMH225	MA 9.1–9.7
MA 10	FV-internes Symposium "Molecular Magnetism"	Sa	09:00–12:30	TU H1012	MA 10.1–10.7
MA 11	FV-internes Symposium "Applied Magnetism"	Sa	09:00–12:30	TU H1028	MA 11.1–11.7
MA 12	Elektronentheorie	Sa	09:00–10:45	TU EMH225	MA 12.1–12.7
MA 13	Spinabhängiger Transport I	Sa	10:45–13:15	TU EMH225	MA 13.1–13.10
MA 14	Molekularer Magnetismus	Sa	13:45–16:45	TU H1012	MA 14.1–14.12
MA 15	Magnetische Kopplungsphänomene / Exchange Bias	Sa	14:00–16:30	TU H1028	MA 15.1–15.10

SYFS: Symposium "Nichtflüchtige Speicher", Sa 14:00-16:30;HE101

MA 16	Hauptvortrag Hellwig	Mo 09:45–10:15	TU H1028	MA 16.1–16.1
MA 17	Spinabhängiger Transport II	Mo 10:30–13:00	TU H1012	MA 17.1–17.10
MA 18	Magnetische dünne Schichten III	Mo 10:30–13:00	TU H1028	MA 18.1–18.10
MA 19	Mikro- und nanostrukturierte magn. Materialien I	Mo 10:30–13:00	TU EMH225	MA 19.1–19.10
MA 20	Poster:Schichten(1-29),Spintrsp.(30-45),Exchange-Bias(46-63),Spindyn.(64-75),Mikro-Nano-Mat.(76-80),Cluster(81-94),Magn.Abbverf.(95-99),Obfmagn.(100-102),Spinelekt.(103-109),Elekrontheorie(110-114),Mikromagn.(115-116),Spinstrukt.+PÜ(117-126),Magn.Mat.(127-151),Methoden.(152-155),Mol.Magn.(156-159),Kondo(160-165)	Mo 14:00–18:00	Poster TU C	MA 20.1–20.165
MA 21	Hauptvortrag Moshnyaga	Di 09:45–10:15	TU H1028	MA 21.1–21.1
MA 22	Magnetische dünne Schichten IV	Di 10:30–13:00	TU H1012	MA 22.1–22.10
MA 23	Spinabhängiger Transport III	Di 10:30–13:00	TU H1028	MA 23.1–23.10
MA 24	Oberflächenmagnetismus	Di 10:30–12:30	TU A060	MA 24.1–24.8
MA 25	Kondo/Schwere-Fermionen	Di 12:30–13:00	TU A060	MA 25.1–25.2
MA 26	Hauptvorträge Fauth / Acet	Di 14:00–15:00	TU H1028	MA 26.1–26.2
MA 27	Spindynamik II	Di 15:15–18:30	TU H1012	MA 27.1–27.13
MA 28	Magnetische Partikel/Cluster I	Di 15:15–18:30	TU H1028	MA 28.1–28.13
MA 29	Magnetische Materialien	Di 15:15–18:45	TU A060	MA 29.1–29.14
MA 30	Hauptvorträge Schilling / Vedmedenko	Mi 09:45–10:45	TU H1028	MA 30.1–30.2
MA 31	Magnetische Partikel/Cluster II	Mi 11:00–13:15	TU H1012	MA 31.1–31.9
MA 32	Mikro- und nanostrukturierte magn. Materialien II	Mi 11:00–13:15	TU H1028	MA 32.1–32.9
MA 33	Messmethoden, Anisotropie, Spinelektronik /Spininjektion	Mi 11:00–13:15	TU EMH225	MA 33.1–33.9

Mitgliederversammlung des Fachverbands Magnetismus

Fr 19:00–19:45 TU H1028

1. Bericht
2. Verschiedenes

Fachsitzungen

– Haupt-, Kurzvorträge und Posterbeiträge –

MA 1 Hauptvortrag Chapman

Zeit: Freitag 09:45–10:15

Raum: TU H1028

Hauptvortrag

MA 1.1 Fr 09:45 TU H1028

Modifying magnetic films by focused ion beams — ●JOHN CHAPMAN — Dept of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, UK

The properties of magnetic films can be modified by low dose irradiation with Ga ions in a focused ion beam machine (FIB). Thus in the case of exchange biased bilayers the strength of the offset field can be changed in a controlled manner, whilst for multilayer films that support perpendicular anisotropy in their as-grown state, local areas supporting

in-plane magnetisation can be introduced. Even in the case of single layer magnetic films grown on a seed layer, local property change can be engineered so that preferential sites for domain walls can be created leading to effective forms of wall traps. Here I describe how magnetic imaging, using Lorentz microscopy, backed up by structural imaging and analytical electron microscopy illustrate the way in which magnetisation processes in the various films are modified. Attention is paid to the changes to the physical microstructure that occur and the potential of the technique for high resolution patterning is assessed. Examples of property modification on a sub-100 nm scale are presented.

MA 2 Magnetische dünne Schichten I

Zeit: Freitag 10:30–13:00

Raum: TU H1012

MA 2.1 Fr 10:30 TU H1012

Magnetische Oberflächenanisotropie von Fe Monolagen auf GaAs(100) — ●KH. ZAKERI, J. LINDNER und M FARLE — Fachbereich Physik, Experimentalphysik, AG Farle, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

Mittels MBE wurden auf Ga-terminierten GaAs(001) Substraten ultradünne Fe-Filme mit einer Schichtdicke von 5 bis 7 ML bei 300K aufgewachsen. Die magnetischen Eigenschaften wurden mit *in situ* Ferromagnetischer Resonanz bei 4 und 9.3 GHz von 40 bis 400K untersucht. Wir finden eine große effektive Magnetisierung ($M_{eff} = 7800$ G) bei 300K und eine uniaxiale in-plane Anisotropie mit leichter Richtung entlang $[1 \bar{1} 0]$, wobei ein großer Beitrag der Oberfläche und der Grenzfläche ($K_{2si} = 8.7 \times 10^{-5}$ J/m²) und nur ein sehr kleiner Wert dem Volumen zugeordnet werden kann.

Unterstützt durch Sonderforschungsbereich 491, TPA9.

MA 2.2 Fr 10:45 TU H1012

Magnetismus an Fe/InAs(001) Grenzflächen — ●R. PETERS¹, W. KEUNE¹, W. STURHAHN² und E. E. ALP² — ¹Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany — ²APS, Argonne National Laboratory, 60439 IL, USA

Spininjektion in Halbleiter spielt in der Spinelektronik eine entscheidende Rolle. Fe/InAs(001) ist bei der Spininjektion aus einem Ferromagneten ein möglicher Kandidat [1]. Dabei ist sowohl die Grenzflächenbeschaffenheit als auch die Beständigkeit des Fe-Films ein wichtiger Aspekt. Mit Mössbauerspektroskopie (CEMS) und der ⁵⁷Fe-Sondenschichtmethode wurde das magnetische Verhalten direkt an der Grenzschicht untersucht. Zu diesem Zweck wurden 4 ML ⁵⁷Fe an der Fe/InAs(001)-Grenzfläche mittels MBE aufgebracht. Die CEM-Spektren ließen sich mit zwei Unterspektren charakterisieren: Ein reines bcc-Fe ($B_{hf} = 33.0$ T) und ein gestörtes bcc-Fe-Unterspektrum. Für das gestörte Spektrum ergab sich eine Verteilung $P(B_{hf})$, mit einem mittleren magn. Hyperfeinfeld $\langle B_{hf} \rangle$ von 23 - 27 T, entsprechend 1.5-1.8 μ_B , was vermutlich auf in bcc-Fe gelöste As-Atome zurückzuführen ist. Ein Jahr später gemessene CEM Spektren weisen auf keine Alterungseffekte hin. Mittels inelastischer kernresonanter Streuung (NRIXS) wurde die Phononenzustandsdichte der ⁵⁷Fe-Sondenschicht gemessen, welche eine deutliche Veränderungen zu bcc-Fe zeigt.

Gefördert durch DFG (SFB 491 und GRK277).

[1] H. Ohno et al., Japn. J. Appl. Phys. **42** (2003) L87

MA 2.3 Fr 11:00 TU H1012

Präparation und Charakterisierung von epitaktischen dünnen Fe(001) Schichten auf GaAs basierender LED für Spininjektion — ●ELLEN SCHUSTER¹, WERNER KEUNE¹, FANG YUH LO², DIRK REUTER², ANDREAS WIECK² und KURT WESTERHOLT³ — ¹Angewandte Physik, Universität Duisburg-Essen, Duisburg — ²Angewandte Festkörperphysik, Ruhr-Universität Bochum, Bochum — ³Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, Bochum

Elektrische Spininjektion von einer magnetisierten Schicht in einen Halbleiter ist eine Grundvoraussetzung für spätere spinelektronische Anwendungen. Bei einem optischen Nachweis wird die Elektrolumineszenz einer LED (light-emitting diode) gemessen, um über die zirkulare Polarisation Rückschlüsse auf die Spinpolarisation ziehen zu können. Der Nachteil der bisherigen Versuche ist die Notwendigkeit eines sehr hohen äußeren magnetischen Feldes von etwa 2 Tesla, da aufgrund der Formanisotropie die dünnen ferromagnetischen Schichten in der Ebene magnetisiert sind. Für den Nachweis der Spininjektion wird jedoch eine senkrechte Magnetisierung des Ferromagneten benötigt, wobei es wesentlich ist, diese spontan - ohne äußeres magnetisches Feld - zu erhalten, um in Remanenz Spininjektion messen zu können. Wir berichten von der Herstellung und Charakterisierung ferromagnetischer Fe/Tb-Vielfachschichten mit senkrechter magnetischer Anisotropie auf sauberen As-terminierten GaAs(001) Oberflächen einer GaAs-basierenden LED-Struktur mittels RHEED, Magnetometrie und ⁵⁷Fe-Mössbauerspektroskopie (CEMS). Gefördert durch DFG (SFB491)

MA 2.4 Fr 11:15 TU H1012

Rastertunnelmikroskopische Charakterisierung von ionenstrahlgesputtertem Fe(001) auf GaAs(001) — ●ALEXANDRA SCHINDLER, THORSTEN DAMM, DANIEL BÜRGLER und CLAUD M. SCHNEIDER — Institut für Festkörperforschung, Elektronische Eigenschaften, Forschungszentrum Jülich

Die Fe-Schichten werden mittels Ionenstrahlputtern unter UHV-Bedingungen epitaktisch gewachsen. Die Untersuchung von Wachstums- und Strukturbildungsvorgängen wird zunächst an Fe auf GaAs-Substraten durchgeführt. Die Schichten werden in Abhängigkeit von der Substratpräparation, der Substrattemperatur und der Fe-Schichtdicke hergestellt. Die Morphologieuntersuchungen werden mit einem Rastertunnelmikroskop durchgeführt. Die Messungen werden in Hinblick auf die Höhenvariation des Eisens und dem Unterschied der RMS-Rauhigkeit bei unterschiedlichen Herstellungsbedingungen verglichen. Dabei ist zu erkennen, dass das Vorsputtern (Reinigen) des GaAs die Aufrauung der Fe-Schicht zur Folge hat. Bei erhöhter Substrattemperatur (300°C) wächst der Fe-Film zunehmend in Form von gleichmäßigen sphärischen Clustern. Die RMS-Rauhigkeit beträgt 5Å (3ML), ist damit etwas niedriger als bei Raumtemperatur hergestelltem Fe (7Å, 5ML). Der Einfluss der Morphologie auf die magnetischen Eigenschaften wird betrachtet und die Untersuchungen werden auf Schichtsysteme wie z.B. Fe/Si/Fe, Fe/MgO/Fe ausgeweitet.

MA 2.5 Fr 11:30 TU H1012

Magnetic properties of Fe₃Si/GaAs(001) thin films — ●K. LENZ¹, E. KOSUBEK¹, K. BABERSCHKE¹, J. HERFORT², H.-P. SCHÖNHERR², and K. H. PLOOG² — ¹Inst. f. Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — ²Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

The magnetic properties of Fe₃Si/GaAs(001) hybrid structures are studied. The ferromagnetic films show a high crystalline and interfa-

cial perfection [1]. Structural characterization and SQUID magnetometry has been done [2]. We present ferromagnetic resonance (FMR) studies showing an exceptional narrow linewidth (<17 Oe) confirming the high structural quality. Secondly, anisotropy fields are determined. The easy axis of magnetization is the in-plane [010] direction. The angular dependence of the resonance field reveals a small uniaxial in-plane anisotropy field of $\approx 10 - 20$ G along the $\bar{1}10$ direction, being not equivalent to the [110] direction. For samples with higher Si content (less Fe) the in-plane anisotropy field is smaller.

Supported by DFG (Sfb 290, TP A2).

[1] J. Herfort *et al.*, Appl. Phys. Lett. **83**, 3912 (2003)

[2] J. Herfort *et al.*, J. Vac. Sci. Technol. B **22**, 2073 (2004)

MA 2.6 Fr 11:45 TU H1012

Magnetism of thin Fe films on GaAs — ●MICHAL KOSUTH, VOICU POPESCU, and HUBERT EBERT — Department Chemie / Physikalische Chemie, Universität München, Butenandstr. 5-13, D-81377 München, Germany

The electronic and magnetic properties of thin Fe layers on GaAs have been studied using the fully-relativistic TB-KKR band structure method. The most important features observed in the magnetisation profiles are that no magnetically dead layers occur and there is an appreciable induced magnetisation in the semiconductor subsystem. An increase of the orbital moment in the Fe layers both at the surface as well as at the GaAs/Fe interface has been observed.

Calculations of the magnetic anisotropy energy for thin layers of Fe on a GaAs substrate lead to an in-plane magnetisation as the ground state configuration with a noticeable uniaxial character in accordance with experiments.

Within the experiments the Fe surface of the GaAs/Fe system is covered by protective layers of Au (or Cu) to avoid corrosion. Corresponding results of calculations on the effects of additional Au (and Cu) layers on top of GaAs/Fe on the magnetic anisotropy will be presented and discussed.

MA 2.7 Fr 12:00 TU H1012

Magnetische und strukturelle Eigenschaften epitaktischer c-FeSi-Filme auf MgO(100) — ●M. WALTERFANG¹, K. TROUNOV¹, W. KEUNE¹, U. RÜCKER² und K. WESTERHOLT³ — ¹Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg — ²Forschungszentrum Jülich, Institut für Festkörperforschung, 52425 Jülich — ³Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

Die metastabile c-FeSi-Phase mit B2-Struktur wurde durch Ko-deposition molekularstrahlepitaktisch auf MgO(100) mit einer Fe- oder Cr-Pufferschicht hergestellt und mößbauerspektroskopisch (⁵⁷Fe-CEMS) untersucht. Die Anpassung der CEM-Spektren erfolgte jeweils mit einem asymmetrischen Quadrupoldublett D1, das die metastabile stöchiometrische c-FeSi-Phase repräsentiert, sowie einem zusätzlichen asymmetrischen Dublett D2, das aus einer statistischen Verteilung von überschüssigen Fe-Atomen auf Si-Gitterplätzen in der B2-Gitterstruktur resultiert. Mit abnehmenden Temperaturen bis auf 4.2 K nimmt die spektrale Fläche des D2-Dubletts, verbunden mit einer drastischen Linienverbreiterung, auf Kosten des D1-Dubletts stark zu. Als Ursache für die Linienverbreiterung kann eine Zunahme der Quadrupolwechselwirkung aufgrund von erhöhter Gitterverzerrung ausgeschlossen werden. Dies folgt aus Röntgenbeugungsergebnissen bei tiefer Temperatur. Mittels SQUID-Magnetometrie wurde bestätigt, dass die beobachteten Effekte bei Abkühlung auf magnetische Ordnungseffekte zurückzuführen sind. Gefördert durch die Deutsche Forschungsgemeinschaft (GRK 277 und Ke 273/17-1).

MA 2.8 Fr 12:15 TU H1012

Fe Spin Structure During Magnetization Reversal of Exchange Biased Fe/MnF₂ — ●B. SAHOO¹, J. EISENMENGER^{2,3}, W. A. A. MACEDO⁴, R. RÖHLSBERGER⁵, W. KEUNE¹, V. KUNCSEK^{1,6}, M. D. MARTINS⁴, J. NOGUÉS⁷, I. K. SCHULLER², KAI LIU⁸, I. FELNER⁹, K. SCHLAGE¹⁰, O. LEUPOLD¹¹, and R. RÜFFER¹¹ — ¹Uni. Duisburg-Essen, Germany — ²Uni. California-San Diego, USA — ³Uni. Ulm, Germany — ⁴CDTN, Brazil — ⁵HASYLAB@DESY, Germany — ⁶NIPM, Romania — ⁷ICREA and Uni. Barcelona, Spain — ⁸Uni. California-Davis, USA — ⁹Hebrew University, Israel — ¹⁰Uni. Rostock, Germany — ¹¹ESRF, France

We have investigated the local spin structure of Fe in Fe/MnF₂ during magnetization reversal. The nuclear resonant scattering technique allowed for the determination of the depth dependent magnetic hyperfine field and Fe spin structure, and their temperature dependence. The obtained Fe spin structure will be discussed. Interestingly, during the magnetization reversal process the spins rotate (in-plane) up to an angle of 45° away from the applied field direction. By further decreasing the negative field the Fe spins jump from the 45° to the 135° direction and then again continuously rotate into the negative applied field direction.

MA 2.9 Fr 12:30 TU H1012

Beobachtung der Korrelation zwischen Defektstruktur und Exchange-Bias-Effekt in Fe/FeSn₂-Doppellagen mittels Mößbauereffekt — ●F. STROMBERG¹, W. KEUNE¹, M. ACET¹ und V.E. KUNCSEK² — ¹Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg — ²NIPM, MG7, 77125 Bucharest-Magurele, Romania

Unter verschiedenen MBE-Bedingungen auf InSb(001) präparierte Fe/FeSn₂(001)-Doppellagen bilden ein neues System mit Exchange-Bias. Isotopisch angereicherte ⁵⁷Fe- und ⁵⁷FeSn₂-Sondenschichten wurden auf die entsprechende Seite der Grenzfläche positioniert, um die Fe-Spinstruktur und die Interdiffusion mittels ⁵⁷Fe-CEMS bei RT und 10 K zu studieren. In den CEM-Spektren wurden Komponenten aufgelöst, die zu reinem bcc-Fe, Sn-haltigem bcc-Fe, antiferromagnetischen (AF) FeSn₂ und defektbehaftetem (paramagnetischen) FeSn₂ zugeordnet werden können. Ergänzend wurde die T-Abhängigkeit des Exchange-Bias-Feldes H_E mittels SQUID gemessen. Die CEMS Ergebnisse weisen auf eine Korrelation zwischen chemischer Unordnung (paramagnetischen defektbehafteten Bereichen) in AF FeSn₂ und H_E sowie T_B hin. Die Blocking-Temperatur T_B ist im Vergleich zu T_N stark erniedrigt. Gefördert durch die Deutsche Forschungsgemeinschaft (SFB491).

MA 2.10 Fr 12:45 TU H1012

Magnetic properties of ultrathin Ni on Pd measured by 111mCd PAC — ●Y. MANZHUR¹, P. IMIELSKI², M. J. PRANDOLINI^{1,2}, K. POTZGER¹, H. H. BERTSCHAT¹, and M. DIETRICH³ — ¹Bereich Strukturforschung, Hahn-Meitner-Institut Berlin GmbH, D-14091 Berlin, Germany — ²Institut für Experimentalphysik, Freie Universität Berlin, D-14195 Berlin, Germany — ³ISOLDE - Collaboration, CERN, Genève 23, Switzerland

Ultrathin two-dimensional magnetic systems grown on non-magnetic substrates, introduces new physical properties important for future applications. One such important property is perpendicular surface anisotropy causing the magnetic layer to come out of the plane. In this work we investigate the direction and the surface magnetic properties using the PAC-method. This method has proven to be a highly sensitive technique to investigate the structure and the magnetic properties of surfaces with atomic resolution. In the present experiment single isolated radioactive 111mCd probe atoms were evaporated in situ at 40 K onto 2 MLs of Ni grown on a Pd(001) single crystal. We could determine the magnetic hyperfine field of the Cd adatoms. The results are compared to the values measured for Cd adatoms on bulk Ni single crystals with the same surface orientation. We could conclude that the magnetic response of a non-magnetic impurity (Cd) on the surface of 2 MLs of Ni(100) on Pd bulk, and on the surface of Ni(100) bulk is equal, however, the magnetic hyperfine field of the Cd probes on 2 MLs of Ni comes out of the plane with an angle of about 60°.

MA 3 Magnetische Abbildungsverfahren

Zeit: Freitag 10:30–12:00

Raum: TU H1028

MA 3.1 Fr 10:30 TU H1028

Hochfrequenz-MFM-Abbildungen von Festplatten-Schreib-/Leseköpfen — ●MICHAEL R. KOBLISCHKA und UWE HARTMANN — FR Experimentalphysik, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken

In diesem Projekt wurde ein Hochfrequenz-MFM-System auf der Basis eines kommerziellen AFM-Systems aufgebaut und mittels Festplatten-Schreib-/Leseköpfen von IBM und SEAGATE bis zu Frequenzen von 650 MHz getestet. Um solche hochfrequenten MFM-Aufnahmen zu erhalten, wird der Kopf mit einem hochfrequenten Strom angeregt und erzeugt so ein Hochfrequenz-Magnetfeld, das mit der weichmagnetischen MFM-Spitze in Wechselwirkung tritt. Um die HF-Feldverteilung um den Schreib-/Lesekopf herum aufnehmen zu können, wird in den Kopf ein amplituden-modulierter HF-Strom eingespeist. Dies ermöglicht es, den hoch- und niederfrequenten Anteil des Mess-Signals in einem Experiment zu trennen. HF-MFM-Abbildungen des Streufeldes bei verschiedenen Frequenzen werden vorgestellt, und die Möglichkeiten dieser Technik diskutiert.

Diese Arbeit ist Teil des EU-Projektes ASPRINT.

MA 3.2 Fr 10:45 TU H1028

Determination of complex magnetic structures with vector Magnetic Force Microscopy — ●SILVIA SASVÁRI, KIRILL KHLOPKOV, OLIVER GUTLEISCH, ULRIKE WOLFF, LUDWIG SCHULTZ, and VOLKER NEU — IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany

The quantitative interpretation of Magnetic Force Microscopy (MFM) response of complex magnetization patterns is still difficult since this technique is not a direct measure of the magnetization. Therefore, the use of vector MFM in combination with MFM image simulation is suggested as a way to extract more information out of the MFM data. The vector MFM approach measures different components of the magnetic stray field derivative by magnetizing a hard magnetic tip in different directions. A longitudinal recording media has been measured with vector MFM and both components of the MFM response have been modelled with a commercial magneto static solver in combination with a rigid tip point probe approximation. To test the applicability to more complex magnetization patterns, vector MFM has been performed on an isotropic NdFeB-magnet. With this study the sensitivity of MFM measurements to tilted magnetization directions of the individual NdFeB grains is evaluated.

MA 3.3 Fr 11:00 TU H1028

Spinpolarisierte Rastertunnelmikroskopie auf S-bedeckten Fe-Inseln — ●STEFAN KRAUSE, LUIS BERBIL-BAUTISTA, TORBEN HÄNKE, MATTHIAS BODE und ROLAND WIESENDANGER — Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg

Bislang ist die spinpolarisierte Rastertunnelmikroskopie (SP-STM) auf Anwendungen unter UHV-Bedingungen beschränkt, da bereits dünne Adsorbatschichten zu einer Depolarisierung der tunnelnden Elektronen führen. Eine Möglichkeit, SP-STM auch in ambients Umgebung anzuwenden, könnte in der kontrollierten Passivierung der zu untersuchenden Oberfläche mittels H_2S liegen. Unsere Untersuchungen der strukturellen Eigenschaften des Systems S/Fe/W(110) mittels LEED, AES und STM zeigen, dass sich Eisenfilme und -inseln mit einer wohlgeordneten, $c(3 \times 1)$ -rekonstruierten Schwefelschicht bedecken lassen [1]. Wir untersuchten ferner, inwieweit SP-STM durch eine solche Deckschicht hindurch möglich ist. Als Testsystem dienten uns hierfür dreidimensionale Inseln mit magnetischer Vortexkonfiguration[2], die durch selbstorganisiertes Wachstum von Eisen auf W(110) entstehen und anschließend mit H_2S begast wurden. Anhand von spin aufgelösten Rastertunnelmikroskopieaufnahmen zeigen wir, wie sogar durch die Schwefel-Monolage hindurch die Abbildung der magnetischen Vortexstruktur möglich ist.

[1] S. R. Kelemen and A. Kaldor, J. Chem. Phys. **75**, 1530 (1981).

[2] A. Wachowiak *et al.*, Science **298**, 577 (2002).

MA 3.4 Fr 11:15 TU H1028

Imaging uncompensated spins in microstructured CoFeB/MnIr — ●T. EIMÜLLER¹, T. KATO², T. MIZUNO², C. QUITMANN³, T. RAMSVIK³, S. TSUNASHIMA², S. IWATA⁴, and G. SCHÜTZ¹ — ¹Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, Germany — ²Department of Electronics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan — ³Paul-Scherrer-Institute, SLS, CH-5232 Villigen, Switzerland — ⁴CCRAST Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan

Exchange bias is assumed to originate in pinned, uncompensated magnetic moments, located at the FM/AFM interface. Recent progress in high resolution magnetic imaging with polarized soft x-rays allows direct observation of uncompensated spins. Using x-ray magnetic circular dichroism (XMCD) as a contrast mechanism in photoemission electron microscopy (PEEM) we studied the element specific domain configuration of a technologically important $Co_{86}Fe_{10}B_4 / Mn_{77}Ir_{23} / Ni_{80}Fe_{20} / Si_3N_4$ exchange bias film [1]. We found that in regions, where the sample was patterned with a 22 keV Ga^+ focused ion beam, the magnetization shows less preferred orientation along the exchange bias direction than in unpatterned areas. Furthermore, we imaged uncompensated Mn spins at the CoFeB/MnIr interface and found an antiferromagnetic coupling between the Mn and the Co magnetic moments.

[1] T. Eimüller, T. Kato, T. Mizuno, S. Tsunashima, C. Quitmann, T. Ramsvik, S. Iwata and G. Schütz, Appl. Phys. Lett. **85**, 2310 (2004)

MA 3.5 Fr 11:30 TU H1028

Micromagnetic properties of epitaxial MnAs films on GaAs studied by XMCDPEEM and LEEM — ●JYOTI MOHANTY¹, THORSTEN HESJEDAL¹, LUTZ DÄWERITZ¹, KLAUS H. PLOG¹, SALIA CHERIFI^{2,3}, STEFAN HEUN², ANDREA LOCATELLI², and ERNST BAUER^{2,4} — ¹Paul Drude Institute, Hausvogteiplatz 5-7, 10117 Berlin, Germany — ²Sincrotrone Trieste, 34012 Basovizza, Italy — ³CNRS-Laboratoire Louis Néel, 38042 Grenoble, France — ⁴Department of Physics and Astronomy, Arizona State University, Tempe, U.S.A

Combing a ferromagnet, MnAs, with a widely used III-V semiconductor, GaAs, has special importance for future spintronics applications. MBE grown MnAs on GaAs exhibits a sharp crystal interface and has proven to be an interesting candidate for spin-injection and magnetologic applications. In MnAs films on GaAs (001), the involved strain causes a coexistence of ferromagnetic α - and paramagnetic β -MnAs over a temperature range of 10-40°C. The two phases arrange in a regular stripe pattern along MnAs [0001] direction with the width of the stripes being a function of temperature, while the stripe period is determined by the film thickness. We employed X-ray magnetic circular dichroism photoemission electron microscopy (XMCDPEEM) in combination with low energy electron microscopy (LEEM) to study the magnetic domain structure as a function of stripe width (i.e. temperature) and film thickness.

MA 3.6 Fr 11:45 TU H1028

Imaging Magnetic Domains by Core-Level XPS — ●N.B. WEBER¹, M. ESCHER¹, M. MERKEL¹, H.-J. ELMERS², S.W. SCHMIDT³, F. REINERT³, F. FORSTER³, S. HÜFNER³, B. KRÖMKER⁴, D. FUNNEMANN⁴, P. BERNHARD², CH. ZIETHEN² und G. SCHÖNHENSE² — ¹FOCUS GmbH, Am Birkhecker Berg 20, D-65510 Hünstetten — ²Johannes Gutenberg Universität, Institut für Physik, Staudinger Weg 7, 55128 Mainz — ³Universität des Saarlandes, FR 7.2. Experimentalphysik, 66041 Saarbrücken — ⁴OMICRON nanotechnology GmbH, 65232 Taunusstein

Element specific quantitative analysis of magnetic domains is a well known task for the x-ray magnetic circular dichroism (X-MCD) in combination with a photoemission electron microscope (PEEM). Usually this method yields one projection of the magnetization direction only. We present a method exploiting magnetic effects in photoemission (MCD, MLDAD) which yields at least two magnetization directions by switching the polarization of the x-rays only. This is demonstrated for domains at the Fe(100) surface. The imaging of photoelectrons up to a kinetic energy of 1600eV with a lateral resolution in the 100nm range is made possible by the new developed nano-ESCA.

MA 4 Mikromagnetismus / Computational Magnetism

Zeit: Freitag 12:00–12:45

Raum: TU H1028

MA 4.1 Fr 12:00 TU H1028

Exact parametrization of the adiabatic magnetic energy hypersurface — ●RALF DRAUTZ^{1,2} and MANFRED FÄHNLE¹ — ¹Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany — ²Department of Materials, University of Oxford, OX1 3PH, UK

The complexity of magnetic interactions in nanostructured magnetic systems makes it necessary to establish a parameter-free multi-scale framework for modelling. First-principles-based dynamics and statistical mechanics for magnetic systems thereby require an accurate and sufficiently general but at the same time computationally efficient representation of the adiabatic magnetic energy of many interacting atoms. We exactly parameterize the adiabatic magnetic energy of generalized interacting spins for the important special case of zero spin-orbit coupling and no applied external field. The expansion classifies the classical Heisenberg model as a first order approximation to the energy, extensions of the Heisenberg model in literature are shown to be of second order. We relate the symmetry-based energy expansion presented in this talk to the more general spin-cluster expansion that we published recently [1].

[1] R. Drautz and M. Fähnle, Phys. Rev. B **69**, 104404 (2004)

MA 4.2 Fr 12:15 TU H1028

Ferromagnetic hollow nanoparticles — ●D. GOLL¹, A.E. BERKOWITZ², and H.N. BERTRAM² — ¹Max-Planck-Institut für Metallforschung, Stuttgart, Germany — ²Center for Magnetic Recording Research, La Jolla, USA

Single-domain nanoparticles are an important prerequisite for ultra-high density magnetic recording. Recently, ferromagnetic nanoparticles with a nonmagnetic core have been successfully produced by spark erosion and colloid chemistry methods. We have analytically calculated and compared the total magnetic energies of zero-field magnetization states of such particles to find out the conditions for single-domain behavior. Therefore, the size of the particles and the thickness of the spheroidal

shell have been systematically varied for different hard and soft magnetic materials. From the micromagnetic calculations the corresponding phase diagrams of the lowest-energy configurations have been derived. The phase diagrams identify two phases which are for hard magnetic materials as Nd₂Fe₁₄B or FePt the single-domain state and the two-domain state. For soft and middle-hard magnetic materials as permalloy, Fe or Co the single-domain state and the curling-vortex state occur. It turns out, that in the case of hard magnetic materials the critical diameter for which the single-domain state becomes energetically unfavorable can become more than doubled for ultrathin spheroidal shells compared to the corresponding bulk sphere. The magnetization reversal process takes place inhomogeneously starting at the magnetic poles of the inner surface. *This project was sponsored by DAAD, Bonn.*

MA 4.3 Fr 12:30 TU H1028

Micromagnetism and the microstructure of cell boundaries in nanostructured Sm₂Co₁₇ based magnets — ●H. KRONMÜLLER and D. GOLL — Max-Planck-Institut für Metallforschung, Stuttgart, Germany

High-quality permanent magnets on the basis of rare earth intermetallic compounds achieve large coercive fields either by large nucleation fields or by strong pinning forces of domain walls (dws). Sm₂Co₁₇ based magnets are characterized by pinning of dws at the cell walls of 1:5 structure within the pyramidal nanostructure. For a micromagnetic calculation of the interaction force between a dw and an extended phase boundary we consider a space dependent magnetocrystalline anisotropy constant, $K_1(r)$, and an exchange constant, $A(r)$, which vary over a distance, d , from the values $K_1^{2:17}$, $A^{2:17}$ of the 2:17 matrix phase to a value $K_1^{1:5}$, $A^{1:5}$ of the 1:5 cell wall phase. Using the $K_1(r)$ profiles as determined by EDX measurements the coercive field due to dw pinning is determined self consistently by numerical methods as a function of the profile parameters taking into account the modification of the spin structure of the dw by the space dependent material parameters.

MA 5 Spinstrukturen und magnetische Phasenübergänge

Zeit: Freitag 10:30–13:15

Raum: TU EMH225

MA 5.1 Fr 10:30 TU EMH225

Oscillatory Curie Temperature in Ultrathin Ferromagnets: Experimental Evidence — ●C. RÜDT, A. SCHERZ, and K. BABERSCHKE — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin

We determined the Curie temperature T_C for 2-3 monolayers of Co/Cu(100) as a function of the Cu-cap thickness d_{Cu} by means of the initial *ac* susceptibility $\chi_{ac}(T)$ *in situ* in UHV. We found an oscillatory $T_C(d_{Cu})$ in agreement with theoretical predictions [1]. The oscillation of T_C has been observed for more than two full oscillation periods for the first time in the range of $1 \text{ ML} \leq d_{Cu} \leq 6 \text{ ML}$. For that purpose films with a fixed Co thickness and variable Cu cap thickness (evaporated step-by-step) have been prepared. In contrast to theory [1] the oscillation amplitude ΔT_C is only a few Kelvin. This can be understood in terms of realistic interlayer exchange parameters [2]. Furthermore, the quantum-well-like oscillatory behavior is superimposed by a monotonic reduction of T_C .

Supported by the DFG (Sfb 290, TP A2).

[1] M. Pajda *et al.*, Phys. Rev. Lett. **85**, 5424 (2000)

[2] C. Rüdt *et al.*, J. Magn. Magn. Mater. (Letter to the Editor) (2004), in print

MA 5.2 Fr 10:45 TU EMH225

Investigation of the topography and the magnetic structure of reconstructed Mn films on Fe(001) — ●C. L. GAO, U. SCHLICKUM, W. WULFHEKEL, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle

It is well known that Mn grows layer-by-layer on Fe(001) up to about 15 to 20 monolayers at a substrate temperature of about 100°C. Mn is a topological antiferromagnet thus, the coupling within a Mn atomic layer is ferromagnetic while adjacent layers are coupled antiferromagnetically to each other. The layer-wise antiferromagnetic order of neighbored Mn

layers was studied on the nanoscale with an in-plane spin-polarized scanning tunneling microscope (Sp-STM) [1]. In additions, three dimensional islands were observed. In this contribution, we focus the topographic and magnetic behavior of these islands. Their typical height is between 0.8 nm and 3 nm. The surface atoms of the Mn islands are reconstructed into a periodic pattern of parallel stripes. An antiferromagnetic order of the reconstructed surface atoms was observed.

[1] U. Schlickum, N. Janke-Gilman, W. Wulfhekel, and J. Kirschner, Phys. Rev. Lett. **92**, 107203 (2004).

MA 5.3 Fr 11:00 TU EMH225

Spin reorientation in high magnetic field and the Co-Gd exchange field in GdCo₅ — ●MICHAEL KUZMIN¹, YURI SKOURSKI¹, DIETER ECKERT¹, MANUEL RICHTER¹, KARL-HARTMUT MÜLLER¹, KONSTANTIN SKOKOV², and IRINA TERESHINA³ — ¹Leibniz-Institut für Festkörper- und Werkstoffforschung, IFW Dresden, PF 270116, D-01171 Dresden — ²Faculty of Physics, Tver State University, 33 Gelabova Str., 170002 Tver, Russia — ³Baikov Institute of Metallurgy and Materials Science RAS, Leninskii Pr. 49, 119991 Moscow, Russia

An upturn in the high-field magnetization curve of a GdCo₅ single crystal is observed at about 46 T, which is interpreted as the onset of a process of spin reorientation from the ferri- towards ferromagnetic structure via an intermediate canted phase. This enables us to evaluate the Co-Gd exchange field in GdCo₅ as $B_{TR} = 233 \pm 12 \text{ T}$. This value is very close to the total exchange field on Gd, $B_R = 236 \pm 8 \text{ T}$, known from earlier inelastic neutron experiments. The difference, $B_{RR} = B_R - B_{TR}$, is attributed to the Gd-Gd exchange interaction. Its smallness provides solid experimental justification for neglecting the 4f-4f exchange in 3d-4f hard magnetic materials. A full-potential density-functional calculation of B_{TR} has been carried out using a new approach within the fixed-spin-moment (FSM) technique. The calculated value, $B_{TR} = 258 \text{ T}$, is 11% too high, most likely because the FSM formalism disregards orbital magnetic moments.

MA 5.4 Fr 11:15 TU EMH225

Fermifläche und Valenzbandstruktur von ferromagnetischen Gd-, Tb- und Dy-Filmen — ●K. M. DÖBRICH¹, J. E. PRIETO¹, K. ROSSNAGEL², A. BOSTWICK², E. ROTENBERG², G. KAINDL¹ und K. STARKE¹ — ¹Fachbereich Physik, Freie Universität Berlin — ²Advanced Light Source, Lawrence Berkeley National Laboratory, U.S.A.

Die schweren Lanthanide Gd, Tb und Dy weisen ein *hcp* Kristallgitter mit drei Valenzelektronen pro Atom auf, weswegen ihre Bandstrukturen und Fermiflächen in der paramagnetischen Phase sehr ähnlich sind. Die Besetzung der *4f*-Schale nimmt von Gd über Tb zu Dy um jeweils ein Elektron zu, womit eine Abnahme des Gesamtspins pro Atom und damit der Austauschspaltung einhergeht. Dies führt in der ferromagnetischen Phase zu signifikanten Unterschieden in den Bandstrukturen und Fermiflächen. Da die magnetischen *4f*-Momente so stark lokalisiert sind, daß ihre direkte Wechselwirkung vernachlässigt werden kann, erfolgt die magnetische Kopplung benachbarter Atome über die itineranten Valenzelektronen (*RKKY*-Wechselwirkung). Unterschiede in der Bandstruktur und Fermifläche haben daher entscheidenden Einfluß auf die Ordnungstemperaturen und magnetischen Phasen der schweren Lanthanide.

Unsere winkelaufgelösten Photoemissionsmessungen an epitaktisch auf W(110) aufgedampften Gd-, Tb- und Dy-Filmen zeigen Unterschiede in Bändern und Fermifläche bei 30 K. Ein Vergleich mit neuen theoretischen Rechnungen erzielt gute Übereinstimmung.

MA 5.5 Fr 11:30 TU EMH225

Magnetic X-Ray Scattering at the Lanthanide M_5 Resonance — ●H. OTT^{1,2}, C. SCHÜSSLER-LANGEHEINE², E. SCHIERLE¹, V. LEINER^{3,4}, H. ZABEL³, G. KAINDL¹, and E. WESCHKE¹ — ¹Institut für Experimentalphysik, Freie Universität Berlin — ²II. Physikalisches Institut, Universität zu Köln — ³Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum — ⁴Institut Laue-Langevin, Grenoble, France

The quantitative analysis of magnetic x-ray scattering from thin Ho-metal films at the lanthanide M_5 resonance reveals magnetic scattering length f_{mag} up to $200r_0$, i.e. of the same order of magnitude as theoretically predicted. The photon-energy dependence of first- and second-order magnetic satellites allows a straightforward identification of circular and linear dichroic contributions to the scattering length. In a few examples we demonstrate the potential of the method for studies of complex magnetic structures in ultrathin films.

MA 5.6 Fr 11:45 TU EMH225

Angular dependent absorption spectroscopy of a de-twinned DyBaCo₂O_{5.5} single crystal — ●MYRSINI LAFKIOTI¹, STEFAN GOLD¹, EBERHARD GOERING¹, GISELA SCHÜTZ¹, JOACHIM DEISENHOFER², and PETER LEMMENS³ — ¹Max-Planck-Institut für Metallforschung, 70569 Stuttgart — ²Lst. für Experimentalphysik V, Uni-Augsburg, 86159 Augsburg — ³Inst. fuer Halbleiterphysik und Optik, TU Braunschweig, 38106 Braunschweig

The Perovskite DyBaCo₂O_{5.5} exhibits a very rich phase diagram including two different paramagnetic, a ferromagnetic, and an antiferromagnetic phase as a function of temperature[1]. In addition to these unusual properties, the system exhibits a very pronounced and strong magnetocrystalline anisotropy, with the easy axis along the crystallographic *a*-axis[2]. We will show detailed angular and temperature dependent X-ray magnetic circular dichroism and nonmagnetic linear polarized absorption spectroscopy results at the Co $L_{2,3}$ and O K edges, performed on a de-twinned single crystal. A clear and quantitative correspondence between the microscopic and macroscopic magnetic behavior has been found. O K edge spectra reveal angular dependent variations, which give insight to the orbital character of the unoccupied states. Our results provide detailed information about the microscopic physics behind the observed unusual and also technical very promising properties. [1] A. Maignan *et al.*, Journal of Solid State Chemistry **142**, 247 (1999). [2] A. A. Taskin *et al.*, Phys.Rev.Lett. **90**, 227201-1 (2003).

MA 5.7 Fr 12:00 TU EMH225

Magnetism of weakly doped spin chains in La₅Ca₉Cu₂₄O₄₁ — ●R. LEIDL¹, R. KLINGELER², B. BÜCHNER², W. SELKE¹, and M. HOLTSCHEIDER¹ — ¹Institut für Theoretische Physik, RWTH Aachen, 52056 Aachen, Germany — ²IFW Dresden, PF 270116, 01171 Dresden, Germany

Recent experiments revealed rather surprising magnetic properties of weakly hole doped spin chains in the "telephone number" compound La₅Ca₉Cu₂₄O₄₁. In particular, at low magnetic fields a small anomaly,

indicating a phase transition, in the susceptibility curves (and other quantities) is observed, followed by a rather broad maximum at higher fields where one would usually expect a spin-flop transition. In an effort to (partially) understand these observations we study a classical anisotropic Heisenberg antiferromagnet with spinless holes, using mainly Monte Carlo simulations. We show that a broad maximum in the susceptibility can be caused by a disorder effect, originating in the influence of randomly distributed, immobile holes on the spin-flop transition.

MA 5.8 Fr 12:15 TU EMH225

Substitution of Manganese in electron-doped manganites — ●UWE AMANN^{1,2}, CLEMENS RITTER², DIETMAR HOHLWEIN^{1,3}, and JÖRG IHRINGER¹ — ¹Universität Tübingen, Institut für Angewandte Physik, Auf der Morgenstelle 10, 72076 Tübingen, Germany — ²Institut Laue-Langevin, 6, Rue Jules Horowitz, B.P. 156, 38042 Grenoble, France — ³Hahn-Meitner-Institut, Glienicker Straße 100, 14109 Berlin, Germany

As part of a systematic investigation[1,2,3] of substitution effects of Manganese by other trivalent atoms, we investigated the temperature-dependant evolution of the magnetic moments in the CMR-compound Y_{0.1}Ca_{0.9}Ga_{1-x}Mn_xO₃ for x = 0.0, 0.02, 0.04.

For temperatures above the Neel temperature the samples display monophasic *Pnma* structure. With the onset of magnetic ordering, the system splits into at least two phases, an antiferromagnetic G-type ordered matrix into which ferromagnetic regions (FM) are embedded and a second, monoclinic antiferromagnetic (M-AFM) phase in nuclear space group $P2_1/m$.

Substitution with different ions acts differently on the magnetic structure: Iron inhibits the formation of FM and M-AFM phases, but doesn't disturb the magnetic exchange paths, so there is no change in phase transition temperature. Gallium on the other hand, without magnetic moment, disturbs the exchange paths, shifting the phase transition to lower temperatures.

[1]Th. Lottermoser, Nature 430 (2004), 541-544.

[2]U. Amann et al., Z. Krist., Suppl. 18 (2000), 79

[3]K. Hagdorn et al., Eur. Phys. J. B, 11 (1999), 243

MA 5.9 Fr 12:30 TU EMH225

Giant Magnetoelectric Response in Multiferroic Manganites due to Rare Earth Ordering — ●THOMAS LONKA^{1,2}, UWE AMANN^{1,3}, MANFRED FIEBIG⁴, DANA TOMUTA⁵, DIETMAR HOHLWEIN^{1,2}, and JÖRG IHRINGER^{1,2} — ¹Institute for Applied Physics, University of Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany — ²Hahn-Meitner-Institut, Berlin, Glienicker Str. 100, 14109 Berlin, Germany — ³Institut Laue-Langevin, 6 Rue Jules Horowitz, BP 156 - 38042 Grenoble Cedex 9, France — ⁴Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany — ⁵Kamerlingh Onnes Laboratory, Leiden University, P.O. Box 9504, 2300 RA Leiden, The Netherlands

We analysed the zero field magnetoelectric phase transitions in hexagonal ErMnO₃ and HoMnO₃ by second harmonic generation, measurements of the specific heat, and neutron powder and single crystal diffraction. The magnetic phase transitions from $P6_3cm'$ to $P63cm$ (HoMnO₃) and $P6_3c'm$ to $P6_3c'm'$ (ErMnO₃) were determined by second harmonic generation. Specific heat data shows the magnetoelectric contribution to the free energy. Refinements of the neutron diffraction data, based on the results of the known symmetries, determines the displacements of the atomic positions and the magnetic ordering process.

Our experiments shows the importance of the rare earth ordering process in the magnetoelectric phase transitions in hexagonal manganites. Due to the large magnetic moment of Er³⁺ and Ho³⁺ the magnetoelectric contribution to the free energy is large enough to trigger an electric phase transition of the O-Mn-O-axis of the MnO₅ coordination polyhedra.

MA 5.10 Fr 12:45 TU EMH225

Optische und magnetooptische Eigenschaften von UN-Einkristallen — ●M. MARUTZKY¹, U. BARKOW¹, R. TROČ² und J. SCHOENES¹ — ¹Inst. Halbleiterphysik u. Optik und Hochmagnetfeldanlage, TU BS, Mendelssohnstr. 3, 38106 Braunschweig — ²Inst. Low Temperature and Structure Research, Polish Academy of Sciences, P.O. Box 1410,50-950 Wrocław

UN ist eine Verbindung mit im Vergleich zu den schwereren Uranpniktiden relativ delokalisierten 5f-Elektronen. Sie kristallisiert in der NaCl-Struktur und ordnet antiferromagnetisch bei $T_N = 50$ K. Bereits in den 1980ern wurde UN mit großem Interesse untersucht. Im Gegensatz zu den schwereren Uranpniktiden wurden die optischen und magnetooptischen

Eigenschaften von UN-Einkristallen noch nicht untersucht. Wir haben die optischen Konstanten im Bereich von 1 bis 10 eV aus Ellipsometrie bestimmt, bei höheren Energien dabei am VUV-Ellipsometer am BESSY II. Der polare Kerreffekt wurde an der Hochmagnetfeldanlage der TU Braunschweig von 1 bis 5 eV bei 8,2 T nahe T_N untersucht. Wir finden Kerrdrehungen bis zu $0,2^\circ$. An die gemessene optische Leitfähigkeit wird ein Drude-Lorentzmodell angepasst und es werden die Nichtdiagonalelemente der optischen Leitfähigkeit berechnet. Mit Hilfe dieser Ergebnisse werden Rückschlüsse auf die elektronische Struktur von UN gezogen und diese mit der übrigen Uranpniktide verglichen. Wir danken der Gruppe von N. Esser, insbesondere C. Cobet, für das Ermöglichen von Messungen am BESSY II und dem BMBF für finanzielle Unterstützung.

MA 5.11 Fr 13:00 TU EMH225

Neutron Crystal Field Spectroscopy on the Antiferroquadrupolar system TmGa_3 — ●MICHAEL BANKS¹, REINHARD K KREMER¹, DANNY MANNIX², and AMIR MURANI³ — ¹MPI-FKF, 70569 Stuttgart — ²ESRF Grenoble, CEDEX 9 — ³ILL Grenoble, CEDEX 9

At room temperature TmGa_3 crystallizes with the cubic Cu_3Au structure type. At low temperature it undergoes two first order phase transitions, ascribed to an antiferroquadrupole (AFQ) ordering at 4.29 K and an antiferromagnetic (AFM) transition at 4.26 K. The Crystal Electric Field (CEF) ground state of the trivalent Tm^{3+} ($4f^{12}$, $J = 6$) in the cubic crystal field environment given by an earlier study [1] to ascertain the CEF parameters (in the Lea-Leask-Wolf scheme [2]) arrived at values of $x=0.32$, $W=1.03\text{K}$ with a $\Gamma_5^{(1)}$ ground state separated by the first excited state Γ_3 at 2.5 meV. To investigate possible quadrupolar splittings of the CEF levels we performed inelastic neutron scattering. Surprisingly, our level scheme suggests a Γ_2 singlet CEF ground state with the first excited state being a Γ_1 singlet and $\Gamma_5^{(2)}$ triplet at ~ 0.5 meV, which are almost degenerate, adverse to previous findings [1].

[1] P. Morin et al., J. Mag. Mag. Mat., 66, 345 (1987)

[2] K.R. Lea et al., J. Phys. Chem. Solids, 23, 1381 (1962)

MA 6 Hauptvorträge Stoll / Fiebig

Zeit: Freitag 14:00–15:00

Raum: TU H1028

Hauptvortrag

MA 6.1 Fr 14:00 TU H1028

Sub-ns Time-Resolved Magnetic Transmission X-Ray Microscopy — ●HERMANN STOLL — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

Fast magnetization dynamics of ferromagnetic elements on short length scales is currently attracting substantial scientific interests for both technological and fundamental reasons [1]. Experiments with a time resolution of 70-100 ps combined with a lateral resolution of 20-40 nm were performed by implementing stroboscopic ‘pump-and-probe’ techniques into a full-field soft X-ray microscope (XM-1, beamline 6.1.2, ALS, Berkeley) [2] and a scanning transmission X-ray microscope (STXM, beamline 11.0.2, ALS). The scanning microscope equipped with a fast avalanche photo diode (APD) detector allowed us to speed up time-dependent measurements on micron-sized patterns by about a factor of 10. Spin precession [2] and gyrotropic vortex motion in micron-sized ferromagnetic patterns were studied. Complementary to the *time-domain* ‘pump-and-probe’ measurements we developed a *frequency-domain* ‘spatially-resolved ferromagnetic resonance (SR-FMR)’ technique in order to excite specific eigenmodes of ferromagnetic patterns. A novel effect has been found: the sense of the gyrotropic vortex motion in micron-sized Permalloy patterns may be changed by adjusting the excitation power in a SR-FMR experiment. This allows a deliberate and reproducible switching of the vortex core chirality (handedness).

[1] I. Tudosa et al., Nature **428** (2004) 831

[2] H. Stoll et al., Appl. Phys. Lett. **84** (2004) 3328

Hauptvortrag

MA 6.2 Fr 14:30 TU H1028

Ultraschnelle Magnetisierungsdynamik von Antiferromagneten — ●M. FIEBIG¹, N.P. DUONG¹ und T. SATOH^{1,2} — ¹Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin — ²RCAST, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo

Die Dynamik antiferromagnetischer Systeme unterscheidet sich grundlegend von der von Ferromagneten: Die Magnetisierungsumkehr wird durch die verschwindende makroskopische Magnetisierung begünstigt, sodass Spinumkehrprozesse auf der Skala von in 10 – 100 fs vermutet werden, und die diskreten Zustände dielektrischer Antiferromagnete erlauben lange Kohärenzzeiten. In unserer Gruppe wurde die Magnetisierungsdynamik verschiedener Übergangsmetalloxide mit optischen Pump/Probe-Experimenten untersucht, wobei die Erzeugung der zweiten Harmonischen als Sensor für die Magnetisierung („Probe“) diente. In NiO wurde eine photoinduzierte ultraschnelle Reorientierung der Ni^{2+} -Spins beobachtet und über die nachfolgend auftretenden Quantenschwebungen nachgewiesen. Die Lebensdauer dieses Zustands liegt bei ca. 1 ns und ist durch Spin-Gitter-Wechselwirkungsprozesse begrenzt. Mithilfe eines zweiten Laserpulses lässt sich die Spinorientierung ultraschnell in den Grundzustand zurückversetzen, sodass erstmals kontrolliertes Schalten eines antiferromagnetischen Ordnungsparameters demonstriert werden konnte. In RMnO_3 ($R = \text{Y, Ho}$) wurde eine Entkopplung von Spinreorientierung und Gittertemperatur im Zuge eines magnetischen Phasenübergangs beobachtet, die im Gegensatz zu kürzlich erfolgten Experimenten an Orthoferriten steht.

MA 7 Magnetische dünne Schichten II

Zeit: Freitag 15:15–18:30

Raum: TU H1012

MA 7.1 Fr 15:15 TU H1012

Fully oriented Nd-Fe-B films grown on MgO(100) substrates — ●AH-RAM KWON, ULLRICH HANNEMANN, SEBASTIAN FÄHLER, VOLKER NEU, BERNHARD HOLZAPFEL, and LUDWIG SCHULTZ — IFW Dresden, Helmholtzstr. 20, 01069 Dresden and SFB 463

For both, applications and the study of their anisotropic intrinsic properties, well textured $\text{Nd}_2\text{Fe}_{14}\text{B}$ film are required. This can be achieved by epitaxial film growth, which is controlled by a suitable choice of buffer and substrate materials as well as deposition conditions. Nd-Fe-B films were prepared by pulsed laser deposition on Ta buffer layer using different substrates: amorphous SiN, Al_2O_3 (0001) and MgO(100) substrates in order to control the texture in the films. On all substrates, Nd-Fe-B films possess an out-of-plane c-axis texture with a high remanence to saturation magnetization ratio of around 0.95 and high coercivities between 1.3 T and 2.0 T. However, whereas films on SiN grow with a fiber texture, the films on MgO(100) have a single in-plane orientation of the NdFeB crystallites, growing epitaxially on the substrate. A detailed comparison of microstructure and magnetic properties is presented together with in-plane anisotropy measurements of these films through the spin reorientation transition.

MA 7.2 Fr 15:30 TU H1012

Epitaxial Sm-Co thin films with uniaxial in-plane anisotropy — ●AARTI SINGH¹, ROLAND TAMM², VOLKER NEU¹, SEBASTIAN FÄHLER¹, LUDWIG SCHULTZ¹, WERNER SKROTZKI², and BERNHARD HOLZAPFEL¹ — ¹IFW Dresden, Helmholtzstr. 20, 01069 Dresden — ²Institut für Kristallographie und Festkörperphysik, TU Dresden, 01062 Dresden

This contribution reports on the epitaxial growth of Sm-Co films on MgO single crystal substrates with (100) and (110) orientation. The films were deposited with pulsed laser deposition. A thin layer of Cr was used as buffer and cover layer. On MgO(100) at deposition temperatures of 400 °C, the films have an in-plane texture and have their c-axis oriented only along the MgO[100] and MgO[010] with MgO(001)[100] || Cr(001)[110] || SmCo(11 $\bar{2}$ 0)[001]. Coercivities of the order of 2.7 T are obtained on these substrates. Varying the film composition leads to strongly increased magnetisation values while the crystallographic texture and the coercivity remain almost constant. On MgO(110) single crystal substrates, Sm-Co grows with the epitaxial relation MgO(110)[001] || Cr(211)[110] || SmCo(10 $\bar{1}$ 0)[001]. This restricts the c-axis of the Sm-Co to grow with

only one orientation on the substrate. The buffer (Cr) microstructure and texture are important in controlling the texture of the Sm-Co layer. For optimised conditions highly anisotropic films with coercivities of more than 3 T have been deposited.

MA 7.3 Fr 15:45 TU H1012

Thickness dependent T-MOKE and XAS study at the 2p edges of ultrathin Co(0001) films on W(110) — ●ARMIN KLEIBERT¹, JOACHIM BANSMANN¹, VOLKMAR SENZ¹, and PETER OPPENEER² — ¹Universität Rostock, Universitätsplatz 3, 18051 Rostock — ²Department of Physics, Uppsala University, Box 530, S-75121 Uppsala, Sweden

X-ray magnetic resonant scattering (XMRS) is a powerful and element-specific tool for investigations on complex, nanoscaled magnetic samples. In the past these studies involved mainly *ex-situ* prepared samples or multilayers, where the capping layer has not been taken into account. In this contribution we present recently obtained results on the thickness dependence of the transverse magneto-optical Kerr-effect (T-MOKE) on *in-situ* prepared atomically smooth ultrathin hcp Co(0001) films on W(110) with thicknesses ranging from several monolayers down to the submonolayer. We observe strong interference effects in the overall reflectivity that are nicely reproduced by magneto-optical calculations. Simultaneously recorded X-ray absorption spectra (XAS) reveal strong changes in the shape of the submonolayer absorption spectra. The corresponding reflectivity is reproduced by simulations based on recalculated optical constants taking into account the reduced atomic density of the submonolayer. Moreover, these Co films possess a strong uniaxial magnetic in-plane anisotropy with the easy axis along the W[110] direction. Thus, one may expect anisotropic orbital magnetic moments which give rise to an anisotropy in the T-MOKE response when rotating the sample around its surface normal. Based on simulations and experimental data we will show the possibility of the observation of such an anisotropy.

MA 7.4 Fr 16:00 TU H1012

Magneto-optical signal superposition in ultra-thin Co/Pd structures — ●M. PRZYBYLSKI, M. NYVLT, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Magnetism of ultrathin Co films grown on clean and atomically flat surfaces of Pd single crystals was studied by magneto-optical (MO) Kerr rotation. The films show very similar behavior independently of the crystallographic orientation of the Pd-substrate surface. Polar MO loops change sign of the MO signal at certain critical thickness, t_c , which varies for different substrate planes and growth conditions. This effect is attributed to a competition between two MO components with different signs originating from the Co-Pd interface and from the inner part of the Co film. At t_c these two contributions cancel each other. For the Co films grown on the "open" Pd(110) surface reversed polar MO loops are detected at low Co coverage after deposition at room temperature and t_c slightly increases with increasing annealing temperature. For Co grown on the most densely packed Pd(111) the same behavior is observed after growing the film above 400 K. The critical thickness at which the polar loops change polarity relates to the Co/Pd interface and does not vary with the expanding thickness range at which the out-of-plane magnetization is kept.

MA 7.5 Fr 16:15 TU H1012

Polar contribution to longitudinal magneto-optical Kerr signal — ●M. PRZYBYLSKI, M. NYVLT, J. BARTHEL, A. WINKELMANN, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Magneto-optical Kerr rotation loops were measured for Co films on single crystal Pd substrates. Variation of the Kerr signal with the Co thickness showed an abnormal behavior in the range where a perpendicular magnetization component is detected in polar geometry. Such a component appears in the low Co thickness limit due to an out-of-plane anisotropy of the Co/Pd system caused by hydrogen adsorption. The abnormal behavior of the Kerr signal arises from the polar contribution to the longitudinal effect. When the magnetic field is applied perfectly in the film plane, the perpendicular component of magnetization cannot be reversed. Consequently, no polar contribution should be detected. A small misalignment between the field and the sample plane is sufficient to produce a small polar field (with respect to the longitudinal one) which can reverse the perpendicular magnetization component. Actually, the applied field must be quite strong in order to achieve its sufficient polar projection. The fact that the "coercivity" of the abnormal longitudinal loops scales with the coercivity of the polar loops supports the above

interpretation. The coercivity scaling factor increases with the angle by which the magnetization is tilted from the sample plane.

MA 7.6 Fr 16:30 TU H1012

Untersuchung struktureller und magnetischer Eigenschaften ultradünner Fe Schichten auf Cu(001) im Bereich des fcc-bcc Phasenübergangs mittels streifender Ionenstreuung — ●M. BARON, T. BERNHARD, M. GRUYTERS und H. WINTER — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstrasse 15, 12489 Berlin

Wachstum, Struktur und Magnetismus ultradünner Fe Schichten auf Cu(001) werden mittels streifender Ionenstreuung untersucht. Der Phasenübergang in eine bcc-Struktur wird innerhalb weniger Fe Atomlagen mit Hilfe von Ionenstrahltriangulation beobachtet. Bei dieser Methode wird ausgenutzt, dass sich die ioneninduzierte Elektronenemission ändert, wenn der azimutale Einfallswinkel der Ionen mit einer niederindizierten Gitterrichtung zusammenfällt. Die strukturellen Änderungen werden von Änderungen im magnetischen Verhalten begleitet. Die bei ca. 4 Atomlagen eintretende in-plane Magnetisierung wurde mit Hilfe des Einfangs spin-polarisierter Elektronen in angeregte atomare Zustände des Projektils studiert. Unsere Methoden zeichnen sich durch eine ausgeprägte Empfindlichkeit auf die oberste Atomlage aus und liefern wichtige ergänzende Informationen zu früheren Untersuchungen des Phasenübergangs mit konventionellen Methoden wie LEED und SMOKE.

MA 7.7 Fr 16:45 TU H1012

Spin polarization, structure and chemical composition of ultrathin Rh layers on Fe(100) — ●MARCO BUSCH, MARKUS GRUYTERS, and HELMUT WINTER — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstrasse 15, D-12489 Berlin, Germany

We report on spin- and energy-resolved secondary electron emission, induced by grazingly scattered 100 keV protons from ultrathin Rh layers on Fe(100). A finite spin polarization of secondary electrons is observed up to 3 monolayers of Rh. The growth of Rh at room temperature is studied by grazing scattering of 50 keV He⁺ ions. We find that growth of Rh on Fe(100) deviates from a perfect pseudomorphic layer-by-layer growth. The chemical composition is investigated by Auger electron spectroscopy induced by 5 keV electrons and grazingly scattered 200 keV protons.

MA 7.8 Fr 17:00 TU H1012

Spin-reorientation-transitions in Co films on Pd(110) — ●L. YAN, M. PRZYBYLSKI, J. BARTHEL, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Ultrathin Co films were grown by thermal deposition on an atomically clean and flat surface of Pd(110) and characterized magnetically by means of magneto-optical Kerr effect (MOKE). Immediately after deposition at room temperature (RT) the films are magnetized in plane. Polar MOKE signal appears only after the film is exposed to the residual atmosphere at low temperature. This is most likely due to hydrogen adsorption. With increasing temperature the magnetization rotates back towards the film plane and no polar MOKE signal is again detected at RT. We interpret this effect as a result of desorption of hydrogen above a certain temperature. At the thickness range at which the out-of-plane magnetization appears, an abnormally large longitudinal signal is detected. This is due to the contribution of the polar component to the longitudinal MOKE signal. With increasing Co coverage the polar signal disappears. The magnetization vector rotates towards the film plane, showing an increasing longitudinal component to the total Kerr signal. Also annealing supports the out-of-plane magnetization of the Co/Pd(110) system. However, in this case the magnetic anisotropy of the system is irreversibly changed due to the structural changes experienced by the sample during annealing.

MA 7.9 Fr 17:15 TU H1012

Magnetism of Co and Fe films grown on Pd-monolayer/Cu(001) — ●Y. LU, M. PRZYBYLSKI, M. NYVLT, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

In order to verify the concept of the Co/Pd interface contribution to the total magneto-optical response from the Co films, a monolayer of Pd was grown by pulsed laser deposition (PLD) on Cu(001) as a template for growth of Co films. Both Co/Pd/Cu(001) and Co/Cu(001) systems prepared under identical conditions have the same slope in the thickness dependence of Kerr rotation. However, a clear increase of the MOKE signal in comparison to the Co films grown directly on Cu(001) is detected. Due to similarity in the structure of Co films on Cu(001) and Pd/Cu(001), any difference in magneto-optical response of both systems could be interpreted as a result of Pd-Co hybridization. When the Pd-

buffer layer is thicker than 1 ML, the Kerr rotation from Co is independent of the Pd thickness. This suggests that the second Pd layer does not contribute significantly to the magneto-optical response of the system. A comparison of these Co films on Pd/Cu(001) and Cu(001) is made to the Fe films grown on the same templates. In particular, the sign reversal of the longitudinal Kerr loops with increasing thickness of the Fe films is discussed.

MA 7.10 Fr 17:30 TU H1012

Influence of deposition method on magnetism of Fe and Co films on Pd(001) — ●Y. SHI¹, M. PRZYBYLSKI¹, M. RAMS², J. BARTHEL¹, H. L. MEYERHEIM¹, and J. KIRSCHNER¹ — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle — ²Institute of Physics, Jagiellonian University, Reymonta 4, PL-30-059, Krakow

Pd is predicted to be polarized by hybridization within a magnetic neighborhood like Fe and Co. Thus, ferromagnetic order in ultrathin Fe and Co films, mediated by the Pd substrate, could be expected even below the percolation threshold, i.e. in the submonolayer regime. We investigated magnetism of Fe and Co on Pd(001) in a thickness range from 0 to 10 monolayers (ML) for films deposited at room temperature by either thermal deposition (TD) or by pulsed laser deposition (PLD). In-plane Kerr rotation measured in saturation immediately after the film deposition shows similar thickness dependence for Fe and Co, with differences between PLD- and TD-grown films below a thickness of 2 ML. In particular, PLD Fe films at low temperature (70 K) exhibit long range order starting from a coverage around 0.2 ML, while the onset of ferromagnetism in Fe films prepared by TD is observed only at 0.5 ML, which is about the percolation threshold. Linear extrapolation of the magneto-optical response at higher film thickness to zero thickness reveals an offset in Kerr rotation equivalent to the signal of more than one ML for PLD films, but less than one ML for TD films. MOKE results for PLD Fe/Pd(001) are discussed in comparison to SQUID measurements of the same system.

MA 7.11 Fr 17:45 TU H1012

Structural effects on the magnetic behavior of ultrathin Co films on Cu(001) at the T_C jump — ●M. GRUYTERS, T. BERNHARD, M. BARON, and H. WINTER — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstrasse 15, 12489 Berlin, Germany

The magnetic ordering in ultrathin Co films on Cu(001) has been investigated via the polarization of light emitted after capture of spin-polarized electrons into excited atomic terms during grazing He scattering. A strong increase in the Curie temperature and the remanent spin polarization has been observed at a critical Co thickness of about 1.7 ML.

In agreement with a recent study on the same heteroepitaxial system, this behavior is attributed to the percolation of Co islands. For growth at an elevated temperature of 410 K, hysteresis loops reveal a strong increase in the irreversibility field at which the loop closes. This behavior is explained by an inhomogeneous distribution of growth-induced local magnetic anisotropies which make a complete reversal of the magnetization more difficult.

MA 7.12 Fr 18:00 TU H1012

On the correlation of intrinsic properties, microstructure and hard magnetic properties of FePt films — ●SEBASTIAN F ÄHLER, MARTIN WEISHEIT, VOLKER NEU, and LUDWIG SCHULTZ — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

Epitaxial, $L1_0$ ordered FePt films can reach a coercivity up to 5.6 T, a fraction of about 50% of the anisotropy field of 11.6 T. This is significant higher than the fraction of 30% typically reached at best in permanent magnets. Thus these granular films are ideally suited to study the switching behaviour of permanent magnets.

Thin FePt films had been prepared by pulsed laser deposition. In order to vary microstructure and intrinsic magnetic properties, films had prepared at different temperature, composition and film thickness. Resulting magnetic properties are strongly correlated to these growth conditions. For a detailed analysis, the domain pattern of some films had been measured by MFM and angular and temperature dependence of coercivity is analysed. These results show that domain reversal in FePt films reaching the highest coercivity is governed by nucleation.

MA 7.13 Fr 18:15 TU H1012

Hard magnetic electrodeposited FePt films — ●KARIN LEISTNER, ANDREAS KRAUSE, HEIKE SCHLÖRB, MARTIN WEISHEIT, LUDWIG SCHULTZ, and SEBASTIAN FÄHLER — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

FePt is a promising material for hard magnetic films in MEMS or magnetic data storage due to its high magnetocrystalline anisotropy and saturation magnetization. Electrodeposition of FePt films would be a low cost alternative to physical vapor deposition techniques. As deposited films are amorphous and a large fraction of oxygen is incorporated. Quartz microbalance studies have been carried out in order to gain knowledge about the deposition processes and the mechanism of oxygen incorporation. The oxygen content is reduced when annealing in hydrogen, and as a result magnetization values are increased. Microstructure evolution during annealing has been studied and can be correlated to the hard magnetic properties. Coercivities up to 1.1 T can be achieved after annealing at 600°C in hydrogen.

MA 8 Spindynamik I

Zeit: Freitag 15:15–18:30

Raum: TU H1028

MA 8.1 Fr 15:15 TU H1028

High wave vector spin waves in ultrathin hcp Co-films on W(110) — ●M. ETZKORN¹, P. S. ANIL KUMAR¹, W. TANG¹, R. VOLLMER¹, Y. ZHANG¹, H. IBACH², and J. KIRSCHNER¹ — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle — ²Institut für Schichten und Grenzflächen ISG3, Forschungszentrum Jülich, 52415 Jülich

We present spin-polarized electron energy loss spectroscopy (SPEELS) measurements of high wave vector spin waves in ultrathin hcp Co-films on W(110) and compare the results to results obtained on fcc Co on Cu(001) [1]. In general, in both systems the spin-wave excitations show similar behaviour. A surprisingly good agreement was found between the measured dispersion of hcp and fcc Co and the dispersion of a surface spin wave in a nearest neighbor Heisenberg model. For both systems the product of the exchange coupling constant and the magnetic moment is $JS = 15$ meV within the experimental error. The spin-wave dispersion measured on thin, hcp Co-films by SPEELS is also compared to results of inelastic neutron scattering experiments performed on bulk hcp Co [2]. A moderate reduction of JS was found for the thin films.

The intensity of the spin-wave loss feature in the SPEEL- spectra strongly depends on the kinetic energy of the scattering electrons. High spin-wave intensities are only observed for incoming electron energies below about 10 eV.

[1] R. Vollmer, M. Etzkorn, P. S. Anil Kumar, H. Ibach and J. Kirschner, Phys. Rev. Lett. 91 (2004) 147201. [2] T. G. Perring, A. D. Taylor and G. L. Squires, Physica B 213&214 (1995) 348.

MA 8.2 Fr 15:30 TU H1028

Phase-sensitive Ultrafast Spin Dynamics in Antiferromagnetic Cr_2O_3 — ●T. SATOH^{1,2}, B.B. VAN AKEN¹, N.P. DUONG¹, TH. LOTTERMOSER¹, and M. FIEBIG¹ — ¹Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin — ²RCAST, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo

With the discovery of magnetization processes on the (sub-) ps time scale the coupling processes between spins, electrons and lattice that allow such rapid manipulation of the magnetic order parameter became a central topic. Here we discuss the temporal evolution of spin and charge lattices in antiferromagnetic Cr_2O_3 upon excitation with an intense 100 fs laser pulse. Optical second harmonic generation (SHG) is used as probe for the magnetic and crystallographic sublattices, since linear magneto-optical techniques fail because of the absence of a macroscopic magnetization. By coherent interference of the magnetic and crystallographic contributions to SHG the temporal evolution of both amplitudes and phases of the magnetically induced signal can be observed. The dynamical response of Cr_2O_3 occurs on three different time scales (~ 1 ps, ~ 10 ps, ~ 1 ns). The result indicate weak spin-lattice coupling in the absence of the pump light field and a different temporal evolution of the amplitude and the phase of the magnetic signal. Possible relations to the magnetoelectric behavior of Cr_2O_3 are discussed.

MA 8.3 Fr 15:45 TU H1028

Magnetization dynamics in all optical pump probe experiments — ●MARIJA DJORDJEVIC, MARIO LÜTTICH, PETER MOSCHKAU, and MARKUS MÜNZENBERG — IV. Physikalisches Institut, Universität Göttingen

Developing spintronics demands new insight in magnetization dynamics in the sub ns regime. Short pulses of Ti: Sapphire laser (50fs) are used in time resolved magneto optical Kerr effect experiments to follow electron and spin dynamics of ferromagnetic and not-magnetic thin films (Fe, Ni, Co, Al, Cu) upon laser heating. Different timescales are observed: ultrafast demagnetization in the first ps after the absorption of the laser pulse and precession of the magnetization in the GHz regime. The mechanisms involved in ultrafast demagnetization can be described within the three temperature model, which relates temperatures of electrons, lattice and spins. From this model electron-phonon and spin-phonon coupling constants can be determined. Standing spin waves are observed for longer time scales, >100ps. The precessional dynamics is in good agreement with dynamic LLG calculations, therefore the intrinsic and non-local Gilbert damping parameter can be determined, as well as the Eigen frequency of magnetic precessional modes.

MA 8.4 Fr 16:00 TU H1028

Spin-Wave Eigenmodes of Permalloy Squares with Closure Domain Structure — ●KORBINIAN PERZLMAIER¹, MATTHIAS BUESS¹, CHRISTIAN H. BACK¹, VLADISLAV E. DEMIDOV², BURKARD HILLEBRANDS², and SERGEJ O. DEMOKRITOV³ — ¹Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, D-93040 Regensburg, Germany — ²Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — ³Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany

We investigate the magnetization dynamics of 16nm thick and 4 μm wide permalloy squares in a closure domain state using two complementary experimental techniques: Time Resolved Scanning Kerr Microscopy (TRSKEM) and Micro Focus Brillouin Light Scattering (μBLS). In the μBLS case, the spin wave spectrum is imaged for a sample excited perpendicularly at different frequencies, while in the TRSKEM case the response of the out-of plane component of the sample's magnetization upon a fast rise time perpendicular field pulse excitation is recorded in the time domain. In the latter case, the mode structure is then extracted using Fourier Transformation. In addition to a low-frequency mode localized in the domain walls, additional modes in the domains with a main quantization perpendicular to the static magnetization were detected. While TRSKEM is better suited for the observation of low frequency modes, BLS yields better results for modes at higher frequencies. In the overlap of these two frequency spaces, good agreement can be found.

MA 8.5 Fr 16:15 TU H1028

Ferromagnetic resonance in magnetic microstructures studied using phase resolved Kerr microscopy — ●INGO NEUDECKER, RAINER HÖLLINGER, DIETER WEISS, and CHRISTIAN H. BACK — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93040 Regensburg

We present a technique to investigate the eigenmode spectrum with a spatial resolution of about 300 nm using phase resolved magneto optic Kerr effect.

Instead of exciting the magnetic elements by a short magnetic field pulse containing a broad frequency spectrum we use a sinusoidal magnetic field to excite only a single mode of the system. The sinusoidal excitation is phase locked to the repetition rate of 80 MHz of our Ti:Sapphire laser system. Due to the bandwidth of the signal generator we are able to investigate the eigenmode spectrum from 80 MHz up to 20 GHz in 80 MHz intervals, limited in principle only by the spatial resolution of the Kerr setup.

The magnetic system investigated are 4 micron diameter permalloy disks with 20 nm thickness defined by electron beam lithography on top of a lithographically fabricated microwave guide.

The in plane high frequency field excites symmetry breaking azimuthal eigenmodes, which we were able to resolve up to the third order. Additionally we identified the spatially resolved evolution of the main mode as a function of a static external bias field. A comparison of the results to Network Analyzer - ferromagnetic resonance measurements and micromagnetic simulations show excellent agreement.

MA 8.6 Fr 16:30 TU H1028

Stopping of spin wave pulses using a non-stationary bias magnetic field — ●ALEXANDER A. SERGA¹, ALEXANDER ANDRÉ¹, BURKARD HILLEBRANDS¹, THOMAS SCHNEIDER¹, SERGEY O. DEMOKRITOV², and ANDREY N. SLAVIN³ — ¹Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — ²Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Münster, Germany — ³Department of Physics, Oakland University, Rochester, Michigan 48309, USA

The new phenomenon of phase-coherent recovery of a spin wave packet stopped and stored in standing spin waves was observed. The process is realized by means of a local alteration of the applied magnetic field. The field change shifts temporarily the dispersion curve in frequency and converts the modes comprising the spin wave packet from magnetostatic surface wave modes into exchange standing spin waves and vice versa. The converted standing spin waves were conserved for a storage time much larger than the spin wave relaxation time using parallel parametric pumping applied to the magnetic medium. The restored propagating spin wave packet preserves its phase coherency with the initial input packet irrespective of the initial phase of the parametrical pumping and the conservation time.

MA 8.7 Fr 16:45 TU H1028

Parametric Generation of Forward and Phase-Conjugated Spin-Wave Bullets in Magnetic Films — ●ALEXANDER A. SERGA¹, BURKARD HILLEBRANDS¹, SERGEY O. DEMOKRITOV², ANDREY N. SLAVIN³, P. WIERZBICKI³, VITALIY VASYUCHKA⁴, OLEKSANDR DZYAPKO⁴, and ANDRIY CHUMAK⁴ — ¹Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — ²Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Münster, Germany — ³Department of Physics, Oakland University, Rochester, Michigan 48309, USA — ⁴Department of Radiophysics, Taras Shevchenko National University of Kiev, Kiev, Ukraine

The new physical effect of parametrically stimulated generation of two-dimensional nonlinear objects, so-called spin-wave bullets, has been observed in a magnetic film. It has been shown experimentally and by numerical simulation that interaction of a linear two-dimensional spin wave packet with the microwave magnetic field in a pulsed parametric pumping process leads to the formation of strongly self-focused spin wave bullets propagating both in forward and reversed directions. The focusing of the reversed (phase-conjugated) bullet is strongly pronounced due to the combined effects of the nonlinear four-wave self-focusing and linear focusing caused by the two-dimensional wave front reversal process.

MA 8.8 Fr 17:00 TU H1028

Quasi-2D nonlinear spin wave waveforms in in-plane confined ferromagnetic films — ●ALEXANDER A. SERGA¹, MIKHAIL KOSTYLEV¹, BURKARD HILLEBRANDS¹, SERGEY O. DEMOKRITOV², and ANDREY N. SLAVIN³ — ¹Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — ²Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Münster, Germany — ³Department of Physics, Oakland University, Rochester, Michigan 48309, USA

The formation of quasi-2D spin-wave waveforms in longitudinally magnetized stripes of ferrimagnetic film was observed by using time- and space-resolved Brillouin light scattering technique. In the linear regime it was found that the confinement decreases the amplitude of dynamic magnetization near the lateral stripe edges. Thus, the so-called effective dipolar pinning of dynamic magnetization takes place at the edges. In the nonlinear regime a pronounced formation of focus and a collapse of the waveform were observed. The experiments and a numerical simulation of the pulse evolution show that the shape of the formed waveforms and their behavior are strongly influenced by the confinement.

MA 8.9 Fr 17:15 TU H1028

Excitations with negative dispersion in a spin vortex — ●MATTHIAS BUESS^{1,2}, TUOMAS P. J. KNOWLES², RAINER HÖLLINGER¹, THOMAS HAUG¹, UWE KREY¹, DIETER WEISS¹, DANILO PESCIA², MICHAEL R. SCHEINFEN³, and CHRISTIAN H. BACK¹ — ¹Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93040 Regensburg, Germany — ²Laboratorium für Festkörperphysik, Eidgenössische Technische Hochschule Zürich, CH-8093 Zürich, Switzerland — ³Simon Fraser University, 8888 University Drive, Burnaby BC U5A 156, Canada

Thin-circular lithographically defined magnetic elements with a spin vortex configuration are excited with a short perpendicular magnetic field pulse. The excited modes are imaged using time resolved magneto-optic Kerr microscopy and Fourier transformation. We extract the excitation spectrum from platelets ranging from 1 to 6 micron diameter and 15 nm thickness. Two types of modes are observed: radially symmetric modes with circular nodes and symmetry breaking modes with diametric nodes. The frequency of the modes with circular nodes increases with the number of nodes. In contrast, the frequency of the modes with diametric nodes decreases with the number of nodes. This behaviour is explained accurately by an analytical model. The model reproduces this phenomenon by considering the magnetostatic energy associated with the excited modes as suggested by Fletcher and Kittel more than 40 years ago (P. C. Fletscher and C. Kittel, Phys. Rev. **120**, 2004 (1960)).

MA 8.10 Fr 17:30 TU H1028

Thickness dependent magnetization dynamics of Permalloy elements observed by time-resolved wide-field Kerr microscopy — ●ANDREAS NEUDERT, JEFFREY MCCORD, RUDOLF SCHÄFER, and LUDWIG SCHULTZ — IFW Dresden, Helmholtzstr. 20, 01069 Dresden

We investigated the magnetization dynamics of 10 to 160 nm thin Permalloy elements using time-resolved wide-field Kerr microscopy (lateral resolution 0.3 μm , temporal resolution 20 ps). The ferromagnetic structures with lateral sizes of some ten micrometers are deposited onto a coplanar waveguide to excite them with in-plane pulsed magnetic fields produced by a standard voltage pulse generator. Due to the varying film thickness the internal domain wall structure changes (Neel, crosstie, Bloch wall) and the influence onto the magnetization dynamics will be discussed.

This work is funded by the DFG Schwerpunktprogramm 1133 "Ultrafast magnetization processes".

MA 8.11 Fr 17:45 TU H1028

Time resolved magnetization dynamics of ultrathin Fe(001) films: Spin-pumping and two-magnon scattering — ●GEORG WOLTERS DORF^{1,2}, MATTHIAS BUSS¹, CHRISTIAN BACK¹, and BRET HEINRICH² — ¹Universität Regensburg, Universitätsstraße 31, 93040 Regensburg Germany — ²Simon Fraser University 8888 University Drive V5A 1S6 Burnaby BC Canada

The time resolved magnetic response of ultrathin epitaxial Fe(001) grown on GaAs(001) and covered by Au, Pd, and Cr capping layers was investigated by time and spatially resolved Kerr effect measurements. The multilayer structures were prepared by Molecular Beam Epitaxy on GaAs(001) substrates. The magnetization was excited by an in-plane magnetic field pulse while the wavelength of the excitation (resonant mode) was roughly 2 μm . Each of the three capping layer represents a unique case of spin dynamics. Au cap layers resulted in the Fe bulk

Gilbert damping. Pd cap layers caused an additional Gilbert damping due to spin-pump/spin-sink effects. Cr cap layers lead to a strong extrinsic damping which can be described by two-magnon scattering. The strength of the extrinsic damping can be controlled by shifting the spin manifold with respect to the excited k-vector using an external bias field.

MA 8.12 Fr 18:00 TU H1028

Field-pulse induced generation of spin waves at domain boundaries in permalloy microstructures observed by XMCD-PEEM — ●A. KRASYUK¹, S.A. NEPIJKO¹, A. OELSNER¹, H.J. ELMERS¹, C.M. SCHNEIDER², and G. SCHÖNHENSE¹ — ¹Institut für Physik, Johannes Gutenberg - Universität, 55099 Mainz — ²Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich

Stroboscopic XMCD-PEEM imaging gives direct access to fast remagnetization processes. At gradients in the region of 1mT/500 ps we have observed the fast formation of blocking domains (incoherent magnetization rotation [1]) and a rapid coherent rotation of the domain magnetization [2] resulting in a field-induced magnetic flux traversing the microstructure. Here we report on measurements with a high time resolution in the 10 ps-range employing the low- α multibunch operational mode of BESSY II providing photon pulses of < 2ps width. Domain images with time increments of down to 10 ps revealed a rapid oscillation of the visible position of the domain boundaries. A micromagnetic simulation using the NIST code (OOMMF) gives evidence of the excitation of spin waves at the domain boundaries as a consequence of the fast displacement of the domain wall during the field pulse. The plane-wave like spin wave travels perpendicular to the wall thus giving rise to an apparent oscillation of the wall position with a frequency in the 10 GHz range. Financial support by BMBF (grants 05KS1UM1/5 and 05KS1BDA/9) and DFG (Schwerpunktprogramm SPP 1133) is gratefully acknowledged.

[1] C.M. Schneider et al., Appl. Phys. Lett. 85 (2004) 2562

[2] D. Neeb et al., J. Phys.: Condens. Matter (2004) in print

MA 8.13 Fr 18:15 TU H1028

Time-resolved photoelectron emission microscopy of magnetic nanostructures — ●B. HEITKAMP, L. HEYNE, H.A. DURR, and W. EBERHARDT — BESSY GmbH, Albert-Einstein-Strasse 15, 12489 Berlin

In view of the ever-growing field of magnetoelectronics it is of major importance to understand the fundamental physical phenomena. Our approach is to combine nm spatial resolution of a photoemission microscope (PEEM) and fsec-laser technique. By analyzing the spin-polarization of the emitted photoelectrons magnetic sensitivity can be obtained. The magnetic nanostructures under investigation show a strong dependence of the emission characteristics on light polarization and wavelength. This can be explained by plasmon-excitation and other coherence effects. Pump-probe experiments can be used to study the electron and spin-dynamics on a fsec-time scale.

MA 9 FV-internes Symposium "Heusler-Legierungen" (Organizers: B. Hillebrands, H. Zabel)

Zeit: Freitag 15:15–18:45

Raum: TU EMH225

Hauptvortrag

MA 9.1 Fr 15:15 TU EMH225

Halfmetallic Alloys: Electronic Structure, Magnetism, and Spin Polarisation — ●PETER H. DEDERICHS, IOSIF GALANAKIS, and PHIVOS MAVROPOULOS — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich

Halfmetallic alloys are ferromagnets which show a metallic behaviour for the majority electrons, but a semiconducting behaviour with a band gap at the Fermi level E_F for the minority electrons. The resulting 100% spin polarisation at E_F makes them of strong interest for spin electronics. Based on ab-initio calculations, we review the basic understanding of the electronic structure of half-metallic Heusler alloys. The origin of the gap is the d-d hybridisation between the lower-valent (magnetic) and the higher valent (non-magnetic) transition elements. Due to the band gap, an integer number of minority bands is occupied, so that an ideal Slater Pauling behaviour is obtained: The total moment M per unit cell scales with the total number Z of valence electrons, such that $M = Z - 18$ for the half and $M = Z - 24$ for the full Heusler alloys. We discuss the role of spin orbit coupling which in principle destroys the gap, but in practice is of minor importance, since the spin polarisation remains very

high. Also other relativistic effects like orbital moments and magnetic anisotropy energies are typically very small. From application point of view the existence of disorder induced impurity gap states and of surface and interface states in the gap represent the biggest challenge. We shortly discuss the halfmetallic zincblende compounds like CrAs which show many similar properties.

Hauptvortrag

MA 9.2 Fr 15:45 TU EMH225

The properties of $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ Heusler compounds — ●CLAUDIA FELSER, GERHARD H. FECHER, SABINE WURMEHL, and THOMAS BLOCK — Johannes Gutenberg - Universität, 55099 Mainz, Germany

The compound $\text{Co}_2\text{Cr}_{0.6}\text{Fe}_{0.4}\text{Al}$ was prepared, guided by striking features in the electronic structure of several magnetic Heusler compounds. Based on band structure calculations, this composition was chosen in order to obtain a ferromagnetic half metal with a van Hove singularity in the vicinity of the Fermi energy in the majority spin channel and a gap in the minority spin channel. The evidence for spinpolarized transport at room temperature was found, showing up in a magnetoresistive effect of

35% in a small magnetic field of 0.1 Tesla. Heusler compounds with composition $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ were prepared by arc melting and comprehensively characterized by means of XRD, SQUID magnetometry, Mößbauer spectroscopy, MXCD, ESCA and AES depth profiling. X-ray diffraction and EXAFS pointed on structural disorder phenomena. Band structure calculations are presented for ordered and disordered compounds. The connection between specific site disorder and the band structure is shown explicitly with particular emphasis on the half-metallic properties. Experimentally observed deviations from the ideal Heusler structure and from the simple Slater-Pauling rule for the magnetization are discussed in close relation to theoretical models.

Hauptvortrag

MA 9.3 Fr 16:15 TU EMH225

Elementspecific electronic properties of the Heusler alloys investigated by X-ray absorption spectroscopy — ●HANS-JOACHIM ELMERS — Johannes Gutenberg Universität Mainz

Doped Heusler alloys and compounds of the $\text{Co}_2(\text{Y}_x\text{Y}'_{1-x})\text{Z}$ type are potential candidates for halfmetallic ferromagnetic materials that can be used in spintronic devices. The electronic properties can be tuned by varying Mn to Fe and Cr to Fe ratio x on the Y site. Of particular interest are properties at the surface of the material since all potential applications rely on electron transfer through an interface. In order to confirm theoretical investigations, that predict a gap in the minority bands, we performed X-ray absorption spectroscopy at the $L_{3,2}$ edges of the 3d transition metals of the pure compounds ($x=0$ and $x=1$) and alloys with varying composition x [1]. The determination of all photoemitted electrons (total yield) provides a moderate surface sensitivity (≈ 10 nm). For in-situ cleaned bulk samples or in-situ capped surfaces we determine element specific magnetic moments. We compare our measurements with simulated spectra based on ab-initio bandstructure calculations. The absorption spectra show distinct features that can be related to the degree of disorder in the $L2_1$ - Heusler structure. The Cr moment is quenched in disordered areas of the sample because of a partly antiparallel alignment and therefore serves as a tracer signal for fully ordered unit cells. The comparison of XMCD spectra of Cr with simulated spectra indicates a high spinpolarization in ordered compounds.

[1] H. J. Elmers, S. Wurmehl, G. H. Fecher, G. Jakob, C. Felser, G. Schönhense, Appl. Phys. A 79, 2004, 557 and references therein.

Hauptvortrag

MA 9.4 Fr 16:45 TU EMH225

Interplay of defects and temperature in NiMnSb — ●ROBERT A. DE GROOT, JISK ATTEMA, LIVIU CHIONCEL, CHANGMING FANG, GILLES A. DE WIJS, and ALEX I. LICHTENSTEIN — ESM, Toernooiveld 1, Nijmegen, The Netherlands

The electronic structure of NiMnSb, the origin of the band gap for one spin-direction as well as the influence of intrinsic defects are discussed. Intrinsic point-defects are unlikely or have a negligible effect but the effect of the surface is detrimental for the half-metallic properties. Genuinely half-metallic interfaces with zinc-blende semiconductors are possible however, and the underlying physics will be discussed. Finally, possibilities of introducing non-intrinsic defects will be explored in order to optimize the spin-polarization of the conduction at finite temperatures through the modification of the magnon density of states.

Hauptvortrag

MA 9.5 Fr 17:15 TU EMH225

Magnetism of $[\text{Co}_2\text{MnGe}/\text{Au}]_n$ and $[\text{Co}_2\text{MnGe}/\text{V}]_n$ multilayers — ●K. WESTERHOLT, A. BERGMANN, J. GRABIS, E. VERDUIJN, A. NEFETOV, and H. ZABEL — Experimentalphysik/Festkörperphysik Ruhr-Uni-Bochum 44780 Bochum, Germany

The magnetic behavior of the fully spin polarized Heusler compounds at interfaces with dielectrics and non magnetic metals is essential when judging the perspective of these materials as ferromagnetic layers in

typical spintronic devices. We review our results on the magnetic and structural properties of multilayers composed of the fully spin polarized Heusler alloy Co_2MnGe with V or Au as interlayers. In $[\text{Co}_2\text{MnGe}/\text{Au}]_n$ multilayers the interlayers cause an exchange bias shift of the ferromagnetic hysteresis loops at low temperatures. The analysis of the x-ray resonant magnetic reflectivity reveals that the magnetization profile of Mn is definitely different from that of Co and asymmetric with respect to the growth direction of the layers. In $[\text{Co}_2\text{MnGe}/\text{V}]_n$ multilayers with very thin Heusler layers we observe an antiferromagnetic interlayer long range ordering below a well defined Néel temperature originating from the dipolar stray fields of the magnetically rather rough Heusler layer interfaces.

Hauptvortrag

MA 9.6 Fr 17:45 TU EMH225

Magnetic tunnel junctions with Heusler alloy electrode: Interface structure and magnetism in the shine of soft X-rays — ●JAN SCHMALHORST — University of Bielefeld, Department of Physics, Nano Device Group, P.O. Box 100131, 33501 Bielefeld, Germany

The implementation of half-metallic materials like full Heusler alloys [1] for spintronic applications [2], e.g., as electrode in magnetic tunnel junctions, is of highest technological relevance. The major challenge is the preparation of preferably defect free interfaces. We fabricate $\text{Co}_2\text{MnSi} / \text{AlO}_x / \text{Co-Fe}$ MTJs with 95% tunneling magnetoresistance (TMR) at low temperature and low bias voltage [3,4]. However, the TMR bias voltage and temperature dependence is considerably stronger than usually found for optimized MTJs with 3d-alloy electrodes. For explaining this conclusively, knowledge of the structural and magnetic properties of the $\text{Co}_2\text{MnSi} / \text{AlO}_x$ interface is of vital importance. In this talk investigations of the $\text{Co}_2\text{MnSi} / \text{AlO}_x$ interface [5] and the Co_2MnSi bulk material by X-ray absorption spectroscopy will be presented and discussed with respect to the temperature dependent transport properties of the junctions. The author gratefully acknowledge the opportunity to perform soft X-ray absorption spectroscopy at the Advanced Light Source, Berkeley, USA and at the BESSY mbH, Berlin, Germany.

[1] R. A. de Groot et al., Rev. Lett. 50 (1983) 2024

[2] S.A. Wolf et al., Science 294, 1488 (2001)

[3] S. Kämmerer et al., Appl. Phys. Lett. 85 (2004) 79

[4] J. Schmalhorst et al., to be published

[5] J. Schmalhorst et al., Phys. Rev. B 70 (2004) 024426

Hauptvortrag

MA 9.7 Fr 18:15 TU EMH225

Anomalous electronic and vibrational effects in magnetic shape memory alloys — ●PETER ENTEL¹, ALEXEY T. ZAYAK², and WAHEED A. ADEAGBO¹ — ¹Physics Section, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany — ²Department of Physics and Astronomy, Rutgers University, Piscataway, NJ 08854-8019, USA

First-principles calculations are used to address the problem of anomalous electronic and vibrational effects in magnetic Heusler compounds. The ferromagnetic shape memory systems $\text{Ni}_2\text{Mn}(\text{Ga}, \text{Ge}, \text{Al})$ undergo a structural transformation from the high-temperature $L2_1$ structure to some low-temperature tetragonal or modulated structure. This can be related to Fermi surface nesting caused by a peculiar combination of electronic states of Ni and, for example, Ga. The resulting tetrahedral-like coordination of the transition metal ions causes also the lattice instability, where the acoustic modes tend to soften while the optical modes disperse in a way which is significantly different from that in stable ferromagnetic $\text{Co}_2\text{Mn}(\text{Ga}, \text{Ge})$. Critical valence electron numbers per atom can still be used to characterize the unstable and stable magnetic alloys. However, in a more detailed description the anharmonic behavior of the unstable magnetic systems is related to the Jahn-Teller splitting and an amplification of anharmonicity by competing ferromagnetic and antiferromagnetic interactions. We discuss the close relationship of anharmonic trends observed in ferroelectrics.

MA 10 FV-internes Symposium "Molecular Magnetism" (Organizer: H.J. Krüger)

Zeit: Samstag 09:00–12:30

Raum: TU H1012

Hauptvortrag

MA 10.1 Sa 09:00 TU H1012

The Molecular Approach to Nanomagnetism — ●ROBERTA SESOLI — Department of Chemistry - INSTM, University of Florence, Italy

The observation about 10 years ago of magnetic bistability in molecules comprising a small number of interacting paramagnetic centers has renewed the interest in molecular magnetism. Molecules of this kind, also

known as Single Molecule Magnets, have proven to be the ideal systems to investigate quantum effects in the dynamics of the macroscopic magnetization, like the tunnelling effect or the topological interference of tunnelling pathways. The research in the area is still very active and the emerging trends in the field will be the topics of this presentation.

Many efforts are actually devoted to the control of the organization of

these molecules, for instance through the preparation of self-assembled monolayers on metallic surfaces. The objectives are the magnetic addressing and investigation of the single molecule as well as the investigation of the environmental effects, that are known to play a crucial role in the quantum dynamics of these objects.

Despite important achievements in the synthesis of new molecules, the blocking temperature, below which bistability is observed, remains quite low. Interestingly a sensible increase has been observed in molecular systems where anisotropic magnetic centers are arranged in 1d structures. These systems can be seen as the molecular analogues of monoatomic nanowires recently investigated.

Hauptvortrag

MA 10.2 Sa 09:30 TU H1012

Minimum single-molecule magnets — ●P. MÜLLER¹, H. RUPP¹, R.W. SAALFRANK², and M. RUBEN³ — ¹Physikalisches Institut III, Universität Erlangen-Nürnberg — ²Institut für Organische Chemie, Universität Erlangen-Nürnberg — ³Institut für Nanotechnologie, FZ Karlsruhe

Even without long-range magnetic order, some molecular crystals show hysteretic magnetization curves at low temperatures. This effect is a single-molecule property caused by a large uniaxial anisotropy combined with a high-spin ground state. This phenomenon has been observed in a class of cluster molecules containing Fe or Mn ions, with Mn₁₂ acetate as a prototype. Until now, the effect is limited to temperatures below 4.2 K. In order to provide strategies for optimizing new systems, it is natural to focus on systems with a small number of metal ions. We present measurements on ferric stars FeFe₃L₆, where the star-like coupling topology forces a high-spin ground state of the molecule. We conclude our talk with recent results on mononuclear lanthanide-phthalocyanine double-decker molecules, which are promising candidates for higher working temperatures.

Hauptvortrag

MA 10.3 Sa 10:00 TU H1012

Frustration effects in magnetic molecules — ●JÜRGEN SCHNACK — Universität Osnabrück, Fachbereich Physik, D-49069 Osnabrück, Germany

Besides being a fascinating class of new materials, magnetic molecules provide the opportunity to study concepts of condensed matter physics in zero dimensions. This contribution will exemplify the impact of molecular magnetism on concepts of frustrated spin systems [1].

We will discuss spin rings and the unexpected rules that govern their low-energy behaviour. Rotational bands, which are experimentally observed in various molecular magnets, provide a useful, simplified framework for characterizing the energy spectrum, but there are also deviations thereof with far-reaching consequences. It will be explained in this context what localized independent magnons are and how they lead to giant magnetization jumps, a new macroscopic quantum effect [2]. In addition, frustration-induced plateaus of the magnetization and related susceptibility minima can be observed in magnetic molecules [3] as well as metamagnetic transitions. Finally, it is demonstrated that magnetic molecules could give rise to an enhanced magnetocaloric effect.

[1] J. Schnack, *Molecular Magnetism*, in *Quantum Magnetism*, Lecture Notes in Physics **645**, Springer, Berlin, Heidelberg (2004) 155-194

[2] J. Schulenburg, A. Honecker, J. Schnack, J. Richter, H.-J. Schmidt, *Macroscopic magnetization jumps due to independent magnons in frustrated quantum spin lattices*, Phys. Rev. Lett. **88** (2002) 167207

[3] C. Schröder *et al.*, *Competing Spin Phases in Geometrically Frustrated Magnetic Molecules*, Phys. Rev. Lett., submitted

Hauptvortrag

MA 10.4 Sa 10:30 TU H1012

Frequency Domain Magnetic Resonance Spectroscopy on Molecular Magnets — ●JORIS VAN SLAGEREN¹, NADESCHDA KIRCHNER¹, SURIYAKAN VONGTRAGOOL¹, MARC DURAN¹, FADI EL HALLAK¹, ALEXANDER MUKHIN², BORIS GORSHUNOV², and MARTIN DRESSSEL¹ — ¹Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — ²General Physics Institute, Russian Academy of Sciences, Moscow, Russia

One of the most important parameters determining the properties of molecular magnets is the magnetic anisotropy in the form of zero-field splitting of the ground spin state. This parameter determines the energy barrier and therefore the slow magnetization relaxation dynamics. We have shown over the past years that frequency domain magnetic resonance spectroscopy (FDMRS) is excellently suited to the determination of zero-field splittings. Among its merits are: the lack of necessity of an

external magnetic field, and easy access to very large zero-field splittings. Several pertinent examples will be shown. The magnetic resonance line-shapes give information on distributions in the sample as well as excited spin state dynamics. Because frequency and magnetic field are independent experimental parameters in the FDMRS technique, more sophisticated experiments can be performed. For example, we have spectroscopically studied the relaxation of the magnetization. We have demonstrated significant differences in line positions and line shapes between nonmagnetized and magnetized single molecule magnet samples. Finally, we will also show that single molecule magnets can function as tunable radiation polarization rotators in the THz range.

Hauptvortrag

MA 10.5 Sa 11:00 TU H1012

Synthetic approaches to oxygen-bridged molecular magnets — ●ANNIE POWELL — Institut für Anorganische Chemie, Universität Karlsruhe, Engesserstr. 15, 76128 Karlsruhe

Hydrolysis reactions are a feature of the chemistry of many metal ions and usually lead to the formation of oxo- and hydroxo-bridged aggregates and then hydroxide, hydroxyoxide or oxide minerals. This chemistry can be controlled by supplying templating ligands which direct the size and shape of the intermediate aggregated species in a manner similar to that employed in Nature in biomineralisation processes. This makes it possible to favour the formation of molecular polymetal-oxo clusters which for paramagnetic metal ions have different magnetic properties from the related extended mineral phases as a result of the strong boundary effects operating in such systems. Furthermore, it is possible to functionalise the encapsulating ligands or supply linking synthons in order to enhance different types of supramolecular interactions amongst the molecules. This makes it possible to create 1-D chains, 2-D sheets or 3-D arrays of linked magnetic particles.

Hauptvortrag

MA 10.6 Sa 11:30 TU H1012

Rational Design of Single-Molecule Magnets — ●THORSTEN GLASER — Institut für Anorganische und Analytische Chemie der Westfälischen Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 8, 48149 Münster

Single-molecule magnets are molecules that exhibit a magnetic bistability of pure molecular origin due to a slow relaxation of the magnetization. Thus, information can be stored in a single molecule with dimensions below 5 nm. The necessary prerequisites are a high spin ground state S along with a strong magnetic anisotropy of the easy-axis type which is described by a negative zero-field splitting D. We have started a program to obtain high spin ground states by ferromagnetic interactions between transition metal ions in polynuclear complexes. In order to control the coupling of the transition metal ions we perform a ligand design based on the principles of double exchange, orthogonality of the magnetic orbitals and spin-polarization. Magnetic anisotropy is introduced by enforcing a strong tetragonal ligand field on the transition metal ions. We have successfully synthesized two heptanuclear transition metal complexes with high spin ground states and magnetic anisotropy: Mn₆Cr with S = 21/2 and Fe₆Cr with S = 27/2. Their magnetic properties and single-molecule magnet behavior will be presented.

Hauptvortrag

MA 10.7 Sa 12:00 TU H1012

Switchable Molecules — ●PHILIPP GÜTLICH — Institut für Anorganische Chemie und Analytische Chemie, Universität Mainz, Staudingerweg 9, 55099 Mainz, Germany

Coordination compounds of transition metal ions with open-shell electron configurations may exhibit dynamic electronic structure phenomena, depending on the nature of the coordinating ligand sphere. Thermal, light- and pressure-induced changes of spin states [1-3] are among the most fascinating electronic games encountered in molecular magnetism of transition metal compounds, which are presently under extensive study by chemists and physicists. The switching properties make such material potential candidates for practical applications in thermal and pressure sensors as well as optical devices. The basics of thermal and optical spin transition will be briefly reviewed. Selected examples of thermal spin crossover complexes will be discussed. It will be shown that switching forth and back between different spin states may be effected with light of different wave lengths. The effect of pressure on the spin transition behaviour will be demonstrated. Possible practical applications will be discussed.

[1] P. Gütllich, Y. Garcia, T. Woike: "Photoswitchable Coordination Compounds" Coord. Chem. Rev. 219-221 (2001) 839-879 [2] P. Gütllich,

Y. Garcia, H. Spiering: "Spin Transition Phenomena", in: *Magnetism: Molecules to Materials IV*, J.S. Miller, M. Drillon (eds.), Wiley-VCH 2003 [3] P. Gütlich, H. A. Goodwin (eds.), "Spin Crossover in Transition

Metal Compounds", *Topics in Current Chemistry*, volumes 233, 234, 235, Springer 2004, Berlin-Heidelberg-New York.

MA 11 FV-internes Symposium "Applied Magnetism" (Organizers: R. Hilzinger, H. Huneus, J. Wecker)

Zeit: Samstag 09:00–12:30

Raum: TU H1028

Hauptvortrag

MA 11.1 Sa 09:00 TU H1028

Magneto-resistive biochips and magnetic field assisted hybridization — ●PAULO P. FREITAS — INESC-MN, Lisbon Portugal

Magneto-resistive biochips use arrays of magneto-resistive sensors to detect the presence of magnetically labelled biomolecules-the targets (DNA, proteins, antibodies) hybridized to immobilized complementary probes. Magnetic labels consist of non-remnant paramagnetic or superparamagnetic particles (typically FeO_x based) with dimensions from μm size down to 50nm in diameter. New generations of ferromagnetic particles with dimensions down to 10nm are also being investigated. Different types of magneto-resistive sensors have been used, GMR multilayers, spin valves, and planar Hall sensors. Low resistance magnetic tunnel junctions, with improved S/N ratio start to be considered. Sensor design, detection geometry and electronics must take into account the required minimum particle concentration to be detected (single label) and the dynamic range (maximum number of labels to be detected). At the moment, and for DNA, c-DNA experiments at our lab using spin-valve based biochips, the detection limit has been pushed to $10\text{ fmole}/\text{cm}^2$ using 250nm FeO_x labels. Recently, biomolecular hybridization rates were strongly enhanced by sweeping target biomolecules over the immobilized probes using a combination of AC and DC magnetic fields. Hybridization now takes place in few minutes in comparison with several hours in a diffusion controlled process.

Hauptvortrag

MA 11.2 Sa 09:30 TU H1028

Magneto-resistive Sensoren: Applikationen, Technologien und industrielle Umsetzung — ●JAN MARIEN — naomi technologies AG, Hechtsheimer Str. 2, 55131 Mainz

Sensoren auf der Basis magneto-resistiver Effekte werden heute in einer Vielzahl von Applikationen eingesetzt und sind in großer Stückzahl im Einsatz. Dabei machen Sensoren auf der Basis des anisotropen MR Effektes den größten Teil des Marktes aus. Wenngleich der physikalische Effekt bereits seit über 100 Jahren bekannt ist, werden für einzelne Applikationen auch heute noch durch gezielte Beeinflussung von Schichteigenschaften neuartige Anwendungsbereiche erschlossen.

Darüber hinaus spielt die Zuverlässigkeit von Sensoren eine herausragende Rolle für den technologischen Erfolg. Hierfür sind vor allem geeignete Diffusionsbarrieren nötig, die eine Eindiffusion von Leiterbahnmaterialien in die MR Schicht verhindern.

Durch den Einsatz von Schichtsystemen, die auf dem gigantischen Magnetowiderstandseffekt (GMR) beruhen, wird der Einsatzbereich von magneto-resistiven Sensoren noch einmal wesentlich erweitert. Diese Schichten lassen sich bezüglich ihrer magnetischen Eigenschaften in einem sehr weiten Bereich anwendungsspezifisch entwickeln. Es werden in diesem Vortrag Beispiele von GMR-Sensoren gezeigt, die sich bereits in der Serienfertigung befinden.

Hauptvortrag

MA 11.3 Sa 10:00 TU H1028

Genauer statt Power ! Permanentmagnete in Sensoranwendungen — ●MARTIN GRÖNEFELD — Magnetfabrik Bonn GmbH, Dorotheenstr. 215, 53119 Bonn / www.magnetfabrik.de / e-mail: martin.groenefeld@magnetfabrik.de

Die klassischen Anwendungen von Permanentmagneten in Motoren, Generatoren oder mechanischen Systemen erfordern höchste magnetische Leistung auf kleinstem Raum. Die Entwicklung immer stärkerer Werkstoffe findet starke Beachtung. Eher unscheinbar entwickelte sich in den letzten Jahren mit berührungslosen Schaltern auf der Basis von Magneten und Sensoren ein weiteres Anwendungsfeld, welches statt hoher Leistung extreme Präzision bei kleinsten Baugrößen, und hohe Reproduzierbarkeit und Wirtschaftlichkeit bei großen Serien erfordert. Kunststoffgebundene Werkstoffe haben gerade bei diesen Anforderungen das höchste Potential. Der Vortrag diskutiert an aktuellen Themen die wissenschaftlichen und technischen Fragestellungen bei einem mittelständischen Magnethersteller. Neben Werkstofffragen mit starkem physikalischen Bezug werden

Anforderungen an die Produktions- und Meßtechnik für Sensoren und Magnete am Beispiel neuer Winkelsensoren betrachtet.

Hauptvortrag

MA 11.4 Sa 10:30 TU H1028

Magnetic tunnel junctions with different barriers for magneto-electronic applications — ●THEODOROS DIMOPOULOS¹, GÜNTER GIERES¹, NILS WIESE¹, JOACHIM WECKER¹, JUANSU LUO², and KONRAD SAMWER² — ¹Siemens AG, CT-MM1, Paul-Gossen-Str. 100, 91052 Erlangen — ²I. Physikalisches Institut, Universität Göttingen, Tammannstr. 1, 37077 Göttingen

Magnetic tunnel junctions (MTJs) are thin film multilayers comprising of two ferromagnets (FMs) separated by an ultra-thin insulator (tunnel barrier). The current traversing the layered structure depends on the relative orientation of the magnetization of the FMs, giving rise to the tunnel magneto-resistance (TMR) effect. MTJs are expected to be widely used in the near future as sensing elements in various applications (e.g. read-heads, biosensors, automotive, etc.), as well as in the data storage (MRAM) and magnetic logic, with each application imposing its own functional demands.

In this contribution we will focus on the influence of the tunnel barrier on key technological requirements for the MTJs, like the amplitude of the TMR, the resistance-area (RA) product and the switching behavior of the magnetic electrodes. We will specifically discuss Al_2O_3 , Y_2O_3 and MgO barriers, which are combined with polycrystalline and amorphous magnetic electrodes (e.g. CoFe and CoFeB) in sputter-deposited junctions. The barriers are fabricated using plasma oxidation or reactive sputtering and significant TMR has been measured for every case. Aspects particularly important to applications, like the thermal stability of the different MTJs will also be addressed.

Hauptvortrag

MA 11.5 Sa 11:00 TU H1028

Elektrische Grossmaschinen mit Permanentmagneterregung — ●AXEL MÖHLE — Siemens AG A&D LD SEB, Nonnendammallee 72, 13629 Berlin

Durch die Verfügbarkeit leistungsfähiger Permanentmagnete hoher Remanenzinduktion und Koerzitivfeldstärke dringt die permanentmagneterregte Synchronmaschine inzwischen auch in den Bereich der elektrischen Grossmaschinen vor. Schiffsantriebe mit einem Drehmoment von bis zu 600 kNm und eine Windkraftanlage mit einem Bemessungsmoment von 1800 kNm sind bereits erfolgreich im Einsatz. Durch die immer noch relativ hohen Kosten für das Magnetmaterial beschränkt sich der Einsatz derzeit jedoch noch auf solche Anwendungen, bei denen durch die Verwendung der Technologie ein überdurchschnittlicher Kundennutzen erzielt wird, der den Mehrpreis rechtfertigt.

Nach einer kurzen Einführung in den Aufbau und die Funktionsweise konventioneller, elektrisch erregter Synchronmaschinen wird dieser durch die Permanentmagneterregung erzielbare Kundennutzen anhand einiger Anwendungsbeispiele erläutert. Bei zwei modernen Schiffsantrieben ermöglicht die verlustarme Permanentmagneterregung den Verzicht auf den herkömmlichen Läuferkühlkreislauf, wodurch in dem einen Fall ein sehr schlanker und damit hydrodynamisch günstiger Pod-Antrieb ermöglicht werden kann, der unter dem Schiffsrumpf hängend, ohne ein von aussen zugeführtes Kühlmedium betrieben wird. In dem zweiten Beispiel wird der durch den Verzicht auf die elektrische Erregung gewonnene Bauraum zur Integration der Umrichter in die Maschine genutzt, wodurch ein kompakter und bezüglich der EMV gut abgeschirmter U-Boot-Hauptantrieb entsteht.

Als weiterer Anwendungsfall wird ein direktangetriebener Windkraftgenerator vorgestellt. Durch den Einsatz von Permanentmagneten kann hier auf die Erregereinrichtung im Turm verzichtet werden. Ferner lassen sich, im Vergleich zur elektrisch erregten Synchronmaschine, höhere Polzahlen verwirklichen, wodurch sich das System Maschine/Umrichter besser optimieren lässt. Auch ist die Ausnutzung im Vergleich zur konventionellen Synchronmaschine höher. Die Gewichtersparnis, die sich daraus ergibt, stellt insbesondere bei dieser Anwendung einen unmittelbaren Kundennutzen dar.

Hauptvortrag

MA 11.6 Sa 11:30 TU H1028

Eigenschaften und Anwendungen weichmagnetischer nanokristalliner Werkstoffe — ●RAINER HILZINGER — Vacuumschmelze GmbH & Co KG, 63450 Hanau

Nanokristalline weichmagnetische FeCuNbSiB-Legierungen besitzen eine einzigartige Kombination von Eigenschaften /1/: verschwindende Kristallanisotropie (als direkte Folge der Mikrostruktur mit Korngrößen um 10 nm) kleine Magnetostriktion, höchste magnetische Permeabilität und geringe Ummagnetisierungsverluste, hohe Sättigungsinduktion und gute Alterungsbeständigkeit. Diese besonderen Eigenschaften sowie Fortschritte im industriellen Herstellverfahren als zunächst amorphe Bänder und eine automatisierte Fertigung von magnetischen Kernen mit Wärmebehandlung unter definierten Temperatur- und Feldbedingungen haben dazu geführt, daß die nanokristallinen Legierungen in einer Reihe von wichtigen Anwendungen in großen Stückzahlen eingesetzt werden wie z.B. als Summenstromwandler in Fehlerstromschutz-

schaltern, Signalübertrager in Telecom-Netzen, Stromwandler für elektronische Energiezähler oder als Drosseln und Leistungsübertrager in Schaltnetzteilen bis in den Bereich 100 kW.

/1/ G. Herzer in Handbook of Magnetic Materials Vol 10 p 415-462 Ed K.H.J Buschow, 1997, Elsevier

Hauptvortrag

MA 11.7 Sa 12:00 TU H1028

The Goss texture formation in silicon steels: Oriented nucleation or growth selection? — ●STEFAN ZAEFFERER¹, NAN CHEN², DOROTHEE DORNER¹, LUDGER LAHN³, KLAUS GÜNTHER³ und DIERK RAABE¹ — ¹Max-Planck-Institut für Eisenforschung, Max-Planck-Str. 1; D-40237 Düsseldorf — ²Engineering Division, Colorado School of Mines, Golden, CO 80401, USA — ³Thyssen-Krupp Electrical Steels, Kurt-Schumacher-Str. 95, D-45881 Gelsenkirchen

The formation of the sharp Goss texture by abnormal growth of 110<001>-oriented grains in primary recrystallized Fe 3

MA 12 Elektronentheorie

Zeit: Samstag 09:00–10:45

Raum: TU EMH225

MA 12.1 Sa 09:00 TU EMH225

Direct Observation of Orbital Magnetism in Cubic Solids

— ●H. WENDE¹, W.D. BREWER¹, A. SCHERZ¹, C. SORG¹, K. BABERSCHKE¹, P. BENCOK², and S. FROTA-PESSOÁ³ — ¹Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin-Dahlem, Germany — ²European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble Cedex, France — ³Instituto de Física, Universidade de São Paulo, CP 66318, 05315-970 São Paulo, S.P. Brazil

We present X-ray magnetic circular dichroism (XMCD) measurements of the orbital/spin magnetic moment ratios of dilute 3d-series impurities (Cr, Mn, Fe, Co) in fcc Au and Cu host matrices [1]. These dilute 3d impurities in noble metal hosts represent an intermediate case between the nearly atomic configuration and a bulk 3d-metal environment, where the usual description includes strong hybridization and crystal field effects. We show the first direct measurement of considerable orbital moments in cubic symmetry for a localized impurity in a bulk metal host. This confirms previous hyperfine structure measurements. Here, it is shown that the unquenching of orbital magnetism depends on a delicate balance of hybridization effects between the local impurity with the host and the filling of the 3d states of the impurity. The results are accompanied by *ab initio* calculations that support our experimental findings. Supported by BMBF (05 KS4 KEB 5).

[1] W.D. Brewer *et al.*, Phys. Rev. Lett. **93**, 077205-1 (2004).

MA 12.2 Sa 09:15 TU EMH225

Magnetism in gold nanostructures — ●INGO OPAHLE, ARTI KASHYAP, MAHDI SARGOLZAEI, KLAUS KOEPERNIK, ULRIKE NITZSCHE, MANUEL RICHTER, and HELMUT ESCHRIC — IFW Dresden, P.O.B. 270016, D-01171 Dresden, Germany

As a bulk material, gold does not show any sign of ordered magnetism. Nanostructured materials, on the other hand, have been shown in recent years to have surprising features, sometimes completely different from the bulk phase. In a recent experiment [1] evidence for magnetism in small gold clusters was provided.

In this work, the electronic structure of gold nanostructures (monoatomic gold chain, small clusters) is investigated by means of relativistic density functional theory calculations, with a particular focus on tendencies towards magnetic instabilities. A monoatomic gold chain, for example, becomes magnetic at Au-Au nearest neighbour distances close to those of bulk gold. The calculated magnetic moment reaches up to 0.2 μ_B with a dominating contribution of the orbital moment of 0.12 μ_B .

[1] Y. Yamamoto *et al.*, Phys. Rev. Lett. **93**, 116801 (2004).

MA 12.3 Sa 09:30 TU EMH225

Self-consistent determination of magnon dispersions in the s-d(f) exchange model — ●TILMANN HICKEL and WOLFGANG NOLTING — Lehrstuhl Festkörpertheorie, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

In many materials the ferromagnetic order is assumed to be due to an indirect interaction of localized magnetic moments via itinerant electrons of a conduction band. This mechanism is described in the s-d(f) exchange

model (also called Kondo-lattice or double-exchange model). Many-body theoretical approaches to the model often focus on the self-energy of the itinerant subsystem, while treating the local-moment subsystem less accurate. We have developed an projection-operator approach to the s-d(f) exchange model that avoids this inequality of the subsystems. It combines the state-of-the-art knowledge on the density of states with a temperature-dependent determination of magnon dispersions and softening effects. In our evaluation we will focus on the latter. Compared to earlier predictions, the obtained magnetization curves yield a further reduction of the parameter regime where ferromagnetism can be expected.

MA 12.4 Sa 09:45 TU EMH225

Ferromagnetic ordering and halfmetallic state in a shandite: Co₃Sn₂S₂ — ●HELGE ROSNER¹, RICHARD WEHRICH², WALTER SCHNELLE¹, M. ZABEL³, and CLAUDIA STUECKL³ — ¹MPI for Chemical Physics of Solids, Dresden — ²Institut für Anorganische Festkörperchemie, Universität Regensburg — ³Institut für Anorganische Chemie, Universität Göttingen

The recent rapid development in spintronics challenges the search for new magnetic half metals with high Curie temperatures as well as an improved understanding of the underlying microscopic properties. Here, we present a joint experimental and theoretical study of the recently reinvestigated shandite Co₃Sn₂S₂ [1]. From magnetic susceptibility, specific heat and resistivity measurements on powder samples we find a phase transition to a ferromagnetic metallic state at 177 K with a saturation moment of 0.87 μ_B /f.u. Full potential electronic structure calculations within the local spin density approximation result in a halfmetallic ferromagnetic groundstate with a moment of 1 μ_B /f.u. and a tiny gap in the minority spin channel. The calculated structure optimization and structure variations show that the size of the gap is rather sensitive to the lattice geometry. Possibilities to stabilize the halfmetallic ferromagnetic behaviour by various substitutions have been studied theoretically and will be discussed in detail.

[1] R. Wehrich *et al.* Z. Anorg. Allg. Chem. **630**, 1767, (2004)

MA 12.5 Sa 10:00 TU EMH225

High-field magnetic susceptibility of ferromagnetic metals and alloys — ●SERGEY MANKOVSKY and HUBERT EBERT — Dept. Chemie und Biochemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany

The results of a theoretical study of the high-field magnetic susceptibility of ferromagnetic metals and alloys are presented. The theoretical description of the magnetic susceptibility is based on a combination of a linear response approach and the fully relativistic Green's function formalism. In contrast to the paramagnetic state, additional contributions to the magnetic susceptibility (e.g. spin-charge response function, contributions related to a Fermi level shift) become important in the ferromagnetic state. These contributions have been taken into account in our calculations as well as the contribution of the Landau susceptibility. The results of calculations of the high-field susceptibility of the 3d transition metals Fe, Ni and Co are found in good agreement with experiment. Also the high-field susceptibilities calculated for binary Fe_xCo_{1-x}, Fe_xNi_{1-x}, Ni_xCu_{1-x} alloys are presented and compared with experimental data.

MA 12.6 Sa 10:15 TU EMH225

Accounting for many-body correlation effects in the calculations of the x-ray photoemission and magneto-optical properties of transition metals — ●STANISLAV CHADOV, JAN MINAR, ALEXANDER PERLOV, and HUBERT EBERT — Department Chemie, University of Munich, Butenandstr. 5-13, D-81377 Munich, Germany

Calculations of valence band photoemission spectra on the basis of the LDA have been very successful in the past for many transition metal systems. However it is well known that correlation effects play for some materials a rather crucial role. Fortunately, it is often well justified to represent these by a local (site-diagonal) self-energy. In this case correlation effects can straightforwardly be incorporated within calculations based on the one-step model of photoemission. This applies in particular for its spin-polarised relativistic version that allows to deal with the Fano-effect and magnetic dichroism. Corresponding results will be presented for transition metal systems, for which the pure Fano-effect, that means the spin-polarisation of the photo-current due to spin-orbit coupling has been investigated. Results of investigations on the spontaneous spin-polarisation in the ground-state by means of spin-resolved VB-XPS will be presented for the half-metallic ferromagnet NiMnSb. In addition, influence of correlation effects on the magneto-optical properties of Fe, Co and Ni will be presented. Within these investigations correlation effects are accounted for via the self-energy calculated by the recently proposed LDA+DMFT scheme (dynamical mean field theory). As it turns out, taking correlation effects into account the agreement between theory and experiment is significantly improved.

MA 12.7 Sa 10:30 TU EMH225

Multiple scattering formalism for correlated systems: A KKR+DMFT approach — ●JÁN MINÁR¹, L. CHIONCEL², A. PERLOV¹, H. EBERT¹, M.I. KATSNELSON² und A.I. LICHTENSTEIN³ — ¹Dep. Chemie, LMU, Butenandstr. 5-13, 81377 München, Germany — ²University of Nijmegen, NL-6525 ED Nijmegen, The Netherlands — ³Institut für Theoretische Physik, Universität Hamburg, 20355 Hamburg, Germany

We present a charge and self-energy self-consistent computational scheme for correlated systems based on the Korringa-Kohn-Rostoker (KKR) multiple scattering theory with the many-body effects described by the means of dynamical mean field theory (DMFT). The corresponding local multi-orbital and energy dependent self-energy is included into the set of radial differential equations for the single-site wave functions. The Green's function is written in terms of the multiple scattering path operator, the later one being evaluated using the single-site solution for the t -matrix that in turn is determined by the wave functions. An appealing feature of this approach is that it allows to consider local quantum and disorder fluctuations on the same footing. Within the Coherent Potential Approximation (CPA) the correlated atoms are placed into a combined effective medium determined by the dynamical mean field theory (DMFT) self-consistency condition. Results of corresponding calculations for pure Fe, Ni and $\text{Fe}_x\text{Ni}_{1-x}$ alloys are presented.

MA 13 Spinabhängiger Transport I

Zeit: Samstag 10:45–13:15

Raum: TU EMH225

MA 13.1 Sa 10:45 TU EMH225

Interplay of atomic ordering and TMR-effect of Co_2MnSi Heusler electrodes in magnetic tunnel junctions — ●ANDREAS HÜTTEN, SVEN KÄMMERER, JAN SCHMALHORST, and GÜNTER REISS — Department of Physics, University of Bielefeld, 33615 Bielefeld, Germany

We have demonstrated that the full Heusler compound Co_2MnSi integrated as one of the magnetic electrodes in technological relevant MTJs is currently characterized by a maximum spin polarization of 66% at 20K. This limitation can mainly be associated with two experimental findings. Firstly, the formation of a step like barrier which is already created during plasma oxidation while preparing the AlO_x tunnel barrier and which is a direct consequence of the oxygen affinity of the Heusler elements Mn and Si. Secondly, it is difficult to avoid Co-Mn antisite formation at the $\text{Co}_2\text{MnSi}/\text{AlO}_x$ -barrier interface. The Co-Mn antisite formation has qualitatively been monitored using the normalized x-ray diffraction intensities of the Co_2MnSi superlattice reflections as a function of the resulting TMR-effect and has additionally been simulated by the intercalation of thin Co layers in between Co_2MnSi and AlO_x .

MA 13.2 Sa 11:00 TU EMH225

Optimization and characterization of Co_2MnGe based magnetic tunneling junctions — ●ERIK VERDUIJN and KURT WESTERHOLT — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

Heusler compounds are materials of great potential in the field of spintronics due to their predicted 100% spin polarization at the Fermi level. We have studied the spin polarization of such Heusler compounds, in particular the Co_2MnGe compound via the magnetotransport properties of magnetic tunneling junctions (MTJs) with Heusler as base electrode and Co as counter electrode. Optimization of the tunnel barrier layer, surface roughness of the base electrode and magnetic properties are critical to the quality of the MTJs and our approach to these issues will be discussed in some detail. Magnetotransport measurements indicate the junctions fulfill all properties expected of good quality MTJs. Furthermore measurements of the TMR effect of these junctions indicate the Co_2MnGe layers we have prepared to have a significant spin polarization, at least as large as that of elemental Co. Although this spin polarization is far from the predicted 100% it is significant, considering the difficulties in both growth of the Heusler layer and successful integration into a MTJ, that any spin polarization has been measured whatsoever. These difficulties e.g. magnetic and crystalline properties of the Heusler layers, surface roughness and interdiffusion and their relation to the measured spin polarization will be presented.

MA 13.3 Sa 11:15 TU EMH225

Low temperature measurement of hot electron energy effects in semi-epitaxial magnetic tunnel transistors — ●THOMAS HAGLER, MARTIN DUMM, CLAUS BILZER, WOLFGANG KIPFERL, and GÜNTHER BAYREUTHER — Universität Regensburg, Universitätsstr. 31, 93040 Regensburg

A magnetic tunnel transistor with Al_2O_3 tunneling barrier, spin-valve metallic base and epitaxial CoFe/GaAs Schottky barrier has been used to probe the energy dependence of hot electron transport at low temperatures. The magnetocurrent ratio (MCR) reaches values up to 900% in our ultrathin microstructured three terminal devices. The effect of hot electron energy has been studied in the range of 0.6 eV - 2.2 eV. We observe a clear maximum of the MCR at about 1.5 eV electron energy. With increasing temperature ($5\text{ K} < T < 185\text{ K}$) the MC remains almost constant, but a rapidly growing spin-independent additional current is measured, due to increasing collector leakage.

MA 13.4 Sa 11:30 TU EMH225

Ballistic Magneto-Current in Magnetic Tunnel Junctions — ●JAN BORNEMEIER, GUENTER REISS, and HUBERT BRUECKL — University of Bielefeld, Department of Physics, Universitaetstr. 25, 33615 Bielefeld

The combination of a magnetic tunnel junction and a Schottky barrier allows the observation of spin scattering of ballistic electrons at energies around 1eV. For this layer stacks of 4-10nm Co/ 1.8nm AlO_x / 4nm Py/ 12nm MnIr/ 50nm Cu/ 50nm Au on (100)-GaAs are deposited and subsequently patterned by e-beam lithography. The injected current is (depending on the base thickness) 4-5 orders of magnitude smaller than the tunnel current. The adjustable current amplitude and the high spin-polarization make these hybrid junctions a promising candidate as spin injector into semiconductors. Varying the base thickness, the spin attenuation length of the majority electrons can be estimated to be 50+/-8nm at 10K and 1.2V bias.

MA 13.5 Sa 11:45 TU EMH225

Spin-polarized tunneling in $\text{Fe}/\text{X}/\text{MgO}/\text{Fe}$ ($\text{X}=\text{V},\text{Cr}$) — ●JUSSI ENKOVAARA, DANIEL WORTMANN, and STEFAN BLÜGEL — Forschungszentrum Jülich, Institut für Festkörperforschung, 52425 Jülich

We present first-principles calculations on $\text{Fe}/\text{X}/\text{MgO}/\text{Fe}$ system where the X element is V or Cr. $\text{Fe}/\text{MgO}/\text{Fe}$ is a prototype system for tunneling magnetoresistance (TMR). Previous experimental and theoretical investigations have reported large magnetoresistance in epitaxial junctions. By adding layers of V or Cr on the one side of the

junction, we can study the effect of interfacial electronic structure on the tunneling conductance.

The calculations are done within the density-functional theory with the full-potential linearized augmented plane wave (FLAPW) method. The novel embedded Green function method enables us to treat semi-infinite junctions and to calculate the ballistic conductance within the Landauer formalism. The results show large changes in the conductance already when one layer of V or Cr is inserted in the system. These findings can be interpreted in terms of the symmetry of the contributing electronic states.

MA 13.6 Sa 12:00 TU EMH225

Interfacial coherence and sign of spin polarization — •ANDY THOMAS¹, BISWARUP SATPATI², and JAGADEESH MOODERA¹ — ¹Francis Bitter Magnet Lab., MIT, Cambridge, USA — ²Institute of physics, Bhubaneswar, India

The inverse TMR in magnetic tunnel junction $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3/\text{SrTiO}_3(\text{STO})/\text{Co}$ structures investigated by DeTeresa et. al. was explained by the influence of interface bonding between the Co and the STO barrier. The d-band matching caused the d-electrons to tunnel predominantly and hence the sign of spin polarization P was negative [1].

Our recent results disagree with this general conclusion. Direct measurements of P in FM/STO/Al structures using the Meservey-Tedrow technique (SPT) gave values of P to be +31% for Co, and +29% (+10%) for Fe (Ni) respectively. These values agree fairly well with values found for Al_2O_3 already 30 years ago, and thus the theoretical explanation of the d-band match in these structures is not generally valid and has to take additional parameters into account (e.g. [2]).

To look further into the coherence of the interface structure and the sign of spin polarization, the interfaces are investigated with HR-TEM and compared to the TEM images of [3]. Factors that determine the sign of P are discussed to give input for a more complete theoretical explanation.

Supported by NSF and Humboldt Foundation funds. [1] DeTeresa et. al., PRL **82**, 4288 (1999), [2] Oleinik et. al., PRB **65**, 020401 (2001), [3] Pailloux et. al., PRB **66**, 014417 (2002)

MA 13.7 Sa 12:15 TU EMH225

Tunneling in Fe/MgO/Fe: Influence of interface structure and bias voltage — •CHRISTIAN HEILIGER, BOGDAN YU. YAVORSKY, PETER ZAHN, and INGRID MERTIG — Martin-Luther-University Halle-Wittenberg, Department of Physics, Von-Seckendorff-Platz 1, 06120 Halle, Germany

Newest experimental results of Fe/MgO/Fe tunnel junctions [1] show a strong dependence of the tunnel magnetoresistance on the sample and in particular the interface quality. An elaborate experimental analysis of the interface composition in Fe/MgO/Fe tunnel junctions reveals the formation of a mixed Fe/O layer [2]. To elucidate their influence on conductance and tunneling magnetoresistance (TMR) electronic structure calculations have been performed. A screened Korringa-Kohn-Rostoker (KKR) method based on density-functional theory was applied. The Landauer conductance of planar junctions was calculated using the Baranger-Stone scheme by means of Green functions. The influence of structural relaxation, formation of a mixed Fe/O-layer and the finite bias voltage on conductance and TMR are discussed.

[1] S. Yuasa, T. Nagahama, A. Fukushima, Y. Suzuki and K. Ando, Nature mat. AOP (31 October 2004); doi: 10.1038/nmat1257

[2] H. L. Meyerheim, R. Popescu, J. Kirschner, N. Jedrecy, M. Sauvage-Simkin, B. Heinrich, and R. Pinchaux, Phys. Rev. Lett. **87**, 076102 (2001).

MA 13.8 Sa 12:30 TU EMH225

Growth and x-ray analysis of Fe/MgO/Fe(100) layers — •CHRISTIAN TUSCHE¹, HOLGER MEYERHEIM¹, JÜRGEN KIRSCHNER¹, NATHALIE JEDRECY², and GILLES RENAUD³ — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle — ²LMCP Univ. Paris VI, 4 place Jussieu, F-75252 Paris — ³CEA-Grenoble, 17 rue des Martyrs, F-38054 Grenoble

For the theoretical understanding of epitaxial tunneling-magneto-resistance (TMR) systems, a detailed knowledge of the geometrical structure at the FM/insulator interface plays a crucial role. As reported before for the prototype Fe/MgO/Fe(100) system, a FeO_x ($x \approx 0.6$) interface layer is formed during MgO deposition onto Fe(100), significantly affecting the TMR effect [1,2]. Surface x-ray diffraction (SXRD) experiments on the structure of the second Fe/MgO interface were carried out at the European Synchrotron Radiation Facility (ESRF).

While for deposition of about 0.5ML Fe in oxygen background pressure $p_{\text{O}_2} = 10^{-7}$ mbar a stoichiometric FeO interface is formed, for Fe-deposition under UHV conditions a substoichiometric FeO_x ($x \approx 0.3$) layer grows on an oxygen depleted MgO-layer. Furthermore, well defined layer by layer growth of subsequently deposited Fe is only observed in the case of the oxygen saturated MgO/FeO interface.

Our results may have considerable importance for the optimization of the Fe/MgO/Fe(100) TMR structure, since the symmetry of the TMR geometric structure is decisive for the TMR-amplitude.

[1] H.L. Meyerheim et al., Phys. Rev. Lett **87** (2001) 076102

[2] W.H. Butler et al., Phys. Rev. B **68** (2003) 092402

MA 13.9 Sa 12:45 TU EMH225

Kompensation des Gesamtmoments in NiFe/CoGd/NiFe für magnetische Tunnelelemente — •ANDREA NIEMEYER, GÜNTER REISS and HUBERT BRÜCKL — Universität Bielefeld, Fakultät für Physik, Universitätsstr. 25, 33615 Bielefeld

Schichtpakete aus Seltenen Erden und Übergangsmetallen lassen sich aufgrund einer antiparallelen Austauschkopplung bei geeigneter Wahl der Schichtdicken so einstellen, dass das totale magnetische Moment Null wird. Eine solche Kompensation des magnetischen Moments erreichen wir mit NiFe/CoGd/NiFe Schichtstapeln erstmals bei Raumtemperatur.

Es wurden magnetische Tunnelelemente hergestellt, deren hartmagnetische Elektrode aus NiFe/CoGd/NiFe mit einer antiferromagnetischen MnIr Schicht durch "Exchange Biasing" gepinnt wurde. Dabei wird ausgenutzt, dass es einen Zusammensetzungsbereich des CoGd gibt, in dem eine antiparallele Kopplung von CoGd zu NiFe besteht. Abhängig von der Schichtdicke bzw. Zusammensetzung der CoGd-Legierung findet bei geeigneten Werten eine Kompensation des totalen magnetischen Moments statt, bei der erhöhte Schaltfelder und eine geringe Néel-Kopplung zu beobachten sind. Zusätzlich wurde der Übergang von positivem zu negativem Nettomoment sowohl in Abhängigkeit von der CoGd Dicke, als auch temperaturabhängig, beobachtet.

MA 13.10 Sa 13:00 TU EMH225

Orbital effects in spin-polarized tunneling thru SRO/STO/SRO — •DANIEL WORTMANN¹, KIYOYUKI TERAKURA², and STEFAN BLÜGEL¹ — ¹IFF, Forschungszentrum Jülich, D-52425 Jülich, Germany — ²Creative Research Initiative "Sousei", Hokkaido University, Sapporo, Japan

We present ab-initio calculations of spin-polarized tunneling in a $\text{SrRuO}_3/\text{SrTiO}_3/\text{SrRuO}_3$ three-layer junction where SrRuO_3 is a ferromagnetic metal and SrTiO_3 forms an insulating barrier. Both SrRuO_3 and SrTiO_3 crystallize in the Perovskite structure with nearly identical lattice constants. Thus epitaxial heterojunctions can be formed with a small tetragonal distortion off an ideal cubic structure. Employing the Landauer formula, the tunneling conductance was calculated within the framework of the DFT using the Green function FLAPW method. The Green function itself was obtained from an embedding approach to account for the semi-infinite leads attached to the tunneljunction. Due to the magnetic exchange splitting in SrRuO_3 , bands of different orbital character contribute to the tunneling current in the two spin channels. While the minority t_{2g} -bands contribute strongly to the tunnel current, for the majority spin these states are only available in a small part of the two-dimensional Brillouin zone. Together with a filtering effect, which is explained in terms of the complex bandstructure of SrTiO_3 , this leads to a significant spin-polarization of the conductance. This cannot be directly linked to the spin-polarization of the density of states of the system, but rather is a consequence of the orbital character of the states.

MA 14 Molekularer Magnetismus

Zeit: Samstag 13:45–16:45

Raum: TU H1012

MA 14.1 Sa 13:45 TU H1012

Quantum corrections for the classical density of states of Heisenberg systems — ●MATTHIAS EXLER, JOCHEN GEMMER, and JÜRGEN SCHNACK — Universität Osnabrück, Fachbereich Physik

We present a method to add quantum corrections to the classical density of states of Heisenberg spin systems. The classical density of states is either available analytically, or we calculate it numerically using a Wang-Landau algorithm.

We use products of spin-coherent states as the source of the quantum corrections. Their energy expectation values match those of the corresponding classical spin configurations by construction. However, they are no eigenstates of the Heisenberg Hamiltonian and therefore yield energy distributions different from delta functions. We calculate moments of these spectra which can then be used to modify the classical density of states in order to get an estimate for the quantum spectrum.

We perform these calculations for different values of the spin quantum number. Therefore, we can give an impression of how the classical limit is approached with increasing spin quantum number.

MA 14.2 Sa 14:00 TU H1012

Quantum Computation Using Endohedral Fullerenes — ●BORIS NAYDENOV¹, WOLFGANG HARNEIT¹, CHRISTIAN SPUDAT¹, MICHAEL SCHELOSKE¹, HEIKE SÜSS², and JÜRGEN HULLIGER² — ¹Institut für Experimentalphysik, Freie Universität Berlin, Arnimalle 14, 14159 Berlin, Germany — ²Dept. f. Chemie und Biochemie, Universität Bern, Freiestrasse 3, 3012 Bern, Switzerland

The endohedral atom in N@C₆₀ and P@C₆₀ is in its atomic state, it is well shielded from the surrounding and it possesses a very sharp EPR signal. These molecules are very suitable for quantum computation (QC) purposes, because of their very long relaxation times and the possibility of good scalability [1]. We present here our work and demonstrate the first steps towards the QC using our fullerenes: one qubit operations, decoherence times (T₂ up to 150 μs) and the alignment of our molecules in 1D channels [2]. The latter provides a way to selectively address the (±3/2;±1/2) and (1/2;-1/2) transitions, giving access to all internal spin degrees of freedom.

[1] W. Harneit, Phys. Rev. A 65 (2003) 032322

[2] H.I. Stüss, M. Lutz, J. Hulliger, Cryst. Eng. Comm. 4 (2002) 610

MA 14.3 Sa 14:15 TU H1012

Spin lattice relaxation rates of heterometallic wheels — ●MOHAMMED ALLALEN and JÜRGEN SCHNACK — Universität Osnabrück, Fachbereich Physik, D-49069 Osnabrück, Germany

In this work we present theoretical estimates of the exchange parameters and the proton nuclear spin-lattice relaxation rate of heterometallic {Cr₇M} wheels using exact diagonalization of the underlying Heisenberg Hamiltonian. Heterometallic {Cr₇M} wheels are antiferromagnetically coupled molecular magnetic rings where in the original ring of eight Chromium ions (*s* = 3/2) one ion is replaced by M=Fe, Cu, Zn or Ni with spin quantum number *s* = 2, 1/2, 0, and *s* = 1, respectively. One of our results is that the nearest neighbor coupling is almost not altered by substituting another paramagnetic ion with the exception of iron.

MA 14.4 Sa 14:30 TU H1012

Modifying the molecular magnetism of ferric stars by intermolecular interaction — ●H. RUPP¹, A. SCHEURER², S. SPERNER², I. BERNT², U. REIMANN², R.W. SAALFRANK², and P. MÜLLER¹ — ¹Physikalisches Institut III, Universität Erlangen-Nürnberg, E. Rommel Str. 1, 91058 Erlangen — ²Institut für Organische Chemie, Universität Erlangen-Nürnberg, Henkestr. 42, 91054 Erlangen, Germany

In the ferric star Fe(III)(Fe(III)L₂)₃, the outer Fe ions are linked via two ligands L = H₃CN(CH₂CH₂O)₂ to the central one in a star-like topology. SQUID and EPR measurements revealed a strong antiferromagnetic intramolecular Heisenberg coupling J = -40 K and zero field splitting parameter D = -0.57 K resulting in a S = 10/2 ground state. Using 2DEG ballistic Hall probes, magnetization measurements have been performed on the two complexes FeFe₃*4CHCl₃ and FeFe₃*3CH₂Cl₂ which differ only in the solvent used for the crystallization process. In both types of crystals, chains of stars are coupled via hydrogen bonds. The strength of this intermolecular coupling depends on the solvent used. FeFe₃*4CHCl₃ shows step-like hysteresis at temperatures below 0.8 K

but FeFe₃*3CH₂Cl₂ even up to 1.2 K. In addition, the two compounds differ significantly in the shape of their magnetization hysteresis. We discuss the observed features in terms of intermolecular interactions between the stars.

MA 14.5 Sa 14:45 TU H1012

¹H-NMR on Fe₆(tea)₆ single crystals — ●ROLAND LEPPIN, LARS SCHNELZER, and BERND PILAWA — Physikalisches Institut, Universität Karlsruhe (TH)

The Fe₆(tea)₆ cluster consists of 6 Fe^{III} ions, which are linked by the (tea)-ligand (tri ethanol amino) to a ringlike structure. The symmetry axis of the molecule is parallel to the hexagonal axis *c* of the crystal structure so that the molecules can be easily oriented with respect to an external magnetic field. The temperature dependence of the proton T₁ rate has been measured for various orientations of the magnetic field. These measurements reveal a strong dependence of the T₁ rate on the direction of the magnetic field. The temperature dependence of the T₁ rate for perpendicular orientation (*B* ⊥ *c*) shows the characteristic variation known for powder samples *i.e.* an exponential increase of the T₁ rate at low temperature, a maximum of the T₁ rate at ~ 40 K and a linear increase for *T* > 120 K. In general, the T₁ rate increases, when the field is turned towards the *c* direction and the T₁ peak disappears for parallel field orientation. The origin of the T₁ anisotropy will be discussed in this contribution.

MA 14.6 Sa 15:00 TU H1012

Hysteresis and Metastability of the Antiferromagnetic Heisenberg Spin-Icosahedron — ●CHRISTIAN SCHRÖDER^{1,2}, HEINZ-JÜRGEN SCHMIDT³, JÜRGEN SCHNACK³ und MARSHALL LUBAN² — ¹University of Applied Sciences Bielefeld, Dept. of Electrical Engineering and Computer Engineering, Bielefeld, Germany — ²Ames Laboratory & Iowa State University, Dept. of Physics, Ames, Iowa, USA — ³University of Osnabrück, Dept. of Physics, Osnabrück, Germany

Mounting on the vertices of an icosahedron classical or quantum spins that interact via nearest-neighbor isotropic antiferromagnetic Heisenberg exchange one generates a system that exhibits surprising physical properties when it is placed in an external magnetic field. At *T* = 0 K the classical system undergoes an abrupt magnetic transition at a critical field *B*_{crit} reminiscent of a first order phase transition. Moreover, this system shows hysteresis effects and metastability with an infinite lifetime at *T* = 0 K and a characteristic lifetime distribution for finite *T*. These properties of the spin-icosahedron may also be of interest for potential applications in the area of nanomagnetic switches. Here, we present a full analytical description of the classical behavior for *T* = 0 K and discuss finite temperature results from numerical quantum and classical calculations.

MA 14.7 Sa 15:15 TU H1012

Quantendynamik des Néel-Vektors in antiferromagnetischen molekularen Rädern und Gittern — ●O. WALDMANN, C. DOBE und H.-U. GÜDEL — Departement für Chemie und Biochemie, Universität Bern, CH-3012 Bern, Schweiz.

Die Dynamik der Untergittermagnetisierungen in Antiferromagneten kann bei tiefen Temperaturen durch den Néel-Vektor beschrieben werden. Wir untersuchten die Néel-Vektor-Dynamik in den molekularen Rädern Cr₈ und CsFe₈ und in dem Gitter Mn-[3 × 3] mittels inelastischer Neutronenstreuung (INS) und/oder Hochfeld-Drehmomentmagnetometrie. Im Cr₈-Rad, welches eine nur schwache magnetische Anisotropie aufweist, konnten wir die quantisierte Rotation des Néel-Vektors mittels INS zweifelsfrei beobachten (PRL **91**, 237202, 2003) - 50 Jahre nach der Vorhersage dieser Anregungsmoden von Antiferromagneten durch Anderson. Im CsFe₈-Rad führt eine ausgeprägte easy-axis-Anisotropie zu einer neuen Situation. Hier konnten wir Tunneln des Néel-Vektors nachweisen; die Analyse der Tunnelresonanz im INS-Spektrum demonstriert dessen Kohärenz. Damit ist uns die erstmalige Beobachtung von mesoskopischer Quantenkohärenz in einem antiferromagnetischen Cluster gelungen (cond-mat/0410447). Im Mn-[3 × 3]-Gitter beobachteten wir spektakuläre Oszillationen in der Feldabhängigkeit des Drehmoments (PRL **92**, 096403, 2004). Diese neuartigen Quanten-Magnetooszillationen resultieren aus dem Wechselspiel zwischen Rotation des Néel-Vektors, magnetischer Anisotropie und angelegtem Magnetfeld. Diese Arbeiten zeigen die Vielfalt von neuartigen Quantenphänomenen in antiferromagnetischen Nanomolekülen auf.

MA 14.8 Sa 15:30 TU H1012

Spin transition and superexchange coupling in metallo-organic assemblies — •YVES BODENTHIN¹, GUNTRAM SCHWARZ², DIRK, G. KURTH^{2,3}, HELMUTH MÖHWALD², and ULLRICH PIETSCH¹ — ¹Institute of Physics, University of Potsdam, P.O. Box 601553, D-14415 Potsdam, Germany — ²Max-Planck-Institute of Colloids and Interfaces, D-14424 Golm, Germany — ³National Institute for Materials Science 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

We report on a novel approach to cause spin crossover by introducing mechanical strain through an amphiphilic phase transition in a metallo-supramolecular architecture. Using SQUID and temperature resolved XMCD (x-ray magnetic circular dichroism) we observed a diamagnetic to paramagnetic phase transition which is connected to a phase transition of the amphiphilic layers within the superstructure. It was investigated by EXAFS, x-ray reflectivity and in-plane diffraction that this structural phase transition induces sufficient mechanical strain to distort the octahedral coordination sphere of the tightly coupled Fe^{2+} ions. Consequently, the energetic separation of the subsets of the iron d-orbitals changes and gives rise to spin transition from $S=0$ to $S=2$. Ferromagnetic behavior of PAC was observed above the spin-crossover temperature by a system with a reduced number of amphiphilic molecules. The appearance of molecular ferromagnetism in these supra-molecular structures can be explained by a super-exchange mechanism. Using element specific XMCD we observed a positive spin density at the iron ion and a negative spin density located at the ligand. This model is confirmed by first ab-initio calculations in term of density-functional approach.

MA 14.9 Sa 15:45 TU H1012

Pressure dependence of superexchange mediated antiferromagnetism in $XCl_2(PM)_2$ ($X = Fe, Co, Ni$; $PM = \text{pyrimidine}$) — •S. SÜLLOW¹, J. KREITLOW¹, A.U.B. WOLTER¹, D. MENZEL¹, J. SCHÖNES¹, K. DOLL² und R. FEYERHERM³ — ¹Institut für Festkörperphysik, TU Braunschweig, 38106 Braunschweig — ²Institut für Mathematische Physik, TU Braunschweig, 38106 Braunschweig — ³Hahn-Meitner-Institut, 14109 Berlin

We present measurements of the magnetic susceptibility $\chi(T)$ on the pyrimidine bridged transition metal complexes $XCl_2(PM)_2$ ($X = Fe, Co, Ni$; $PM = \text{pyrimidine} = C_4N_2H_4$) under externally applied pressure. From our data we derive the pressure response of the antiferromagnetic phase transition temperatures (ambient pressure values of T_N : 6.4 K for $X = Fe$, 4.7 K for Co and 15.9 K for Ni). For the three materials the transition temperatures increases by about 15% at a highest pressure of ~ 8 kbar. We compare our data with electronic structure calculations and find very good agreement between the theoretically predicted pressure response of T_N and the bulk module of $FeCl_2(PM)_2$, $B_0 = 15$ GPa, with our experimental observations.

Supported by DFG under contract no. SU229/6-1

MA 14.10 Sa 16:00 TU H1012

Simulation of Frequency Domain Magnetic Resonance Spectra on Molecular Magnets — •NADESCHDA KIRCHNER, JORIS VAN SLAGEREN, and MARTIN DRESSSEL — 1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

The FDMRS-technique is an advanced method that allows direct determination of the Zero Field Splittings (ZFS) in magnetic molecules in absence of an external magnetic field. Here we report a FDMRS study on $(PPh_4)[Mn_{12}O_{12}(O_2CEt)_{16}(H_2O)_4]$, $[Mn_9O_7(OAc)_{11}(\text{thme})(py)_3(H_2O)_2]$, $[Ni(\text{Himpy})_2NO_3](NO_3)$ and $[Ni_4(\text{MeOH})_4(\text{sae})_4]$ complexes,

in powder form. The FDMRS-spectra of these molecules were simulated in the strong-exchange limit within the ground spin multiplet for all complexes mentioned above. The ZFS-parameters were fitted to the absorption line positions observed in the FDMRS-experiment; they correlate well with those obtained by INS measurements.

We are currently exploring the simulation of FDMRS spectra beyond the strong exchange/spin only approximation. On one hand we are interested in how the simulated magnetic resonance spectrum changes when considering the isotropic exchange interaction and magnetic anisotropy. On the other hand we are interested in orbitally degenerate systems. As an example the results obtained for the $[Ni_4(\text{MeOH})_4(\text{sae})_4]$ cluster will be shown. The comparison of the FDMRS-measurements with their simulation resulting from irreducible tensor operator calculations and the discussion of the origin of magnetic anisotropy in the cluster will be presented.

MA 14.11 Sa 16:15 TU H1012

First-principles DFT calculations of the magnetic anisotropy in transition metal compounds — •JENS KORTUS¹, JORDI CIRERA², and ELISEO RUIZ² — ¹Institut de Physique et Chimie des Materiaux de Strasbourg, 23 rue du Loess, F-67034 Strasbourg Cedex 2, France — ²University of Barcelona, Department of Inorganic Chemistry, Diagonal 647 08028 Barcelona, Spain

We performed first-principles density-functional based calculations on the nature of electronic states and the magnetic coupling of single molecule magnets (SMM) using the massively parallel cluster code NRL-MOL [1], which has been used successfully to study several SMM in the past [2], in order to calculate the second order magnetic anisotropy parameters for several mono- and polynuclear transition metal systems. The theoretical results will be compared with available experimental data. Further, we investigate the effect of different basis sets and DFT functionals on the numerical values. Using simple model systems we explore structural dependencies of the magnetic anisotropy on different distortion pathways.

The ability to predict computationally the magnetic anisotropy energy should allow for a microscopic understanding of the magnetic anisotropy parameters based on the electronic structure of SMM, which is crucial for a rational design of molecular magnets.

[1] M. R. Pederson, D. V. Porezag, J. Kortus and D. C. Patton, phys. stat. sol. (b) 217, 197 (2000)

[2] J. Kortus, M. R. Pederson, T. Baruah, N. Bernstein, and C. S. Hellberg, Polyhedron 22, 1871-1876 (2003)

MA 14.12 Sa 16:30 TU H1012

Many-body Landau-Zener effect at fast sweep — •DMITRY GARANIN and ROLF SCHILLING — Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz, Germany

We investigate the influence of interaction between tunneling particles and disorder on their avoided-level-crossing transitions in the fast-sweep limit. Whereas the results confirm expectations based on the mean-field arguments that ferromagnetic/antiferromagnetic couplings suppress/enhance transitions, we found large deviations from the mean-field behavior for dipole-dipole interactions (DDI) in molecular magnets Mn-12 and Fe-8. For ideal crystals of the needle, spherical, and disc shapes DDI tends to enhance transitions. This tendency is inverted for the needle shape in the presence of even small disorder in the resonance fields of individual particles, however.

MA 15 Magnetische Kopplungsphänomene / Exchange Bias

Zeit: Samstag 14:00–16:30

Raum: TU H1028

MA 15.1 Sa 14:00 TU H1028

Dilution dependence of the irreversible domain state magnetization in antiferromagnetic $Co_{1-y}O$ (100) and its relevance for exchange bias in $Co/Co_{1-y}O$ — •REZA GHADIMI, BERND BESCHOTEN und GERNOT GÜNTHERODT — 2. Physikalisches Institut, RWTH Aachen, Templergraben 55, 52056 Aachen

In the domain state model (DSM), exchange bias in ferro-/antiferromagnetic (FM/AFM) bilayers is attributed to the formation of a domain state in the volume of the antiferromagnet, which develops during field cooling. The domain state carries an irreversible domain

state magnetization M_{IDS} which yields uncompensated spins at the FM/AFM interface triggering and controlling the exchange bias [1-3]. Here, we use epitaxial $Co_{1-y}O(100)$ layers which grow untwinned on $MgO(100)$ -substrates. The non-magnetic defects are intentionally introduced by overoxidizing CoO leading to Co deficiencies in $Co_{1-y}O$. The irreversible domain state magnetization is measured after field cooling in $B = 7T$ using SQUID magnetometry. Both, the dilution and temperature dependence of M_{IDS} can directly be linked to the exchange bias field of corresponding samples with an additional ferromagnetic Co layer. Supported by DFG/SPP1133

[1]P. Miltényi, et al. Phys. Rev. Lett. 84, 4224 (2000) [2] J. Keller, et al. Phys. Rev. B 66, 014431 (2002) [3] U. Nowak, et al. Phys. Rev. B 66, 014430 (2002)

MA 15.2 Sa 14:15 TU H1028

Detailed agreement between simulated hysteresis loops and experimental vector-MOKE data of CoFe/IrMn exchange bias bilayer — ●FLORIN RADU, ANDREAS WESTPHALEN, KATHARINA THEIS-BRÖHL, KURT WESTERHOLT, and HARTMUT ZABEL — Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

We show simulations based on the Meiklejohn and Bean approach and compare them with longitudinal and transversal hysteresis loops (vector MOKE) of CoFe/IrMn exchange biased bilayer. In the model we split the interfacial exchange energy in two parts: one term is the unidirectional contribution which is responsible for the exchange bias shift; the other term is an effective uniaxial anisotropy which contributes to the increased coercive field of the exchange bias effect observed in all F/AF systems. This is a key assumption of the model which we attributed to a spin-glass behavior of the interface. The hypothesis involved in the approach is suggested by recent experiments performed by neutron and soft-xray magnetic scattering which highlights the different nature of the interface in relation to the ferromagnetic and antiferromagnetic layer. The simulations we have performed are in excellent agreement with the experimental data.

This work was supported by SFB 491.

MA 15.3 Sa 14:30 TU H1028

Controlling orbital occupation and spin orientation in CoO layers by strain — ●M. W. HAVERKORT¹, S. I. CSISZAR², Z. HU¹, A. TANAKA³, H. H. HSIEH⁴, H.-J. LIN⁵, C. T. CHEN⁵, T. HIBMA² und L. H. TJENG¹ — ¹II. Physikalisches Institut, Universität zu Köln, Zùlpicher Str. 77, 50937 Köln, Germany — ²Materials Science Center, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands — ³Department of Quantum Matter, ADSM, Hiroshima University, Higashi-Hiroshima 739-8530, Japan — ⁴Chung Cheng Institute of Technology, National Defense University, Taoyuan 335, Taiwan — ⁵National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu 30077, Taiwan

We have observed that CoO films grown on different substrates show dramatic differences in their magnetic properties. Using polarization dependent x-ray absorption spectroscopy at the Co $L_{2,3}$ edges, we revealed that the magnitude and orientation of the magnetic moments strongly depend on the strain in the films induced by the substrate. We presented a quantitative model to explain how strain together with the spin-orbit interaction determine the $3d$ orbital occupation, the magnetic anisotropy, as well as the spin and orbital contributions to the magnetic moments. Control over the sign and direction of the strain may therefore open new opportunities for applications in the field of exchange bias in multilayered magnetic films.

MA 15.4 Sa 14:45 TU H1028

Magnetic domain structure dependence of the exchange-bias field in exchange-coupled ferrimagnetic bilayers — ●M. ZIESE¹, R. HÖHNE¹, A. BOLLERO¹, H. C. SEMMELHACK¹, P. ESQUINAZI¹, and K. ZIMMER² — ¹University of Leipzig, Division of Magnetism and Superconductivity, Linnéstrasse 5, 04103 Leipzig — ²Institute for Surface Modification, 04318 Leipzig

Exchange biasing was studied in an exchange-spring system consisting of two ferrimagnetic films with different coercivity. Magnetite and Co-Fe ferrite were chosen as the soft and hard magnetic bilayer components, respectively. The samples were epitaxially grown on MgO single crystal substrates by pulsed laser deposition. The exchange-bias field was investigated as a function of system size and shape, magnetic field direction and magnetization reversal in the hard layer. A clear dependence of the exchange-bias field on the sample size and shape was found. This was attributed to an interplay between exchange and dipolar energies. Micromagnetic simulations support the experimental results.

MA 15.5 Sa 15:00 TU H1028

Magnetization reversal in CoFe/IrMn exchange biased structures — ●CHRISTINE HAMANN¹, JEFFREY MCCORD¹, RUDOLF SCHÄFER¹, LUDWIG SCHULTZ¹, and ROLAND MATTHEIS² — ¹Leibniz-Institut für Festkörper- und Werkstofforschung (IFW), Helmholtzstraße 20, 01069 Dresden — ²Institut für Physikalische Hochtechnologie e.V. (IPHT), Albert - Einstein - Str. 9, 07745 Jena

For fundamental understanding of exchange biased systems, the magnetization reversal process of $\text{Co}_{90}\text{Fe}_{10}(20\text{nm})/\text{Ir}_{23}\text{Mn}_{77}$ bilayer structures with varying antiferromagnetic layer thickness (0-10nm) has been investigated by means of Kerr microscopy and spatially resolved magneto-optical magnetometry. At the onset of exchange bias (2.5nm IrMn), the bilayers exhibit a misalignment of the effective easy magnetization axis relative to the direction of the deposition field. The magnetization reversal of the systems with 2.5-10nm IrMn first takes place by small angle magnetization rotation and generation of multi-domain configurations that are finally annihilated by domain wall movement. The amount of rotation strongly depends on the field direction, as there is a distinct asymmetry between forward and recoil branch. Hereby, the asymmetry also strongly depends on the misalignment between the external field and the 'true' easy axis. Moreover, creeping effects depending on IrMn layer thickness have been observed. The results are discussed in terms of reversible and irreversible antiferromagnetic contributions to the reversal process.

MA 15.6 Sa 15:15 TU H1028

Controlling MnO spin direction by antiferromagnetic exchange bias in MnO adjoined CoO — ●T. BURNUS¹, S. I. CSISZAR², M. W. HAVERKORT¹, T. HIBMA², A. TANAKA³, H.-H. HSIEH⁴, H.-J. LIN⁴, C. T. CHEN⁴, and L. H. TJENG¹ — ¹II. Physikalisches Institut, Universität zu Köln — ²MSC, Rijksuniversiteit Groningen, The Netherlands — ³ADSM, University of Hiroshima, Japan — ⁴NSRRC, Hsinchu, Taiwan

While exchange bias is a well-known phenomenon between ferro- and antiferromagnetic layers, we found evidence for exchange bias between two antiferromagnets. MnO has twenty-four equivalent magnetization axes, leading to randomly orientated domains and thus to vanishing magnetic linear dichroism (MLD) signals when probed with X-ray spectroscopy. So far, attempts to create thin MnO films with preferred domains, utilizing dipolar or single ion anisotropy, has failed; this is evident from the absence of MLD for thin films on Ag or MgO.

We observed magnetic linear dichroism in MnO when using CoO as substrate. That the orientation of the MnO spins is due to the coupling to the Co spins becomes obvious, when MnO is grown on on differently prepared CoO films with easy axes either in or out of plane. In both cases, the spin in MnO is as parallel as possible to the CoO spin direction; the Mn spins do not completely align with the Co spins, however, since MnO keeps its bulk magnetization structure with its preferred $\{112\}$ domains.

MA 15.7 Sa 15:30 TU H1028

Direct evidence for anti-ferromagnetically coupled Mn-Mn pairs in ZnGeP_2 — ●WOLFGANG GEHLHOFF¹, DMITRI AZAMAT¹, AXEL HOFFMANN¹, and VALERIY VOEVODIN² — ¹Institute for Solid State Physics, Technical University Berlin — ²Siberian Physico-Technical Institute, Tomsk, Russian Federation

The ternary pnictides $A^{\text{II}}M^{\text{IV}}X_2^{\text{V}}$ have attracted much interest because of their nonlinear optical properties and the recent discovery of room temperature ferromagnetism in highly Mn-doped CdGeP_2 , ZnGeP_2 and ZnSnAs_2 , which will enable new nonlinear magneto-optical device structures for nonlinear optics and spintronic applications. The origin of the ferromagnetism in these highly Mn-doped semiconductors is controversially discussed. To decide between the different predictions detailed knowledge concerning the incorporation of Mn in the different charge states on the different lattice site are necessary. For low Mn concentration in ZnGeP_2 we found by electron paramagnetic resonance (EPR) studies a drastic Mn-induced change of the free parameter x_f of the chalcopyrite structure, which can affect the formation of the stable magnetic state. For higher Mn concentration the formation of anti-ferromagnetically coupled $\text{Mn}_{\text{Zn}}^{2+}\text{-Mn}_{\text{Zn}}^{2+}$ pairs [1] could be confirmed by the finding of the characteristic hyperfine structures: 11 hyperfine lines with the characteristic intensity ratio 1:2:3:4:5:6:5:4:3:2:1 and a HF-splitting of 3.5mT, the half value of the HF-splitting of the isolated Mn^{2+} ion on Zn site.

[1] W. Gehlhoff, D. Azamat, A. Hoffmann, Materials Science in Semiconductor Processing, Vol.6 (2003) pp. 379-383

MA 15.8 Sa 15:45 TU H1028

Herkunft der Temperaturabhängigkeit der Interlagen-Kopplung in einem Ni/Cu/Co/Co(001) System — ●STEPHAN SCHWIEGER, JOCHEN KIENERT und WOLFGANG NOLTING — Humboldt Universität zu Berlin, Institut für Physik, Lehrstuhl Festkörpertheorie, Newtonstr. 15, 12489 Berlin

Ferromagnetische Resonanz Experimente (FMR) an einem Ni/Cu/Co/Cu(001) System haben gezeigt, dass die Interlagen-Austauschkopplung, also die Kopplung zwischen magnetischen Schich-

ten, die durch eine paramagnetische Zwischenschicht getrennt sind, eine deutliche Temperaturabhängigkeit aufweist. Bis heute ist noch nicht geklärt, welcher physikalische Mechanismus das Absinken der Kopplungsstärke mit der Temperatur verursacht. Es gibt zwei Kandidaten: zum einen könnten das Aufweichen der Fermi-Oberfläche der Zwischenschicht oder die Verringerung der Spin-Anisotropie der Reflektionskoeffizienten an der Grenzfläche zwischen Zwischenschicht und magnetischer Schicht die Kopplungsenergie absenken (Spacer-Effekt), zum anderen könnten Wechselwirkungen zwischen den Magneten angeregten Spinwellen eine wichtige Rolle spielen (magnetischer Effekt). Durch einen Vergleich von theoretisch berechneten Spinwellen Spektren und den FMR Daten ist es nun möglich diese beiden Effekte zu trennen und den dominierenden Mechanismus zu identifizieren. Für die Rechnungen wurde ein erweitertes Heisenbergmodell benutzt, das äussere Felder, Gitteranisotropien, die dipolare Wechselwirkung innerhalb der magnetischen Schichten und die Interlagenkopplung zwischen den magnetischen Schichten berücksichtigt.

MA 15.9 Sa 16:00 TU H1028

Relativistic theory of indirect nuclear spin-spin coupling — ●HUBERT EBERT — Department Chemie, LMU, Butenandtstr. 5-13, 81377 München, Germany

A fully relativistic theory of indirect nuclear spin-spin coupling is presented that is based on the Green's function formalism. Implementation by the use of the multiple scattering or Korringa-Kohn-Rostoker (KKR) method leads to a very flexible and numerically efficient approach. Results obtained for fcc-Cu are found in full accordance with previous non- or scalar-relativistic calculations and show essentially a behavior expected from Ruderman-Kittel theory for free-electron like systems. This

does not hold for fcc-Pt for which in particular appreciable non-isotropic contributions have been obtained.

MA 15.10 Sa 16:15 TU H1028

Detection of Spin and Charge States in Centrosymmetric Materials by Nonlinear Optics — ●T. SATOH^{1,2}, TH. LOTTERMOSER¹, M. FIEBIG¹, Y. OGIMOTO^{2,3}, H. TAMARU², M. IZUMI², K. MIYANO², and S. ISHIHARA⁴ — ¹Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin — ²RCAST, University of Tokyo, Meguro-ku, Tokyo 153-8904, Japan — ³Devices Technology Res. Labs., SHARP Corp., Nara, Japan — ⁴Dept. of Physics, Tohoku University, Sendai 980-8578, Japan

Over the last decade nonlinear optics has evolved into a powerful tool for studying the magnetic properties of matter. We investigated two magnetic systems with multiphoton techniques where linear optical methods fail. (i) The interface of transition metal oxides has attracted recent attention: it represents a 2D electron system in titanates and displays interface ferromagnetism in manganites. Degradation of tunnelling magnetoresistance due to charge transfer at the interface has been suggested. We apply interface sensitive second harmonic generation to manganese thin films and reveal the nature of charge transfer at the interface. The experimental results were compared with theoretical calculations. (ii) Resonance-enhanced sum-frequency generation is introduced as novel tool for investigation of magnetically ordered compounds. A tunable laser at frequency ω_1 is used to excite an intermediate electronic transition *resonantly* while a second laser at frequency ω_2 is used to scan the nonlinear spectrum at $\omega_1 + \omega_2$. The technique is particularly useful for the investigation of centrosymmetric structures that the majority of magnetic compounds possess. The technique is demonstrated on antiferromagnetic NiO.

MA 16 Hauptvortrag Hellwig

Zeit: Montag 09:45–10:15

Raum: TU H1028

Hauptvortrag

MA 16.1 Mo 09:45 TU H1028

Magnetic domain structure and magnetization reversal in perpendicular AF coupled films — ●OLAV HELLWIG¹, ANDREAS BERGER², and ERIC E. FULLERTON² — ¹BESSY GmbH, Albert-Einstein-Str. 15, 12489 Berlin, Germany — ²Hitachi San Jose Research Center, 650 Harry Road, San Jose, CA 95120, USA

We explored the magnetic properties of a model system for AF-coupled films with perpendicular anisotropy ((Co/Pt)_XCo/Ru)_N multilayers. In the perpendicular geometry the dipolar fields and the interlayer exchange coupling compete with each other, thus resulting in novel phase transitions and a surprisingly rich array of domain structures not seen with in-plane systems. I will present Magnetic Force Microscopy (MFM)

imaging studies of these domains together with corresponding energy calculations that explain our observations. I will show that the different magnetic energy contributions in perpendicularly AF coupled systems can be tuned to stabilize two very different magnetic ground states with similar total magnetic energy. Increasing the thickness of the AF-coupled layer stacks (X) we observe a transition from an exchange dominated laterally uniform antiferromagnetic state to ferromagnetic labyrinth stripe domains [1,2]. Finally I will demonstrate how our model system can also be used to learn more about the nature of AF domain walls [3].

[1] Olav Hellwig et al, Nature Materials 2 (2003) 112. [2] Olav Hellwig et al, J. Magn. Magn. Mater., in print (2004). [3] Olav Hellwig et al, Phys. Rev. Lett. 91 (2003) 197203.

MA 17 Spinabhängiger Transport II

Zeit: Montag 10:30–13:00

Raum: TU H1012

MA 17.1 Mo 10:30 TU H1012

Influence of domain wall stray fields on the magnetization reversal of an FeNi/Al₂O₃/Co tunnel junction — ●K. FUKUMOTO¹, W. KUCH¹, J. VOGEL², R. HERTEL¹, J. CAMARERO³, S. PIZZINI², F. ROMANENS², M. BONFIM², A. FONTAINE², and J. KIRSCHNER¹ — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — ²Laboratoire Louis Néel, CNRS, 25 avenue des Martyrs, B. P. 166, F-38042 Grenoble Cedex 9, France — ³Dpto. Física de la Materia Condensada, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

Understanding and controlling the magnetization reversal of magnetic trilayers in which two ferromagnetic layers (FM) are coupled across a non-magnetic spacer layer is an important issue for the investigation of many interesting phenomena as well as for applications. We used a novel combination of photoelectron emission microscopy, x-ray magnetic circular dichroism and stroboscopic pump-probe technique, in which nanosecond-short magnetic field pulses (the pump) are synchronised to x-ray pulses from BESSY (the probe), to study the magnetization reversal dynamics of a permalloy layer in a FeNi/Al₂O₃/Co magnetic tunnel junction with temporal, layer, and spatial resolution. We observe that the stray field from domain walls in the magnetically harder Co layer plays an important role in the magnetization reversal of the softer permalloy layer. During the field pulse, magnetic domains in the permalloy layer nucleate

preferentially above domain walls in the Co layer. This is compared to micromagnetic simulations of a hard-soft trilayer system.

MA 17.2 Mo 10:45 TU H1012

Niederfrequente 1/f-Rauschanalyse der Grenzflächeneigenschaften magneto-resistiver LSMO:MgO Komposit-Schichten — ●M. ESSELING¹, V. MOSHNYAGA¹, A. MARX², R. GROSS¹ und K. SAMWER² — ¹Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen — ²Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meissner-Str. 8, 85748 Garching

LSMO:MgO-Komposit-Schichten zeigen einen ausgeprägten Magnetowiderstand in kleinen Feldern, wobei der Einfluss der Grenzflächeneigenschaften auf die Feld- und Temperaturabhängigkeit des Magnetowiderstandes Gegenstand aktueller Forschung ist. Mittels niederfrequenter 1/f-Rauschmessungen soll untersucht werden, ob ein strukturell und/oder elektronisch gestörter Bereich innerhalb des Manganats vorhanden ist, der das tiefer als die Curie-Temperatur liegende Maximum in der Widerstandscharakteristik sowie die reduzierte Curie-Temperatur erklären kann. Rauschmessungen werden bei Magnetfeldern $H < 1000 \text{ Oe}$ ($H > H_C$) und Temperaturen 10K-100K durchgeführt. Dabei ist die normierte Rauschleistungsdichte unabhängig vom äußeren Magnetfeld und größenordnungsmäßig vergleichbar mit reinen, epitaktischen Manganat-

schichten. Weiterhin zeigt sich in der Temperaturabhängigkeit der normierten Rauschleistungsdichte ein Maximum bei ca. 25K.

MA 17.3 Mo 11:00 TU H1012

Galvanomagnetische Transporteigenschaften von Stickstoffsubstituiertem $\text{La}_{0.65}\text{Sr}_{0.30}\text{MnO}_3$ und LaMnO_3 — ●M. VON KREUTZBRÜCK¹, G. LEMBKE¹, C. KORTE² und B. FRANZ² — ¹Institut für Angewandte Physik, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen — ²Physikalisch-Chemisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 58, 35392 Giessen

Dünne Filme von stickstoffsubstituiertem $\text{La}_{0.65}\text{Sr}_{0.30}\text{MnO}_3$ wurden epitaktisch auf MgO(100)-Substraten mittels Gepulster Laser-Deposition (PLD) aufgebracht. Die Substitution von Sauerstoff durch Stickstoff in den Proben wurde durch einen kontinuierlichen Stickstofffluss in der PLD-Kammer mit Drucken von 0.08 bis 0.12 mbar erreicht und durch TOF-SIMS, SNMS, XPS und XRD nachgewiesen. Durch Ga^+ -Sputtern wurden mittels TOF-SIMS- und SNMS der Stickstoffgehalt der Proben zu wenigen Prozent bestimmt. Der Stickstoff-Gehalt konnte durch eine Heizspirale zwischen Substrat und Target um den Faktor 4 erhöht werden. Vor der Stickstoffsubstitution zeigten die $\text{La}_{0.65}\text{Sr}_{0.30}\text{MnO}_3$ -Filme einen Metall-Isolator (MI) Übergang bei 170 K. Der MR-Effekt ($\Delta R/R(0)$) betrug etwa -50% bei der MI-Übergangstemperatur. Durch den geringen Stickstoffgehalt wurde der MI-Übergang komplett eliminiert und der Widerstand der Proben stieg um mehr als 3 Größenordnungen an. Durch sukzessive Reoxidation konnte der MI-Übergang wieder nachgewiesen werden. Es wurde für abfallende Temperaturen ein kontinuierlich ansteigender MR-Effekt von mehr als -99% gemessen. Wir interpretieren die Ergebnisse als Perkolationserscheinung von ferromagnetisch-leitfähigen Clustern in einer isolierenden Matrix.

MA 17.4 Mo 11:15 TU H1012

Collective spin fluctuations in Fe and Fe_3Si films on GaAs substrates — ●K. - J. FRIEDLAND, M. BOWEN, J. HERFORT, P. K. MUDULI, H. P. SCHÖNHERR, and K. H. PLOOG — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

The planar Hall effect is a powerful tool to study the magnetization and its reversal in ferromagnetic layers as a function of the external magnetic field. Complementary to other methods such as superconducting quantum interference device magnetometry, magnetotransport measurements can extract magnetization information from small volumes and even low-dimensional structures, demonstrating the importance of magnetotransport measurements for spintronics. In addition, a detailed investigation of related transport phenomena can give insight into the spin texture and the ordering of magnetic substructures. Using Fe and in Fe_3Si films grown by molecular-beam epitaxy on GaAs(001) and (113)A substrates, we present experimental evidence for additional contributions to the planar Hall effect due to collective spin fluctuations and the non-trivial spin topology in the lattice with a non-zero Berry phase. Experiments performed on the Heusler alloy $\text{Fe}_{3+x}\text{Si}_{1-x}$ in the range $-0.08 < x < 0.06$ demonstrate the impact of structural ordering and thermally regulated magnetic ordering on this intrinsic magnetotransport regime.

MA 17.5 Mo 11:30 TU H1012

Conductance through single atoms: Eigenchannel analysis within the *ab initio* screened KKR method. — ●ALEXEI BAGRETS¹, NIKOS PAPANIKOLAOU², and INGRID MERTIG¹ — ¹Martin-Luther-Universität Halle-Wittenberg, Fachbereich Physik, D-06099 Halle, Germany — ²Institute of Microelectronics, NCSR "Demokritos", GR-15310 Athens, Greece

A formalism is presented to evaluate the transmission probabilities and the conductance eigenchannels of atomic-sized contacts from first principles. The approach is based on the *ab initio* screened KKR method combined with the Kubo Green's function formulation of the linear response theory. The proposed method is applied to the study of ballistic electron transport through Cu and Pd atomic-sized contacts contaminated by impurities. The nanocontacts are simulated by two semi-infinite crystalline electrodes attached to an atomic cluster of such configuration that a single atom contact is formed. We assume this atom to be (i) a host atom (Cu or Pd), (ii) an *sp*-impurity (Na, Mg, Al, Si, P and S), and (iii) a 3d impurity. We demonstrate that the conductance of considered systems is mainly determined by the electronic properties of the atom forming the single atom contact. It is shown how the eigenchannels can be classified according to the atomic orbitals of the contact atom, thus leading to the microscopic understanding of the conductance values. In particular, if the pronounced impurity resonances appear at the Fermi energy, it leads

either to the opening of the additional channels of the appropriate symmetry or to the reduction of the transmission of the existing channels.

MA 17.6 Mo 11:45 TU H1012

Transport in nanowires: An *ab initio* description — ●MICHAEL CZERNER¹, ALEXEJ BAGRETS¹, VALERI STEPANYUK^{1,2}, ANDREY KLAVSYUK¹, and INGRID MERTIG¹ — ¹Martin Luther University Halle-Wittenberg, Department of Physics, Von-Seckendorff-Platz 1, 06120 Halle, Germany — ²Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany

We present *ab-initio* calculations of the transport properties of metallic atomic-sized nanowires. The nanowires were modelled by atomic chains of Cu, Co and Al suspended between two semi-infinite leads of the same material. We used the first principle screened Korringa-Kohn-Rostoker method to calculate the electronic properties of the systems, treating the leads and atomic chains on the same footing without any model parameters. The geometrical structure of the atomic chains was relaxed using *ab initio* based many body potentials. The Landauer formalism was applied to investigate the conductance. Quantum size effects, the influence of relaxation and the channel decomposition of the conductance is discussed in detail.

MA 17.7 Mo 12:00 TU H1012

Conductivity of ultrathin Fe layers: influence of quantum confinement and local defects — ●DIMITRI V. FEDOROV^{1,2}, PETER ZAHN¹, and INGRID MERTIG¹ — ¹Physical-Technical Institute, Ural Branch of Russian Academy of Sciences, 426001 Izhevsk, Russia — ²Martin-Luther-Universität Halle-Wittenberg, Fachbereich Physik, Fachgruppe Theoretische Physik, D-06099 Halle, Germany

We propose a model for the description of the transport properties of metallic films on a large scale of slab thickness. This model is based on solving the linearized Boltzmann equation in the relaxation-time approximation using *ab initio* calculations within the framework of the density functional theory. The expression for the relaxation time is derived from the microscopic treatment of the scattering processes and provides the correct thickness dependence for very thin as well as very thick films.

The method is applied to the calculation of the in-plane conductivity and the Drude-type plasma frequency of thin Cu and magnetic Fe films for different crystal orientations in the thickness range between 1 and 32 monolayers.

MA 17.8 Mo 12:15 TU H1012

Effect of interface interdiffusion on the electronic, magnetic and transport properties of Fe/GaAs/Fe Trilayer Systems — ●VOICU POPESCU and HUBERT EBERT — Department Chemie/Physikalische Chemie, University of Munich, Butenandtstr. 5-13, 81377 Munich, Germany

We report results of calculations on the electronic, magnetic and transport properties of As-terminated Fe/GaAs/Fe trilayer systems that have been obtained using the tight-binding Korringa-Kohn-Rostoker Green function method in a spin-polarised relativistic formulation (TB-SPR-KKR).

By means of the Coherent Potential Approximation alloy theory (CPA), interdiffusion at the Fe/GaAs interface has been accounted for. The changes induced by this in the properties of the whole Fe/GaAs/Fe junction (magnetisation profile, conductance) have been thoroughly investigated for different degrees of intermixing.

For the electronic transport it could be shown, in particular, that the main effect produced is a reduction of the spin selectivity at the ferromagnet-semiconductor interface, in line with previous model or *ab initio* calculations.

MA 17.9 Mo 12:30 TU H1012

Magnetowiderstand in verunreinigten Fe/V/Fe Systemen — ●HEIKE C. HERPER, ANDREY BEZNOGOV und PETER ENTEL — Theoretische Physik, Universität Duisburg-Essen, Campus Duisburg, D-47048 Duisburg

Der Magnetowiderstand (GMR) in Schichtsystemen ist eng mit dem Auftreten von antiferromagnetischer Austauschkopplung verknüpft. Das Vorzeichen der Austauschkopplung ist abhängig von der Wachstumsrichtung, der Dicke der nichtmagnetischen Schicht und den im System enthaltenen Verunreinigungen. Wir haben die Austauschkopplung und die Transporteigenschaften von Fe/V/Fe in (001) und (110) Richtung unter Verwendung einer vollrelativistischen Greenfunktionsmethode und der Kubo-Greenwood-Gleichung untersucht, wodurch auch die Bestimmung des anisotropen Magnetowiderstands ermöglicht wird. Insbesondere

re wurde dabei Legierungsbildung an der Grenzfläche und der Einfluss von Al bzw. Si Verunreinigungen diskutiert. In Übereinstimmung mit experimentellen Ergebnissen finden wir eine schwache Austauschkopplung und einen kleinen GMR. Verunreinigungen oder Diffusion an den Grenzflächen führen zu einer weiteren Verringerung des GMR. Bei dünnen V-Schichten zeigen alle Systeme zusätzlich einen deutlichen AMR.

Gefördert durch die Deutsche Forschungsgemeinschaft im Rahmen des SFB 491

MA 17.10 Mo 12:45 TU H1012

Disorder effects on spin-dependent tunneling — ●MICHAEL WIMMER and KLAUS RICHTER — Institut für Theoretische Physik, Universität Regensburg

In contrast to Al₂O₃-based tunnel junctions recent experiments on one-crystalline GaAs barriers showed only a very small tunneling magnetoresistance (TMR) effect, although band structure considerations predicted a very high TMR ratio. Some experimental evidence hints at the importance of interfacial disorder and spin-flips [1,2].

We calculate numerically the effect of interfacial scattering and spin flips on the TMR using a phenomenological model. Our results show that disorder decreases the TMR effect significantly and identify the lifting of the conservation of the parallel momentum as the responsible mechanism. Surprisingly, allowing spin flips during a scattering event has only little influence on the TMR ratio.

We further study the influence of the barrier height on the TMR ratio. The TMR effect of high barriers is found to be more robust against disorder than low barriers.

References:

- [1] S. Kreuzer *et al.*, Appl. Phys. Lett. **80**, 4582 (2002)
 [2] M. Zenger *et al.*, J. Appl. Phys. **96**, 2400 (2004)

MA 18 Magnetische dünne Schichten III

Zeit: Montag 10:30–13:00

Raum: TU H1028

MA 18.1 Mo 10:30 TU H1028

Quantitative SQUID Magnetometrie im UHV: Einfluss magnetischer Randidomänen — ●TH. KEBE, R. RAMCHAL, F. CIUBOTARU, J. LINDNER und M. FARLE — Fachbereich Physik, Experimentalphysik AG Farle, Universität Duisburg-Essen, Campus Duisburg, Lotharstrasse 1, 47048 Duisburg, Germany.

Aus der Größe und Richtung des magnetischen Streufeldes kann mit Raster-HTS-SQUID-Magnetometrie die Magnetisierung magnetischer Monolagen *in situ* im UHV quantitativ bestimmt werden [1]. Da man in der Analyse für die Magnetisierungsverteilung einen eindomänen Magnetisierungszustand annimmt, schätzen wir den Fehler bei der Magnetisierungsbestimmung für den Fall ab, dass Domänen in Remanenz vorliegen. Hierzu wurden Magnetkraftmikroskopie, Kerr-Effekt und Kerr-Mikroskopiemessungen an 15 ML Fe Filmen auf Ga terminierten GaAs(100) Substraten mit Pt Deckschicht *ex situ* durchgeführt. Der Vergleich mit theoretischen Berechnungen gibt eine quantitative Abschätzung des Einflusses auf das dipolare Streufeld.

Unterstützt durch Sonderforschungsbereich 491, TP A9.

[1] A. Ney, P. Pouloupoulos, M. Farle and K. Baberschke, *Phys. Rev. B* **62**, 11336 (2000).

MA 18.2 Mo 10:45 TU H1028

Erzeugung ferromagnetischer Schichten durch Oxidation von CoAl (100) — ●KLAUS BRÜGGEMANN, VOLKER ROSE, STELLA VAN EEK, RENÉ FRANCHY und HARALD IBACH — Institut für Schichten und Grenzflächen (ISG3), Forschungszentrum Jülich, D-52425 Jülich

Im Rahmen unserer Untersuchungen zum Aufbau eines TMR-Modellsystems wurden mittels MOKE die magnetischen Eigenschaften von Cobalt_{0.5} Aluminium_{0.5} (100) gemessen. Gemäß Literaturangaben zeigt die Verbindung erst ab 63 Atomprozent Co Ferromagnetismus. Der reine Kristall zeigte somit zunächst keine Hysterese. Die Probe wurde nun bei Raumtemperatur mit einer Dosis von 400 L Sauerstoff oxidiert, wobei an der Oberfläche eine ca. 7 Å dicke Schicht amorphes Al₂O₃ entstand. Dadurch werden die obersten Schichten des Kristalls an Al verarmt und eine Cobalt angereicherte Schicht, die Ferromagnetismus aufweist, entsteht. Somit konnte eine Hysterese mit 5 Oe Hc gemessen werden. Das Oxid wurde danach durch Ionenätzen mit Ar entfernt und das Substrat schrittweise auf 600K erwärmt. Dabei diffundierte Al in die verarmte Schicht, was sich durch eine abnehmende Magnetisierung und einer zunehmendes Hc äußerte. Dies kann durch Abnahme der Beweglichkeit der Domänenwände und des magnetischen Materials erklärt werden.

MA 18.3 Mo 11:00 TU H1028

Austauschgekoppelte magnetische Schichten: Variation der Kopplung durch externe Magnetfelder — ●T. KLEIN¹, R. RÖHLSBERGER², K. SCHLAGE¹ und E. BURKEL¹ — ¹Institut für Physik Universität Rostock, August-Bebel-Str. 55, 18051 Rostock — ²HASYLAB am DESY, Notkestr. 85, 22607 Hamburg

In diesem Beitrag wird die Austauschkopplung zwischen weich- und hartmagnetischen Schichten über nichtmagnetische Zwischenschichten untersucht. Weichmagnetische Fe-Schichten sind über Cu-Zwischenschichten an hartmagnetische FePt-Schichten mit unidirektionaler Anisotropie ferromagnetisch gekoppelt. Durch externe Magnetfelder, die kurzzeitig senkrecht oder antiparallel zur

FePt-Magnetisierungsrichtung angelegt werden, können die Kopplungseigenschaften verändert werden. Für bestimmte Cu-Schichtdicken wird der Kopplungswinkel zwischen den Magnetisierungsrichtungen der Schichten remanent verändert. Es können beliebige Kopplungswinkel durch die externen Magnetfelder induziert werden. Diese Kopplungswinkel wurden mit Hilfe der nuklear resonanten Streuung mit einer hohen Genauigkeit (+/- 3°) bestimmt.

Für senkrecht und antiparallel angelegte Magnetfelder ergeben sich signifikante Unterschiede bezüglich der induzierten Kopplungswinkel als Funktion der Cu-Zwischenschichtdicke. Ein Teil der Resultate konnte mit bekannten Modellen [1] beschrieben werden. Es wird ein neues Modell präsentiert, welches weitere magnetfeldinduzierten Kopplungsphänomene beschreibt.

[1] V. K. Vlasko-Vlasov *et al.*, Phys. Rev. Lett. **86**, 4386-4389 (2001)

MA 18.4 Mo 11:15 TU H1028

First-principles study of thin magnetic transition-metal alloy films on Si(001) — ●HUA WU, PETER KRATZER, and MATTHIAS SCHEFFLER — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, D-14195 Berlin

Ferromagnetic (FM) metal/semiconductor heterojunctions have promising technological applications in the field of magnetoelectronics (or spintronics). Here we present density-functional theory calculations addressing the thermodynamic stability and magnetism both of the pseudomorphic CsCl-like *M*Si (*M*=Mn,Fe,Co,Ni) thin films and of the Heusler alloy *M*₂MnSi (*M*=Fe,Co,Ni) films on Si(001). The results show that the *M*Si films prefer a Si-termination, and that the *M*-Si bond-strength increases as *M* varies from Mn to the later transition metals, which is helpful to understand a number of experimental observations. The ultrathin MnSi film is FM; the FeSi and NiSi films are nonmagnetic; while the CoSi film is surprisingly FM due to its peculiar electronic band structure. For the *M*₂MnSi films, the Si termination has a higher chemical stability due to stronger surface chemical bonds, while the MnSi termination has a higher thermodynamic stability due to a lower formation energy. The calculated strength of the effective intralayer Mn-Mn coupling scales with the measured FM Curie temperatures of the bulk *M*₂MnSi. In particular, the Co₂MnSi/Si(001) thin film is stable against a phase separation and has a robust FM ground state as in the bulk Co₂MnSi. However, we note that in the Co₂MnSi/Si(001) film, the formation energies of Co/Si and MnSi/Si interfaces are similar, which could lead to interfacial disorder degrading spin injection.

MA 18.5 Mo 11:30 TU H1028

Revealing Antiferromagnetic Order of the Fe Monolayer on W(001) — ●ANDRÉ KUBETZKA¹, PAOLO FERRIANI¹, MATTHIAS BODE¹, STEFAN HEINZE¹, GUSTAV BIHLMAYER², KIRSTEN VON BERGMANN¹, OSWALD PIETZSCH¹, STEFAN BLÜGEL², and ROLAND WIESENDANGER¹ — ¹Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — ²Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

Although the system of one monolayer Fe on W(001) has been studied extensively in the past, experiments only deduced that the magnetic ground state is not ferromagnetic [1] while theoretical predictions are still controversial [2,3]. Employing spin-polarized scanning tunneling mi-

croscopy (SP-STM) we obtained atomic resolution images showing that a $c(2 \times 2)$ antiferromagnetic structure with an out-of-plane magnetization direction is the magnetic ground state. Since, in contrast, the Fe ML is ferromagnetic on $W(110)$, we thereby show that the type of magnetic order can be changed by a proper choice of the substrate orientation alone. These results are explained based on first-principles calculations.

- [1] G.A. Mulhollan *et al.*, Phys. Rev. B **43**, 13645 (1991)
 [2] R. Wu and A.J. Freeman, Phys. Rev. B **45**, 7532 (1992)
 [3] X. Qian and W. Hübner, Phys. Rev. B **67**, 184414 (2003)

MA 18.6 Mo 11:45 TU H1028

Displacement Profile of Domain Walls at Critical Depinning — ●THOMAS NATTERMANN and ANDREAS GLATZ — Institut für Theoretische Physik der Universität zu Köln, Zülpicher Str. 77, 50937 Köln

The influence of a strong surface potential on the critical depinning of an elastic system driven in a random medium is considered. If the surface potential prevents depinning completely the elastic system shows a parabolic displacement profile. Its curvature \mathcal{C} exhibits at zero temperature a pronounced rhombic hysteresis curve of width $2f_c$ with the bulk depinning threshold f_c . The hysteresis disappears at non-zero temperatures if the driving force is changed adiabatically. If the surface depins by the applied force or thermal creep, \mathcal{C} is reduced with increasing velocity. The results apply, e.g., to driven magnetic domain walls, flux-line lattices and charge-density waves

MA 18.7 Mo 12:00 TU H1028

Hysteresis mediated by a domain wall motion — ●THOMAS NATTERMANN¹ and VALERY POKROVSKY² — ¹Institut für Theoretische Physik der Universität zu Köln, Zülpicher Str. 77, 50937 Köln — ²Department of Physics, Texas A&M University, College Station TX, USA

The position of an interface (domain wall) in a medium with random pinning defects is not determined unambiguously by the instantaneous value of the driving force, even on average. Employing the general theory of the interface motion in a random medium, we study this hysteresis, different possible shapes of the hysteresis loop, and the dynamical phase transitions between them. Several principal characteristics of the hysteresis, including the coercive force and the curves of dynamical phase transitions obey scaling laws and display a critical behavior in the vicinity of the mobility threshold. At finite temperature the threshold is smeared and a new range of thermally activated hysteresis appears. At a finite frequency of the driving force there exists a range of the non-adiabatic regime in which not only the position, but also the average velocity of the domain wall, displays hysteresis.

MA 18.8 Mo 12:15 TU H1028

Permalloy microstructures at high current densities — ●SALEH GETLAWI, IVO KNITTEL, MICHAEL KOBLISCHKA, and UWE HARTMANN — Universität des Saarlandes, 66041 Saarbrücken

It is now less than ten years that magnetization reversal by spin transfer and current-induced domain wall movement has been discovered. Now it is discussed more and more as a possible mechanism for devices, namely

as microwave generator and for permanent information storage. However, the current densities involved are without precedent in technology. We have set up a number of experiments to observe the effects of high current densities on permalloy microstructures. We investigate current-induced domain wall movement by magnetic force microscopy, map the local temperature distribution by Near-Infrared Scanning Near Field Microscopy, and study the effects of electromigration by atomic force microscopy and electron microscopy.

MA 18.9 Mo 12:30 TU H1028

Switching behaviour of small FePt grains observed by magnetic force microscopy — ●ULRIKE WOLFF, STEFAN POFAHL, MARTIN WEISHEIT, SEBASTIAN FÄHLER, LUDWIG SCHULTZ, and VOLKER NEU — IFW Dresden, P.O. Box 270116, 01171 Dresden

FePt films of small grains with an average grain size of 100-500nm have been prepared by pulsed laser deposition onto MgO(001) substrates at high temperatures of 800°C in order to form the $L1_0$ hard magnetic phase. The grains are isolated, fully out-of-plane oriented in c -axis, exhibit a coercivity of 3-5.6T, depending on the grain size, and show in the remanent state single domains [1]. The magnetization process is investigated by means of Magnetic Force Microscopy by measuring in an applied magnetic field of up to 7T (Cryogenic SFM, Omicron) or by imaging the magnetic domain structure of different remanent states with a Dimension 3100 (Digital Instruments). This local study allows the evaluation of grain size dependence on the switching behaviour of individual FePt grains.

- [1] M. Weisheit, L. Schultz, S. Fähler, J. Appl. Phys. 95 (2004) 7489

MA 18.10 Mo 12:45 TU H1028

Strain and disorder effects on the transport properties of manganite thin films — ●CARMINE ANTONIO PERRONI, VITTORIO CATAUDELLA, GIULIO DE FILIPPIS, and VINCENZO MARIGLIANO RAMAGLIA — Dipartimento Scienze Fisiche, Università "Federico II", Napoli

Thickness dependence, strain and disorder effects in films of $La_{1-x}A_xMnO_3$ perovskites are analyzed in the colossal magnetoresistance regime. A reduction in the thickness of the film causes a decrease of critical temperature and an increase of resistivity at low temperatures. The strain effects are in good agreement with experimental data only if the dependence of the hopping matrix elements on the Mn-O-Mn bond angle is properly taken into account. In collaboration with experimental groups, the resistivity is investigated in a wide temperature range for films grown by different techniques and on several substrates allowing to analyze samples with different amounts of disorder. In the low-temperature state the prominent contribution to the resistivity scales as T^α with $\alpha \simeq 2.5$ supporting the role of single magnon scattering in presence of minority spin states localized by the disorder. In the high temperature insulating paramagnetic phase the resistivity shows the activated behavior characteristic of polaronic carriers. Finally in the whole range of temperatures the experimental data are found to be consistent with a phase separation scenario also in films doped with strontium.

MA 19 Mikro- und nanostrukturierte magn. Materialien I

Zeit: Montag 10:30–13:00

Raum: TU EMH225

MA 19.1 Mo 10:30 TU EMH225

Depth-resolved investigation of the lateral magnetic correlations in polycrystalline multilayers by reflectivity and off-specular scattering of polarized neutrons — ●EMMANUEL KENTZINGER¹, ULRICH RÜCKER¹, BORIS TOPERVERG¹, FRÉDÉRIC OTT², and THOMAS BRÜCKEL¹ — ¹Institut für Festkörperforschung, Forschungszentrum Jülich GmbH — ²Laboratoire Léon Brillouin, Saclay, France

The remagnetization process of a remanent magnetic multi-bilayer system with a gradient in the bilayer thicknesses was studied by reflectivity and off-specular scattering of polarized neutrons with polarization analysis performed on the HADAS reflectometer located at the research reactor FRJ-2 in Jülich. From the specular reflectivity, it is figured out that, by increasing the external magnetic field $\mu_0 H$, the magnetizations inside the ferromagnetic (FM) layers orient sequentially along $\mu_0 H$, from the bottom-most, thinnest FM layer to the top-most, thickest FM layer. This thickness dependency of the coercive field can be related to an evolution

of the grain size. Also, the net magnetizations inside the FM layers that have not yet flipped have reduced magnitude with respect to their saturation value. The off-specular data lead to a more accurate description of the magnetization arrangement. They reveal that the reduced net magnetizations are a consequence of lateral fluctuations of both components of the magnetizations, perpendicular and parallel to $\mu_0 H$. Those interpretations are confirmed by simulations of the data in the framework of the Distorted Wave Born Approximation (DWBA).

MA 19.2 Mo 10:45 TU EMH225

Band Structure in Strong Magnetic Fields — ●MANFRED TAUT — Leibniz Institute for Solid State and Materials Research, POB 270116, 01171 Dresden

The one-electron Schrödinger equation in a **periodic effective potential** and a **homogenous magnetic field** is solved for rational flux quantum numbers p/q and several lattice structures. A LCAO formalism is used. The **total energy** $E_{tot}(\mathbf{B}, z_0) = \sum_{\mathbf{k}, n}^{occ.} \varepsilon_{\mathbf{k}, n}(\mathbf{B})$ is calculated as a

function of magnetic field B and of band filling z_0 . The **magnetization** $M(\mathbf{B}) = \nabla_{\mathbf{B}} E_{tot}(\mathbf{B}, z_0)$ shows novel oscillations.

The gap pattern of a two-dimensional magnetic band structure (e.g. the Hofstadter butterfly) can be puzzled together out of three basic quasi-classical spectra. The spectra *around* a certain flux quantum number p_0/q_0 can be obtained by quasiclassical quantisation of the exact magnetic band structure for p_0/q_0 .

The **total energy** as a function of B shows kinks for integer filling factors (full Landau levels) and, in the high magnetic field regime, also for certain rational filling factors.

The exact **magnetization** contains information not only about the (zero-magnetic-field) band structure, but also about any finite-magnetic-field band structure. The asymptotic oscillations in $M\left(1/(B - B_0)\right)$ provide the Fermi surface cross sections for the magnetic band structure at B_0 . Unlike the standard Lifshitz-Kosevich type approaches, our magnetizations contain the effects of magnetic breakdown, forbidden orbits and interband coupling.

MA 19.3 Mo 11:00 TU EMH225

Einfluss der Dimensionsreduzierung auf den Magnetismus in MnS — •THOMAS KURZ¹, HANS-ALBRECHT KRUG VON NIDDA¹, ALOIS LOIDL¹, PETER KLAR², LIMEI CHEN², WOLFRAM HEIMBRODT², FELIX BRIELER³ und MICHAEL FRÖBA³ — ¹Experimentalphysik 5, Institut für Physik, Universität Augsburg, Universitätsstrasse 2, 86135 Augsburg — ²Experimentelle Halbleiterphysik, Institut für Physik, Philipps Universität Marburg — ³Festkörperchemie und Materialwissenschaften, Institut für Anorganische und Analytische Chemie, Universität Gießen

Unser Ziel ist die Untersuchung der Dimensionsreduzierung magnetischer Halbleiter. Magnetische Nanostrukturen mit wohldefinierter Größe im Bereich von 2 bis 12nm können innerhalb hochgradiger geordneter, mesoporöser SiO₂ Strukturen mit scharfen Porenverteilungen synthetisiert werden. Unter Verwendung der Elektronenspinresonanz (ESR) präsentieren wir die Veränderung des magnetischen Verhaltens solcher MnS Nanostrukturen und zeigen die weitgehende Unterdrückung des Magnetismus in den kleinsten Strukturen im Vergleich zum bulk Material. Zu den beobachteten Effekten zählen die Verschiebung des Curie-Weiss-Parameters in die Nähe von $\theta = 0\text{K}$, sowie das Verschwinden der antiferromagnetischen Ordnung, sichtbar in ESR-Linienbreite und Intensität. Optische Messungen komplettieren die Ergebnisse, indem sie das Nachlassen langreichweitiger Ordnung dokumentieren, wohingegen die Nahordnung erhalten bleibt.

MA 19.4 Mo 11:15 TU EMH225

Schaltverhalten amorpher, nanostrukturierter CoFeB-Elemente — •N. WIESE^{1,2}, T. DIMOPOULOS¹, M. RÜHRIG¹, J. WECKER¹, H. BRÜCKL² und G. REISS² — ¹Siemens AG Corporate Technology, CT MM 1, Paul-Gossen-Str. 100, 91052 Erlangen — ²Universität Bielefeld, Nano Device Group, Universitätsstr. 25, 33615 Bielefeld

Magnetische Tunnelbarrieren mit Elektroden aus amorphem Co₆₀Fe₂₀B₂₀ zeigen hohe TMR Effekt-Amplituden von mehr als 50%, eine erhöhte thermische Stabilität des TMR Effektes und sehr gute weichmagnetische Eigenschaften.[1] Sie eignen sich daher als Alternative zu Elektroden aus polykristallinen Materialien (wie NiFe, CoFe) in magnetischen Tunnelbarrieren.

Das Ummagnetisierungsverhalten von nanostrukturierten Elementen dieser amorphen CoFeB-Legierung ist mit dem magneto-optischen Kereffekt (MOKE) untersucht worden. Dazu wurden Arrays der Elemente mit verschiedenen Aspektverhältnissen und Geometrien bei einer Breite von 200nm mittels Elektronenstrahl-Lithographie hergestellt. Ein Vergleich zu Elementen aus üblicherweise untersuchten polykristallinen Materialien wie NiFe und CoFe wird gegeben.

In Systemen, bestehend aus zwei Lagen der amorphen CoFeB-Legierung und einer dünnen Ru-Zwischenschicht, kann eine stabile antiferromagnetische Kopplung eingestellt werden.[2] Die Eignung solcher Schichtsysteme mit einem reduzierten Netto-Moment als weiche Elektrode in magnetischen Tunnelbarrieren wird abschließend diskutiert.

[1] T. Dimopoulos et al., accepted for publication in JAP 96 (2004)

[2] N. Wiese et al., APL 85, 2020 (2004)

MA 19.5 Mo 11:30 TU EMH225

Structure and Magnetic Properties of Nanocrystalline Fe_{100-x}Pt_x Powders — •JULIA LYUBINA, OLIVER GUTFLEISCH, KARL-HARTMUT MÜLLER, and LUDWIG SCHULTZ — IFW Dresden, Institute for Metallic Materials, P.O. Box 270016, D-01171 Dresden, Germany

The ordered tetragonal L1₀ FePt phase has excellent intrinsic magnetic properties ($K_1 = 6.6 \text{ MJm}^{-3}$, $J_s = 1.43 \text{ T}$, $T_c = 750 \text{ K}$), good mechanical properties and corrosion resistance. The combination of these unique properties makes it interesting both from the scientific and application points of view. Here we report on the preparation of nanocrystalline hard magnetic Fe_{100-x}Pt_x ($x = 39.5; 45; 50; 55; 60$) powders by mechanical ball milling at 77 K followed by annealing (450 °C). According to Rietveld refinement of x-ray data, annealed powders contain a mixture of the highly ordered L1₀ FePt and disordered cubic A1 FePt, as well as Fe₃Pt and FePt₃. The amount of the A1 FePt phase remains almost unchanged (6-10 vol. %), whereas the fraction of the L1₀ FePt, Fe₃Pt and FePt₃ phases varies with Pt concentration x . Coercivity $\mu_0 H_c$ was found to increase with Pt concentration from 0.33 T ($x = 39.5$) to 0.95 T ($x = 60$), whereas remanence J_r reduce: from 0.8 T ($x = 39.5$) to 0.4 T ($x = 60$). In Fe-rich powders exchange-spring behaviour was observed. The evolution of magnetic properties is discussed in terms of phase composition, distribution of the phases and degree of chemical order.

MA 19.6 Mo 11:45 TU EMH225

Ion-Irradiation-Induced Chemical Ordering of Intermetallic Alloys: Predictions Based on Atomistic Simulations — •KARL-HEINZ HEINIG¹ and HARRY BERNAS² — ¹Forschungszentrum Rossendorf, Dresden — ²CSNSM, CNRS-University Paris XI, Orsay, France

The L1₀ transition temperatures for chemical ordering in FePd and FePt intermetallic alloys may be substantially reduced by ion irradiation [1]. Alignment of the strong magnetic axis normal to the surface layer was achieved. Recently, we showed via kinetic Monte Carlo simulations [2] that (i) ion-beam-induced reduction of the L1₀ transition temperature may be understood in terms of vacancy-assisted atomic ordering and that (ii) superstructure alignment results from a small initial directional short range order (DSRO). In this contribution (i) we present systematic studies of the ion-irradiation-induced L1₀ ordering in thin layers, (ii) we predict the evolution of chemical ordering in layers with well-designed initial DSRO, (iii) we study in non-stoichiometric alloys (e.g. Fe_{1-x}Pd_x) the competition of L1₀ ordering (FePd) with L1₂ ordering (Fe₃Pd), and (iv) we evaluate the influence of interfaces in nanostructures on the ordering process.

[1] D. Ravelosona, C. Chappert, V. Mathet and H. Bernas, Appl. Phys. Lett. 76 (2000) 236.

[2] H. Bernas, J.-Ph. Attane, K.-H. Heinig, D. Halley, D. Ravelosona, A. Marty, P. Auric, C. Chappert, Y. Samson, Phys. Rev. Lett. 91 (2003) 77203

MA 19.7 Mo 12:00 TU EMH225

Anisotropy patterning of amorphous CoFeSiB films by He-ion irradiation — •JEFFREY MCCORD¹, JÜRGEN FASSBENDER², MICHAEL FROMMBERGER³, MACIEJ OSKAR LIEDKE², ECKHARD QUANDT³, and LUDWIG SCHULTZ² — ¹Leibniz Institute for Solid State and Materials Research Dresden - Institute for Metallic Materials - 01169 Dresden — ²FZ Rossendorf - Institut für Ionenstrahlphysik und Materialforschung - 01314 Dresden — ³Stiftung caesar - Smart Materials Laboratory - 53175 Bonn

The alteration of magnetic properties in magnetic thin films by ion radiation has gained increasing attention in recent years. Here, we present data on the local alteration of the magnetic anisotropy axis in amorphous soft magnetic FeCoBSi films by He-ion irradiation in an applied magnetic in-plane field. Sputtered CoFeSiB (thickness 30 nm) were irradiated with 5 keV He-ions. A magnetic field of 600 Oe was applied during irradiation aligned orthogonal to the initial easy axis of anisotropy. Above a critical fluence an alignment of anisotropy in the applied field direction is observed by MOKE magnetometry and complementary domain observation by Kerr microscopy. Using irradiation together with photolithography the films were irradiated locally, thus resulting in anisotropy-patterned structures. Domain patterns in different elements with varying angles of anisotropy and edge orientation, separating regions of different anisotropy alignment, are shown. The influence of the patterning on the (still) full film reversal is discussed in detail.

MA 19.8 Mo 12:15 TU EMH225

DOMAIN PROPAGATION IN ION BOMBARDED MAGNETIC WIRES WITH OPPOSITE EXCHANGE BIAS — •K. THEIS-BRÖHL¹, B. P. TOPERVERG¹, J. MCCORD², U. RÜCKER³, J. SCHMALHORST⁴, V. HÖINK⁴, H. BRÜCKL⁴, T. WEIS⁵, D. ENGEL⁵, A. EHRESMANN⁵, and H. ZABEL¹ — ¹Department of Experimental and Solid State Physics, Ruhr-University Bochum, 44780 Bochum — ²Material Research Institute, Helmholtzstr. 20, 01169 Dresden — ³Institute of Solid State Research, Forschungszentrum Jülich, 52425 Jülich — ⁴Department of Physics, University Bielefeld, Universitätsstr. 25, 33615 Bielefeld — ⁵Faculty of Physics, Kaiserslautern University of Technology, 67663 Kaiserslautern

Exchange biased CoFe/MnIr films are magnetically patterned with He-ion bombardment into two magnetic regions (stripes) with oppositely aligned exchange bias. The longitudinal magnetization reversal occurs through head-on domain wall motion and partial penetration of magnetization from neighboring stripes. It is highly asymmetric and involves ripple-like domain structures and incoherent rotation of magnetization. This was measured using Kerr microscopy and polarized neutron reflectivity methods. For the quantitative analysis of our data we applied a theoretical model using the Distorted Born Wave Approximation which provides us with a set of parameters quantifying the magnetization arrangement in the magnetic pattern. This all together gives access to a detailed understanding of the magnetization arrangement and the magnetization reversal. We acknowledge funding by DFG, SFB 491 and BMBF 032AESBO.

MA 19.9 Mo 12:30 TU EMH225

SOFT MAGNETIC PROPERTIES OF Fe-Cr-Mo-Ga-P-C-B BMG — •STOICA MIHAI¹, ROTH STEFAN¹, RELLINGHAUS BERND¹, SCHULTZ LUDWIG¹, and ECKERT JÜRGEN² — ¹IFW Dresden, Institute for Metallic Materials, P.O. Box 270016, D-01171 Dresden, Germany — ²Physical Metallurgy Division, TU Darmstadt, Petersenstraße 23, D-64287 Darmstadt, Germany

The Fe_{65.5}Cr₄Mo₄Ga₄P₁₂C₅B_{5.5} bulk metallic glass (BMG) exhibits good soft magnetic properties. However, the maximum achievable diameter of this Fe-based BMG is limited to only a few millimeters. Amorphous

rods with diameters of 1.5-3 mm and discs with diameters and thicknesses of 10 mm and 1 mm, respectively, were prepared by copper mold casting. The coercivity of the as-cast rods and disc is around 5 A/m and it decreases to less than 1 A/m upon annealing. The saturation polarization is around 0.8 T at room temperature, increasing to up to 1 T at 77 K.

On the other hand, powder metallurgical methods (i.e. ball milling combined with subsequent consolidation of the resulting powders) provide the advantages to prepare bulk amorphous samples with larger sizes and a large variety of shapes. The present contribution aims at comparing the magnetic properties of the as-prepared and annealed bulk metallic glasses obtained by copper mold casting and powder metallurgy, respectively.

MA 19.10 Mo 12:45 TU EMH225

Magnetic multilayers on nanospheres — •ILDICO GUHR¹, TILL ULBRICH¹, GUOHAN HU², JOHANNES BONEBERG¹, GÜNTER SCHATZ¹, and MANFRED ALBRECHT¹ — ¹University of Konstanz, Department of Physics, 78457 Konstanz, Germany — ²Hitachi San Jose Research Center, San Jose, CA 95120, USA

Nanoparticle media using arrays of monodisperse nanoparticles with high magnetic anisotropy are assumed to be the ideal future magnetic recording media [1]. However, key requirements like control of the magnetic anisotropy orientation along with magnetic domain isolation have not been achieved so far. Here, we report on a combination of a two-dimensional topographic pattern formed of self-assembled polystyrene particles [2] with sizes as small as 20 nm and magnetic film deposition. The so formed nanostructures on top of a sphere are monodisperse and reveal a uniform magnetic anisotropy which can be tailored by changing the stack of a Co/Pd multilayer film and the deposition angle. Magnetic exchange isolation depends strongly on the total film thickness and the particle size as observed by MFM imaging and MOKE studies. Moreover, results on the switching mechanism as a function of nanostructure size will be presented.

This project is funded by the DFG through the SFB 513/TP A8 and the Emmy-Noether program at the University of Konstanz.

[1] M. Albrecht et al., Physik Journal, 10 (2003).

[2] F. Burmeister et al., Appl. Surf. Sci. 144-145, 461 (1999).

MA 20 Poster: Schichten(1-29), Spintrsp(30-45), Ex-Bias(46-63), Spindyn(64-75), Mikromat.(76-80), Cluster(81-94), Abbv.(95-99), Obflm(100-02), SpElek.(103-09), E-Theo(110-14), Mikromag.(115-16), Spin+PÜ(117-26), Mag.Mat.(127-51), Meth.(152-55), Mol.Mag(156-59), Kondo(160-65)

Zeit: Montag 14:00–18:00

Raum: Poster TU C

MA 20.1 Mo 14:00 Poster TU C

Pulsed laser deposition of electron-doped $La_{1-x}Ce_xCoO_3$ thin films — •DIRK FUCHS¹, PETER ADELMANN¹, PETER SCHWEISS¹, THORSTEN SCHWARZ^{1,2}, and RUDOLF SCHNEIDER¹ — ¹Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe, Germany — ²Universität Karlsruhe, Fakultät für Physik, D-76128 Karlsruhe, Germany

The electron doping of $LaCoO_3$ perovskites with the substitution of trivalent La^{3+} by tetravalent Ce^{4+} ions is usually strongly limited by the small solubility of Ce under standard conditions. With thin film preparation we succeeded in the growth of highly cerium-doped thin films. $La_{1-x}Ce_xCoO_3$ (LCCO) thin films, with $0.1 \leq x \leq 0.5$, were deposited by laser ablation using a KrF excimer laser. The deposition was carried out from polycrystalline LCCO targets prepared by the sol-gel route and standard solid state reaction. The film growth was studied as a function of the substrate temperature and material, laser energy and oxygen partial pressure. The films were optimised with respect to crystalline quality. The magnetic and electric properties of the samples were characterized by magnetization and resistivity measurements.

MA 20.2 Mo 14:00 Poster TU C

Unusual finite-size scaling behavior of $La_{0.7}Sr_{0.3}CoO_3$ thin films — •THORSTEN SCHWARZ^{1,2}, DIRK FUCHS¹, PETER SCHWEISS¹, and RUDOLF SCHNEIDER¹ — ¹Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe — ²Universität Karlsruhe, Fakultät für Physik, D-76128 Karlsruhe

$La_{0.7}Sr_{0.3}CoO_3$ thin films were prepared by pulsed laser deposition on

(001) oriented $(LaAlO_3)_{0.3}(Sr_2AlTaO_8)_{0.7}$ substrates with different film thickness, $400 \text{ nm} > d \geq 2.6 \text{ nm}$, and optimized with respect to their structural and magnetic properties. We carried out X-ray diffraction, transmission electron microscopy, Rutherford-backscattering spectrometry and energy dispersive X-ray absorption analysis in order to check the structural quality and chemical composition of the samples. The magnetic and electric properties were characterized by dc-SQUID and transport measurements, respectively. The microstructure and film magnetization seem to be homogeneous over the whole film thickness. Impurities or precipitations could not be observed. The decrease of the magnetic ordering temperature, T_C , with decreasing d , reflects finite-size effects with a critical scaling exponent of $\lambda \approx 1$, which is usually only expected for the 2 dimensional Ising model. Nearly the same scaling behavior was obtained for $La_{0.7}Ca_{0.3}CoO_3$ and $La_{0.7}Ba_{0.3}CoO_3$ thin films.

MA 20.3 Mo 14:00 Poster TU C

La-doping in epitaxial thin films of $La_xSr_{2-x}CrWO_6$ — •ROBERT GEISSLER, PETRA MAJEWSKI, STEPHAN GEPRÄGS, ANDREA BOGER, ANDREAS ERB, MATTHIAS OPEL, LAMBERT ALFF, and RUDOLF GROSS — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Str. 8, 85748 Garching

Ferromagnetic double perovskites show high Curie temperatures T_C up to 600 K. For the system Sr_2FeMoO_6 ($T_C \approx 420 \text{ K}$), it was shown that electron doping via the substitution of Sr^{2+} by La^{3+} increases T_C by about 80 K in polycrystalline samples [1]. For Sr_2CrWO_6 , the synthesis of bulk samples of electron doped $La_xSr_{2-x}CrWO_6$ is difficult because of the preferential formation of $LaCrO_3$. However, due to the

non-equilibrium growth conditions in pulsed laser deposition (PLD), $\text{La}_x\text{Sr}_{2-x}\text{CrWO}_6$ with $x = 0.5$ could be grown epitaxially on SrTiO_3 substrates with good crystalline quality [2]. Here we report on the properties of $\text{La}_x\text{Sr}_{2-x}\text{CrWO}_6$ films with various doping concentrations x . Using in-situ RHEED, the layer-by-layer growth mode is confirmed. The epitaxial thin films are analyzed by HRXRD to examine the crystalline quality and to exclude parasitic phases. A systematic increase of the c -axis with increasing doping has been found. The magnetic properties have been measured up to 800 K using a SQUID magnetometer to determine the doping dependence of the Curie temperature $T_C(x)$.

This work is supported by the BMBF via grant no. 13N8279.

[1] C. Frontera *et al.*, Phys. Rev. B **68**, 012412 (2003).

[2] P. Majewski *et al.*, J. Magn. Magn. Mater., in print (2004).

MA 20.4 Mo 14:00 Poster TU C

Anisotropic Current-Voltage Characteristics of Strained Sr_2CrWO_6 Thin Films — ●ANDREA BOGER, PETRA MAJEWSKI, STEPHAN GEPRÄGS, ANDREAS ERB, MATTHIAS OPEL, LAMBERT ALFF, and RUDOLF GROSS — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Str. 8, 85748 Garching

It was predicted that the electrical conductivity of the ferromagnetic double perovskite $\text{Sr}_2\text{FeMoO}_6$ (space group $4I/mmm$, $T_C \approx 420$ K) is intrinsically two-dimensional due to the symmetry of the involved oxygen orbitals and can be varied by pressure [1]. The related material Sr_2CrWO_6 ($Fm\bar{3}m$, $T_C \approx 460$ K) has similar electronic structure. We have prepared coherently strained thin films of Sr_2CrWO_6 in an UHV-system by pulsed laser deposition (PLD). Due to the small but finite lattice mismatch to the substrate (SrTiO_3) the films grow in $4I/mmm$ -symmetry. The electrical transport properties of Sr_2CrWO_6 can be studied by introducing a thin, insulating NdGaO_3 buffer layer between the substrate and the double perovskite. High-resolution four circle X-ray diffractometry shows a FWHM below 0.04° for the rocking curves of the (004)-film peaks. Electrical transport measurements were performed in and out of plane from 25 K to 300 K. We detect a strong *anisotropic* behavior in the current-voltage characteristics (IVC): while the in-plane IVCs are ohmic over the whole temperature range, the c -axis transport shows a pronounced non-linear behavior.

This work is supported by the BMBF via grant no. 13N8279.

[1] P. Petrone *et al.*, Phys. Rev. B **66**, 104418 (2002).

MA 20.5 Mo 14:00 Poster TU C

Influence of a forming gas atmosphere on the properties of laser deposited FePt thin films — ●ROBERT MAASS, MARTIN WEISHEIT, SEBASTIAN FÄHLER, and LUDWIG SCHULTZ — Institut für Metallische Werkstoffe, IFW Dresden, Helmholtzstr. 20, 01069 Dresden

The FePt $L1_0$ phase is one of the most promising candidates for future perpendicular high density magnetic recording media. However, high temperatures are required for a well ordered structure, around 800°C for laser deposited films [1]. Lowering the ordering temperature is therefore of great interest. Recent work on electrodeposited FePt thin films has shown that a hydrogen atmosphere during post annealing strongly enhances the ordering of the FePt $L1_0$ phase [2]. We report on the influence of forming gas (5% H_2 in Ar) on the ordering temperature of $L1_0$ FePt alloy films prepared by pulsed laser deposition onto single crystal MgO substrates. Pressure and temperature dependent changes in microstructure, crystallographic texture and resulting magnetic properties are discussed.

[1] M. Weisheit, L. Schultz, and S. Fähler, J. Appl. Phys. **95** (2004) 7489

[2] K. Leistner, H. Schlörb, M. Weisheit, L. Schultz, and S. Fähler, Appl. Phys. Lett. **85** (2004) 3498

MA 20.6 Mo 14:00 Poster TU C

Rapid Thermal Annealing of FePt thin films — ●JÖRG BUSCHBECK, MARTIN WEISHEIT, SEBASTIAN FÄHLER, and LUDWIG SCHULTZ — IFW Dresden, Institut für Metallische Werkstoffe, Helmholtzstr. 20, 01069 Dresden

The outstanding intrinsic magnetic properties of the FePt $L1_0$ phase make this material a promising candidate for thin film applications. However, the high temperature required to form the $L1_0$ phase is a major disadvantage. One overcomes this problem by using thin films, as they allow for rapid heating and cooling without significantly heating the substrate. Such a rapid temperature change can be realized by the application of a pulsed excimer laser (KrF, 248 nm, 25 ns) post-annealing process on films deposited at room temperature. Because of the extremely short heat pulse in the range of μs and the small absorption length of less than

50 nm in the film, the substrate temperature can be kept at ambient temperature during the annealing process. Electrodeposited and pulse-laser deposited FePt films of 700 nm and 40 nm in thickness, respectively, were pulse-heated by the excimer laser. Phase formation and magnetization behavior were studied as a function of laser energy, pulse number, and substrate base temperature.

MA 20.7 Mo 14:00 Poster TU C

Micromagnetic properties of MnAs films on GaAs (001) studied by variable temperature and field MFM — ●JYOTI MOHANTY, THORSTEN HESJEDAL, LUTZ DÄWERITZ, and KLAUS H. PLOOG — Paul Drude Institute, Hausvogteiplatz 5-7, 10117 Berlin, Germany

MnAs on GaAs(001) is a hybrid ferromagnet-semiconductor system that shows a first order magneto-structural phase transition that proceeds via a continuous variation of the phase ratio over a temperature range of $10\text{-}40^\circ\text{C}$. The coexisting phases, namely hexagonal, ferromagnetic α -MnAs and orthorhombic, paramagnetic β -MnAs form a periodic stripe structure, oriented along the MnAs[0001] direction. The system exhibits a strong in-plane uniaxial anisotropy. Magnetic force microscopy (MFM) images show a variety of domain configurations in the demagnetized state of the film. The domain structures and their dependence on the ferromagnetic stripe width (temperature dependence), stripe period (film thickness), and inter-stripe coupling distance were studied. Employing an external field, further insight into the coupling between the stripes and the magnetization reversal process was gained.

MA 20.8 Mo 14:00 Poster TU C

Temperature dependence of the magnetization in ultrathin epitaxial FeCo layers with vanishing crystal anisotropy — ●MATTHIAS SPERL, WOLFGANG KIPFERL, MARTIN DUMM und GÜNTHER BAYREUTHER — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

Epitaxial ultrathin $\text{Fe}_x\text{Co}_{1-x}$ (001) layers were grown with molecular beam epitaxy on Au(001) surfaces. The alloy composition was chosen in the range of the composition dependent in-plane reorientation transition at about 30% Co [1]. Epitaxial growth was achieved by using an Fe seed layer and Au buffer layer on GaAs(001). Epitaxial quality and surface structure were verified in-situ by RHEED. The magnetic properties were investigated by MOKE and SQUID magnetometry between 10 and 400 K. All films show a reduced four-fold anisotropy compared to Fe layers on Au(001) at room temperature and a negligible uniaxial in-plane anisotropy. The samples were studied with respect to the critical behavior at the phase transition and thermal excitations due to spinwaves. This allows the determination of the influence of a reduced in-plane anisotropy on the temperature dependence of the spontaneous magnetization M_S which is discussed in connection with the increased exchange interaction of the used FeCo alloy compared to Fe.

[1] G. Bayreuther *et al.*, J. Appl. Phys. **93**, 8230 (2003)

MA 20.9 Mo 14:00 Poster TU C

Magnetic saturation and anisotropy in FeCo alloy films grown on Pd(001) — ●A. WINKELMANN, M. PRZYBYLSKI, Y. SHI, J. BARTHEL, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Theoretical first-principles calculations for tetragonally distorted $\text{Fe}_x\text{Co}_{1-x}$ alloys predict a high saturation magnetization and a high uniaxial magnetic anisotropy energy at specific values of the lattice distortion c/a and alloy composition x [1]. An unusually large magnetic anisotropy energy is expected for the $\text{Fe}_{40}\text{Co}_{60}$ alloy at a c/a ratio of about 1.2. Comparable tetragonal distortions in Fe and Co films have been observed on Pd(001). This suggests the deposition of $\text{Fe}_x\text{Co}_{1-x}$ alloy films on Pd(001) by molecular beam epitaxy.

For $\text{Fe}_{40}\text{Co}_{60}$ at a film thickness of 3 monolayers (ML), scanning tunneling microscopy shows rough film surfaces. This is due to a structural transition caused by the large lattice misfit between the Pd substrate and the alloy film. Intensity oscillations in reflection high energy electron diffraction indicate a change in the growth mode after 2 ML of $\text{Fe}_{40}\text{Co}_{60}$. Low energy electron diffraction (LEED) patterns confirm a pseudomorphic growth of the $\text{Fe}_{40}\text{Co}_{60}$ film. Measurements of energy resolved LEED intensities point to the existence of a tetragonal distortion perpendicular to the film plane. Hysteresis loops were taken using the magneto-optical Kerr effect (MOKE). The results of the MOKE analysis are discussed in comparison to the results obtained for the Fe/Pd(001) and Co/Pd(001) systems.

[1] T. Burkert *et al.*, Phys. Rev. Lett. **93**, 027203 (2004)

MA 20.10 Mo 14:00 Poster TU C

On origin of perpendicular anisotropy in Co/Pd(111) system — ●J. ZUKROWSKI, M. PRZYBYLSKI, M. WASNIOWSKA, W. WULFHEKEL, J. BARTHEL, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Ultrathin Co films were grown on clean and atomically flat surfaces of Pd(111). Scanning tunneling microscopy (STM) measurements show that at room temperature (RT) the growth starts by a formation of double-layer patches. This is very different in comparison to the initial monolayer formation during the growth at 420 K. The films deposited at RT exhibit perpendicular magnetic anisotropy after exposure to a residual atmosphere for a long time at low temperatures (70 K). Our detailed magneto-optical Kerr effect (MOKE) analysis documents step by step an appearance of the perpendicular anisotropy and indicates a rotation of the magnetization vector from the sample plane. With increasing temperature the magnetization rotates back to the sample plane abruptly when the temperature approaches 200 K. For the growth at 420 K the STM images show that the film morphology is drastically changed. This is associated with changes of the magnetic properties detected by MOKE. In particular, the Kerr rotation loops measured in polar configuration change sign at a critical thickness of the Co film.

MA 20.11 Mo 14:00 Poster TU C

On the origin of perpendicular anisotropy in Co/Pd(111) — ●J. ZUKROWSKI, M. PRZYBYLSKI, M. WASNIOWSKA, W. WULFHEKEL, J. BARTHEL, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Ultrathin Co films were grown on clean and atomically flat surfaces of Pd(111). Scanning tunneling microscopy (STM) shows that at 300 K the growth starts by the formation of double-layer patches. This is very different in comparison to the initial monolayer formation during the growth at 420 K. The films deposited at 300 K exhibit perpendicular magnetic anisotropy after exposure to the residual atmosphere at low temperatures (70 K). Our detailed magneto-optical Kerr effect (MOKE) analysis documents step by step the appearance of the perpendicular anisotropy and indicates a rotation of the magnetization vector out of the sample plane. With increasing temperature the magnetization rotates back to the plane abruptly when the temperature approaches 200 K. For the growth at 420 K the STM images show that the film morphology is drastically changed. This is associated with changes of the magnetic properties detected by MOKE. In particular, the Kerr rotation loops measured in polar configuration change sign at a critical thickness of the Co film.

MA 20.12 Mo 14:00 Poster TU C

Strukturelle und magnetische Charakterisierung von Fe-Strukturen auf InAs(001) und GaAs(110)-Spaltflächen — ●MATTHIAS HAAK¹, D. YOU², C. URBAN¹, M. KNEPPE¹, I. RAUSCHENBACH¹, H. STEIN¹, U. KÖHLER¹, D. SPÖDDIG², R. MECKENSTOCK² und J. PELZL² — ¹Experimentalphysik IV/Oberflächenphysik — ²Experimentalphysik III/Festkörperspektroskopie

Zur Untersuchung des Raumtemperaturwachstums dünner Fe-Schichten auf InAs(001)-, bzw. GaAs(110)-Spaltflächen unter UHV-Bedingungen wurden in-situ STM- und ex-situ MOKE-, SQUID- und FMR-Experimente eingesetzt. Spaltflächen wurden verwendet, um eine Oberfläche mit möglichst hoher Reinheit und geringer Stufung zu erreichen. Diese Spaltflächen wurden innerhalb der UHV-Kammer hergestellt. Epitaktisches Fe-Wachstum ist sowohl auf InAs- als auch auf GaAs-Substraten bei Raumtemperatur mittels STM zu erkennen. Das initiale Wachstum und die Nukleation der Fe-Schichten konnte im Submonolagenbereich untersucht werden. Zur ex-situ magnetischen Charakterisierung wurden die Fe-Filme mit einer Ag/Au Schicht als Oxidationsschutz abgedeckt. Durch MOKE-Messungen konnte die schichtdickenabhängige Remanenz bestimmt werden. Mittels SQUID und FMR wurden die Sättigungsmagnetisierungen und die Anisotropiebeiträge exakt ermittelt. Der Einfluß des Wachstums auf das magnetische Verhalten wird diskutiert. Weiterhin waren die Einflüsse von Tunnelbarrieren (z.B. MgO) Gegenstand unserer Untersuchung. Erste Ergebnisse werden vorgestellt. Unterstützt durch SFB 491.

MA 20.13 Mo 14:00 Poster TU C

Digital Lock-In XMCD-experiments with a quarter wave plate — ●MAX HARLANDER, JOCHEN GEISLER, EBERHARD GOERING, UWE GRÜNER, SEBASTIAN MACKE und GISELA SCHÜTZ — Max-Planck-Institut für Metallforschung, 70569 Stuttgart

We have developed an ultra low noise digital lock in technique, utilizing a diamond single crystal quarter wave plate. At the ANKA MPG diffraction beamline we have achieved a degree of circular polarisation above 85%. The diamond quarter wave plate is controlled and flipped with a square wave shaped modulation, with a ground frequency up to 80Hz, by a positional controlled piezo element. The related right and left polarised light absorption of the magnetized sample has been measured and recorded by an a/d-signal converting PC card. The sampled signals are numerically evaluated and analysed to obtain a digital lock-in-XMCD signal. FePt alloy measurements are in perfect agreement with conventional XMCD measurements. To demonstrate the capability of this method, XMCD and XAS spectra of an effective very small PtCo single crystal are shown. This improved method achieves a signal to noise ratio at the level of the pure photon statistics. Our system is portable and allows measurement at virtually any synchrotron radiation source.

MA 20.14 Mo 14:00 Poster TU C

Advanced fitting algorithm for resonant magnetic and non magnetic soft and hard X-ray reflectometry simulations — ●MAX HARLANDER, JOCHEN GEISLER, EBERHARD GOERING, UWE GRÜNER, SEBASTIAN MACKE, and GISELA SCHÜTZ — Max-Planck-Institut für Metallforschung, 70569 Stuttgart

We developed a new fit program to simulate and fit the reflectivity of multilayer systems, based upon a modified Parratt-formalism. Conventional Parratt programs allow simulations and fits of the reflectivity of magnetic and non magnetic multilayers, where the reflection curves depend on the thickness, roughness and non resonant and resonant optical constants (δ and β) of the layered system. With the advanced algorithm, even for single buried layers the resulting resonant and element specific asymmetry ratios for reversed magnetization directions could be fitted and optimized. The resonant magnetic scattering has been introduced by superposed magneto optical profiles, which are approximated by Gaussian lines and/or splines at each individual interface. Some additional aspects have been introduced to improve the fit quality beyond the small angle scattering limit, even for large scattering angles as observed in the soft X-ray region. The π - and σ components and the degree of circular polarization of the incident X-Ray beam could be taken into account and independently chosen. The major improvement is related to the fitting speed. After a careful optimization, the magnetic fitting is roughly 300 times faster than the previous implementation. In addition, a simulated annealing algorithm has been integrated to avoid local minima convergence.

MA 20.15 Mo 14:00 Poster TU C

Spectroscopy of unoccupied states and spin-depolarization dynamics of materials with a high spin-polarization — ●M. CINCHETTI, O. ANDREYEV, M. SÁNCHEZ-ALBANEDA, P. WÜSTENBERG, M. BAUER, and M. AESCHLIMANN — Universität Kaiserslautern

Half-metallic ferromagnetic Heusler alloys have been studied with two-photon photoemission (2PPE) spectroscopy. First spin-resolved measurements have been performed in order to investigate the behaviour of the surface spin polarization and its dependence on the surface preparation procedure. They show that significant changes occur in the spin polarization depending on the surface preparation. Moreover, the spin-dependent energy relaxation of excited electrons is under study using a pump-probe technique (time-resolved 2PPE). The obtained results give insight into the fundamental mechanisms of spin depolarization at the surface of half-metallic ferromagnets.

Funded by DFG: FOR 559/1

MA 20.16 Mo 14:00 Poster TU C

Core-valence interactions in 2p photoemission of 3d metals - a study of magnetic dichroism in spinresolved photoelectron spectroscopy — ●C. BETHKE¹, E. KISKER¹, N.B. WEBER², and F.U. HILLEBRECHT³ — ¹Institut für Angewandte Physik, Heinrich-Heine-Universität, Universitätsstraße 1, D-40225 Düsseldorf, Germany — ²Focus GmbH, Am Birkecker Berg 20, D-65510 Hünstetten, Germany — ³Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich, Germany

The magnetic linear and circular dichroism (MLDAD and MCD) in the 2p photoemission spectra of ultrathin 3d metal films have been determined. Although the 3d electrons in transition metals like Fe and Co are itinerant, we can describe the spectra in terms of an atomic model in jj and jK coupling. The results of the model compare reasonably well

with the experimental data, especially for iron[1]. Because of the low energy difference between the different pd^n configurations in the final state the intensity of the satellite structures is transferred to the two dominant main structures with $j = 1/2, 3/2$. So for Fe mainly the hybridization between the configurations in the final state main lines is vital to describe the 2p photoemission spectrum. We will show that the fine structure of the measured spectra and the correlation between magnetic dichroism and spin-orbit and exchange induced spinpolarization can be explained in the final state model presuming a pure coupling approximation like jj coupling. Supported by the BMBF under grant no. 05 KS1 PFA 3.

[1] C. Bethke, E. Kisker, N.B. Weber, and F.U. Hillebrecht, Phys. Rev. B, accepted.

MA 20.17 Mo 14:00 Poster TU C

Der Einfluss von Spinwellen-Wechselwirkungen auf die Interlagen-Austauschkopplung — ●STEPHAN SCHWIEGER, JOCHEN KIENERT und WOLFGANG NOLTING — Humboldt Universität zu Berlin, Institut für Physik, Lehrstuhl Festkörpertheorie, Newtonstr. 15, 12489 Berlin

Die Interlagen-Austauschkopplung, also die Kopplung zwischen magnetischen Schichten, die durch eine paramagnetische Zwischenschicht getrennt sind, zeigt eine deutliche Temperaturabhängigkeit. Es ist noch nicht geklärt, welcher physikalische Mechanismus das Absinken der Kopplungsstärke bei steigender Temperatur verursacht. Es gibt zwei Kandidaten: zum einen könnte das Aufweichen der Fermi-Oberfläche der Zwischenschicht die Kopplungsenergie absenken (Spacer-Effekt), zum anderen könnten Wechselwirkungen zwischen in den Magneten angeregten Spinwellen eine wichtige Rolle spielen (magnetischer Effekt). Wir stellen eine Methode vor, mit der temperaturabhängige FMR Experimente in einer Weise ausgewertet werden können, die eine Trennung dieser beiden Effekte ermöglicht. Dazu wird theoretisch direkt die FMR Observable, die Frequenz der Spinwelle mit unendlich langer Wellenlänge, mittels eines erweiterten Heisenbergmodells berechnet. Das Modell berücksichtigt äussere Felder, Gitteranisotropien, die Dipol-Dipol-Wechselwirkung zwischen den magnetischen Momenten einer Schicht, sowie die Interlagenkopplung zwischen den magnetischen Schichten. Dieses Verfahren erlaubt nun sowohl die separate Messung des Spacer Effekts als auch eine Untersuchung des Einflusses des Spinwelleneffektes auf das FMR Signal

MA 20.18 Mo 14:00 Poster TU C

Theory of field induced spin reorientation transition in thin Heisenberg films — ●JOCHEN KIENERT, STEPHAN SCHWIEGER, and WOLFGANG NOLTING — Humboldt University Berlin, Institute of Physics, Solid State Theory, Newtonstrasse 15, 12489 Berlin

We consider the spin reorientation transition in a ferromagnetic Heisenberg monolayer with a second order single ion anisotropy as a function of temperature and external field. Up to now analytical methods give satisfying results only for the special case that the external field is aligned parallel to the easy axis of the crystal. We propose a theory based on a generalization of the Callen decoupling, which can be used for arbitrary direction of the external field. Excellent agreement between our results and Quantum Monte Carlo data is found for the field induced reorientation at finite temperatures. Additionally, we discuss the temperature dependence of the transition in detail.

MA 20.19 Mo 14:00 Poster TU C

Observation of the Fe Spin Spiral Structure in Fe/Sm-Co Exchange Spring Bilayers by ^{57}Fe -Probe Layer Mössbauer Spectroscopy — ●A. KHRENOV¹, W. KEUNE¹, V.E. KUNCSE², J.S. JIANG³ und S.D. BADER³ — ¹Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg — ²NIPM, RO-76900 Bucharest Magurele, Romania — ³Materials Science Div., Argonne National Laboratory, Argonne, IL 60439, USA

The layer resolved Fe spin spiral structure for Fe/Sm-Co(1100) exchange spring magnetic bilayers was investigated by ^{57}Fe conversion electron Mössbauer spectroscopy (CEMS) during the magnetization reversal process, and correlated with the hysteresis loops measured via the magneto-optic Kerr effect. 2 nm thick isotopically enriched ^{57}Fe -probe layers were sputter-deposited in the 20 nm thick natural Fe layer at different distances from the Fe/Sm-Co interface. A direct experimental proof for a relaxed spiral angular spin distribution in the Fe layer is presented. Contrary to expectation, weak out-of-plane Fe spin components were observed in a certain applied field range.

Sponsored through Deutsche Forschungsgemeinschaft (SFB491) and DOE Contract No. W.31-109-ENG-38.

MA 20.20 Mo 14:00 Poster TU C

Magnetism of atomic chains, islands and surface alloys of Fe on Pt substrates — ●A. ENDERS¹, T.Y. LEE¹, J. HONOLKA¹, K. KUHNKE¹, D. REPETTO¹, K. FAUTH², M. HESSLER², G. SCHÜTZ², and K. KERN¹ — ¹MPI für Festkörperforschung, Stuttgart, Germany — ²MPI für Metallforschung, Stuttgart, Germany

The structure and magnetic properties of submonolayer coverages of Fe on Pt substrates have been investigated. By adjusting the preparation conditions and substrate orientation the Fe could be stabilized as atomic chains, flat monolayers, islands or as Fe-Pt surface alloy. Growth mode and structure of the Fe have been investigated under ultrahigh vacuum condition by thermal He-atom scattering (TEAS), low energy electron diffraction (LEED), and scanning tunneling microscopy (STM). The magnetism has been explored in-situ by X-ray magnetic circular dichroism (XMCD). The experiments clearly show a very sensitive dependence of the magnetic properties on the local atomic environment and dimensionality. For the Fe chains we find an oscillating magnetic anisotropy between perpendicular and in-plane direction with increasing chain width. Significantly enhanced magnetic moments and coercive fields are found for the Fe-Pt surface alloy, which is formed on stepped Pt(997) substrates at growth temperatures above 550 K. Element specific XMCD measurements on the alloys revealed an induced magnetic moment in the Pt which is a result of indirect exchange interaction. The comparison of the results underline the potential of stepped substrates for nanostructure fabrication due to their influence on growth mode, structure and magnetism in the thin film limit.

MA 20.21 Mo 14:00 Poster TU C

Magnetic structures in dipolar coupled multilayers — ●OLEG PETRACIC, SUBHANKAR BEDANTA, and WOLFGANG KLEEMANN — Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Metal-insulator multilayers can show various kinds of magnetization structures due to the competition of the usual magnetostatic and the so-called Néel inter-layer coupling. The second one becomes significant, when the roughness of the ferromagnetic films is large. We performed micromagnetic simulations motivated by recent experimental studies on the multilayers $[\text{Co}_{80}\text{Fe}_{20}/\text{Al}_2\text{O}_3]_n$. Varying different parameters, like roughness and interlayer distance various regimes of layer ordering can be observed.

MA 20.22 Mo 14:00 Poster TU C

Electric control of exchange bias — ●PAVEL BORISOV, ANDREAS HOCHSTRAT, XI CHEN, and WOLFGANG KLEEMANN — Universität Duisburg-Essen, Angew. Physik, 47048 Duisburg

Gaining electric control on the Exchange Bias (EB) is one of the most challenging tasks in modern thin film magnetism. Apart from direct control of the EB by an applied electric field at a given temperature $T < T_N$, also the complete switching of the EB from positive to negative values and vice versa by a variation of the applied electric freezing field is possible. We realized the demonstration of this huge effect in Molecular Beam Epitaxy grown magnetic Co-Pt-heterostructures based on antiferromagnetic Cr_2O_3 , the prototypical system for investigations of the magneto-electric (ME) effect. The magnetic characterization was done by means of polar Magneto-Optical Kerr Effect as well as by SQUID-magnetometry. ME controlled perpendicular EB opens access to a broad variety of new applications in data storage technology, as there are e.g. a new design for a thermally assisted writing mechanism for perpendicular recording systems or a way to manage voltage induced writing in MRAM technique. Another spintronic application based on ME EB has been presented recently [1].

[1] Ch. Binek *et al.*, J. Appl. Phys (2005) *accepted*

MA 20.23 Mo 14:00 Poster TU C

X-ray and Neutron Scattering studies of NiMn-CoFe exchange bias systems — ●DANICA SOLINA¹, DIETER LOTT¹, R. KALTOFEN², J. SCHUMANN², JÜRGEN FASSBENDER³, URSULA TIETZE¹, and ANDREAS SCHREYER¹ — ¹Institute for Materials Research, Dept. WFN (Neutron-/Synchrotron Scattering), GKSS-Research Center, PO Box 1160, D-21494 Geesthacht, Germany — ²Leibniz Institute of Solid State and Materials Research Dresden, Germany, Helmholtzstr. 20, D-01069 Dresden — ³Institut fuer Ionenstrahlphysik und Materialforschung, Forschungszentrum Rossendorf, Postfach 51 01 19, 01314 Dresden Germany

Preliminary results are presented on the structural and magnetic properties of epitaxial antiferromagnetic NiMn and their correlation to the Exchange Bias Effect. Included are x-ray diffraction, reflection and rocking curves of pertinent diffraction peaks. The rocking curves have a FWHM of less than 3° indicating good epitaxial growth of the film. Polarized neutron reflectivity and high angle scattering measurements have been made in order to assess the magnetic properties of the system.

MA 20.24 Mo 14:00 Poster TU C

Magnetische und chemische Grenzflächeneigenschaften von Tunnelementen mit FeO_x Elektroden — ●MARC SACHER, JAN SCHMALHORST und GÜNTER REISS — Universität Bielefeld, Dünne Schichten und Nanostrukturen, Universitätsstr.25, 33615 Bielefeld

Magnetische Tunnelemente (MTJ) werden seit kurzem erfolgreich als Speicherbaustein in nichtflüchtigen Schreib-Lese-Bausteinen verwendet. Für die weitere Entwicklung sind dabei halbmetallische Elektrodenmaterialien mit theoretischen Spinpolarisationen von 100% für die Steigerung des TMR-Effektes von entscheidender Bedeutung. Auch für Magnetit (Fe_3O_4) wird eine Spinpolarisation von 100% vorhergesagt, allerdings konnte diese in magnetischen Tunnelementen bisher nicht verifiziert werden. In dieser Arbeit wurden mittels verschiedener kombinierter Sputter- und Oxidationsverfahren hergestellter Eisenoxidschichten als Elektrodenmaterial in MTJ untersucht. Dabei wurde besonderes Augenmerk auf sowohl die magnetischen und strukturellen Eigenschaften des Volumenmaterials als auch die chemischen und magnetischen Eigenschaften an der FeO_x / Barrierengrenzfläche gelegt. Dazu wurde zum einen Magnetometrie (AGM und MOKE) durchgeführt und zum anderen die Beugung (XRD) und Absorption von polarisierter Röntgenstrahlung (XAS und XMCD) gemessen. Ein besonderer Fokus wurde auf die Präparation von Al_2O_3 Barrieren auf den Eisenoxidschichten gesetzt, um mögliche ungewollte Veränderungen in der Fe_3O_4 Stöchiometrie zu minimieren.

MA 20.25 Mo 14:00 Poster TU C

Magnetic domain structures in Fe_3O_4 thin films studied by magnetic force microscopy (MFM) — ●JIANDONG WEI¹, MICHAEL KOBLISCHKA¹, UWE HARTMANN¹, YANG ZHOU², SHANE MUPHY², and I.V. SHVETS² — ¹Experimental Physics Department, University of Saarbruecken, Saarbruecken, Germany — ²SFI Nanoscience Laboratory, Trinity College Dublin, Dublin 2, Ireland

Epitaxial Fe_3O_4 thin films of various thicknesses and thermo-chemical treatments have been studied by MFM. The subtle magnetic domain structures and their changes with varying preparation processes were clearly revealed, which is a basis for the understanding of the anomalous magnetic behavior caused by antiphase boundaries in the films. The film thickness and the temperature, atmosphere and duration of the annealing procedure are important factors to determine the final magnetic properties of the films. Particularly, the annealing time for epitaxial thin films has a significant influence on the formation of micromagnetic structures. The influence of external magnetic fields up to 50mT on the magnetic domain structures was also investigated by MFM. This work is supported by EU project of ASPRINT.

MA 20.26 Mo 14:00 Poster TU C

Structure and Electronic Properties of the $\text{Fe}_3\text{O}_4(100)$ Surface: Evidence of a Half-Metal to Metal Transition — ●M. FONIN^{1,2}, YU. DEDKOV^{3,2}, R. PENTCHEVA⁴, M. SPERLICH², M. SCHEFFLER⁵, U. RÜDIGER¹, and G. GÜNTHERODT² — ¹Fachbereich Physik, Universität Konstanz, 78467 Konstanz, Germany — ²II. Physikalisches Institut, Rheinisch-Westfälische Technische Hochschule Aachen, 52056 Aachen, Germany — ³Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden, Germany — ⁴Dept. of Earth and Environmental Sciences, University of Munich, Theresienstr. 41, 80333 Munich, Germany — ⁵Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Highly spin-polarized transition metal oxide films, among them magnetite (Fe_3O_4), are a subject of intensive research due to the possible future applications in spin-electronic devices.

In situ prepared $\text{Fe}_3\text{O}_4(100)$ thin films were studied by means of scanning tunneling microscopy (STM) and spin-polarized photoelectron spectroscopy (SP-PES). The $(\sqrt{2} \times \sqrt{2})R45^\circ$ "wave-like" surface atomic structure observed by STM is in good agreement with the new structural model predicted by density functional theory (DFT) in the framework of *ab initio* thermodynamics. For the bulk oxide a spin polarization (SP) value of -100% was predicted by LSDA calculations [1]. On the

$\text{Fe}_3\text{O}_4(100)$ surface both SP-PES and DFT results indicate a strong reduction of SP to about -55% and a transition from half-metallic to metallic behavior.

[1] Z. Zhang and S. Satpathy, Phys. Rev. B **44**, 13319 (1991).

MA 20.27 Mo 14:00 Poster TU C

Growth of thin Ni_2MnIn Heusler alloy films on in-situ cleaved InAs (110)-surfaces — ●MAHDI MAHAJERI, JAN M. SCHOLTYSEK, MALTE A. KURFISS, MALTE LIESKE, RAINER ANTON, and GUIDO MEIER — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

Heusler alloys are interesting candidates as spin-injectors in prospective spintronic devices. A spinpolarisation of 100% is predicted for the $\text{Ni}_2\text{MnIn}/\text{InAs}$ interface. In particular, this was calculated for the (100) and (110)-planes [1]. We fabricate thin Ni_2MnIn films by coevaporating Ni and a MnIn alloy from two independent sources. The usage of only two crucibles is possible due to the similar vapour pressures of Mn and In. The layers are deposited on the (110)-surface of in situ cleaved InAs and on amorphous carbon films. The latter are used for stoichiometric, morphological, and structural investigations in a transmission-electron microscope. We measure the resistivity $\rho(T)$ of the samples grown on InAs. The same samples are used for determination of the spinpolarisation by point contact Andreev-reflection spectroscopy (PCAR) [2]. Investigations concerning the magnetic properties of the layers are performed using a SQUID-magnetometer [3].

[1] K. A. Kilian and R. H. Victora. J. Appl. Phys. **87**, 7064 (2000)

[2] S. von Oehsen, et. al. JMMM, accepted (09/2004)

[3] M. Kurfiß, et. al. JMMM, accepted (10/2004)

MA 20.28 Mo 14:00 Poster TU C

Properties of thin LaMnO_3 layers and its characterization as a tunneling barrier — ●ANDREAS KLEINE, YUANSU LUO, MARKUS ESSELING, and KONRAD SAMWER — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The effort of preparing a full-oxid all-manganite TMR system motivates the characterization of thin LaMnO_3 (LMO) layers as a tunneling barrier. Good magnetic and electronic properties are expected due to the conservation of symmetry at the interface. Below the Neel temperature of 140K stoichiometric $\text{LaMnO}_{3+\delta}$ is a canted antiferromagnetic insulator with a small magnetic moment. The excess oxygen δ in $\text{LaMnO}_{3+\delta}$ mainly changes the electronic and magnetic properties, which are to be optimized. Structural, magnetic and electronic properties of DC-magnetron sputtered LMO layers are presented in dependency of the oxygen excess. Moreover the results of tunneling contacts with LMO barrier and its dependency on the preparation parameters and barrier thickness, as well as the property changes due to annealing, will be shown and discussed.

This work was supported by the DFG Sa 337/9-1.

MA 20.29 Mo 14:00 Poster TU C

Piezo-controlled cantilever magnetometer for de Haas-van Alphen effect studies on MnAs — ●O. RÖSLER¹, A. KROHN¹, M. WILDE¹, J.I. SPRINGBORN¹, D. GRUNDLER¹, CH. HEYN¹, D. HEITMANN¹, L. DÄWERITZ², K.J. FRIEDLAND², and K.H. PLOOG² — ¹Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — ²Paul Drude Institut für Festkörperelektronik, Hausvogteiplatz 5 - 7, 10117 Berlin

Measuring the de Haas-van Alphen (dHvA) effect in a ferromagnetic thin film by means of a torque magnetometer is a challenging task. The spontaneous spin magnetization might induce such a large torque that the inherent high sensitivity of the magnetometer degrades significantly at high magnetic field B. We have realized a micromechanical cantilever magnetometer (MCM) with a piezo-controlled capacitance readout which circumvents the problem. Using the MCM, we first measured the hysteretic ferromagnetic behavior of an epitaxial MnAs layer at $B < 3$ T. Second, the large MCM deflection was compensated at $B = 3$ T using a piezoceramics-based walker. With the optimized configuration, we then measured the dHvA effect up to 15 T and down to 270 mK. Temperature-dependent data obtained at different tilt angles revealed an anisotropic Fermi surface and an anisotropic effective mass of the electrons. The absolute value was near the free-electron mass. We acknowledge financial support by the BMBF via 13N8283 "Spintronik" and by the DFG via SFB508 and Gr1640/1-2.

MA 20.30 Mo 14:00 Poster TU C

Magnetische sub-mikrometer Tunnelstrukturen in Logikgattern — ●DIRK MEYNER¹, HUBERT BRÜCKL¹, GÜNTER REISS¹, NILS WIESE^{1,2} und JOACHIM WECKER² — ¹Universität Bielefeld, Fakultät für Physik, Universitätsstr. 25, D-33615 Bielefeld — ²Siemens AG Corporate Technology, CT MM 1, Paul-Gossen-Str. 100, 91052 Erlangen Siemens

Der Einsatz magnetischer Tunnelstrukturen in logischen Bauteilen erscheint aufgrund der Nichtflüchtigkeit gespeicherter Information, hoher Integrationsdichte und schneller Programmierbarkeit vielversprechend. Dazu notwendig sind Tunnelstrukturen mit reproduzierbarem Schaltverhalten sowie geringer Fluktuation in Widerstand und TMR-Amplitude. Die mittels EBL elliptisch strukturierten Elemente mit einer lateralen Ausdehnung kleiner $0.04\mu\text{m}^2$ sind daher auf Zellpaarigkeit untersucht worden, um Aufschluß über Ursprung und Stärke jener Fluktuation zu erhalten. Die untersuchten Schichtsysteme bestehen neben elektrischen Zuleitungen aus der Schichtfolge MnIr 10.8/ CoFe 2.3/ Al 1 plasmaoxidiert/ NiFe 5 (in nm) bzw. PtMn 25/ CoFe 3/ Ru 9/ CoFe 2.8/ Al 1.2 plasmaoxidiert/ CoFeB 4. Die Funktion bereits realisierter Logikgatter mit einer Gesamtausdehnung von $10\times 10\mu\text{m}^2$ wird gezeigt.

MA 20.31 Mo 14:00 Poster TU C

Aspects of spin-dependent scattering in magnetic nanoconstrictions — ●JAMAL BERAKDAR¹, V.K. DUGAEV¹, J. BARNAS², M. VIEIRA³, W. DOBROWOLSKI⁴, and V.F. MITIN⁵ — ¹MPI für Mikrostrukturphysik, Halle, Germany — ²A. Mickiewicz University, Poznan, Poland — ³ISEL, Lisbon, Portugal — ⁴Institute of Physics, PAN, Warsaw, Poland — ⁵Institute of Semiconductor Physics, Kiev, Ukraine

Magnetoresistance of nanowires and nanoconstrictions based on GaMnAs magnetic semiconductors can be as large as 2000% [1]. We analyze theoretically this effect in terms of a thin domain wall model [2] and under the depletion conditions. The model is valid for long wavelengths of charge carriers as compared to the domain wall width (realizable for magnetic semiconductors). Largest magnetoresistance occurs when the splitting of electron bands is large enough to ensure full spin polarization of holes in p-type materials. Such a situation is realizable in heavily Mn-doped and strongly compensated GaMnAs semiconductors. We calculated the resistance of the domain wall as a function of the polarization and the hole density. Spin-orbit interaction is shown to play an important role in the magnetoresistance. We also discuss the role of localization corrections related to disorder. At low temperatures the magnetoresistance is strongly influenced by localization effects. Magnetoresistance can be electrically controlled by a gate in the nanoconstriction region.

- [1] C. Rueter, T. Borzenko, et al. Phys. Rev. Lett. 91, 216602 (2003).
 [2] V.K. Dugaev, J. Berakdar, J. Barnas, Phys. Rev. B 68, 104434 (2003).

MA 20.32 Mo 14:00 Poster TU C

Aluminum oxide tunnel junctions and all-metal mesoscopic spin-valve devices — ●ALEXANDER VAN STAA, CHRISTINE M. S. JOHNAS, ULRICH MERKT, and GUIDO MEIER — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstraße 11, 20355 Hamburg

In tunnel magnetoresistance devices aluminum oxide is a well established material for tunnel barriers. The oxidation of aluminum in pure oxygen has been investigated by varying the contact sizes on the μm -scale and the oxidation time in all-metal systems. We will apply aluminum oxide tunnel barriers to improve the spin-injection efficiency in lateral Py/Al/Py spin-valve devices, which we have successfully characterized without tunnel barriers. On these devices simultaneous measurements of the spin-valve effect and the anisotropic magnetoresistance of the Py-electrodes have been performed at temperatures of liquid helium. Their micromagnetic behaviour has been imaged with a magnetic-force microscope at room temperature in external magnetic fields.

MA 20.33 Mo 14:00 Poster TU C

Die level uniformity of magnetic tunnel junctions under lithographic aspects — ●KARSTEN ROTT and HUBERT BRÜCKL — Universität Bielefeld, Nano Device Group, Universitätsstr. 25, 33615 Bielefeld

The uniform behaviour of magnetic tunnel junctions on a memory or logic chip is an absolutely necessary requirement for product fabrication. The junctions should show an equal and reproducible magnetic switching, the same area resistance and magnetoresistance amplitude. The first issue guarantees a reliable bit setting, the latter two the operation within certain voltage levels predefined by the according CMOS environment.

Since the tunnel resistance depends exponentially on the barrier thickness, the deviation from the mean thickness of 0.9 to 1.2 nm should be less than 0.01 nm. Electrical pinholes or defect states have to be avoided. The same arguments hold for the TMR amplitude where a standard deviation of 2% is tolerable. Besides the intrinsic film properties, the additional lithographic procedure is another source of errors and deviations. The impact of lithographic features on the die level uniformity will be discussed in dependence on the cell size. The lateral dimensions of the investigated junctions range from 100 nm up to a few microns.

MA 20.34 Mo 14:00 Poster TU C

Fabrication and characterization of magnetic tunnel junctions with ultrathin barriers — ●A. PARGE, G. EILERS, and M. MÜNZENBERG — IV. Phys. Inst., Universität Göttingen

The fundamental properties of ultrathin barriers in magnetic tunnel junctions (MTJs) have recently become an interesting aspect in the field of spindynamics, since ultrathin barriers can provide extremely high tunnel current densities, which are required for spin current induced switching experiments.

We have prepared AlOx tunnel barriers by means of e-beam evaporation in UHV followed by either plasma or natural oxidation, thus changing the concentration of defects in the barriers. Besides, the barrier thickness and its lateral size (structured by shadow masks or lithography) were varied.

After the optimization of the growth parameters we are planning to characterize the exact transport properties (IV characteristics, TMR at different temperatures). Finally, the MTJs are supposed to be integrated into a strip line with a photoconductive switch in order to study the spin current induced switching effect.

MA 20.35 Mo 14:00 Poster TU C

Fe on GaAs(110) cleaved edges - magnetic, electrical and optical investigations — ●P. KOTISSEK¹, M. BAILLEUL^{1,2}, M. SPERL¹, W. KIPFERL¹, P. CHEN¹, W. WEGSCHEIDER¹ und G. BAYREUTHER¹ — ¹Universität Regensburg, 93040 Regensburg — ²CNRS Strasbourg

The aim of our work is to successfully inject spinpolarized carriers from a ferromagnetic metal into GaAs and to vary spin injection by optical methods. The crucial spin dependent resistance is given by the Schottky barrier system (Fe/(n+)GaAs) that is grown epitaxially on the (110) cleaved edge of an n-GaAs substrate. The magnetic properties of the Fe films were investigated by Kerr microscopy and SQUID magnetometry. We also measured the I-V characteristics of Fe/(n+)GaAs Schottky contacts with respect to the temperature to get information about the different transport mechanisms across the Schottky barrier. To gain information about the optical properties of our samples we also measured photoluminescence spectra at low temperatures.

Two different methods are used to detect the spin polarization of the injected electrons: i) via the polar optical Kerr effect and ii) via the circular polarization of the recombination light of the injected electrons with unpolarized holes.

MA 20.36 Mo 14:00 Poster TU C

Magnetotransport measurements and simulations of permalloy microstructures — ●J. KRUSE, R. EISELT, M. BOLTE, M. STEINER, U. MERKT, and G. MEIER — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

Spatially resolved measurements and simulations of magnetoresistance effects are required for a detailed understanding of magneto-transport in magnetic micro- and nanostructures at the fundamental level [1]. The anisotropic magnetoresistance of permalloy microstructures of various geometries are measured in the temperature range between 2 K and 300 K. We investigate rectangles of 20 nm, 40 nm, and 70 nm thickness with different aspect ratios and in addition rounded structures we address as eggs, beans, and lemons. By transport measurements, micromagnetic simulations, and magnetic-force microscopy we can clearly identify magnetic configurations and their electrical resistances. For the rectangular geometry we plan to study barber pole structures to linearize the magnetoresistance effect [2].

- [1] R. Meckenstock, M.V. Rastei, and J.P. Bucher, J. Appl. Phys. 95, 6753 (2004).

- [2] Philips Semiconductors, Data Sheet SC17 (2000).

MA 20.37 Mo 14:00 Poster TU C

Large room temperature TMR effect in Fe₃O₄ based magnetic tunnel junctions — ●EDWIN MENZEL, SULEMAN QURESHI, DANIEL REISINGER, ANDREAS ERB, MATTHIAS OPEL, and RUDOLF GROSS — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Str. 8, 85748 Garching

Magnetite (Fe₃O₄) is an interesting candidate for applications in spin electronics. It shows a Curie temperature of 860 K and has been predicted to be half-metallic at room temperature [1]. We have fabricated Fe₃O₄/oxide/FM (FM = Ni, Co, Fe₃O₄) trilayer structures using pulsed laser deposition and electron beam evaporation. The thin film stacks have been studied by in-situ RHEED, SQUID magnetometry, and high-resolution X-ray diffraction. Magnetic tunnel junctions have been fabricated using optical lithography and Ar ion beam milling. The junctions have been characterized by magnetotransport measurements between 150 K and 350 K. They show a reproducible tunneling magnetoresistance (TMR) effect with almost ideal switching behavior. We obtain TMR values of up to 20% for Fe₃O₄/AlO_x/Co and Fe₃O₄/AlO_x/Ni at room temperature. We also found a geometry enhanced TMR effect due to an inhomogeneous current distribution in the junction electrodes. This effect has been modeled by finite element methods. We find that the geometry enhanced TMR effect can be optimized by adjusting the junction geometry and the electrode resistivity. In our experiments, reproducible TMR effects exceeding 1000% at room temperature have been found.

This work is supported by the BMBF via grant no. 13N8279.
[1] Z. Zhang, and S. Satpathy, Phys. Rev. B, **44**, 13319 (1991).

MA 20.38 Mo 14:00 Poster TU C

Magnetoresistance in bicrystal Fe₃O₄ thin films — ●A. BOLLERO¹, M. ZIESE¹, P. ESQUINAZI¹, K. DÖRR², and I. MÖNCH² — ¹University of Leipzig, Division of Magnetism and Superconductivity, Linnéstrasse 5, 04103 Leipzig — ²Institute for Metallic Materials, IFW Dresden, Helmholtzstr. 20, 01069 Dresden

Epitaxial and polycrystalline Fe₃O₄ films can have a large high-field magnetoresistance (absent in bulk material) attributed to electron transfer across the antiphase boundaries (APBs) [1]. In the present work an epitaxial magnetite (Fe₃O₄) film has been deposited by the pulsed laser deposition (PLD) technique on a bicrystal substrate. Magnetoresistance measurements on patterned stripes (width = 20 μm) across the bicrystal grain boundary have not revealed a distinguishable grain boundary contribution, by comparison with similar experiments performed on manganese perovskites [2]. Post-annealing of the film leads to a significantly enlarged high-field magnetoresistance with decreasing temperature for $T < T_V$ (T_V : Verwey transition temperature). Decreased resistivity and coercivity values are obtained after annealing of the film which is attributed to a reduction in the density of APBs.

[1] M. Ziese and H. J. Blythe, J. Phys. Cond. Matt.: **12** (2000) 13.
[2] K. Steenbeck, T. Eick, K. Kirsch, H.-G. Schmidt and E. Steinbeiß, Appl. Phys. Lett. **73** (1998) 2506.

MA 20.39 Mo 14:00 Poster TU C

Heusler alloy based MTJs with afm coupled reference layer system — ●J. SCHUMANN, H. VINZELBERG, R. KALTOFEN, D. ELEFANT, I. MÖNCH, J. THOMAS, and M. HECKER — IFW Dresden, POB 270116, 01171 Dresden

For advanced TMR switching elements applied e.g. in MRAMs, magnetic thin films with high spin polarization are indispensable. Half-metallic Heusler alloys are expected to be promising candidates for the magnetic components in prospective spin-electronic devices. Band structure studies for the compound Co₂CrAl [1] have proved the half-metallic state to be preserved in the immediate surface region. This is important for the spin transport through MTJs. A partial substitution of Fe for Cr enhances the Curie temperature ensuring thus stable working parameters at 300 K. Co₂Cr_{1-x}Fe_xAl based MTJs with an Al_xO_y barrier and an IrMn pinned CoFe top electrode present the typical switching behavior and a TMR ratio of ca. 28 % at 4.2K. The influence of the sputter conditions (growth rate, Ar-pressure, substrate temperature) on the structural and magnetic properties of the Heusler films is studied and the consequences on the TMR process are discussed.

[1] I. Galanakis, J. Phys. C, **14**, 6329 (2002).

MA 20.40 Mo 14:00 Poster TU C

Präparation und Eigenschaften dünner Manganat-Titanat-Kompositschichten — ●KAI GEHRKE¹, ALEXANDR BELENCHUK², OLEG SHAPOVAL², VASILY MOSHNYAGA¹ and KONRAD SAMWER¹ — ¹Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen — ²Institute of Applied Physics, Academiei 5, MD-2028 Chisinau, Moldova

Multiferroische Materialien zeigen zugleich die Eigenschaften von Ferromagnetika und Ferroelektrika. Nanokomposite, bestehend aus einer Manganat- (M) und einer Titanatphase (T), können multiferroisch sein und die Eigenschaften treten aufgrund von elastischer Kopplung zwischen M- und T-Phase in Wechselwirkung. Ausgangspunkt sind dünne LCMO-Schichten, die mit metallorganischer Aerosoldeposition (MAD) hergestellt wurden. Temperaturabhängige Messungen des elektrischen Widerstandes zeigen den für viele Manganate typischen Metall-Isolator-Übergang. Die Übergangstemperatur von T=275K und der extrem große Temperaturkoeffizient des Widerstandes TCR=31%/K sind dabei ein Maß für die hohe Qualität der Schichten. Dünne Manganat-Titanat Kompositschichten, mit nomineller Zusammensetzung (LCMO)_x : (BaTiO₃)_{1-x}, wurden mit der MAD-Technik hergestellt. Röntgendiffraktometrie-messungen zeigen, daß die Schichten auf MgO(100) Substraten epitaktisch gewachsen sind. Magnetische Eigenschaften wurden mit Hilfe eines SQUID-Magnetometers untersucht. Die multiferroischen Eigenschaften sollen mit magneto-optischen Methoden untersucht werden.

MA 20.41 Mo 14:00 Poster TU C

Spin-dependent tunneling in the nearly-free-electron model — ●PETER BOSE¹, INGRID MERTIG¹, and JÜRGEN HENK² — ¹FG Theoretische Physik, FB Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle an der Saale — ²Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle an der Saale

Spin-dependent ballistic transport through a tunnel barrier is treated within the one-dimensional nearly-free-electron model. The comparison with free electrons reveals significant effects of band gaps, in particular in the bias dependence. The results can be qualitatively explained by the number of incident and transmitted states in the leads. With an extension to ferromagnetic leads the bias dependence of tunnel magneto-resistance is discussed.

MA 20.42 Mo 14:00 Poster TU C

Scanning Tunneling Spectroscopy on La_{0.7}Ca_{0.3}MnO₃ — ●SIGRUN A. KÖSTER, LAKSHAMANA SUDHEENDRA, VASILY MOSHNYAGA, BERND DAMASCHKE, and KONRAD SAMWER — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Manganites show the colossal magnetoresistance effect (CMR), which already has been very well investigated. The main effect is observed at the temperature induced transition from a ferromagnetic metallic to an insulating behavior. According to the percolation model of Dagotto et al. [1] two different phases, an insulating and conducting one, exist in parallel. In our work we can show by scanning tunneling spectroscopy, that low resistivity and high resistivity regions do exist in the samples. These depend on several parameters like the microstructure of the samples, temperature of magnetic fields. Our investigations concentrate on achieving a more detailed picture of these phases and their origin.

[1] E. Dabotto, T. Hotta, A. Moreo, Physics Reports 344, (2001).

MA 20.43 Mo 14:00 Poster TU C

Magnetotransport in Sr₂CrWO₆ thin films — ●PETRA MAJEWSKI, ANDREA BOGER, STEPHAN GEPRÄGS, ROBERT GEISSLER, ANDREAS ERB, MATTHIAS OPEL, LAMBERT ALFF, and RUDOLF GROSS — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Str. 8, 85748 Garching

High Curie temperatures T_C and large magnetoresistive effects in polycrystalline double perovskite samples raised renewed interest in these materials, due to possible applications in magnetoelectronics. Here we report on the structural, magnetic, and electrical properties of thin epitaxial Sr₂CrWO₆ films. The samples were grown in an UHV pulsed laser deposition (PLD) system. In-situ RHEED and AFM were used to monitor the growth process and surface quality. The epitaxial thin films show no parasitic phases in HRXRD measurements. Rocking curves of the (004)-film peaks have a FWHM as narrow as 0.016°. From SQUID magnetometry measurements between 4 and 380 K, T_C is estimated to be well above 380 K. Since the surface of the SrTiO₃ substrate becomes

conducting under the deposition conditions of Sr_2CrWO_6 , an insulating heteroepitaxial NdGaO_3 buffer layer was introduced in order to obtain reliable electrical transport data. The magnetotransport properties and the Hall effect have been measured in a wide temperature range (5 to 300 K) and in magnetic fields up to 15 T. The resistivity vs. temperature curves could be well described by a variable range hopping transport mechanism. In addition, grain-boundary junctions have been prepared to investigate spin-dependent tunneling effects.

This work is supported by the BMBF via grant no. 13N8279.

MA 20.44 Mo 14:00 Poster TU C

Tunneling magnetoresistance of C_nH_m ($n=1,2,6$, $m=2,4,6$) molecules sitting between Co clusters — ●H. ZARE KOLSARAKI and H. MICKLITZ — II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, D-50937, Köln, Germany

Spin-dependent transport in artificially nano-structured materials composed of magnetic clusters separated by insulating molecules is an actual field of research. Films composed of in-beam prepared Co clusters (mean diameter $\simeq 4.5$ nm) and various hydrocarbon molecules C_nH_m ($n=1,2,6$, $m=2,4,6$) have been prepared by co-deposition onto a cold ($T \simeq 35$ K) substrate. The temperature dependence of the resistivity ρ for all films shows the expected $\ln\rho \propto T^{-1/2}$ behavior, typical for variable range tunneling. The tunneling magnetoresistance (TMR) is independent of the cluster volume fraction v_{cl} in Co/CH_4 , $\text{Co}/\text{C}_2\text{H}_2$ and $\text{Co}/\text{C}_6\text{H}_6$, while TMR in $\text{Co}/\text{C}_2\text{H}_4$ strongly depends on v_{cl} . $\text{TMR}(T=0)$ in Co/CH_4 and $\text{Co}/\text{C}_2\text{H}_4$ (for largest v_{cl}) is similar to that observed in non-interacting $\text{Co}/\text{Kr}(\text{Xe})$ -systems [$\text{TMR}(0) \simeq 15\%$], while $\text{TMR}(0)$ in $\text{Co}/\text{C}_2\text{H}_2$, $\text{Co}/\text{C}_6\text{H}_6$ and $\text{Co}/\text{C}_2\text{H}_4$ (for smallest v_{cl}) is increased by a factor of about 2 [$\text{TMR}(0) \simeq 30\%$]. We propose that the direct contact between Co-cluster surface-atoms and C-atoms is responsible for the enhanced TMR. The change of the TMR in C_2H_4 with changing v_{cl} reflects the change in the orientation of the C_nH_m molecules sitting between two Co clusters: for large v_{cl} one molecule sits with its C-C axis perpendicular to the cluster surface [small $\text{TMR}(0)$], while for small v_{cl} two molecules are positioned with the C-C axis parallel to the cluster surface [large $\text{TMR}(0)$].

MA 20.45 Mo 14:00 Poster TU C

Magnetowiderstandsmessungen an granularen Strukturen synthetisiert aus magnetischen Nanopartikeln — ●INGA ENNEN¹, DANIELA SUDFELD¹, ANDREAS HÜTTEN¹, KLAUS WOJCZYKOWSKI², PETER JUTZI² und GÜNTER REISS¹ — ¹Universität Bielefeld, Fakultät für Physik, Universitätsstr.25, 33615 Bielefeld — ²Universität Bielefeld, Fakultät für Chemie, Universitätsstr.25, 33615 Bielefeld

Eine physikalisch interessante Anwendung von magnetischen Nanopartikeln liegt in der bottom-up Herstellung granularer Strukturen. Diese lässt sich für ligandenstabilisierte Nanopartikel in folgende Schritte einteilen: 1. Aufbringung einer Partikelmonolage auf ein Substrat, 2. Entfernung der isolierenden, organischen Hülle durch Auslagerung in einem reduzierenden Gasgemisch, 3. Einbettung der metallischen Partikelkerne in eine nichtmagnetische Matrix. An so präparierten granularen Systemen, bestehend aus Co-Partikeln in einer Cu-Matrix, sind bislang GMR-Effekte von 4,5% bei Raumtemperatur gemessen worden. Die Messungen lassen sich darüber hinaus mit der aus elektronenmikroskopischen Aufnahmen gewonnenen Teilchengrößenverteilung und den magnetischen Eigenschaften, die mittels AGM-Messungen bei Raumtemperatur bestimmt worden sind, im Rahmen eines Modells korrelieren.

MA 20.46 Mo 14:00 Poster TU C

X-ray absorption and magnetic circular dichroism studies of ion bombarded ferromagnet-antiferromagnet bilayers — ●J. SCHMALHORST¹, M. SACHER¹, V. HÖINK¹, G. REISS¹, D. ENGEL², and A. EHRESMANN² — ¹University of Bielefeld, Department of Physics, Nano Device Group, P.O. Box 100131, 33501 Bielefeld, Germany — ²Department of Physics, Kaiserslautern University of Technology, D-67663 Kaiserslautern, Germany

The influence of He ion bombardment on the structural and magnetic interface properties of a polycrystalline $\text{Mn}_{83}\text{Ir}_{17}$ / Co antiferromagnet-ferromagnet bilayer system is investigated¹. For annealed as well as for not annealed samples an exchange bias field of up to 200 Oe is induced by the ion bombardment for doses up to 5×10^{14} ions/cm². The X-ray absorption and the X-ray magnetic circular dichroism of Co and Mn is not significantly altered by this ion dose. For higher doses the exchange bias field is strongly reduced and accompanied by an increase of the ratio of the Mn to Co X-ray absorption intensities and a reduction of the

Co X-ray magnetic circular dichroism signal. A model with a gaussian like intermixing zone at the AF / FM interface is developed to account for the observed changes of the X-ray absorption spectra. The authors gratefully acknowledge the opportunity to perform soft X-ray absorption spectroscopy at the Advanced Light Source, Berkeley, USA.

[1] J. Schmalhorst, M. Sacher, V. Höink, G. Reiss, D. Engel, A. Ehresmann, Phys. Rev. B, in press

MA 20.47 Mo 14:00 Poster TU C

Initialization of unidirectional anisotropy in a ferromagnet - antiferromagnet bilayer by keV-He ion bombardment — ●D. ENGEL¹, A. EHRESMANN¹, J. SCHMALHORST², M. SACHER², V. HÖINK², and G. REISS² — ¹Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — ²Fakultät für Physik, Universität Bielefeld, D-33501 Bielefeld, Germany

A polycrystalline $\text{Cu}/\text{Ni}_{80}\text{Fe}_{20}/\text{Mn}_{83}\text{Ir}_{17}/\text{Co}/\text{AlO}_x$ ferromagnet-antiferromagnet layer system was grown without applying an external magnetic field showing no unidirectional anisotropy in the as prepared state. After 10-keV He-ion bombardment in an external in-plane magnetic field a clear unidirectional anisotropy collinear to the magnetic field direction during bombardment is observed, indicating that ion bombardment can be used for this system to initialize the unidirectional exchange anisotropy. The magnetization reversal processes for various ion doses are discussed, based on longitudinal Magneto-optical Kerr-Effect measurements.

MA 20.48 Mo 14:00 Poster TU C

Thermische Stabilität magnetischer Nanostrukturen in ionenstrahlmodifizierten Exchange Bias Systemen — V. HÖINK¹, M. SACHER¹, ●J. SCHMALHORST¹, G. REISS¹, D. ENGEL² und A. EHRESMANN² — ¹Universität Bielefeld, Fakultät für Physik, Dünne Schichten und Nanostrukturen, 33501 Bielefeld — ²Fakultät für Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern

Der Exchange Bias Effekt in Ferromagnet / Antiferromagnet Schichtsystemen kann durch He-Ionenbeschuss im Magnetfeld sowohl in seiner Stärke als auch in seiner Richtung gezielt eingestellt werden. Wird durch Verwendung von Resistmasken der Ionenbeschuss lokal eingeschränkt, so können magnetische Nanostrukturen in den Ferromagneten geschrieben werden, welche einer lateralen Variation der Orientierung der Magnetisierung im remanenten Zustand entsprechen. Diese magnetische Nanostrukturierung wird für neuartige Anwendungen im Bereich Magneto Elektronik nutzbar sein. In der hier vorgestellten Arbeit wurden in Co / Mn-Ir und Co-Fe / Mn-Ir Doppelschichtsystemen magnetische Nanostrukturen mit Strukturgrößen unter $1\mu\text{m}$ erzeugt. Durch die ortsaufgelöste Messung der Absorption elliptisch polarisierter weicher Röntgenstrahlung in einem Photoelektronenemissionsmikroskop (PEEM) wurden die magnetischen Nanostrukturen in Remanenz direkt abgebildet und die Entwicklung ihrer Domänenkonfiguration als Funktion der Proben temperatur zwischen Raumtemperatur und 370°C verfolgt. Die PEEM-Messungen wurden an der PEEM2-Beamline 7.3.1.1 der Advanced Light Source, Berkeley, USA durchgeführt und durch die Deutsche Forschungsgemeinschaft (DFG) gefördert.

MA 20.49 Mo 14:00 Poster TU C

AF thickness dependence of the 10keV He-ion bombardment induced exchange-bias modification in multilayers containing MnIr as antiferromagnet — ●T. WEIS, D. JUNK, D. ENGEL, A. EHRESMANN, V. HÖINK, J. SCHMALHORST, and G. REISS — tanja.jacob@web.de

It is known that the exchange bias field H_{eb} of antiferromagnet/ferromagnet (AF/F) bilayers can be modified by keV He-ion bombardment in an external magnetic field. The modification of the magnitude and the direction of H_{eb} is dependent on the He-ion dose and the direction of the external magnetic field applied during the ion bombardment.

In this contribution the AF layer thickness dependence of keV He-ion bombardment induced modifications of H_{eb} in magnetic multilayers with MnIr as AF and CoFe or Co as F was investigated. It was found that the ion dose dependence of H_{eb} is strongly influenced by the IrMn layer thickness. First experimental results for varying AF thicknesses will be presented.

MA 20.50 Mo 14:00 Poster TU C

Azimuthal dependence of exchange bias and coercive field of Fe(110)/CoO(111) exchange bias bilayer — ●GREGOR NOWAK, FLORIN RADU, KURT WESTERHOLT, and HARTMUT ZABEL — Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

We have prepared epitaxial Fe(110)/CoO(111) bilayers and characterized their structure by x-ray diffraction. Structurally, the bilayer shows a single domain growth for the CoO layer with six-fold in-plane symmetry. The Fe layer, however, shows a Nishiyama-Wassermann growth of three equivalent domains. The exchange bias (EB) properties were investigated by SQUID magnetometry. First, we measured the EB field as a function of the field cooling direction. The EB field exhibits a twofold symmetry which defines the uniaxial anisotropy orientation of the AF layer. Then we cooled down the system for different orientations of the applied field with respect to the uniaxial axis of the AF layer. For each field-cooling orientation we recorded hysteresis loops as a function of the azimuth angle of the sample with respect to the applied field. The maximum EB field is not found along the field cooling direction instead we observed this maximum to be parallel to the easy axis of the AF layer. This is in very good agreement with the theoretical predictions of Nowak and Usadel¹. Also, the unidirectional behaviour of the EB field shows modulations created by the uniaxial nature of the AF layer anisotropy.

¹B. Beckmann, U. Nowak, and K. D. Usadel, Phys. Rev. Lett. 91, 187201 (2003).

This work was supported by SFB 491.

MA 20.51 Mo 14:00 Poster TU C

Coercivity and exchange bias of ferromagnetic/antiferromagnetic multilayers — ●ULRICH NOWAK, GREGOR SCHOLTEN, and KLAUS D. USADEL — Fachbereich Physik, Universität Duisburg-Essen, 47058 Duisburg, Germany

For a model system consisting of a ferromagnetic layer exchange coupled to an antiferromagnetic layer with a compensated interface detailed mean field type calculations are performed. For the coercive field a rather broad enhancement around the Néel temperature T_N of the antiferromagnetic layer is found irrespectively of whether the antiferromagnetic layer is structurally disordered or not, while exchange bias is only found for systems with defects. The results for the exchange bias field are in qualitative agreement with those obtained previously with Monte Carlo simulations [1,2].

With some simplifying assumptions, we can obtain from this approach analytic results for the coercive field and the exchange bias field. We show that the observed enhancement of the coercivity around T_N and the occurrence of exchange bias are of different origin.

Work supported by the *Deutsche Forschungsgemeinschaft* through SFB 491.

[1] P. Miltenyi, M. Gierlings, J. Keller, B. Beschoten, G. Güntherodt, U. Nowak, and K. D. Usadel, Phys. Rev. Lett. 84, 4224 (2000).

[2] U. Nowak, K. D. Usadel, P. Miltényi, J. Keller, B. Beschoten, and G. Güntherodt, Phys. Rev. B 66, 14430 (2002).

MA 20.52 Mo 14:00 Poster TU C

Nano-structured exchange bias systems — ●BJÖRN BECKMANN, ULRICH NOWAK, and KLAUS D. USADEL — Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Recently, attention has been drawn to exchange bias (EB) systems where the size of either the ferromagnetic (FM) or antiferromagnetic (AFM) layer or even both was modified on a nanoscale. Using Monte Carlo simulations of the domain state model [1,2] we study exchange bias of an array of squared ferromagnetic dots on a continuous antiferromagnetic substrate.

For sufficiently large dot sizes the results agree with those obtained earlier for continuous systems [2]. With decreasing FM dot size the average (over many dots) EB field decreases before it eventually vanishes when reaching a certain critical size. To explain this effect we note that during field cooling domains in the AFM layer are formed which then influence the FM. Thus, once the lateral size of the FM is below the average size of the AFM domains EB has to vanish. It is noteworthy, however, that for the single dots strong fluctuations of the bias field occur where both, negative or even positive bias may be observed.

Work supported by the *Deutsche Forschungsgemeinschaft* through SFB 491.

[1] P. Miltenyi, M. Gierlings, J. Keller, B. Beschoten, G. Güntherodt, U. Nowak, and K. D. Usadel, Phys. Rev. Lett. 84, 4224 (2000).

[2] U. Nowak, K. D. Usadel, P. Miltényi, J. Keller, B. Beschoten, and G. Güntherodt, Phys. Rev. B 66, 14430 (2002).

MA 20.53 Mo 14:00 Poster TU C

Magnetic domain structure of micro-patterned PtMn/NiFe exchange bias bilayers — ●K. POTZGER¹, L. BISCHOPF¹, M. O. LIEDKE^{1,2}, B. HILLEBRANDS², M. RICKART³, P. FREITAS³, J. MCCORD⁴, and J. FASSBENDER¹ — ¹FZ Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, 01314 Dresden — ²Fachbereich Physik, TU Kaiserslautern, 67663 Kaiserslautern — ³INESC MN, 1000 Lisbon, Portugal — ⁴IFW Dresden, Institut für Metallische Werkstoffe, 01069 Dresden

A bottom pinned exchange bias bilayer system consisting of 20 nm PtMn and 6 nm NiFe (produced using ion beam deposition (IBD) and physical vapour deposition (PVD, magnetron sputtering)) was laterally magnetic patterned by means of focused ion beam irradiation (FIB) on a micrometer scale. 25 keV ion irradiation with a fluence of $2 \times 10^{14} \text{Ga}^+ \cdot \text{cm}^{-2}$ leads to a disordering of the as prepared chemically ordered PtMn-phase with only minor changes in sample topography. Thus the exchange bias field as well as the coercive field was reduced to a large extent on a local scale. The magnetic properties of FIB written $1 \mu\text{m}$ wide stripes and their interaction with the non-irradiated spacing were analyzed by means of magneto-optic Kerr effect, magnetic force microscopy, and Kerr microscopy. The application of a magnetic field between -12 Oe and -80 Oe with respect to the exchange bias field direction leads to an antiparallel alignment of irradiated and non-irradiated stripes forming pronounced domain walls. A parallel alignment was found below -100 Oe and in the positive field region.

MA 20.54 Mo 14:00 Poster TU C

All-optical probe of magnetization dynamics in exchange bias systems — ●M. C. WEBER¹, H. NEMBACH¹, H. SCHULTHEISS¹, C. BAYER¹, S. BLOMEIER¹, R. KALTOFEN², J. SCHUMANN², M. J. CAREY³, B. HILLEBRANDS¹, and J. FASSBENDER⁴ — ¹Fachbereich Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — ²Institut für Dünnfilmsysteme der Mikroelektronik, IFW Dresden, 01171 Dresden, Germany — ³Hitachi Global Storage Technologies, San Jose Research Center, San Jose CA 95120, USA — ⁴Institut für Ionenstrahlphysik und Materialforschung, FZ Rossendorf, 01314 Dresden, Germany

The picosecond optical control of the exchange bias anisotropy was investigated in real time for different exchange bias bilayers (NiFe/FeMn, CoFe/NiMn, CoFe/IrMn) using time-resolved magneto-optics. Upon photoexcitation the spin temperature is increased leading to a collapse of the interfacial exchange coupling. Both the shift fields and the easy axis coercivities are reduced within the first 10 ps. The unpinning is followed by a slower spin-lattice relaxation process. The deduced relaxation times turn out to be quite comparable (< 205 ps) for all bilayers. The thermal decoupling of the bilayers can lead to a high frequency precession of the magnetization of the ferromagnetic layers. The precessional response of the CoFe/IrMn system reveals a Kittel type field dependence of the precession frequency. Brillouin light scattering measurements of the field dependence of the FMR frequency are in good agreement with the real time measurements, further supporting the homogeneous mode character of the optically excited precession.

MA 20.55 Mo 14:00 Poster TU C

Bi-domain state in the exchange bias system FeF₂/FM with FM=Fe, Co or Ni — ●OLEG PETRACIC^{1,2}, IGOR V. ROSHCIN¹, ZHI-PAN LI¹, RAFAEL MORALES¹, XAVIER BATTLE¹, and IVAN K. SCHULLER¹ — ¹Physics Department, University of California, San Diego, La Jolla, California 92093, USA — ²Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Independently exchange biased subsystems can coexist in FeF₂/FM bilayers (FM=Fe, Co or Ni) after various field-cooling protocols. This is evidenced from double hysteresis loops found in magnetization and spatially resolved magneto-optic Kerr-data. Surprisingly the double loops are not only found after zero-field cooling, but also using intermediate cooling fields. In both cases the ferromagnet does not experience an average bias from the antiferromagnet but rather two independent subsystems ('bi-domain' state). This idea is confirmed by micromagnetic simulations including the effect of the antiferromagnet. We also present experiments, where thermally activated motion of these antiferromagnetic 'domain' boundaries can be achieved.

MA 20.56 Mo 14:00 Poster TU C

“Gigantic” Magnetoelectric Effect in Multiferroic Manganites — ●M. FIEBIG¹, TH. LOTTERMOSER¹ und T. LONKAI^{1,2,3} — ¹Max-Born-Institut, Max-Born-Straße 2a, 12489 Berlin — ²Institut für Angewandte Physik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen — ³Hahn-Meitner-Institut, Glienicker Straße 100, 14109 Berlin

The crosslink between magnetic and electric properties expressed by the magnetoelectric (ME) effect opens new degrees of freedom for device construction. Recently, an enormous interest in ME phenomena is observed because composite materials and multiferroics, i.e. materials with multiple magnetic, electric and/or elastic ordering, exhibit structural and gigantic ME effects which exceed previous effects by many orders of magnitude and control phase transitions. We will discuss three types of “gigantic” ME coupling that were observed in ferroelectric (FEL) antiferromagnetic (AFM) RMnO₃ (R = Sc, Y, In, Ho-Lu). (i) An external magnetic or electric field induces ferromagnetic R³⁺ ordering which is reversibly switched on or off. The process is monitored by magneto-optical techniques (second harmonic generation, Faraday rotation). Its microscopic origin is disclosed by neutron and x-ray powder diffraction. (ii) An interaction of FEL and AFM domain walls which clamps the AFM to the FEL domain structure. It roots in piezomagnetic interaction between magnetization of the AFM walls and strain in the FEL walls which lowers the free energy. (iii) A massive formation of *spin-rotation domains* which supplement *spin-reversal domains* in the course of a reorientation of Mn³⁺ spins. This leads to a local ME effect which is only allowed because of the low symmetry of the domain walls.

MA 20.57 Mo 14:00 Poster TU C

Magnetization Reversal in Exchange Biased Multilayers with Field Direction — ●AMITESH PAUL, EMMANUEL KENTZINGER, ULRICH RÜCKER, DANIEL BÜRGLER, and THOMAS BRÜCKEL — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

The magnetization reversal in exchange-biased multilayers is studied by specular reflection and off-specular scattering of polarized neutrons for polycrystalline [Ir₂₀Mn₈₀(6.0 nm)/Co₈₀Fe₂₀(3.0 nm)]₁₀ multilayers. For increasing and decreasing applied fields, we have observed earlier symmetric and sequential reversal only via domain formation [1], when the applied field direction was along the exchange bias direction. In the present study, the CoFe layer remagnetizes symmetrically for both field branches in a uniform (via coherent rotation) as well as non-uniform mode (via domain formation) for different directions (90 and 45 deg.) of the applied fields w.r.t. the unidirectional anisotropy direction. We observe the enhanced spin-flip specular intensity at the HADAS reflectometer [1] indicating coherent rotation of the in-plane component of magnetization perpendicular to the field due to the variation of the field direction, which is in agreement with the theoretical model of Beckmann *et al* [2]. However, we show that such uniform mode of reversal can take place irrespective of the underlying domain wall motion. The small scale magnetization fluctuations as revealed by off-specular spin-flip scattering at reversal points clearly demonstrates this for different field directions.

[1] A. Paul *et al*, Phys. Rev. B (in press) 2004.[2] B. Beckmann *et al*, Phys. Rev. Lett. 91, 187201, 2004.

MA 20.58 Mo 14:00 Poster TU C

Reversal of interlayer coupling with temperature — ●M. WIETSTRUK, K.M. DÖBRICH, J.E. PRIETO, O. KRUPIN, F. HEIGL, G. KAINDL, and K. STARKE — Freie Universität Berlin, Fachbereich Physik

The oscillatory nature of interlayer coupling has been analyzed for the case of Gd/Y/Tb trilayers. This epitaxial all-rare-earth system differs from the well known transition metal systems as both the interlayer and the intralayer coupling are of the indirect RKKY type, and hence of similar strength. We used x-ray magneto-optical Kerr effect (XMOKE) at the 3d-4f excitation thresholds to record element specific hysteresis loops of Gd and Tb for different Y spacer thicknesses up to 2 nm. For a constant spacer thickness, the interlayer coupling is found to change with temperature between antiferromagnetic and ferromagnetic. This up to now unobserved effect shows a systematic behavior with spacer thickness; it will be discussed in light of a simple model for interlayer exchange coupling.

MA 20.59 Mo 14:00 Poster TU C

Asymmetric fixed and rotatable magnetic anisotropy at the onset of exchange bias — ●JEFFREY MCCORD¹ and ROLAND MATTHEIS² — ¹Leibniz Institute for Solid State and Materials Research Dresden - Institute for Metallic Materials - 01169 Dresden — ²Institut für physikalische Hochtechnologie IPHT Jena - 07745 Jena

The strength of exchange bias and rotatable anisotropy in polycrystalline NiFe/IrMn ferromagnet/antiferromagnet systems is quantified from dc down to the ps time-scale by regular quasi-static and microwave magnetometry, as well as magnetic domain observation. A transition from superparamagnetic to antiferromagnetic behavior with increasing IrMn thickness is derived from the magnetic resonance frequency and the effective magnetic damping parameter. A discrepancy between magnetic loop shift and dynamically obtained exchange bias strength is explained by asymmetric rotatable anisotropy contributions with different relaxation times in the antiferromagnetic layer. The time dependent relaxation is directly confirmed by magnetic domain observations. Partially switching in the IrMn layer even with strong exchange bias is concluded. The increase of coercivity rises solely from the rotatable anisotropy contribution.

MA 20.60 Mo 14:00 Poster TU C

Tuning the Exchange Bias in FeMn/Ni₈₁Fe₁₉ by nonmagnetic Cu defects in the FeMn layer — ●J.O. HAUCH, C. PAPUSOI, M. FECIORU, and G. GÜNTHERODT — II. Physikalisches Institut, RWTH Aachen, 52056 Aachen

Previous theoretical [1] and experimental [2] work on CoO/Co antiferromagnetic/ferromagnetic (AFM/FM) bilayer systems revealed that increasing the nonmagnetic defect concentration at the Co site in the AFM layer leads to an enhancement of the exchange bias. In this study we present the dependence of the exchange bias in FeMn/Ni₈₁Fe₁₉ on nonmagnetic Cu dilution in the AFM layer. Experiments have been performed on Au(5nm)/(Fe₅₀Mn₅₀)_{1-x}Cu_x(10nm)/Ni₈₁Fe₁₉(10nm)/Cu/SiO₂ layer systems. The exchange bias shows a maximum at around 10% Cu defect concentration. These results can be explained as a consequence of a competition between two effects: The increase of the defect concentration leads to an increase of the number of uncompensated moments in the AFM enhancing the exchange bias. On the other hand, the distance of the nonmagnetic pinning sites is decreased by increasing Cu concentration inducing domain walls in the AFM layer. Thereby the thermal instability of the uncompensated moments is increased, thus decreasing the exchange bias. Monte Carlo simulations have been performed to prove the above statement. [1] U. Nowak, K.D. Usadel, J. Keller, P. Miltenyi, B. Beschoten, and G. Güntherodt, Phys. Rev. B **66**, 014430 (2002). [2] J. Keller, B. Beschoten, G. Güntherodt, U. Nowak, and K.D. Usadel, Phys. Rev. B **66**, 014431 (2002).

MA 20.61 Mo 14:00 Poster TU C

Orbital polarons versus itinerant e_g electrons in doped manganites — ●MARIA DAGHOFER¹, ANDRZEJ OLES², and WOLFGANG VON DER LINDEN¹ — ¹Institute for Theoretical and Computational Physics, TU Graz, Austria — ²Marian Smoluchowski Institute of Physics, Jagellonian University, Kraków, Poland

We study an effective one-dimensional (1D) orbital t - J model derived for strongly correlated e_g electrons in doped manganites. At half doping, an FM chain with alternating orbital order competes with an orbitally polarized AFM chain. Alternating orbitals are supported by an alternating Jahn-Teller potential, while spin AFM is favored by the t_{2g} superexchange. Because the FM and AFM states have very similar energy, small changes in the concerning parameters can have a large impact and can switch the system from one scenario to the other.

At finite doping, the kinetic energy favors both ferromagnetism and orbital polarization. The transition from the undoped chain with alternating spin or orbital order to the polarized chain at high doping is investigated by examining a variety of observables. Upon doping, orbital polarons enter the FM chain with alternating orbital order, and spin polarons are found for the AFM chain. Phase separation into regions of high and low carrier density is only observed for FM chains *without* Jahn-Teller distortions.

The Jahn-Teller potential is found to hinder the transition to the orbitally polarized state, but at least for small potentials, it does not substantially decrease the kinetic energy once this transition has occurred.

MA 20.62 Mo 14:00 Poster TU C

Magnetization Reversal in Exchange Biased Multilayers with Field Direction — ●AMITESH PAUL, EMMANUEL KENTZINGER, ULRICH RÜCKER, DANIEL BÜRGLER, and THOMAS BRÜCKEL — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

The magnetization reversal in exchange-biased multilayers is studied by specular reflection and off-specular scattering of polarized neutrons for polycrystalline $[\text{Ir}_{20}\text{Mn}_{80}(6.0 \text{ nm})/\text{Co}_{80}\text{Fe}_{20}(3.0 \text{ nm})]_{10}$ multilayers. For increasing and decreasing applied fields, we have observed earlier symmetric and sequential reversal only via domain formation [1], when the applied field direction was along the exchange bias direction. In the present study, the CoFe layer remagnetizes symmetrically for both field branches in a uniform (via coherent rotation) as well as non-uniform mode (via domain formation) for different directions (90 and 45 deg.) of the applied fields w.r.t. the unidirectional anisotropy direction. We observe the enhanced spin-flip specular intensity at the HADAS reflectometer [1] indicating coherent rotation of the in-plane component of magnetization perpendicular to the field due to the variation of the field direction, which is in agreement with the theoretical model of Beckmann *et al* [2]. However, we show that such uniform mode of reversal can take place irrespective of the underlying domain wall motion. The small scale magnetization fluctuations as revealed by off-specular spin-flip scattering at reversal points clearly demonstrates this for different field directions.

[1] A. Paul *et al*, Phys. Rev. B (in press) 2004.

[2] B. Beckmann *et al*, Phys. Rev. Lett. 91, 187201, 2004.

MA 20.63 Mo 14:00 Poster TU C

Exchange bias effects in [Pt/Co] - IrMn multilayers with perpendicular anisotropy — ●S. BRÜCK¹, J. SORT^{1,2}, V. BALTZ², B. RODMACQ², B. DIENY², S. SURINACH¹, J. S. MUÑOZ¹, M. D. BARÓ¹, and J. NOGUÉS³ — ¹Dept. de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain — ²SPINTEC, CEA/Grenoble, 17 Rue des Martyrs, 38054 Grenoble Cedex 9, France — ³Institució Catalana de Recerca i Estudis Avançats (ICREA) and Dept. de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain

Exchange coupled [Pt/Co]-IrMn multilayers (ML), where IrMn is antiferromagnetic at room temperature, exhibit simultaneously a perpendicular to film magnetic effective anisotropy and a shift of the hysteresis loop along the magnetic field axis (i.e., perpendicular exchange bias). By varying the thickness of the Co layers in the ML or by inserting a Pt spacer between the ML and the AFM the magnitudes of both, the exchange bias field H_E and the coercivity H_C , can be accurately tailored. The perpendicular magnetic anisotropy is found to play a significant role on the shape of the hysteresis loops and the exchange bias effects. Some outstanding properties of the [Pt/Co]-IrMn ML compared to the commonly studied ferromagnetic-antiferromagnetic bilayers with in-plane anisotropy will be discussed. Our results are particularly appealing for the design of novel types of magnetic reading heads consisting of spin valves or magnetic tunnel junctions with perpendicular anisotropy.

MA 20.64 Mo 14:00 Poster TU C

Dynamic quasi-particle behaviour of geometrically confined domain walls — ●DANIEL BEDAU¹, MATHIAS KLÄUI¹, ULRICH RÜDIGER¹, DIRK BACKES², L. J. HEYDERMAN², GIANCARLO FAINI³, C.A.F. VAZ⁴ und J.A.C. BLAND⁴ — ¹FB Physik, Universität Konstanz, Konstanz, Germany — ²LMN, Paul Scherrer Institut, Villigen, Switzerland — ³LPN-CNRS, Marcoussis, France — ⁴CavendishLaboratory, University of Cambridge, UK

Geometrically confined domain walls in which the spin structure of a wall can be controlled via the lateral dimensions and film thickness have recently become the focus of intense research. Ferromagnetic rings are of particular interest, since in these structures simple magnetic states with head-to-head domain walls are found that make this geometry suitable for probing domain wall properties, e.g. the pinning at or the repulsion from notches depending on the domain wall type [1]. Transverse domain walls are attracted by constrictions and due to their small lateral dimensions they act as quasi-particles in an attractive potential well. Using magnetoresistance measurements, the depth and the width of the potential well can be determined [2]. To completely characterize the potential 'landscape', the curvature of the potential well needs to be ascertained by studying dynamic oscillation of the domain wall (resonance frequencies). Apart from the fundamental oscillation, higher-order resonances are found with frequencies in the GHz range.

[1] M. Kläui *et al.*, Phys. Rev. B 68, 134426 (2003), Physica B 343, 343 (2004) [2] M. Kläui *et al.*, Phys. Rev. Lett. 90, 97202 (2003)

MA 20.65 Mo 14:00 Poster TU C

Superparamagnetic behaviour of vortex cores. — ●ROBERT WIESER, NATALIA KAZANTSEVA, ULRICH NOWAK und K. D. USADEL — Fachbereich für Physik, Universität Duisburg-Essen

Magnetic vortices have been studied for a long time. The reviewed interest is triggered by the possibility of a direct observation of vortices in permalloy and Co magnetic nanodots. Such vortex structures are discussed in connection with high density data-storage and miniature sensors.

Earlier theoretical investigations in this regime have been done mostly at zero temperature. In this contribution we report on the thermodynamical behaviour of such vortex structures.

Our simulation based on Langevin dynamics show that the vortex core becomes superparamagnetic with increasing temperature. The energy barrier is estimated as difference between the energy of the in-plane vortex (all spins in plane) and the energy of the out-of-plane vortex (with central polarization). The barrier decreases with increasing core radius, which is given by the relation between dipol-dipol and exchange interaction.

Additional we found that with increasing temperature the magnetization inside the vortex core decreases faster than the magnetization outside the central region.

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MA 20.66 Mo 14:00 Poster TU C

Ultrafast photo-conductive switches — ●M. PIETZ¹, S. BRETSCHNEIDER¹, A. PARGE¹, T. SALDITT², A. FÖRSTER³, and M. MÜNZENBERG¹ — ¹4. Phys. Institut Universität Göttingen — ²Institut für Röntgenphysik Universität Göttingen — ³Institut für Schichten und Grenzflächen (ISG1) Forschungszentrum Jülich

Ultrafast photoconductive switches, based on metal-semiconductor-metal contact pads using low temperature grown GaAs as a semiconductor, deliver the fastest current pulses on a chip so far. Using fs-laser pulses from a TiSa-laser system for the excitation of the carriers, current pulses of a few picoseconds (2-3 ps) in length are generated. The pulses are characterised with autocorrelation and photoconductive sampling techniques. The field pulse in the order of 10 Oe can be used to trigger the magnetization dynamics in a magnetic nanostructure. Therefore, magnetic structures on a strip line are prepared with the help of optical and e-beam lithography, with the aim to explore magnetic Eigen mode oscillations and extrinsic as well as intrinsic damping parameters in a pump-probe experiment with ps time resolution.

MA 20.67 Mo 14:00 Poster TU C

Spin-lattice relaxation phenomena in manganite $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films — ●MARKUS C. WEBER¹, VASILY MOSHNYAGA², KONRAD SAMWER², and BURKARD HILLEBRANDS¹ — ¹Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany — ²I. Physikalisches Institut, Universität Göttingen, Bunsenstr. 9, 37073 Göttingen, Germany

All-optical pump-probe experiments employing magneto-optics as a probe were performed to study spin and lattice relaxation dynamics in thin epitaxial $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ films. The perovskite manganites were grown by a metalorganic aerosol deposition technique [1] onto MgO substrates. The films reveal a ferromagnetic-paramagnetic phase transition at a Curie temperature of about $T_C = 360 \text{ K}$. Upon photoexcitation the spin temperature is elevated close to or even above T_C . By properly choosing the pump pulse energy it is possible to demagnetize the sample completely within the pump pulse width ($\tau = 8.3 \text{ ps}$), associated with a collapse of the remanence. Two distinct recovery regimes of the ferromagnetic order can be resolved upon arrival of the pump pulse, which manifest themselves by two different relaxation times. A pump pulse energy independent spin-lattice relaxation time of about 200 ps can be deduced from the real time evolution of the remanence. One dimensional heat flow out of the manganite film into the substrate with a time constant of about 0.5 ns up to 1 ns depending on the pump pulse energy sets the ultimate speed of recovery of the ferromagnetic order.

[1] V. Moshnyaga *et al.*, Appl. Phys. Lett. 74, 2842 (1999).

MA 20.68 Mo 14:00 Poster TU C

New 3D coplanar wave guide design using organic isolation layers for ultrafast magnetic switching investigations — ●P. MARTIN PIMENTEL¹, H.T. NEMBACH¹, B. LEVEN¹, B. HILLEBRANDS¹, S. TRELLENKAMP², and S. WOLFF² — ¹FB Physik und FSP MINAS, TU Kaiserslautern, — ²Nano+Bio-Center, TU Kaiserslautern, Paul-Ehrlich-Str. 13, 67663

In order to push magnetic random access memory (MRAM) into the GHz operation regime, coplanar wave guides must be used for applying the magnetic field pulses. We have developed a complex 3D sample structure consisting of a base stack of three different microstructured field pulse lines isolated against each other which form the carrier of the magnetic element. In contrast to using inorganic isolation layers we improved the sample processing using the organic photoresist benzocyclobutene BCB (Dow Chemical, cyclothene™ 4026), which provides fast usage, high planarization, good isolation and flexibility to adjust the isolation layers to the sample design.

This work is supported by the EU-RTN ULTRASWITCH (HPRN-CT-2002-00318).

MA 20.69 Mo 14:00 Poster TU C

Ferromagnetic resonance in mesoscopic rectangular permalloy structures — ●P. REUTER, F. GIESEN, and D. GRUNDLER — Institut für Angewandte Physik und Mikrostrukturforschungszentrum, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The magnetization dynamics of miniaturized ferromagnets is increasingly interesting for applications in magnetic storage devices. We have studied the dynamics of 20 nm thin ferromagnetic permalloy films shaped to squares ($1 \times 1 \mu\text{m}^2$) and rectangles (1×2 and $1 \times 4 \mu\text{m}^2$) using network-analyzer ferromagnetic resonance (FMR) measurements in the range of 45 MHz to 20 GHz at room temperature. By electron beam lithography and lift-off processing of thermally evaporated $\text{Ni}_{80}\text{Fe}_{20}$ the permalloy structures were deposited in arrays on broadband coplanar wave guides. In our devices we find several FMR modes which shift systematically with the applied in-plane magnetic field H_b and which reflect the different domain configurations. We attribute these modes to localized spin waves. FMR frequencies up to 13 GHz are observed at 90 mT, higher than the uniform precession mode of 10 GHz in an unpatterned permalloy film. Through aligning H_b in hard- or easy-axis direction we have addressed the dynamics originating from the bulk area and from the edge area, respectively. We thank D. Heitmann and J. Podbielski. Financial support by the BMBF via 13N8283 is gratefully acknowledged.

MA 20.70 Mo 14:00 Poster TU C

Localized spin waves in nanostructured permalloy rings — ●JAN PODBIELSKI, FABIAN GIESEN, and DIRK GRUNDLER — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg.

Due to the increased data transfer rates in magnetoelectronic devices the dynamic properties of ferromagnetic nanostructures have become increasingly important. Using a broadband microwave spectrometer (45 MHz - 20 GHz) we have studied the ferromagnetic resonance (FMR) in periodic arrays of $\text{Ni}_{80}\text{Fe}_{20}$ rings. The outer diameter of the rings was $2 \mu\text{m}$ and the ringwidth w was varied in the different arrays down to 300 nm. The devices were deposited on broadband coplanar wave guides. For all rings we observe a series of FMR modes which shift characteristically as a function of w and external magnetic field. These modes are attributed to localized spin waves.[1] We developed an extended macrospin model subdividing the ring into characteristic segments which explains the observed features. Further intriguing observations are made on rings with a small width: hysteretic behavior and irreversible jumps of FMR modes as well as microwave assisted switching. We explain these features by the magnetic-field dependent spin configurations, namely the onion and vortex states in the rings. We thank D. Heitmann, T. Korn and M. Steiner. Financial support by the BMBF via 13N8283 and by the DFG is gratefully acknowledged.

[1] F. Giesen, J. Podbielski, T. Korn, and D. Grundler, J. Appl. Phys. (in press).

MA 20.71 Mo 14:00 Poster TU C

Magnetic excitations in finite rectangular elements — ●C. BAYER¹, J. JORZICK¹, H. SCHULTHEISS¹, B. HILLEBRANDS¹, S.O. DEMOKRITOV², A.N. SLAVIN³, K. GUSLIENKO⁴, and M.P. KOSTYLEV⁵ — ¹Fachbereich Physik and Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, Germany — ²Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Germany — ³Department of Physics, Oakland University, Rochester, Michigan 48309, USA — ⁴Materials Science Division, Argonne National Laboratory, Argonne, USA — ⁵St. Petersburg Electrotechnical University, 197376 St. Petersburg, Russia

We report on progress in the understanding of spin-wave modes in arrays of micron-size magnetic $\text{Ni}_{80}\text{Fe}_{20}$ stripes and rectangular elements. Several effects caused by the lateral confinement in the stripes are investigated using Brillouin light scattering: (i) lateral quantization of dipole-dominated Damon-Eshbach spin-wave modes in a longitudinally magnetized stripe due to its finite width, (ii) localization of exchange-dominated spin wave modes near the edges and dipole-dominated spin wave modes near the center of a transversely magnetized long magnetic stripe due to the inhomogeneity of its internal magnetic field, (iii) combination of quantization and localization effects for the spin wave modes in rectangular elements. The observed effects are analyzed theoretically using an analytical approach as well as numerical simulations. From the comparison of the latest experimental findings with the results of new calculations the mode spectrum of rectangular elements can now be described quantitatively with very good accuracy .

MA 20.72 Mo 14:00 Poster TU C

Ferromagnetische Resonanz an Fe/ZnSe detektiert mit nicht-zeitaufgelöstem Magnetooptischen Kerr-Effekt — ●MARC MÖLLER, DETLEF SPODDIG und RALF MECKENSTOCK — AG Festkörperspektroskopie, Institut für Experimentalphysik, Ruhr-Universität Bochum, D-44780 Bochum

In der Ferromagnetischen Resonanz (FMR) wird die Magnetisierung einer magnetischen Schicht zur Präzession um ihre Gleichgewichtslage angeregt. Die Präzession kann mit Hilfe des magnetooptischen Kerr-Effektes (MOKE) in einem konventionellen Aufbau ohne die Notwendigkeit der zeitaufgelösten Messung detektiert werden. Durch geeignete Wahl der Einfallsebene des Lichts können verschiedene Magnetisierungskomponenten selektiert werden. Für die Messung wird ein konventionelles FMR-Spektrometer mit offenem Zylinderresonator verwendet, so dass das anregende Mikrowellenfeld am Probenort wohldefiniert und homogen ist. Durch Verwendung eines fokussierten Laserstrahls wird eine Ortsauflösung im Mikrometerbereich erreicht. Es wurden (001)-Fe Schichten auf ZnSe mit ZnSe-Deckschicht untersucht und die Ergebnisse mit numerischen Simulationen verglichen.

Diese Arbeit wurde unterstützt vom Sonderforschungsbereich 491.

MA 20.73 Mo 14:00 Poster TU C

Ab initio Calculation of Excitation Spectra in Magnetic Materials — ●MANFRED NIESERT, CHRISTOPH FRIEDRICH, ARNO SCHINDLMAYR, and STEFAN BLÜGEL — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

Although spin-wave excitations play an important role in the thermodynamics of magnetic materials, theoretical studies are still mostly based on simple lattice systems with empirical parameters, such as the Heisenberg model. Constrained density-functional theory does not suffer from this disadvantage, but the frozen-magnon approximation restricts practical calculations to the adiabatic regime. Dynamical properties like excited-state lifetimes can only be obtained from a true many-body approach. The key quantity in this respect is the dynamical spin susceptibility. As a first step towards a full ab initio treatment, we investigate time-dependent density-functional theory at the level of the Kohn-Sham response function. This approach is inherently dynamical and can be made formally exact with the inclusion of an exchange-correlation kernel. In addition, quasiparticle excitations are studied using the *GW* approximation for the electronic self-energy. We assess the performance of these approaches for different classes of magnetic materials. The implementations are based on the full-potential linearized augmented plane-wave (FLAPW) method.

MA 20.74 Mo 14:00 Poster TU C

Near-field imaging of magnetic nanostructures with high lateral and temporal resolution — ●GEREON MEYER, ANDREAS BAUER, ANDREAS GORIS, and GÜNTER KAINDL — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin-Dahlem

Magnetic-domain patterns can be imaged with high magnetic contrast, sub-wavelength lateral resolution and in the presence of external magnetic fields by utilizing a scanning near-field optical microscope in combination with a Sagnac interferometer (Sagnac-SNOM), which measures the magneto-optical Kerr effect [1,2]. One major advantage of magneto-optics is the ability to study magnetization dynamics on ultrashort time scales. We report on first test measurements of time-resolved magneto-optical SNOM based on Sagnac interferometry: In a stroboscopic measurement, a femtosecond pulse of a frequency-doubled Ti:sapphire laser is split into two counter-propagating pulses of different intensity. One of them is used as pump pulse that optically excites the sample, the other, delayed one, probes the sample with a variable time delay. The non-reciprocal phase shift between the two pulses is a measure of the transient magnetization [2]. In this way, we intend to monitor spin-precessions in ultrathin films with a lateral resolution of < 150 nm.

[1] G. Meyer et al., Appl. Phys. Lett. **83**, 1394 (2003).

[2] G. Meyer, A. Bauer, and G. Kaindl, *Near-Field Imaging of Magnetic Domains*, in: *Progress in Nano-Electro Optics IV*, M. Ohtsu (ed.) (Springer, Berlin, 2005).

MA 20.75 Mo 14:00 Poster TU C

Dynamic properties of geometrically confined domain walls — ●FREDERIK WEGELIN¹, ALEXANDER KRASYUK¹, MATHIAS KLÄUI², HANS-JOACHIM ELMERS¹ und GERHARD SCHÖNHENSE¹ — ¹Johannes Gutenberg-Universität Mainz — ²FB Physik, Universität Konstanz

The critical property for the use of any ferromagnetic nanostructure in applications such as memory or sensor devices is the magnetodynamic switching. While switching by coherent rotation has been widely studied [1], recently switching by domain wall motion has become the focus of intense investigations, since large wall velocities have been observed by Kerr microscopy [2]. To gain a deeper understanding of the domain wall dynamics, we have probed the nanoscale domain wall spin structure in real time using time resolved photoemission electron microscopy (XMCD-PEEM). Micron-sized permalloy structures with square, round and ring geometries have been excited by field pulses down to 100ps length and the magnetization dynamics has been probed with 3ps long x-ray pulses. The propagation and the modification of the domain wall spin structure have been measured during the pulse injection. In particular we observe oscillatory behaviour of transverse head-to-head domain walls [3] in rings, when subjected to 300 ps field pulses.

[1] H. W. Schumacher et al., Phys. Rev. Lett. **90**, 17201 (2003) [2] D. Atkinson et al., Nature Mat. **2**, 85 (2003) [3] M. Kläui et al., J. Phys.: Condens. Matter **15**, R985 (2003)

MA 20.76 Mo 14:00 Poster TU C

Ground state and constrained domain walls in Gd/Fe multilayers — ●BAS B. VAN AKEN^{1,2}, JOSÉ L. PRIETO¹, and NEIL D. MATHUR¹ — ¹Department of Materials Science, University of Cambridge, Cambridge U.K. — ²present address: Max-Born-Institut, Berlin

The study of spin-polarised transport is key for the understanding of processes involved in spin-electronics. A particular interesting point is the effect of domain walls (DWs) on the transport properties of ferromagnetic materials. The magnetic ground state of antiferromagnetically coupled Gd/Fe multilayers and the evolution of in-plane domain walls is modelled with micromagnetics. The twisted state is characterised by a rapid decrease of the interface angle with increasing magnetic field. We found that for certain ratios of the Gd and Fe layer thicknesses, the twisted state is already present at low fields. However, the magnetic ground state is not only determined by the layer thickness ratio, or magnetic moment ratio. It is also effected by the thicknesses of the layers, that is the total moment of each layer. The dependence of the magnetic ground state is explained by the amount of overlap of the domain walls at the interface. Thicker layers suppress the Fe aligned state and the Gd aligned state in favour of the twisted state. On the contrary, ultrathin layers exclude the twisted state, since wider domain walls can not form in these ultrathin layers.

MA 20.77 Mo 14:00 Poster TU C

Magnetisch Wechselwirkende Permalloy Inseln auf Si(100) — ●CENGİZ BIRCAN, ANDREAS WESTPHALEN, ARNDT REMHOF und HARTMUT ZABEL — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

Wir haben das Ummagnetisierungsverhalten von periodisch angeordnete Permalloy (Ni₈₀Fe₂₀) Inseln in Abhängigkeit des lateralen Abstand untersucht. Die künstlich strukturierten magnetischen Inseln wurden mittels Elektronenstrahlolithographie und Ionensputtern hergestellt. Drei verschiedene Strukturen wurden realisiert: (i) 0.3 μm×3 μm×30 nm große Inseln, (ii) geschlossene und (iii) offene Rahmen von 0.3 μm Breite, 3 μm Länge und 30 nm Dicke. Die magnetische Charakterisierung erfolgte durch SQUID-Magnetometrie, Magneto-optischen Kerr Effekt (MOKE) und durch resonante magnetische Röntgenbeugung im Bereich der magnetisch sensitiven Absorptionskanten (L-Kanten). Sowohl bei der Röntgenbeugung als auch bei MOKE wurde insbesondere die spekulären Beugungsmaxima (Bragg-MOKE) untersucht. In Abhängigkeit von der Probengeometrie und der gewählten Abständen ändern sich sowohl das Koerzitivfeld als auch die magnetische Ausrichtung der einzelnen Py-Inseln. Bei den Rahmenstrukturen konnten je nach vorhergehender Aufmagnetisierung verschiedene remanente Anordnungen, wie z. B. der Vortex state, aber auch der sogenannte Onion state und der Horseshoe state realisiert werden.

Gefördert durch die DFG im Rahmen des SFB 491.

MA 20.78 Mo 14:00 Poster TU C

Magnetic domain structure of micro-patterned PtMn/CoFe exchange bias bilayers — ●M.O. LIEDKE^{1,2}, K. POTZGER¹, B. HILLEBRANDS², M. RICKART³, P. FREITAS³, and J. FASSBENDER¹ — ¹FZ Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, 01314 Dresden — ²Fachbereich Physik, TU Kaiserslautern, 67663 Kaiserslautern — ³INESC MN, 1000 Lisabon, Portugal

Using magnetron sputtering deposition a number of high exchange bias field samples were prepared for magnetic patterning investigations. The system prepared is as follow: glass/Ta 70 Å/PtMn 200 Å/ t_{CoFe} = 20 - 60 Å/Ta 40 Å. One of such bottom pinned samples with 40 Å of CoFe was used for optical lithography. Several patterns have been etched physically with decreasing lateral sizes of either the edges or the spacing between the elements. The largest square is 50 × 50 μm and the smallest only 1 μm². The separating lines are ranging from 10 μm to 2 μm width. The magnetic characterization of the samples have been done by VSM and MOKE. All samples exhibit well defined exchange bias field. A series of MFM images were taken from the structures. All images show a monodomain magnetization state in zero magnetic field. The shape of the structure itself dose not influence stray field direction. The shape anisotropy contribution is thus smaller than the unidirectional anisotropy given by the exchange bias. MFM investigation in an applied magnetic field have been done to get a deeper understanding of the domain pattern.

MA 20.79 Mo 14:00 Poster TU C

Untersuchungen an elektrolytisch abgeschiedenen Permalloy nano Strukturen mittels lokaler thermischer Ferromagnetischer Resonanz — ●D. SPÖDIG¹, M. V. RASTEI², M. BAIFFEUL², E. BEAUREPAIRE², R. MECKENSTOCK¹, J.-P. BUCHER² und J. PELZL¹ — ¹AG Festkörperspektroskopie, Ruhr-Universität Bochum, D-44780 Bochum, Deutschland — ²IPCMS, Université Louis Pasteur, F-67037 Strasbourg Cedex, Frankreich

Magnetische Untersuchungen von nano-strukturierten Probensystemen werden von immer größerer Bedeutung. In diesem Beitrag werden lateral strukturierte Permalloy(Py)-Schichten auf Si-Substraten untersucht. Die Strukturierung erfolgt durch Elektronenstrahlolithographie. Als Strukturen wurden Streifen mit 80 Mikrometer Länge und Breiten zwischen 200 und 500 nm gewählt. Der Abstand wurde zwischen 200 und 1000 nm variiert. Durch einen elektrolytischen Prozess wurde die Py-Schicht abgeschieden. Da der Fotolack nicht entfernt wird, sind die Kanten der Strukturen wohl definiert. Die lokale Detektion der Ferromagnetischen Resonanz (FMR) erfolgt durch ein scannendes thermisches Mikroskop (SthM), welches durch einen Temperatursensor (100 nm Auflagefläche) an der Spitze des eingesetzten Cantilevers eine Temperaturänderung im mK-Bereich feststellen kann. Eine solche Erwärmung wird in der Probe durch die FMR Absorption erzeugt. Durch die lokale Detektion ist es möglich das Signal der FMR in der Mitte, am Rand und den Enden der Streifen zu untersuchen. Einflüsse durch die Formanisotropie können dabei diskutiert werden. Unterstützt von SFB 491.

MA 20.80 Mo 14:00 Poster TU C

Nanoscale Mechanosynthesized Magnesium Ferrite with Enhanced Magnetization — •VLADIMIR ŠEPELÁK¹, INGO BERGMANN², FRANK KRUMEICH³, DIRK MENZEL⁴, and KLAUS DIETER BECKER² — ¹Center for Solid State Chemistry and New Materials, University of Hannover, 30167 Hannover, Germany; on leave from Slovak Academy of Sciences, Košice, Slovakia — ²Institute of Physical and Theoretical Chemistry, TU Braunschweig, 38106 Braunschweig, Germany — ³Laboratory of Inorganic Chemistry, Swiss Federal Institute of Technology Zurich, 8093 Zurich, Switzerland — ⁴Institute of Semiconductor Physics and Optics, TU Braunschweig, 38106 Braunschweig, Germany

Nanosized spinel-type ferrites are currently key materials for advancements in electronics, magnetic storage, ferrofluid technology, optoelectronics, and in many bioinspired applications (for example, as drugs carriers for magnetically guided drug delivery and as contrast agents in magnetic resonance imaging). In this contribution, nanocrystalline magnesium ferrite (MgFe_2O_4) with crystallite size of 8 nm has been synthesized by high-energy milling method from a mixture of $\alpha\text{-Fe}_2\text{O}_3$ and MgO. High-field Mössbauer spectroscopy, X-ray powder diffraction, transmission electron microscopy, and magnetization (SQUID) measurements have been used to investigate the structural and magnetic states of the nanoscale mechanosynthesized spinel ferrite. Several interesting features are involved in the work, e.g., superparamagnetism and an irreversible magnetic behavior. The observed enhancement of the magnetization in nanosized mechanosynthesized MgFe_2O_4 is discussed with respect to the non-equilibrium cation distribution and spin canting.

MA 20.81 Mo 14:00 Poster TU C

Investigation of $(\text{Fe}_{(1-x)}\text{Co}_x)_{(1-y)}\text{Pt}_y$ nanoparticles by different electron microscopic methods — •DANIELA SUDFELD¹, INGA ENNEN¹, ANDREAS HÜTTEN¹, GÜNTER REISS¹, DANIEL MEISSNER², KLAUS WOJCZYKOWSKI², and PETER JUTZI² — ¹Thin Films and Nanostructures, Department of Physics, University of Bielefeld, Universitätsstr. 25, D-33615 Bielefeld, Germany — ²Inorganic Chemistry III, Department of Chemistry, University of Bielefeld, Universitätsstr. 25, D-33615 Bielefeld, Germany

Today iron oxide particles are used for diverse biological or medical applications as magnetic carriers, for example. For the next generation of magnetic markers ligand stabilized $(\text{Fe}_{(1-x)}\text{Co}_x)_{(1-y)}\text{Pt}_y$ nanoparticles are interesting to substitute the usually used beads. Especially analytical and high-resolution transmission electron microscopy is a primary tool to investigate the ternary alloyed nanocrystals. Additionally the particles have been investigated by other methods like transmission scanning electron microscopy, x-ray analyses and magnetization measurements. The combination of all techniques give closer insights in the formation and composition of the $(\text{Fe}_{(1-x)}\text{Co}_x)_{(1-y)}\text{Pt}_y$ cluster, the particle size distributions, self-assembling and magnetization behavior.

MA 20.82 Mo 14:00 Poster TU C

Growth Kinetics and Magnetic Properties of Alloyed Fe/Co Nanoparticles — •KLAUS WOJCZYKOWSKI¹, DANIELA SUDFELD², INGA ENNEN², ANDREAS HÜTTEN², and PETER JUTZI¹ — ¹Inorganic Chemistry III, Department of Chemistry, University of Bielefeld, Universitätsstr. 25, D-33615 Bielefeld, Germany — ²Thin Films and Nanostructures, Department of Physics, University of Bielefeld, Universitätsstr. 25, D-33615 Bielefeld, Germany

Future applications of magnetic nanoparticles will require well-defined magnetic properties of these systems. Monodisperse Nanoparticles of the high-moment iron-cobalt-alloy were synthesized by the co-decomposition of metalorganic cobalt and iron precursors in solution. We found a strong dependence between particle composition and precursor decomposition kinetics. The use of $\text{Co}_2(\text{CO})_8$ as cobalt precursor and $\text{Fe}(\text{CO})_5$ as iron precursor can lead to a core shell structure with iron enriched at the particle surface. Faster decomposing iron precursors of the type $\text{Fe}(\text{CO})_4\text{L}$, where L means donor-ligand, can reverse the situation. Microstructural and magnetic methods are used to elucidate the true structure of the alloyed Fe/Co system.

MA 20.83 Mo 14:00 Poster TU C

Interface Magnetism in Co/CoO core-shell nanoparticles — •U. WIEDWALD¹, H.-G. BOYEN¹, J. EISENMENGER¹, F. WEIGL¹, K. ZÜRN¹, P. ZIEMANN¹, K. FAUTH², J. LINDNER³, M. SPASOVA³ und M. FARLE³ — ¹Abteilung Festkörperphysik, Universität Ulm, D-89069 Ulm — ²Experimentelle Physik IV, Universität Würzburg, Am Hubland, D-97074 Würzburg — ³Institut für Physik, Universität Duisburg-Essen, D-47048 Duisburg

Colloidal Co particles (9-13 nm) were prepared by organometallic synthesis. The magnetism of these particles is heavily influenced by unavoidable surface modifications due to the attachment of hydro-carbonic ligands and the formation of a 2-3 nm thick antiferromagnetic CoO layer. To study the magnetic response of both Co/CoO core-shell particles and ligand-free metallic particles we employed a combination of hydrogen and oxygen plasma treatments. The degree of surface oxidation/reduction was tracked by x-ray absorption spectroscopy. By combining para/ferromagnetic resonance techniques with x-ray magnetic circular dichroism we quantitatively address the interface magnetism of the particles. Core-shell Co/CoO particles show a rigorous increase in the ratio of orbital-to-spin magnetic moment while metallic Co particles reveal the expected fcc bulk-like behaviour for particles with a low ratio of surface-to-volume atoms ($d > 8$ nm). The separation of the magnetic dichroism of Co atoms in metallic and oxidic environments suggests that the exchange coupling at the interface favours parallel alignment. All results are compared with detailed structural analysis by high-resolution transmission electron microscopy.

MA 20.84 Mo 14:00 Poster TU C

Monte Carlo simulations for Hollow Invar Nanoparticles — •SANJEEV K. NAYAK, MARKUS E. GRUNER, and PETER ENTEL — Institute of Physics, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany

Monte Carlo simulations for $\text{Fe}_{65}\text{Ni}_{35}$ hollow spherical Invar nanoparticles have been performed with an effective spin-1 Ising model with coupled magnetic and spatial degrees of freedom taking into account the occurrence of high and low magnetic moments in Fe rich $\gamma\text{-FeNi}$ alloys. Heating the system up above the Curie point starting from the ferromagnetic ground state and subsequent cooling breaks the system into domains. This effect depends on the size of the particle and the thickness of the shell. The energy difference between the domain state and the ferromagnetic phase is very low due to the fact that the low spin atoms form the domain boundary. To compare these results similar calculations were performed on pure hollow Ni nanoparticles.

MA 20.85 Mo 14:00 Poster TU C

Magnetoelastic properties and stability of hollow nanocomposites — •MARKUS E. GRUNER, SANJEEV K. NAYAK, and PETER ENTEL — Institute of Physics, Universität Duisburg-Essen, Campus Duisburg, D-47048 Duisburg

We investigate the magnetic and elastic properties of hollow spherical nanocomposite systems using the Hybrid Monte Carlo method. The nanocomposites consist of ferromagnetic nanoparticles with a diameter of 14 nm, which are arranged densely packed on the surface of a sphere. The magnetic coupling is described by dipolar interactions, whereas the elastic properties are given by pair potentials. We consider especially the stability and deformation of the systems under the influence of a magnetic field and external pressure.

MA 20.86 Mo 14:00 Poster TU C

Kettenbildung bei dipolaren magnetischen Nanopartikeln — •STEPHAN BUSCHMANN, ALFRED HUCHT und PETER ENTEL — Theoretische Physik, Universität Duisburg-Essen und SFB 445, 47048 Duisburg

Neue Untersuchungen an Fe- und Ni-Nanopartikeln aus der Gasphase zeigen, dass diese sich unter bestimmten Bedingungen in Form langer Ketten anordnen [1]. Es wird angenommen, dass die Dipolwechselwirkung zwischen den magnetischen Nanopartikeln Ursache für die Kettenbildung ist.

Dieser Kettenbildungsübergang wird theoretisch mit Hilfe von Molekulardynamik-Simulationen untersucht. Hierbei kann auch eine Rückwirkung der Partikelkonfiguration auf den inneren Zustand (magnetisches Moment) der Partikel berücksichtigt werden. Es werden Phasendiagramme in den Variablen Partikelgröße, Temperatur und Magnetfeld präsentiert.

[1] J. Knipping *et al.*, Nanotechnology 15, 1665 (2004).

MA 20.87 Mo 14:00 Poster TU C

Jahn–Teller Effect in $CuFe_2O_4$ Nanoparticles — ●BALAJI GOPALAN¹, JÖRG WEISSMÜLLER^{1,2}, and NAMDEO GAJBHIYE³ — ¹Institute for Nanotechnology, Forschungszentrum Karlsruhe, P. O. Box 3640, D-76021, Germany — ²Universität des Saarlandes, Fachrichtung Technische Physik, Saarbrücken, P.O. Box 151150, D-66041, Germany — ³Department of Chemistry, Indian Institute of Technology, Kanpur, 208016 India

Nanosize $CuFe_2O_4$ particles are prepared by coprecipitation method. The particles of various sizes are obtained by heat treatment at temperatures between 573–1273 K and are characterized by X–ray diffraction, Mössbauer spectroscopy and magnetization measurements. X–ray diffraction pattern indicates that the crystal structure of nanosize $CuFe_2O_4$ particles obtained above 973 K is tetragonal while that prepared below 973 K is cubic. The room temperature Mössbauer spectrum indicates that the isomer shift, quadrupole splitting and hyperfine field values are found to change with heat treatment temperature. These changes in Mössbauer parameters may also be due to the Jahn–Teller effect that essentially arises due to the migration of Cu^{2+} ions from tetrahedral sites to octahedral sites resulting in crystal structure change from cubic to tetragonal system. The maximum coercivity obtained has been 700 Oe at heating temperature of 823 K. The enhanced coercive force can be mainly attributed to uniaxial magnetic anisotropy produced by crystal distortion.

MA 20.88 Mo 14:00 Poster TU C

FMR an Fe_xPt_{1-x} Nanopartikeln: Messung der temperaturabhängigen Anisotropieenergie — F. WIEKHORST^{1,2}, ●D. GÖRLITZ¹ und J. KÖTZLER¹ — ¹Institut f. Angewandte Physik, Univ. Hamburg, 20355 Hamburg — ²Physikalisch-Technische Bundesanstalt, 10587 Berlin

Es werden zwischen 10 K und 500 K bei 9 GHz gemessene FMR-Spektren von 4–6 nm großen Pt-reichen nanokristallinen FePt-Partikeln untersucht. Die zu tiefen Temperaturen zunehmend breiter werdenden Resonanzen lassen sich sehr gut mit der Gilbert-Shape beschreiben, die das Resonanzfeld und den Gilbert-Parameter definiert. Aus Magnetisierungs- und AC-Suszeptibilitätsmessungen [1] ist eine starke Anisotropie bekannt, woraus $H_A(0) > \omega/\gamma$ resultiert. Für diesen Fall gibt es kein analytisches Modell zur Analyse der FMR-Spektren. Wir beschreiben daher ein Mittelungsverfahren für die Resonanzfeldstärke, dessen Ergebnisse recht gut mit vorliegenden temperaturabhängigen Anisotropieenergien aus aufwendigen Analysen von Magnetisierungsisothermen [2] übereinstimmen.

[1] F. Wiekhorst et al., Phys. Rev. B 67, 224416 (2003)

[2] F. Wiekhorst et al., J.Magn.Magn. Mat.272-276 ,1559 (2004)

MA 20.89 Mo 14:00 Poster TU C

Magnetization of blocked magnetic nanoparticles — ●H. BREMERS, O. MICHELE, and J. HESSE — Institut für Metallphysik und Nukleare Festkörperphysik, Technische Universität, Mendelssohnstrasse 3, D-38106 Braunschweig, Germany

The basic properties of magnetic nanoparticle systems can be understood in the highly idealized well known Stoner-Wohlfart (SW) model. The simplicity of this model sometimes becomes more complex when considering the energy minima of the particles magnetic moments and very special the equilibrium angles corresponding with respect to the direction of the applied external magnetic field [1]. We show that in a rather simple vector model representing the effective behaviour of the nanoparticle system the estimation of the mean equilibrium angles can be simplified. The description of the magnetization of a blocked nanoparticle system versus magnetic field becomes easy and applicable to measurements performed on real magnetic particle systems. [1] H. Pfeiffer, phys. stat. sol. (a) 118(1990)295-306.

MA 20.90 Mo 14:00 Poster TU C

Magnetization measurements on frozen ferrofluids - an attempt to separate interaction and anisotropy influences — ●H. BREMERS, O. MICHELE, and J. HESSE — Institut für Metallphysik und Nukleare Festkörperphysik, Technische Universität, Mendelssohnstrasse 3, D-38106 Braunschweig, Germany

In this contribution we focus on a novel way to perform magnetization experiments on frozen ferrofluids or magnetic nanoparticles fixed in space. The basic idea is to project the behaviour of a real particle system onto a Stoner-Wohlfart (SW) particle ensemble behaviour. Therefore first an ideal SW particle system with unique size and orientation of easy axis was

studied numerically by introducing a particle - particle interaction via an demagnetizing field. We have shown that for non-interacting SW particles the universal mean value rule holds that the magnetization measured after ZFC (zero field cooling) can be expressed as a mean value of the magnetization measured after PHFC and NHFC (positive and negative high field) [1] cooling processes. Any deviation from this mean value rule is due to interactions only and can be derived from the magnetization measurements and assigned to equivalent behaviour of a SW particles system. By this new method it is possible to determine the mean value of the particles anisotropy and the mean interaction which is expressed as magnetic field. [1] O. Michele, J. Hesse, H. Bremers, E.K. Polychroniadis, K.G. Efthimiadis, H. Ahlers; J. Phys.: Cond. Matter 16 (2004) 427-443

MA 20.91 Mo 14:00 Poster TU C

Magnetic property of a weakly interacting nanoparticle system — ●XI CHEN¹, SUBANKAR BEDANTA¹, WOLFGANG KLEEMANN¹, S. CARDOSO², and P. P. FREITAS² — ¹Angewandte Physik, Universität Duisburg-Essen, D-47048 Duisburg, Germany — ²INESC, Rua Alves Redol 9-1, 1000, Lisbon, Portugal

The magnetic property of a weakly interacting nanoparticle system $[CoFe(0.7\text{ nm})/Al_2O_3(3\text{ nm})]_{10}$ is investigated by a Superconducting Quantum Interference Device (SQUID) magnetometer. The temperature T dependence of the field cooled magnetization shows a clear increase at low temperature following a simple Curie law, which can be due to the “lost” spins undetectable in Transmission Electron Microscopy (TEM) images. The relaxation curves of the thermoremanent magnetic moment at different temperatures collapse onto one master curve under $T \ln(t/\tau_0)$ scaling. Aging and memory effects are also observed, which evidence a collective spin glass-like behavior in this nanoparticle system.

MA 20.92 Mo 14:00 Poster TU C

Segregation properties of Fe-Ni clusters — ●SANJUBALA SAHOO, GEORG ROLLMANN und PETER ENTEL — Theoretical Low-Temperature physics, University of Duisburg-Essen, Lotharstr. 1, D-47048 Duisburg

Structure optimisation of Fe_nNi_{N-n} clusters has been performed using density functional theory and the generalised gradient approximation allowing for noncollinear magnetisation density. The calculations are carried out without imposing any symmetry constraints. Evaluation of the mixing energy of the clusters shows that mixed clusters are energetically more favourable than pure Fe and Ni clusters. Furthermore, the mixing energy not only depends on the size and composition of the clusters but also on their geometrical structures. Significant difference in energy is found for different arrangement of Fe and Ni atoms in the mixed cluster.

MA 20.93 Mo 14:00 Poster TU C

Entwicklung von Leiterbahnstrukturen zum Transport von magnetischen Teilchen — ●A. SHOSHI, M. PANHORST und H. BRÜCKL — Universität Bielefeld, Fakultät für Physik, Universitätsstr. 25, 33615 Bielefeld

Paramagnetische Teilchen, wie beispielsweise Fe_3O_4 Beads, die in vielen unterschiedlichen Konfigurationen für biotechnologische Anwendungen kommerziell erhältlich sind, lassen sich durch externe Magnetfelder manipulieren.

Bei dem hier vorgestellten on-chip Manipulationssystem erzeugen Ströme durch Leiterbahnen radiale Magnetfelder, die den Transport von magnetischen Markern und eine genaue Positionierung auf der Chipoberfläche ermöglichen. Diese Magnetfelder können durch zusätzliche ferromagnetische Schichten, die als Flusskonzentratoren wirken, verstärkt werden. Direkt auf die Gold-Leiterbahnen wird dazu eine ferromagnetische Schicht variabler Dicke gesputtert. Die Leiterbahnstrukturen bestehend aus Gold und Permalloy (NiFe) werden auf einem Si-Wafer mit optischer Lithographie strukturiert. Der Transport paramagnetischer Teilchen in Flüssigkeiten ist in einem optischen Mikroskop beobachtbar und die wirkenden Kräfte auswertbar.

MA 20.94 Mo 14:00 Poster TU C

Ferromagnetic filled carbon nanotubes: Synthesis, magnetic properties and delivery into human tumor cells — ●I. MÖNCH¹, A. MEYE², D. ELEFANT¹, S. NING², R. KOZHUHAROVA¹, M. RITSCHHEL¹, T. GEMMING¹, J. ACKER¹, and A. LEONHARDT¹ — ¹Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Helmholtzstr. 20, D 01069 Dresden, Germany — ²Department of Urology, Technical University of Dresden, Fetscherstrasse 74, D 01307

We describe the synthesis and the properties of Fe-filled multi-walled carbon nanotubes (MWNTs) produced by chemical vapor deposition (CVD) for biomedical applications. The magnetic properties and the interaction of the material with human cancer cells were determined. The preincubation of the nanotube suspension with cationic lipid caused an efficient delivery of the lipid-nanostructure complexes into the cytoplasm within two hours after adding to the culture medium /1/. The Fe-concentration in the cells was determined by chemical analyses. These results are in good agreement with the magnetic measurements (AGM, SQUID).

/1/ I. Mönch, A. Meye, A. Leonhardt, K. Krämer, R. Kozhuharova, T. Gemming, M.P. Wirth, and B. Büchner; JMMM (in press)

MA 20.95 Mo 14:00 Poster TU C

Quantitative imaging of magnetization distributions of nanostructured ferromagnetic films — ●SEBASTIAN DREYER¹, CHRISTIAN JOOSS¹, SIBYLLE SIEVERS², MARTIN ALBRECHT² und UWE SIEGNER² — ¹Institut für Materialphysik, Universität Göttingen, D-37077 Göttingen — ²Physikalisch-Technische Bundesanstalt, D-38116 Braunschweig

An important issue of nanomagnetism is a full quantitative mapping of magnetization distributions also with a great importance for high-density magnetic recording applications. We report on the development of a quantitative spatially resolved measurement technique with a spatial resolution of $\sim 500\text{nm}$ and its application to the mapping of magnetization distributions of patterned ferromagnetic films. This quantitative magnetic imaging is based on magneto-optics, using the Faraday effect in advanced sensor films, for nanostructures with a size down to $\sim 700\text{nm}$ and smaller sizes in combination with MFM measurements. The stray field imaging was performed on Permalloy, Co and CoPt nanostructures in the thickness range of $2\mu\text{m}$ down to 10nm .

Co as example for inplane magnetized structures and CoPt nanostructures with a perpendicular anisotropy serve as test systems for the two limits of pure in- and pure out-of-plane magnetization. Results of an advanced inversion method, based on the Fourier transform ansatz, for the determination of magnetization distributions from the measured stray field are presented for these systems.

MA 20.96 Mo 14:00 Poster TU C

Herstellung von speziellen MFM-Cantilevern für HF-MFM — ●MICHAEL R. KOBLISCHKA¹, MICHAEL KIRSCH¹, UWE HARTMANN¹ und THOMAS SULZBACH² — ¹FR Experimentalphysik, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken — ²Nanoworld Services GmbH, Schottkystrasse 10, D-91058 Erlangen

Für die magnetische Abbildung werden bei der Hochfrequenz-MFM (HF-MFM)-Technik MFM-Cantilever benötigt, die auch bei hohen Frequenzen (derzeit bis zu 650MHz , geplant bis 2GHz) noch eine magnetische Hysterese aufweisen. Aus diesem Grund besputtern wir kommerzielle, mikrostrukturierte Si-Cantilever mit verschiedenen Ferrit- und Granat-Schichten. Die Herstellungsparameter der Schichten auf (100)-Si Substraten und Cantilevern und die resultierenden Eigenschaften werden im Detail diskutiert.

Diese Arbeit ist Teil des EU-Projektes 'ASPRINT'.

MA 20.97 Mo 14:00 Poster TU C

Study of the micromagnetic structure of a $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ film — ●MICHAEL ZIESE — University of Leipzig, Division of Magnetism and Superconductivity, Linnéstrasse 5, 04103 Leipzig

The magnetic domain-structure of easy-plane $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ films has been studied by various groups and a "feather-like" pattern has been typically observed, see e.g. [1]. This pattern was recently interpreted as arising from magnetic ripples, a substructure of magnetic domains [2]. In this work the micromagnetic structure of a $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ film was studied using magnetic force microscopy and micromagnetic simulations. For a 150nm thick epitaxial, strain relaxed film grown on SrTiO_3 evidence is shown from experiment and simulation that magnetic domains

have a typical size of $1\mu\text{m}$ at room temperature and well explain the "feather-like" pattern.

[1] J. Dho, Y. N. Kim, Y. S. Hwang, J. C. Kim and N. H. Hur, Appl. Phys. Lett. **82**, 1434 (2003).

[2] Y.-A. Soh, G. Aeppli, C.-Y. Kim, N. D. Mathur and M. G. Blamire, J. Appl. Phys. **93**, 8322 (2003).

MA 20.98 Mo 14:00 Poster TU C

Simulation of magnetic force microscopy of MnAs/GaAs(001) — ●ROMAN ENGEL-HERBERT, JYOTI MOHANTY, and THORSTEN HESJEDAL — Paul-Drude-Institut, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Magnetic force microscopy (MFM) is a commonly employed tool for the micromagnetic investigation of a sample, however, the quantitative interpretation and analysis of MFM experiments is difficult. We performed a more realistic simulation based on the extended tip model. This allows a more accurate description of the tip-sample interaction in the near-field, as compared to the commonly applied point-dipole model. Following this approach one is able to predict optimal scan parameters (working distance, oscillation amplitude of the cantilever) and tip properties for a given experimental problem. The simulation was applied to MnAs thin films that exhibit a self-organized array of ferromagnetic stripes in the phase-coexistence regime. The magnetic domain structure is governed by the strong uniaxial anisotropy and shape anisotropy of the film that lead to simple domain configurations, where the magnetic moments are all aligned in-plane along the easy axis direction of the film. Therefore the individual domains can be approximated by bar magnets, for which we derived an analytical solution for the magnetic stray field.

MA 20.99 Mo 14:00 Poster TU C

Lokale thermische Detektion der Ferromagnetischen Resonanz an Permalloy-Streifen Gittern — ●IGOR BARSUKOV¹, DETLEF SPODDIG¹, RALF MECKENSTOCK¹, CENGIZ BIRCAN², ARNDT REMHOF² und HARTMUT ZABEL² — ¹AG Festkörperspektroskopie, Institut für Experimentalphysik III, Ruhr-Universität Bochum, D-44780 Bochum — ²Institut für Experimentalphysik IV, Ruhr-Universität Bochum, D-44780 Bochum

Die lokale Detektion der Ferromagnetischen Resonanz (FMR) an nanostrukturierten magnetischen Systemen ist von immer größerem Interesse. Dabei ist insbesondere die Untersuchung einzelner Strukturen von Bedeutung. In diesem Beitrag zeigen wir erstmals den Nachweis der FMR mittels Detektion der Temperaturänderung in einer Nano-Struktur durch die absorbierte Mikrowellenleistung. Dazu wurde ein scannendes thermisches Mikroskop (SthM) eingesetzt. Der Temperatursensor an der Spitze ist in der Lage, Temperaturänderungen im mK-Bereich nachzuweisen bei einer Auflagefläche von ca. 100nm Durchmesser. Die untersuchten Proben waren Permalloy-Streifen mit 1000nm Länge und 300nm Breite, die zwei senkrecht aufeinander stehende Untergitter bilden. Es werden die konventionellen und die orts aufgelösten FMR Ergebnisse miteinander verglichen. Die beobachteten zwei Resonanzen in der konv. FMR konnten eindeutig den beiden Untergittern zugeordnet werden. Bei der orts aufgelösten SthM-FMR wurden sowohl einzelne Spektren an festen Positionen auf den Nano-Strukturen als auch Image-Scans der thermischen Response an den Positionen der beiden Hauptresonanzfeldern aufgenommen. Unterstützt vom SFB 491.

MA 20.100 Mo 14:00 Poster TU C

Photoelektronenbeugung (PED) und magnetischer Dichroismus in Rumpfniveau-Photoemission von Fe und Co — ●C. BETHKE¹, N.B. WEBER², F.U. HILLEBRECHT³ und A. CHASSÉ⁴ — ¹Inst. f. Angewandte Physik, Uni Düsseldorf, 40225 Düsseldorf. — ²Focus GmbH, 65510 Hünstetten — ³IFF, FZ Jülich, 52425 Jülich — ⁴FB Physik, MLU Halle, 6099 Halle

Photoemissionsspektren von Rumpfniveaus magnetischer Festkörper zeigen i.A. magnetischen Dichroismus. Bei kristallinen Proben wird die Größe des magnetischen Dichroismus durch Photoelektronenbeugung beeinflusst. Außerdem ist eine Beeinflussung der Spektren durch spinabhängige Streuung der Photoelektronen möglich. Für PE aus dem $3s$ -Niveau variiert das Intensitätsverhältnis I/I_0 von Hauptlinie zur Gesamtintensität um den Mittelwert von 0.7 , wobei gilt $\Delta(I/I_0)(\Theta) = -\Delta(I/I_0)(-\Theta)$. Ähnliches Verhalten wurde im magnetischen Dichroismus für die $3p$ und die $2p$ Niveaus beobachtet. Die entgegengesetzte Abweichung vom mittleren Intensitätsverhältnis bzw. Dichroismus beiderseits der senkrechten Emissionsrichtung identifiziert den Bahndrehimpulscharakter der auslaufenden Photoelektronenwelle als bestimm-

mende Eigenschaft. Die Daten sind in Übereinstimmung mit Rechnungen zur Photoelektronenbeugung, die auf Mehrfach-Streuung in einem Cluster-Modell basieren, und die Austauschwechselwirkung der Spin-Bahn-aufgespaltenen Rumpfniveau-Zustände mit dem spinpolarisierten Valenz-Zuständen enthalten.

MA 20.101 Mo 14:00 Poster TU C

Variation of the Magnetic Moment of Nickel by Electrochemical Charging — ●CHRISTIAN LEMIER¹, SADHAN GHOSH¹, JÖRG WEISSMÜLLER^{1,2}, and RAGHAVAN N. VISWANATH¹ — ¹Institut für Nanotechnologie, Forschungszentrum Karlsruhe GmbH — ²Fachrichtung Tech. Physik, Universität des Saarlandes

It has been proposed that changes in the electronic structure in superficial space-charge regions may substantially affect the properties of metals near the surface [1]. In nanostructured materials, due to the high surface to volume ratio, even changes in a thin surface layer involve considerable amounts of the volume fraction. Therefore, these materials can be used to study the effect of charging on the surface properties. An implementation of this principle is to use a nanoporous material immersed in an electrolyte. Application of an electric field gives rise to an electric double layer region at the metal-electrolyte interface and allows to store a considerable amount of charge. Recently, changes in the lattice parameter of nanoporous Pt [2] and macroscopically bending of nanoporous Au cantilevers [3] have been observed. Here, we examine the possibility of tuning of the magnetic moment of Ni, deposited with a few monolayer thickness on nanoporous Au, and on high surface area Carbon. Changes in the magnetic moment of up to 10% have been observed by in-situ charging experiments. Special focus has been on the discrimination of the relative influence of band-filling versus that of hydride formation, OH adsorption and oxidation. [1] H. Gleiter, et al., *Acta Mater.* 49 (2001), 737. [2] J. Weissmüller, et al., *Science* 300 (2003), 312. [3] D. Kramer, et al., *Nano Lett.* 4 (2004), 793.

MA 20.102 Mo 14:00 Poster TU C

Reduced Magnetic Ordering Temperatures in Polycrystalline Ho Films — ●E. SCHIERLE, E. WESCHKE, and G. KAINDL — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

The magnetic structure and ordering temperatures of polycrystalline Ho metal films were studied by magnetic x-ray scattering at the Ho- M_5 resonance. Ho metal is characterized by a long-period helical magnetic structure with a period of 10 layers at 40 K. As recently demonstrated, the helical magnetic ordering temperature drops substantially in single-crystalline films with thicknesses comparable to the length of the magnetic period [1]. In the polycrystalline films, we observe a substantial reduction of the ordering temperature even in films as thick as 100 layers, where finite-size effects are expected to be absent. This shows that the magnetic coherence does not extend across the whole film, i.e. exchange coupling across the grain boundaries is negligible and the helical domains are limited to the individual grains. The work was supported by the BMBF, project 05 KS1KEE/8.

[1] E. Weschke *et al.*, *Phys. Rev. Lett.* **93**, 157204 (2004).

MA 20.103 Mo 14:00 Poster TU C

Charakterisierung von Fe/GaAs(110) Grenzflächen mittels Ballistischer Elektronen Emissions Mikroskopie — ●SANDRA SCHMAUNZ, JOHANN VANCEA und CHRISTIAN H. BACK — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93040 Regensburg, Germany

Die Spininjektion aus einem ferromagnetischen Metall über die Schottky - Barriere in einen Halbleiter ist für zukünftige Bauelemente der Spintronik von entscheidender Bedeutung. Die lokale Beschaffenheit der Metall / Halbleiter Grenzfläche hat dabei einen entscheidenden Einfluss. Als Untersuchungsmethode bietet sich dafür die Ballistische Elektronen Emissions Mikroskopie (BEEM) an. Dazu wurden epitaktische Fe - Schichten auf GaAs(110) Spaltkanten hergestellt und mit Au abgedeckt. Mittels BEEM im UHV konnten lokale IU - Kennlinien mit einer lateralen Auflösung von ca. 1nm gemessen werden. Die Auswertung dieser Kennlinien führten folglich zur Bestimmung der lokalen Schottky - Barrierenhöhen.

MA 20.104 Mo 14:00 Poster TU C

Atomic structure and magnetic properties of MnSi thin films — ●M. HORTAMANI, P. KRATZER, and M. SCHEFFLER — Fritz Haber Institut der Max-Planck Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Epitaxial manganese silicide compounds are promising candidates as materials for magneto-electronic and spintronic devices. We compare the structural and magnetic properties of Mn-silicide films on Si(111) and Si(001) surfaces using density functional theory calculations performed with the full-potential augmented plane wave plus local orbital method (FP-LAPW+lo). Experimental studies find initial epitaxial growth of Mn or Mn_xSi_y clusters in the Volmer-Weber growth mode on both Si(001) and Si(111) substrates, which later grow together to form a rough thin film in case of Si(111). Our calculations show that ferromagnetic manganese-silicon multilayers are the most stable epitaxial films on both surfaces. These films have a CsCl-like atomic structure with a lattice mismatch of less than 2% to the substrate. Their formation is exothermic in thermodynamic equilibrium with bulk Mn, and endothermic in equilibrium with bulk MnSi. Moreover, MnSi films with CsCl-like structure on Si(111) are found to be more stable than films of other epitaxial silicides, such as Mn_3Si or Mn_5Si_3 . The Mn magnetic moments are as high as $1.8 \mu_B$ at the surfaces and interfaces, and saturate at $0.3 \mu_B$ in the interior of the film. The calculated spin polarization at the Fermi level for CsCl-like MnSi on Si is higher than 30% and for the (001) interface, and 35% for the (111) interface, which opens up the possibility for a highly spin-polarized current to be injected into the Si substrate.

MA 20.105 Mo 14:00 Poster TU C

Co-doped zinc oxide — ●M. LÜBBE¹, K.-W. NIELSEN¹, A. ERB¹, J. SIMON², W. MADER², L. ALFF¹, M. OPEL¹, and R. GROSS¹ — ¹Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, D-85748 Garching — ²Institut für Anorganische Chemie, Rheinische Friedrich-Wilhelm Universität, D-53117 Bonn

Due to their potential application in spintronics diluted magnetic semiconductors have attracted much interest. In particular, thin films of ZnO with a few atomic percent of a transition element substituted for zinc are studied intensively. Recently, a model based on a narrow impurity band [1] has been proposed for explaining the ferromagnetic exchange in ZnO. According to this model, $Zn_{1-x}Co_xO$ is expected to show ferromagnetism at room temperature and hence has attracted broad interest.

We have prepared quasi-homoepitaxial $Zn_{0.95}Co_{0.05}O$ and $Mn_{0.95}Co_{0.05}O$ films on ZnO substrates by UHV pulsed laser deposition with substrate temperatures ranging between room temperature and 600°C and different background atmospheres (Ar or Ar + 1% O_2). During growth the thin films are characterized by in-situ RHEED. Furthermore X-ray diffraction and reflectometry as well as transmission electron microscopy have been applied for structural characterization. The magnetic properties have been analyzed by SQUID magnetometry and magnetotransport experiments. The Co substituted samples show ferromagnetic hysteresis at room temperature and a saturation magnetization of up to $1\mu_B/Co$.

This work is supported by the DFG via SPP 1157.

[1] M. Venkatesan *et al.*, *Phys. Rev. Lett.* **93**, 177206 (2004)

MA 20.106 Mo 14:00 Poster TU C

Heterostructures based on ZnO and Magnetic Materials – a Possible Way to Artificial Magnetic Semiconductors?

— ●KARL-WILHELM NIELSEN¹, MAIKE LÜBBE¹, ANDREAS ERB¹, JÜRGEN SIMON², WERNER MADER², MATTHIAS OPEL¹, LAMBERT ALFF¹, and RUDOLF GROSS¹ — ¹Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner Straße 8, 85748 Garching — ²Institut für Anorganische Chemie, Rheinische Friedrich-Wilhelm Universität, Römerstraße 164, 53117 Bonn

Diluted Magnetic Semiconductors (DMS) are interesting materials for spintronics due to the combination of semiconducting and magnetic properties. A promising candidate in this field is transition metal doped ZnO, since this material systems allows for ferromagnetism at room temperature. Very recently, the observed room temperature ferromagnetism in ZnO-based DMS was explained by Venkatesan *et al.* [1] in term of a model based on a narrow impurity band.

Whereas in usual DMS the magnetic ions are distributed statistically within the semiconducting matrix, in our work we want to artificially synthesize a new class of DMS by growing epitaxial heterostructures consisting of semiconducting and magnetic materials. We present our first steps in this direction based on heterostructures consisting of ZnO and

magnetic materials. The samples are prepared by UHV pulsed laser deposition and are characterized by SQUID-magnetometry, transport measurements and transmission electron microscopy.

This work is supported by the DFG via SPP 1157.

[1] M. Venkatesan *et al.* Phys. Rev. Lett. **93** 177206 (2004).

MA 20.107 Mo 14:00 Poster TU C

Inelastic electron tunneling spectroscopy and bias voltage dependence of magnetic tunnel junctions with polycrystalline Co_2MnSi electrode — ●JAN SCHMALHORST, S. KÄMMERER, G. REISS, and A. HÜTTEN — University of Bielefeld, Department of Physics, Nano Device Group, P.O. Box 100131, 33501 Bielefeld, Germany

Spintronics needs half-metallic materials implemented in technologically relevant devices. We prepare $\text{Co}_2\text{MnSi} / \text{AlO}_x / \text{Co}_7\text{Fe}_3$ junctions showing a tunneling magnetoresistance of 95% at 1mV and 20K. Their inelastic electron tunneling spectra at 20K show typical magnon and phonon excitations in the electrode and the barrier and an additional shoulder around -22mV not observed in $\text{Co}_7\text{Fe}_3 / \text{AlO}_x / \text{Ni}_{81}\text{Fe}_{19}$ reference junctions. Furthermore, the bias voltage and temperature dependence of the tunneling magnetoresistance is considerably larger than for the reference junctions. The transport properties are discussed with respect to a variety of current contributions associated with the structural and magnetic properties of the $\text{Co}_2\text{MnSi} / \text{AlO}_x$ interface.

MA 20.108 Mo 14:00 Poster TU C

Implementation of Co_2MnSi electrodes in magnetic tunnel junctions: magnetic and chemical bulk properties compared to the interface — ●JAN SCHMALHORST¹, M. SACHER¹, S. KÄMMERER¹, V. HÖINK¹, G. REISS¹, A. HÜTTEN¹, D. ENGEL², A. EHRSMANN², and E. ARENHOLZ³ — ¹University of Bielefeld, Department of Physics, Nano Device Group, P.O. Box 100131, 33501 Bielefeld, Germany — ²Department of Physics, Kaiserslautern University of Technology, D-67663 Kaiserslautern, Germany — ³Lawrence Berkeley National Laboratory, Advanced Light Source, Berkeley, CA 94720, USA

The 100% spin polarization predicted theoretically for some Heusler alloys make them attractive for spintronic applications, e.g., as electrode material in magnetic tunnel junctions. The formation of a high quality tunneling barrier without generating defects in the adjacent half-metallic electrode is the crucial preparation step. We have prepared $\text{Co}_2\text{MnSi} / \text{AlO}_x / \text{Co}_7\text{Fe}_3$ junctions showing a low temperature / low bias voltage tunneling magnetoresistance of 95% corresponding to an effective spin polarization of 66% instead of the predicted half-metallicity. By comparing soft X-ray absorption in total electron and total fluorescence detection we have determined differences of the chemical and the magnetic properties in bulk Co_2MnSi and at the $\text{Co}_2\text{MnSi} / \text{AlO}_x$ interface. These results show up a way of how to improve the magnetoresistive transport in the future. The authors gratefully acknowledge the opportunity to perform soft X-ray absorption spectroscopy at the Advanced Light Source, Berkeley, USA and at the Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H., Berlin, Germany.

MA 20.109 Mo 14:00 Poster TU C

Thin epitaxial films of the Heusler compound $\text{Co}_2\text{Cr}_{0.6}\text{Fe}_{0.4}\text{Al}$ — ●HORST SCHNEIDER¹, GERHARD JAKOB¹, FREDERICK CASPER^{1,2}, ANDRÉS CONCA¹, MARTIN JOURDAN¹, HANS-JOACHIM ELMERS¹, and CLAUDIA FELSER² for the DFG Forschergruppe 559 collaboration — ¹Institut für Physik, Universität Mainz, Staudinger Weg 7, 55128 Mainz — ²Institut für Anorganische und Analytische Chemie, Universität Mainz, Düsbergweg 10-14, 55128 Mainz

Co based Heusler alloys as $\text{Co}_2\text{Cr}_{0.6}\text{Fe}_{0.4}\text{Al}$ possess a high Curie temperature and according to band structure calculations this material is half metallic, i.e. there exists only one spin direction for the charge carriers at the Fermi edge. We prepared thin epitaxial films of this compound in the B2 structure by sputtering and laser ablation and realized first tunnel magnetoresistive elements. Films grown at high temperatures ($T=600^\circ\text{C}$) on *a*-plane (11 $\bar{2}$ 0) Al_2O_3 are fully epitaxial with the (110) and (1 $\bar{1}$ 0) planes of the film parallel to the (11 $\bar{2}$ 0) and (0001) planes of the substrate, respectively. The films show nearly rectangular hysteresis loops with coercitive fields of the order of 10 mT. On GaAs substrates film deposition at lower temperatures and subsequent annealing improved the magnetic moment to 3.5 μ_B per formula unit. Magneto-optical Kerr measurements show an in-plane anisotropy of the magnetization with the easy axis in {001} direction. Hall measurements show a strong anomalous Hall effect and a weak normal Hall voltage signalling the existence of a compensated Fermi surface.

MA 20.110 Mo 14:00 Poster TU C

Current-density-functional theory approach to persistent currents and orbital magnetism — ●MARC SIEGMUND and OLEG PANKRATOV — Lst. für Theoretische Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen

A local approximation of current-density-functional theory [1] (LCDA) permits to derive a universal relation between current and density distributions in inhomogeneous systems [2]. We apply this relation to a homogeneous, non-interacting electron gas of a finite spatial extension. The magnetization of such a system is commonly calculated as a derivative of the free energy with respect to the magnetic field strength. Physically, however, it arises due to the diamagnetic persistent current at the edges of a system and one should be able to find it directly from the current density. We verify that LCDA indeed leads to a correct universal magnetization, despite the current density distribution is affected by the inaccuracy of the LCDA. Finally the applicability of the current-density relation to an inhomogeneous system in an ultra-strong magnetic field is studied for a non-interacting electron gas in a parabolic potential.

[1] G. Vignale and M. Rasolt, Phys. Rev. B **37**, 10685 (1988)

[2] G. Vignale and P. Skudlarski, Phys. Rev. B **46**, 10232 (1992)

MA 20.111 Mo 14:00 Poster TU C

Orbital Polarization in the Kohn-Sham-Dirac Theory — ●MAHDI SARGOLZAEI, HELMUT ESCHRIG, MANUEL RICHTER, KLAUS KOEPERNIK, and INGO OPAHLE — Leibniz Institute for Solid State and Materials Research, IFW-Dresden, P.O.Box 270016, D-01171 Dresden, Germany

The consequent relativistic form of density functional theory is the 4-current density functional theory (CDFT). With Gordon's decomposition of the 4-current, the spin density enters, and is used to obtain the spin density functional theory (SDFT). The orbital current and orbital polarization effects are usually neglected in SDFT. This orbital current density of unfilled inner shells can be used to define a kind of an orbital angular momentum density, which may be treated in a local density approximation of the correlation energy leading to orbital polarization correction terms to the ordinary Kohn-Sham or Kohn-Sham-Dirac equation. Results for transition metal and rare-earth atoms are presented.

MA 20.112 Mo 14:00 Poster TU C

XMCD studies of magnetic properties of ZrZn_2 — ●SERGEY MANKOVSKY¹, HUBERT EBERT¹, FABRICE WILHELM², and ANDREJ ROGALEV² — ¹Dept. Chemie und Biochemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany — ²ESRF, B.P.220, 38043 Grenoble, France

The ZrZn_2 weak ferromagnet attracts the attention for last few years due to coexistence in it of ferromagnetism and superconductivity on the one side and due to its very interesting magnetic properties on another. The magnetic properties of this compound have been studied using the X-ray magnetic circular dichroism (XMCD) method, which allows to probe locally the spin and orbital magnetic moments and therefore is a very efficient tool for studies of complex magnetic materials. The XMCD spectra of ZrZn_2 have been measured at the $L_{2,3}$ edges of Zr. The experiments have been performed both without and in the presence of external magnetic field to study the field-dependent behaviors of spin and orbital magnetic moments. To interpret the experimental results, they are accompanied by SPR-KKR calculations of electronic structure and XMCD spectra of a compound under investigation. An analysis of the XMCD spectra of ZrZn_2 is done also in comparison with the spectra obtained for ZrFe_2 .

MA 20.113 Mo 14:00 Poster TU C

Correlation effects in the valence bands of EuS — ●ANAND SHARMA and WOLFGANG NOLTING — Lehrstuhl Festkörpertheorie, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr.15, 12489, Berlin, Germany.

We present a many body analysis of the multiband Kondo lattice model. The study is then combined with the first principles TB-LMTO band structure calculations, in order to investigate the temperature dependent correlation effects in the 3*p* valence bands of the ferromagnetic semiconductor, EuS . Some of the physical properties of interest like the quasi-particle density of states (Q-DOS), spectral density (SD) and quasi-particle band structure (Q-BS) are calculated and discussed. Therewith, we propose a spin resolved ARPES of the valence bands of EuS to be performed.

MA 20.114 Mo 14:00 Poster TU C

Calculated Magnetic Susceptibility of Palladium metal — ●MAENG-SUK KIM, MANUEL RICHTER, MICHAEL D. KUZ'MIN, INGO OPAHLE, and KLAUS KOEPERNIK — Leibniz Institute for Solid and Materials Research, IFW, P.O. Box 270016, D-01171 Dresden

Magnetization curves of Pd have been calculated in the local spin density approximation (*LSDA*). The scalar-relativistic version of the full-potential local orbital code (*FPLO-4*) was used. The character of the calculated curves depends most strongly on the assumed lattice constant. A ferromagnetic ground state is obtained at the experimental lattice constant, $a = 3.89 \text{ \AA}$. At $a = 3.84 \text{ \AA}$ (the *LSDA* equilibrium value) the $M(B)$ dependence is still noticeably curved upwards in small fields ($B < 8 \text{ T}$) and downwards in higher fields, the initial susceptibility exceeding the experimental value by a factor of two. At a yet smaller lattice constant, $a = 3.79 \text{ \AA}$, the calculated initial susceptibility equals the experimental one, the upward curvature in small fields being hardly noticeable. The inflection point in the magnetization curve is associated with the presence of a saddle point in the 4d bands just below the Fermi level. The curvature of $M(B)$ changes sign as the related Van Hove singularity in the minority subband hits the Fermi level.

MA 20.115 Mo 14:00 Poster TU C

Breakdown of magnetization in nano-constricted domain walls. — ●NATALIA KAZANTSEVA, ROBERT WIESER, ULRICH NOWAK, and KLAUS D. USADEL — Fachbereich für Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

The understanding and control of domain wall properties is important for future magneto-electronic applications, but only few publications have considered the influence of finite temperatures on domain walls [1] which becomes increasingly important for decreasing sizes of the magnetic systems considered. We investigate static aspects of nano-constricted domain walls with analytical (micromagnetic) and numerical methods (mean field approximation, Monte Carlo simulation). We find that the magnetization within a domain wall has a stronger temperature dependence than in a region with uniform magnetization. Even a continuous disappearance of the magnetization at a temperature T_h below the Curie temperature T_c can be observed inside a domain wall. This effect is much bigger for nano-constricted domain walls. In this case the temperature T_h decreases with $\cos(\pi/L)$, where L is the length of the constriction.

ACKNOWLEDGMENTS: Work supported by the Deutsche Forschungsgemeinschaft (SFB 491).

[1] J. Kötzer, D. A. Garanin, M. Hartl, and L. Jahn Phys. Rev. Lett. **71**, 177 (1993)

MA 20.116 Mo 14:00 Poster TU C

Analyse magnetischer Volumendomänen in FeSi (111)-Kristallen — ●RUDOLF SCHÄFER und SABINE SCHINNERLING — IFW Dresden, Helmholtzstr. 20, 01069 Dresden

Die magnetischen Domänen in eisenartigen Materialien mit stark fehl-orientierten Oberflächen sind charakterisiert durch aufgespaltene Strukturen, die sich in fraktaler Weise in mehreren Generationen auf die Oberfläche zu verfeinern. Zur Dickenabhängigkeit der Volumendomenweite gibt es bislang nur theoretische Modellbetrachtungen [1], welche bei kleinen Dicken eine Wurzelabhängigkeit und bei Dicken oberhalb beginnender Domänenaufspaltung eine lineare Dickenabhängigkeit der Volumendomenweite vorhersagen. In diesem Beitrag berichten wir von erstmaligen experimentellen Messungen der Volumendomenweite in keilförmigen Fe_{12.8at%}Si Kristallen mit (111)-Oberfläche. Zum einen wurde durch kernmikroskopische Oberflächenbeobachtungen indirekt auf die Volumenweite geschlossen, indem durch gezielte Entmagnetisierung eine geeignete Domänenüberstruktur erzeugt wurde. Dabei konnten die Vorhersagen bestätigt werden. Zum andern wurden die Volumendomen direkt ausgewertet, nachdem die Domänen als Ausscheidungsmuster eingefroren wurden [2, 3]. Hier wurden andere Gesetzmäßigkeiten gefunden. [1] A. Hubert and R. Schäfer: Magnetic Domains. Springer Verlag (1998). [2] S. Libovicky, Phys. Status Solidi A **12** (1972) 539. [3] R. Schäfer and S. Schinnerling, J. Magn. Magn. Mat. **215-216**, 140-146 (2000)

MA 20.117 Mo 14:00 Poster TU C

Spin structure of domain walls in ferromagnetic ring magnets — ●M. LAUFENBERG¹, M. KLÄUI¹, D. BEDAU¹, U. RÜDIGER¹, C.A.F. VAZ², J.A.C. BLAND², L.J. HEYDERMAN³, D. BACKES^{1,3}, F. NOLTING³, E. BAUER⁴, S. CHERIF⁴, S. HEUN⁴ und A. LOCATELLI⁴ — ¹Fachbereich Physik, Universität Konstanz, Germany — ²Cavendish Laboratory, University of Cambridge, U.K. — ³Paul-Scherrer-Institut, 5232 Villigen, Switzerland — ⁴Sincrotrone Trieste, 34012 Basovizza, Italy

The spin structure of domain walls (DW) in ferromagnetic rings has been studied by high-resolution photoemission electron microscopy for various ring widths (110-1800 nm), thicknesses (2-38 nm), and materials (permalloy, Co).

Experimental phase diagrams show transitions between transverse and vortex walls [1]. Micromagnetic simulations reproduce the experimental results for Co rings very well while in permalloy rings an unexpected second phase boundary at ultralow thicknesses is observed.

By varying the edge-to-edge spacing, the influence of dipolar DW coupling on the DW spin structure is studied. Furthermore, a linear dependence of the DW width on the ring width is found.

[1] M. Kläui *et al.*, Appl. Phys. Lett., in press

MA 20.118 Mo 14:00 Poster TU C

Entanglement and the phase diagram of spin-1 chains — ●CLEMENS MÜLLER-GUGENBERGER, ANDREAS SCHADSCHNEIDER, and ACHIM ROSCH — Institut für Theoretische Physik, Universität zu Köln

Entanglement as a resource for quantum computing and communication is a central concept in quantum information science. Furthermore, it can be used to quantify nonclassical correlations in interacting systems.

Here, we investigate antiferromagnetic spin-1 chains. These systems are generically gapped and therefore robust against external disturbances. Already the case of isotropic interactions exhibits a rich phase diagram with several quantum phase transitions and the occurrence of topological order. While the model allows analytical treatment at special points of the phase diagram, for the general case a numerical treatment like the density matrix renormalisation group (DMRG) is necessary.

Using DMRG techniques, we investigate various entanglement properties in the ground state of the bilinear biquadratic spin-1 chain. We test the applicability of different entanglement measures to these models with special emphasis on the various phases, their phase transitions and the topological order.

MA 20.119 Mo 14:00 Poster TU C

Ferromagnetic Polarons in the 1D ferromagnetic Kondo Model with quantum mechanical $S = 3/2$ corespins — ●DANILO NEUBER¹, MARIA DAGHOFER¹, HANS GERD EVERTZ¹, REINHARD NOACK², and WOLFGANG VON DER LINDEN¹ — ¹Inst. f. Theo. Physics, TU Graz, Petersg. 16, 8010 Graz, Austria — ²FB Physik, Philipps-Universität Marburg, 35032 Marburg, Germany

We present the first exhaustive numerical study of the ferromagnetic (FM) Kondo lattice model with quantum mechanical $S = 3/2$ corespins. We treat non-degenerate orbitals in one dimension using the density matrix renormalization group (DMRG). We examine parameters relevant to manganites and the range of low to intermediate doping $0 \geq x > 0.5$ and we include on-site Coulomb repulsion between the electrons.

In particular, we examine whether quantum fluctuations favor phase separation over the ferromagnetic polarons observed in a model with classical corespins. We find that quantum spins instead enhance the polaronic behavior and we find no phase separation for small doping. Coexistence of larger FM and antiferromagnetic (AFM) regions is only occasionally observed at rather high doping $x \approx 0.3$ near the transition to the FM ordered state.

We present a phase diagram with respect to doping and the t_{2g} superexchange parameter J' with and without Coulomb repulsion.

MA 20.120 Mo 14:00 Poster TU C

Size-effects on the magnetic phase transition of Fe/GaAs(001) — ●ROLAND MEIER, FRANK BENSCH, WOLFGANG KIPFERL, and GUENTHER BAYREUTHER — Universitätsstraße 31, 93040 Regensburg

For ultrathin single crystalline Fe-films on GaAs(001) an extraordinary sharp magnetic phase transition at T_c was found in addition to a strong uniaxial anisotropy [1]. Furthermore, an effective $T^{3/2}$ -dependency of the spontaneous magnetization is valid at $T < 1/2 \cdot T_c$ for both, the extended layer and submicron disks [2]. In the present work we study the details of the phase transition in these confined magnetic systems.

Approaching T_c , the correlation length of order parameter diverges: in a real Fe/GaAs-system it can exceed one micron. Thus, the critical behavior of submicron-particles should be affected massively by finite size effects. By means of the longitudinal Kerr effect large area ensembles of uniform nanostructures produced with EBL were investigated. We systematically varied structure size (below 100 nm to 1 micron), shape and the distance between the elements. The influence on the phase transition and the Curie temperature is discussed. The determined critical exponents are compared to theoretical models. Ref. [1] F. Bensch, JAP 89, 7133 (2001) [2] W. Kipferl, JAP 95, 7417 (2004)

MA 20.121 Mo 14:00 Poster TU C

Oberflächenmagnetisierung an flüssigem $Co_{80}Pd_{20}$ in der Nähe der Curietemperatur — ●LUCIAN ISFAN und KARL MAIER — Helmholtz - Institut für Strahlen- und Kernphysik der rheinischen Friederich-Wilhelms Universität zu Bonn

Magnetisierungsverläufe an flüssigem $Co_{80}Pd_{20}$ wurden mit Hilfe des Magneto-Optischen Kerr-Effektes aufgenommen. Zu diesem Zweck wurden Proben mit 10-11mg Masse in einer reinen H_2 -Atmosphäre mittels einer Kurzwellenlevitationsanlage prozessiert. Diese Anlage erlaubt eine Unterkühlung der Proben von mehr als $\Delta T = 350K$ unter ihre Liquidustemperatur ($T = 1610K$). Eine computergesteuerte Probenstabilisierung ermöglicht ortsgenaue optische Messungen auch in der Nähe der Curietemperatur. Auf der Probe wird ein linear polarisierter Laserstrahl fokussiert und an der Reflektion die Drehung der Polarisationsachse untersucht. Die Signaldifferenz der an zwei Dioden erfasste Intensität des Lichts ist ein Maßstab für die erfahrene Drehung der Polarisationsachse (Kerr-Winkel) und für die lokale Magnetisierung. Es wurden temperaturabhängige Messungen des Kerr-Winkels bis zur Curietemperatur durchgeführt. Die aufgenommenen Magnetisierungskurven weisen einen typischen Curie-Weiss Verlauf auf. Die Genauigkeit der Messmethode gibt Hoffnung auf ortsaufgelöste Untersuchungen der Domänenstruktur einer ferromagnetische Substanz in der flüssigen Phase.

MA 20.122 Mo 14:00 Poster TU C

New model for conversion process in RCu_2 ($R = \text{rare earth}$) — ●SEBASTIAN RAASCH^{1,2}, MATHIAS DOERR¹, MARTIN ROTTER^{3,1}, ANDREAS KREYSSIG¹, JENS-UWE HOFFMANN², and MICHAEL LOEWENHAUPT¹ for the HMI Berlin - TUD collaboration — ¹TUD-IFP, D-01062 Dresden, Zellescher Weg 16 — ²HMI Berlin, D-14109 Berlin — ³Uni Wien-IPC, A-1090 Wien

Since the 1990s a magnetic field induced conversion effect in orthorhombic RCu_2 compounds (space group $Imma$) has been observed. To force the conversion a strong magnetic field (3 to 20 T) has to be applied in the a - c plane away from the magnetic easy axis. As the magnetization properties of the hard and easy axis exchange during the conversion, this effect has been misleadingly called *Ising axis conversion effect* based on a metamagnetic transition. Further a giant magnetostrictive effect of more than two percent due to the conversion has been found in 1996 by Takeuchi by macroscopic measurements. We present a new conversion model and its experimental proof: the twin-domain model. It explains the change of the easy axis by structural changes during the conversion. The atoms undergo a slight shift of either 0.29(1) Å or 0.50(1) Å in their atomic positions driven by the external field. Due to the *pseudo-hexagonal structure* the crystal decays into many small identical twin-domains of three different orientations. They are rotated along b direction by ± 60.52 deg. Thereby the GMS effect of more than two percent in a direction can be explained. The structural changes due to the conversion have been studied intensely by neutron scattering.

MA 20.123 Mo 14:00 Poster TU C

A nuclear magnetic resonance study of $RMn_6Ge_{6-x}Ga_x$ -compounds — ●JENS SCHNELZER und ELMAR DORMANN — Physikalisches Institut, Universität Karlsruhe (TH); D-76128 Karlsruhe

⁷³Ge-nuclear magnetic resonance spectra on the $RMn_6Ge_{6-x}Ga_x$ -series ($R = \text{rare earth metal}$) will be presented. All representatives of this series have the hexagonal $HfFe_6Ge_6$ -type structure in common. These compounds are characterized by ferromagnetic Mn Kagomé layers and by different interplane couplings giving rise to various magnetic ordering-phenomena such as antiferromagnetic, helical or ferrimagnetic structures, depending on the nature of the R element and the Ge/Ga-proportion. The main effect of this substitution is to enhance the relative strength of the ferromagnetic interaction with respect to the antiferromagnetic one and for critical Ga concentration ferromagnetic or ferrimagnetic structures are stabilized. The influence of these different magnetization configurati-

ons on the NMR spectra is analysed.

We thank G.Venturini, Nancy for providing the samples, and GK 284 (DPG) for financial support.

MA 20.124 Mo 14:00 Poster TU C

Magnetic structure of Tb_2PdSi_3 : Investigation of long- and short-range magnetic order in external magnetic fields — ●MATTHIAS FRONTZEK¹, ANDREAS KREYSSIG¹, MATHIAS DOERR¹, JENS-UWE HOFFMANN², and MICHAEL LOEWENHAUPT¹ — ¹TU Dresden, Institut für Festkörperphysik, D-01062 Dresden — ²Hahn-Meitner-Institut, BENSC, Glienicke Straße 100, D-14109 Berlin

Tb_2PdSi_3 , crystallizing in an AlB_2 derived hexagonal structure (space group $P6/mmm$) shows a very complex magnetic behavior due to low-dimensional magnetism as well as spin-glass like properties. The hexagonal structure allows the possibility of a 2-dimensional geometrical frustration which might be the cause of the observed spin-glass like behavior.

Tb_2PdSi_3 orders antiferromagnetically at $T_N = 23$ K and undergoes a spin-glass like transition at $T_2 = 9$ K. For the zero field long-range antiferromagnetic structure we determine a propagation vector $(1/2, 1/2, 1/16)$ at $T = 2$ K. Additionally we observe intensity due to antiferromagnetic short-range order (SRO) with a correlation length of about 30 Å. The observed antiferromagnetic SRO is probably linked to the spin-glass like transition. The magnetic behaviour of Tb_2PdSi_3 investigated with ac susceptibility and magnetisation delivered ambiguous results and left open several questions. Using neutron diffraction in external magnetic fields we studied the microscopic cause of the hysteretic behaviour and the co-existence of different long-range and short range ordered magnetic phases up to a field of $\mu_0 H = 6.5$ T. In our contribution we will present and discuss the results.

MA 20.125 Mo 14:00 Poster TU C

Thermodynamic and Transport Properties of the Antiferromagnetic Order in $EuZn_2Sb_2$ — ●F. WEBER^{1,2}, S. DROBNIK^{1,2}, K. GRUBE², C. PFLEIDERER^{1,2}, A. COSCEEV¹, M. UHLARZ¹, H. V. LÖHNEYSEN^{1,2} und A. NATEPROV³ — ¹Physikalisches Institut, Wolfgang-Gaede Str. 1, D-76128 Karlsruhe, Germany — ²Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe, Germany — ³Institute of Applied Physics, Academei 5, MD-2028 Kishinev, Moldova

We report an experimental study of the specific heat, thermal expansion, magnetisation, Hall effect and resistivity of $EuZn_2Sb_2$. Single crystals have been synthesized by means of a solid state reaction using carbon glass crucibles. The crystal structure of $EuZn_2Sb_2$ is trigonal, space group $P\bar{3}m1$. A second order phase transition at $T_N = 13.27$ K bears all the Hall marks of 3D-XY antiferromagnetic order, where the high field magnetisation and evidence of a spin-flop transition at very low fields are consistent with a weak magnetic anisotropy. Microprobe analysis reveals, however, that the samples are Eu-deficient. Remarkably, the Eu-deficiency may be accounted for purely in terms of two metallurgically segregated phases, where one of the phases is stoichiometric $EuZn_2Sb_2$.

MA 20.126 Mo 14:00 Poster TU C

Effective spin description of crystal field effects in $NdAl_2$ — ●ULRICH KÖBLER¹ and ANDREAS HOSER^{1,2} — ¹IFF, FZ-Jülich — ²Inst.f.Kristallographie, RWTH-Aachen

We propose a new analysis of the paramagnetic susceptibility and the spontaneous magnetization of the ferromagnet $NdAl_2$ (electronic configuration $4f_9/2$). As a consequence of a large crystal field splitting the observed saturation magnetic moment of $m = 2.484\mu_B$ per Nd is considerably smaller than the free Nd^{3+} value of $3.273\mu_B$. On the other hand, the effective magnetic moment of the high temperature Curie-Weiss susceptibility conforms well to the theoretical value of the Nd^{3+} ion. We show that the number of relevant states, N, is the important quantity for the thermodynamics. This number is always an integer. The character of the states seems to be less important. Far above $T_c = 78K$ all states of the Nd^{3+} are relevant, i. e. $N = 2J + 1 = 10$. For $T \rightarrow 0$ the effective spin is only $J_{eff} = 3$, i. e. $N = 7$. The decrease of N is in steps of unity. Each decrease of N is associated with a crossover phenomenon. This crossover can be in the paramagnetic phase as well as in the ordered state. The thermodynamics can therefore be considered as quantized. Depending on whether N is even or odd the temperature dependence of the spontaneous magnetization is according to different universality classes.

MA 20.127 Mo 14:00 Poster TU C

Spin correlations in disordered spin chain with itinerant electrons — ●ANDREAS ROTHE and ALEXANDER CHUDNOVSKIY — Universität Hamburg Jungiusstrasse 9 20355 Hamburg

We investigate spin-spin correlations mediated by itinerant electrons. We calculate the localization length in a special model of a disordered Ising spin chain. We treat this model by means of real space renormalization group (RG). Further we analyse the frequency dependence of the spin-spin correlation function.

MA 20.128 Mo 14:00 Poster TU C

Electronic structure and magnetism of "Ferric Star" molecule — ●A. F. TAKÁCS¹, M. NEUMANN¹, M. PRINZ¹, A. POSTNIKOV², J. KORTUS³, A. SCHEURER⁴, S. SPERNER⁴, and R. W. SAALFRANK⁴ — ¹Universität Osnabrück, Fachbereich Physik, Barbarastr. 7, D-49069 Osnabrück, Germany — ²IFF F2 Jülich, D-52425 Jülich, Germany — ³IPCMS- GMI F -67037 Strasbourg -France — ⁴University of Erlangen-Nuernberg, 91054 Erlangen- Germany

The electronic structure of magnetic molecules of the type $[M(FeL_2)_3] \cdot 4CHCl_3$ where $M=Fe, Cr$ and $L=H_3CN(CH_2CH_2O)_2^{2-}$ has been studied using X-ray photoelectron spectroscopy, soft X-ray emission spectroscopy as well as theoretical density-functional-based methods. Three peaks have been found in the valence band region by XPS, which are excellently reproduced by the calculated tDOS, also the partial DOS agrees very well with the XES results. The top of the valence band is dominated by the hybridization between M 3d and O 2p bands. The Fe core level spectra indicate that Fe is in the Fe^{2+} state, which is in a good agreement with the calculated magnetic moment of $\approx 4\mu_B$. The neighbouring atoms primarily oxygen and nitrogen exhibit a magnetic polarisation yielding effective spin $S=5/2$ per iron atom. Due to antiparallel orientation of the magnetic moments of the central M ion relatively to three peripheral Fe, the total resulting spin per molecule in the ground state amounts to $S=5$ ($M=Fe$) or $S=6$ ($M=Cr$).

MA 20.129 Mo 14:00 Poster TU C

Synthese formanisotroper magnetischer Partikel im Submikrometerbereich — ●FRANK DÖBRICH, ANDREAS TSCHÖPE und RAINER BIRNINGER — 7.3 Technische Physik, Universität des Saarlandes, Geb. 43B, D-66123 Saarbrücken

Zur Modifikation der magnetoviskosen und viskoelastischen Eigenschaften von Ferrofluiden wird versucht, statt sphärischer Partikel solche mit starker Formanisotropie der Brownschen Teilchen in einer Trägerflüssigkeit zu dispergieren. Dieser Beitrag befasst sich mit Methoden zur Synthese solcher formanisotroper Partikel. Dabei wird zum einen die Synthese auf dem Aearsolwege verfolgt und zum anderen der Herstellung auf einer nasschemischen Route nachgegangen. Die hergestellten Partikel werden in erster Linie bezüglich ihrer Morphologie mittels Transmissionselektronenmikroskopie charakterisiert, wobei Unterschiede, bedingt durch die verschiedenen Syntheserouten oder durch Variation verschiedener Syntheseparameter, diskutiert werden.

MA 20.130 Mo 14:00 Poster TU C

Correlation between structural and magnetic characteristics of aligned Fe-filled carbon nanotubes grown on Si substrates — ●RADINKA KOZHUHAROVA¹, STEFKA GROUDEVA-ZOTOVA¹, DIETER ELEFANT¹, ANDREAS GRAFF², ALBRECHT LEONHARDT¹, INGOLF MÖNCH¹, THOMAS MÜHL¹, MANFRED RITSCHEL¹, and CLAUD SCHNEIDER³ — ¹IFW Dresden, Helmholtzstr. 20, D-01069 Dresden — ²now at: MPI of Microstructure Physics, Halle — ³now at: IFF-IEE, Jülich

Aligned Fe-filled multi-walled carbon nanotubes (MWNTs) were grown perpendicularly to oxidized Si substrates by pyrolysis of ferrocene. Recently, we have reported on encapsulated Fe nanowires having at room temperature the bcc and the fcc phase and possessing a pronounced uniaxial magnetic anisotropy with easy axis of magnetization perpendicular to the substrate surface.

Here we present a systematic comparison of the magnetic properties of Fe-filled MWNTs samples having different phase compositions and an establishment of possible correlations between structural and magnetic characteristics of the carbon nanotube filling. It was found that the specific saturation magnetization and the magnetic anisotropy strongly depends on the relative amount of the bcc Fe phase and the bcc Fe crystallite grain size.

MA 20.131 Mo 14:00 Poster TU C

Druckabhängigkeit der Suszeptibilität von $Fe_{1-x}Co_xSi$ — ●M. FINKE, D. MENZEL, D. ZUR und J. SCHOENES — Institut für Halbleiterphysik und Optik, TU Braunschweig, Mendelssohnstrasse 3, 38106 Braunschweig, Germany

Während FeSi ein paramagnetischer Halbleiter mit einer Bandlücke von ca. 60 meV und CoSi ein diamagnetisches Metall ist, ordnet $Fe_{1-x}Co_xSi$ ab einer Konzentration von 5% Co ferromagnetisch. Druckuntersuchungen an diesem Material können Hinweise geben, ob dieses System in einem Einteilchen- oder einem korrelierten Bild zu beschreiben ist. Es wurden die magnetischen Eigenschaften von $Fe_{1-x}Co_xSi$ -Einkristallen bei Drücken bis 0,7 GPa untersucht. Während der Curie-Anteil der Suszeptibilität als Funktion des Druckes konstant bleibt, nimmt bei Proben mit einem Co-Anteil von über 5% die Pauli-Suszeptibilität mit zunehmendem Druck ab. Dagegen zeigen Proben mit niedrigerer Co-Konzentration bei Feldern bis ca. 3 Tesla den umgekehrten Effekt. In höheren Magnetfeldern nimmt auch bei geringen Co-Konzentrationen die Suszeptibilität mit zunehmendem Druck ab. Dieses Verhalten wird mit Hilfe von Bandstrukturberechnungen nach der SPRKKR-Methode interpretiert.

MA 20.132 Mo 14:00 Poster TU C

Lokale Struktur fester Lösungen von Mn und Fe in Ge — ●I. KRUG, H. BRAAK, R. GAREEV, D. BÜRGLER, ST. CRAMM, F.U. HILLENRECHT und C.M. SCHNEIDER — IFF, FZ Jülich, 52425 Jülich

Halbleiter mit ferromagnetischer Ordnung sind für Anwendungen in Bauelementen der Spinelektronik von Interesse, um spinpolarisierte Ladungsträger in Halbleiter zu injizieren. Durch Einbringen von magnetischen Spezies in konventionelle Halbleiter, z.B. Mn in GaAs, konnte eine ferromagnetische Ordnung in diesem Material induziert werden. Kürzlich wurde in Mn-Ge-Lösungen ebenfalls Ferromagnetismus beobachtet, dessen Ordnungstemperatur durch den Zusatz von Fe deutlich über Raumtemperatur gebracht werden kann. Um zu klären, ob es sich hierbei um echten Ferromagnetismus handelt, ist u.a. eine möglichst genaue Kenntnis der Struktur erforderlich. Deshalb haben wir EXAFS-Untersuchungen an diesen Materialien durchgeführt. Die Ergebnisse zeigen, dass Mn in die Ge-Struktur eingebaut wird. Allerdings sind in den EXAFS-Spektren die Maxima der zweiten und höheren Koordinationsschale nur sehr schwach, was auf einen hohen Grad von Unordnung in der Umgebung der Dotieratome hinweist.

MA 20.133 Mo 14:00 Poster TU C

Magnetic properties of the diluted semiconductor $Ge_{1-x}Mn_x$ ($Ge_{1-x}Co_x$) — ●ERWIN BIEGGER, LORENZ STÄHEL, MIKHAIL FONIN, and ULRICH RÜDIGER — FB Physik/LS Rüdiger/Universitätsstraße10/78457 Konstanz

Diluted magnetic semiconductors (DMS) attract extensive attention because of their possible applications to spintronics based on the semiconductor technology [1]. DMS are made by substitution of small amount of magnetic transition metal (TM) such as Cr, Mn, Fe, Co, and Ni into semiconductors. The coupling mechanism in these systems are still unclear. Recently, Mn substitution has yielded ferromagnetism in germanium with T_C at 285 K in bulk single crystals [2]. Magnetic properties have been investigated between 5 and 400 K. The magnetisation showed two distinct transitions at about 150 K and about 285 K which were identified as antiferromagnet-ferromagnet and ferromagnet-paramagnetic transition, respectively.

$Ge_{1-x}Mn_x$ ($Ge_{1-x}Co_x$) have been grown in vertical furnaces. Bulk crystals have been cut to analyse its crystal structure with X-ray diffraction techniques. SQUID measurements have been done to investigate the magnetic properties.

[1] R. Fiederling *et al.*, Nature (London) 402, 787 (1999); Y. Ohno, D. K. Young, B. Beschoten, F. Matsukura, H. Ohno, and D. D. Awschalom, *ibid.* 402, 790 (1999); T. Dietl, H. Ohno, F. Matsukura, J. Cibert, and D. Ferrand, Science 287, 1019 (2000). [2] S. Cho *et al.*, Phys. Rev. B 66, 033303 (2002).

MA 20.134 Mo 14:00 Poster TU C

Ultraviolette Photoelektronen-Spektroskopie von $Mn:TiO_2$ — ●IVAN JURŠIĆ, DIRK MENZEL und JOACHIM SCHOENES — Institut für Halbleiterphysik und Optik, Mendelssohnstr. 3, 38106 Braunschweig

$Mn:TiO_2$ ist ein verdünnter magnetischer Halbleiter, bei dem sogar oberhalb Raumtemperatur Ferromagnetismus beobachtet werden kann.

Das $Mn:TiO_2$ wurde mittels Ionenimplantation von Mn^{+} -Ionen in TiO_2 hergestellt. Zum einen wurden kommerzielle, kristalline $TiO_2(001)$ Sub-

strate in der Rutil Phase implantiert und zum anderen amorphe Schichten, die mit einer thermischen Aufdampfanlage hergestellt wurden. Dies ermöglicht die Untersuchung des Einflusses der Kristallstruktur auf den Magnetismus. Es wurden Mn-Konzentrationen von 3%, 5% und 7% hergestellt, um die Konzentrations- bzw. Abstandsabhängigkeit der Mn-Atome zu untersuchen. Um die durch die Ionenimplantation hervorgerufenen Defekte auszuheilen, wurde bei verschiedenen Temperaturen in einer Sauerstoffatmosphäre mit einem Druck von $3 \cdot 10^{-3}$ mbar *getempert*.

SQUID-Messungen ergaben nach der Ionenimplantation ein maximales magnetisches Moment von $0,41 \mu_B$ pro Mn-Atom und eine Curie-Temperatur von 650K. Die elektronische Struktur wurde mittels Ultravioletter Photoelektronen-Spektroskopie mit der He-I-Linie untersucht.

Die beobachteten Veränderungen in der elektronischen Struktur und im magnetischen Verhalten nach dem *tempem* deuten auf zwei Ursachen für den Ferromagnetismus; zum einen einen Austausch über die Leitungselektronen und zum anderen eine Abstandsabhängigkeit der Mn-Atome.

MA 20.135 Mo 14:00 Poster TU C

Elektroresistiver Effekt im sauerstoffdefizitären Manganit Nd_{0.7}Sr_{0.3}MnO_{3-d}. — •KLAUS BAERNER¹, CHANGPING YANG¹, VLADIMIR MORCHSHAKOV¹ und IGOR TROYANCHUK² — ¹FB Physik, 4 Physik, Uni-Goettingen — ²Institute of solid state and semiconductor physics, Minsk

Wir beobachten einen starken elektroresistiven Effekt (ER) in leicht sauerstoffdefizitärer Nd_{0.7}Sr_{0.3}MnO_{3-d} Keramik ($0 < d < 0.2$) der sich ganz ähnlich verhält wie der bekannte magnetoresistive Effekt (MR) in diesen Verbindungen und der wie dort offenbar sowohl die besser isolierenden Korngrenzen wie auch Teile des Korn- oder Domänenvolumens involviert. Während beim MR das externe magnetische Feld direkt auf die magnetischen Dipole der Mn-Ionen einwirkt, ist die Natur der korrespondierenden elektrischen Dipolmomente zur Zeit noch unklar. Da sich der ER-Effekt jedoch dramatisch mit zunehmendem d steigert, sieht es so aus als ob die (induzierten) elektrischen Dipole etwas mit der lokalen Gitterrekonstruktion zu tun hat, die sich aus dem Sauerstoffdefizit notwendig ergibt. Ein um eine elektrische Suszeptibilität erweitertes deGennes Modell ermöglicht eine eingehendere Analyse sowohl des ER-Effektes als auch der Verschiebung der Übergangstemperaturen im E-Feld.

MA 20.136 Mo 14:00 Poster TU C

Ferrimagnetism in the Brownmillerit compounds Sr₂M₂O₅ M = Fe, Co — •FRANZISKA EMMERLING, GERHARD H. FECHER, VADIM KSENOFONTOV und CLAUDIA FELSER — Johannes Gutenberg - Universität, D-55099 Mainz, Germany

The oxides Sr₂M₂O₅ (M=Fe, Co) were prepared via ceramic and sol-gel methods. The samples were characterized by X-ray diffraction, SQUID magnetometry, XPS- and Mößbauer spectroscopy. The XRD diffraction patterns confirmed that, at least within the sensitivity of XRD, the samples are single phase with the expected lattice parameter (Ima2, $a=15.66/15.59$ Å, $b=5.56/5.66$ Å, $c=5.46/5.53$ ÅCo/Fe). SQUID measurements revealed a total magnetic moment of 0.34 (Co) and 0.46 (Fe) μ_B . The ⁵⁷Fe Mößbauer spectrum of Sr₂Fe₂O₅ indicates the two expected Fe positions and points on magnetic order at room temperature.

The electronic structures were calculated using the self-consistent, linearized muffin-tin orbital (LMTO) program of Anderson et al. The calculations revealed a ferrimagnetic ordering with magnetic moments of 1.30 (Co)/2.67 (Fe) for the octahedral coordinated A-site and 1.29 (Co)/2.90 (Fe) for the tetrahedral coordinated B-site and a resulting moment of 0.215(Co)/0.94 (Fe) μ_B .

The series Sr₂Co_{2-x}Fe_xO₅ with varying Co to Fe ratio x will be discussed on hand of experimental data and calculated results.

MA 20.137 Mo 14:00 Poster TU C

Substitutional effects in rare earth based half Heusler compounds — •FRED CASPER, VADIM KSENOFONTOV, GERHARD H. FECHER, and CLAUDIA FELSER — Johannes Gutenberg - Universität, 55099 Mainz, Germany

Half Heusler compounds offer a variety of half-metallic ferromagnetic materials. This study focuses on Heusler compounds RE_{1-x}M_xXY containing mixed rare earth - transition metal sublattices, because one expects an interplay of d- and f- electrons with respect to the magnetic properties. The families of compounds RENiBi and REAuSn are of particular interest. GdAuSn is known to be a semiconducting antiferromagnetic compound with $T_N \cong 60K$, whereas MnAuSn belongs to the ferromagnetic metals. A dramatic increase of the Neel temperature up to

approximately 200 K was found during the study of the doped compound Gd_{0.9}Mn_{0.1}AuSn from the series Gd_{1-x}Mn_xAuSn. Gd, Au and Sn Mößbauer spectroscopy is applied to elucidate the magnetic state of the constituents of this compound. Band structure calculations using the FLAPW method provide an insight in the magnetic and electronic properties of doped, rare earth based half Heusler compounds.

(This work is funded by the DFG.)

MA 20.138 Mo 14:00 Poster TU C

Calculated electronic structure of semiconducting Gd compounds with Half-Heusler and LiGaGe-structure — •HEM C. KANDPAL, GERHARD H. FECHER, and CLAUDIA FELSER — Johannes Gutenberg - Universität, 55099 Mainz, Germany

We present spin polarized LSDA calculations of different semiconducting Gd-compounds with cubic Half-Heusler (C1_b, $F\bar{4}3m$) or hexagonal LiGaGe (P6₃mc) structure. Half Heusler compounds may be described by a partial filling (4b or 4d site) of the Zinblendestruktur with a third element and LiGaGe as Wurtzitestruktur with the origin (2a site) filled by a third element. Most of the investigated compounds follow the Slater-Pauling rule with the magnetic moment per unit cell scaling with the number of valence electrons. The f-electrons at Gadolinium sites are localized. Nearly all compounds are semiconductors or semimetals because of the total number of 18 valence electrons, remaining. The potential of these semiconducting materials for spininjection devices will be discussed.

(This work is funded by the DFG.)

MA 20.139 Mo 14:00 Poster TU C

Calculated electronic structure of X₂YZ Heusler compounds — •HEM C. KANDPAL, GERHARD H. FECHER, CLAUDIA FELSER, and GERD SCHÖNHENSE — Johannes Gutenberg - Universität, 55099 Mainz, Germany

We present calculations on a series of X₂YZ full Heusler compounds which show the phenomenon of half metallic ferromagnetism. The crystal structures have been obtained for some of the compounds through structural relaxation in the first principles framework determining the minimum total energy as function of the lattice parameter. We find that mostly Co based Heusler compounds are exhibiting half-metallic behavior. We also analyze the influence of the lattice parameter on the minority band gap. We find that smaller lattice parameter result in larger minority band gaps. The width of the gap is seemingly a linear function of the lattice constant. X=Co based Heusler compounds exhibit high Curie temperature with a linear dependence on the number of valence electrons. Our results show that Co based Heusler compounds obey the Slater-Pauling rule, while most of the others do not. There are slight changes in the magnetic moment of the Co atoms, while the magnetic moment of Y increases with the number of valence electrons. The peculiarities of the electronic structure suggest that the Co based Heusler compounds are the best candidates for potential spintronics applications.

(This work is funded by the DFG in FG 559.)

MA 20.140 Mo 14:00 Poster TU C

EXAFS-measurements on doped Heusler compounds — •SABINE WURMEHL¹, GERHARD H. FECHER¹, JONDER MORAIS², MARIA C. M. ALVES², SERGIO R. TEIXEIRA², CLAUDIA FELSER¹, and GERD SCHÖNHENSE¹ — ¹Johannes Gutenberg - Universität, 55099 Mainz, Germany — ²Universidade Federal do Rio Grande do Sul, Porto Alegre, 91501-970 RS, Brazil

Doped Heusler compounds with composition Co₂Cr_{1-x}Fe_xAl were prepared by arc melting and comprehensively characterized by means of SQUID magnetometry, Mößbauer spectroscopy, ESCA and AES depth profiling. X-ray diffraction pointed on structural disorder phenomena. Therefore, EXAFS measurements on polished discs and powders were performed. The XAS spectra were taken at the 3d-metal K-edges to compare each edge of the contributing d-metals in powder and bulk samples. The near edge region (NEXAFS) is similar for each edge and gives no hint for chemical alteration. The EXAFS signal of Cr and Co in the same composition differs significantly if the measurements were taken from powder or polished discs. This shows that the neighborhood of Fe is not changed when grinding a sample, whereas Cr and Co exhibit different surroundings in powder and bulk material. It indicates that determining structural properties from powder diffraction may lead to wrong conclusions.

(This work is funded by the DFG in FG 559.)

MA 20.141 Mo 14:00 Poster TU C

First-principles investigation of electronic structures and vibrational modes of various types of ternary Heusler alloys with L2₁ structure — ●WAHEED ADENIYI ADEAGBO¹, ALEXEI T. ZAYAK², and PETER ENTEL¹ — ¹Institute of Physics, MC 328, University of Duisburg-Essen, Duisburg Campus, Lotharstr.1, 47048, Duisburg, Germany — ²Department of Physics and Astronomy, Rutgers University, 136 Frelinghuysen Rd, Piscataway, NJ 08854-8019, USA

The first-principles method is used to show the trend of instabilities and stabilities exhibited by many Heusler alloys. We have calculated the phonon spectra of various types of ternary Heusler alloys (X₂YZ) with ferromagnetic order (where X and Y are mostly 3d-metals and Z non-magnetic metallic atoms). We correlate the results of the spectra with their corresponding electronic density of states at the Fermi level in order to address some of the trends of anomalous softening behaviour, which is mostly dictated by the TA₂ mode in the acoustic region of the phonon dispersion of some magnetic Heusler alloys. While most series of the non-magnetic Heusler alloys show non-softening in the acoustic mode, the magnetic counterparts are either non-softened or softened. Our phonon calculations are based on the direct method which yields good agreement with existing experimental data.

MA 20.142 Mo 14:00 Poster TU C

First-principles investigation of electronic structures and vibrational modes of various types of ternary Heusler alloys with L2₁ structure — ●WAHEED ADENIYI ADEAGBO¹, ALEXEI T. ZAYAK², and PETER ENTEL¹ — ¹Institute of Physics, University of Duisburg-Essen, Duisburg Campus, Lotharstr.1, 47048, Duisburg, Germany — ²Department of Physics and Astronomy, Rutgers University, 136 Frelinghuysen Rd, Piscataway, NJ 08854-8019, USA

The first-principles method is used to show the trend of instabilities and stabilities exhibited by many Heusler alloys. We have calculated the phonon spectra of various types of ternary Heusler alloys (X₂YZ) with ferromagnetic order (where X and Y are mostly 3d-metals and Z non-magnetic metallic atoms). We correlate the results of the spectra with their corresponding electronic density of states at the Fermi level in order to address some of the trends of anomalous softening behaviour, which is mostly dictated by the TA₂ mode in the acoustic region of the phonon dispersion of some magnetic Heusler alloys. While most series of the non-magnetic Heusler alloys show non-softening in the acoustic mode, the magnetic counterparts are either non-softened or softened. Our phonon calculations are based on the direct method which yields good agreement with existing experimental data.

MA 20.143 Mo 14:00 Poster TU C

Magnetic properties in chromium-chalcogenide systems — ●DIANA BENE¹, HUBERT EBERT¹, WOLFGANG BENSCH², and ZHONG-LE HUANG² — ¹Department of Chemistry and Biochemistry, LMU-Munich, Germany — ²Institute for Inorganic Chemistry, CAU-Kiel, Germany

A detailed theoretical and experimental investigation on the electronic and magnetic properties of several Cr-Te systems with the Te concentration between 60.6 and 62.2 % have been performed. Depending on the heat treatment and on the composition, these systems show different structures with a monoclinic, trigonal supercell and trigonal basic unit cell. The phase transitions between these crystallographic structures induced by a change in composition is discussed. The preferential occupation of the metal layers evidenced by X-ray and neutron scattering experiments is investigated by theoretical calculations. In addition, the influence of the substitution of Cr and Te by Ti and Se, respectively, on the magnetic properties of the system is discussed. All investigations of the electronic, magnetic and structural properties have been done using the Korringa-Kohn-Rostoker (KKR) band structure method. The disorder in the system has been accounted for by means of the Coherent Potential Approximation (CPA).

MA 20.144 Mo 14:00 Poster TU C

Canted antiferromagnetism in U_{1-x}La_xCu₉Sn₄ — ●E.-W. SCHEIDT¹, U. KILLER¹, H. MICHOR², H.-A. KRUG VON NIDDA³, and W. SCHERER¹ — ¹CPM, Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany — ²Institut für Festkörperphysik, TU Wien, 1040 Wien, Austria — ³EKM, Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

UCu₉Sn₄ crystallizes in the tetragonal space group *I4/mcm* with the lattice parameters $a = 0.86\text{nm}$ and $c = 1.236\text{nm}$. This compound is iso-

typ to the ferromagnetic systems RECu₉Sn₄ (RE = Ce, Pr, Nd) with Curie-Weiss temperatures of $\Theta_{CW} = 5.5\text{K}$, 10.5K and 15K , respectively. UCu₉Sn₄ exhibits an uncommon magnetic behaviour which is reflected in three different magnetic phase transitions: i) valence shift at 105 K, ii) onset of helimagnetic order at 32 K, and iii) transition into a commensurate antiferromagnetic structure at 22 K with magnetic field induced canting [1]. Here we present specific heat, susceptibility and resistivity studies on La-substituted samples U_{1-x}La_xCu₉Sn₄. [1] U. Killer, E.-W. Scheidt, H. Michor, J. Hemberger, H. A. Krug von Nidda and W. Scherer, *Physica B*, in print.

MA 20.145 Mo 14:00 Poster TU C

Magnetic and electrical properties of intermetallic ternary rare earth compounds — ●H. HARTMANN¹, O. HEYER¹, S. JODLAUK¹, K. KORDONIS¹, T. LORENZ¹, A. FREIMUTH¹, T. FICKENSCHER², and R. PÖTTGEN² — ¹II. Physikalisches Institut, Universität zu Köln, 50937 Köln — ²Anorganisch-Chemisches Institut, Universität Münster, D-48149 Münster

We present measurements of the magnetization M , the specific heat c_p , and the resistance ρ of GdAuIn, GdAuMg, EuAuMg, EuAgMg, YbAuMg, YbAgMg, and LaAgMg. The measurements of the magnetization and the specific heat indicate a ferromagnetic ordering in EuAuMg ($T_c \simeq 36\text{K}$) and EuAgMg ($T_c \simeq 22\text{K}$). According to a very small hysteresis, EuAgMg and EuAuMg may be classified as soft ferromagnets. An antiferromagnetic ordering is present in GdAuIn ($T_N \simeq 12\text{K}$) and GdAuMg ($T_N \simeq 80.5\text{K}$). For LaAgMg and YbAgMg we find no indications for magnetic ordering, but in YbAuMg c_p and M show small anomalies around 2.5 K, whose origin is yet to be clarified. In all samples with magnetic order we find a large negative magnetoresistance around the respective ordering temperature. Moreover, the magnetocaloric effect is very pronounced in some of the samples. For example, when GdAuIn is magnetized under adiabatic conditions it drastically lowers its temperature. *supported by the DFG through SPP 1166*

MA 20.146 Mo 14:00 Poster TU C

Investigation of Sr₂FeMoO₆ by means of magnetic circular dichroism in x-ray absorption and resonant x-ray emission at Fe L-edge — ●M. RAEKERS, K. KUEPPER, A. F. TAKÁCS, H. HESSE, and M. NEUMANN — Universität Osnabrück, Fachbereich Physik, Barbarastr. 7, D-49069 Osnabrück, Germany

Ordered double perovskites like Sr₂FeMoO₆ have attracted much attention since the discovery of colossal magnetoresistance at room temperature by Kobayashi *et al.* [1].

The electronic and magnetic properties of Sr₂FeMoO₆ have been already intensely studied, i. e., [2]. We present here magnetic circular dichroism (MCD) on the Fe L edge of Sr₂FeMoO₆ in x-ray absorption (XAS) and resonant inelastic x-ray scattering (RIXS). The results are discussed in the light of other XAS-XMCD spectra, Mössbauer data and available theoretical calculations.

[1] K.-I. Kobayashi *et al.*, *Nature* 395 677 (1998)[2] *phys. stat. sol. (a)*, in press, DOI 10.1002/pssa.200405432

MA 20.147 Mo 14:00 Poster TU C

Absorption spectroscopy and XMCD at the Verwey transition of Fe₃O₄ — ●EBERHARD GOERING, MIRSI NI LAFKIOTI, STEFAN GOLD, and GISELA SCHÜTZ — Max-Planck-Institut für Metallforschung, 70569 Stuttgart

Fe₃O₄ has been investigated since decades, because of its magnetic and unusual electronic transport properties, which exhibit significant changes at the so called Verwey transition. Nevertheless, recent investigations have shown that Fe₃O₄ has a remarkable high spin polarization at the Fermi energy [1], which transfers this system into a promising magnetic layer material for spin electronic devices. We will show detailed magnetic and nonmagnetic absorption spectroscopy results of an *in situ* cleaved high quality single crystal. We clearly observe a reproducible and very small energy shift (14 meV) of the O K edge threshold across the Verwey transition. In addition, our observed orbital moments and the magnetic changes across the Verwey transition are much smaller and in strong contradiction to recently published data [2]. [1] Dedkov, Yu. S., Rüdiger, U., *et al.*; *Phys. Rev. B* **65** (2002) 64417 [2] D.J. Huang *et al.*, *Phys. Rev. Lett.* **93**(2004) 77204

MA 20.148 Mo 14:00 Poster TU C

Doping and lattice effects in the half-metallic double perovskite A_2CrWO_6 — •OLIVER SANGANAS, STEPHAN GEPRÄGS, PETRA MAJEWSKI, ANDREAS ERB, MATTHIAS OPEL, LAMBERT ALFF, and RUDOLF GROSS — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Str. 8, 85748 Garching

Ferromagnetic double perovskites have attracted renewed interest due to the fact that they combine high Curie-temperature T_C and a half-metallicity [1]. Recently, in the compound Sr_2FeMoO_6 the substitution of Sr^{2+} by trivalent La^{3+} has been reported to lead to an even further increase of T_C [2]. With respect to the mechanism of ferromagnetism in the double perovskites it is important to clarify whether this behavior is general [3]. We have fabricated a series of polycrystalline samples of the two compounds with different La doping in order to compare carefully the different effects on T_C . All samples were characterized by x-ray powder diffractometry, neutron scattering, magnetization and transport measurements. We find that the preferential formation of $LaCrO_3$ prevents the formation of La-doped Sr_2CrWO_6 . However, in the system Ca_2CrWO_6 La doping can be achieved. In agreement with the results for Sr_2FeMoO_6 , T_C is increased as a function of La doping, paving the way for double perovskites with very high T_C as functional material for magnetoelectronics.

[1] K.-I. Kobayashi *et al.*, Nature **395**, 677 (1998)

[2] J. Navarro *et al.*, Phys. Rev. B **64**, 092411 (2001).

[3] J. B. Philipp *et al.*, Phys. Rev. B **68**, 144431 (2003).

MA 20.149 Mo 14:00 Poster TU C

Investigation of Transition Metal Substituted Polyoxotungstates by X-ray Photoelectron Spectroscopy — •M. PRINZ¹, A. F. TAKÁCS¹, M. NEUMANN¹, U. KORTZ², I. BALASZ³, and E. BURZO³ — ¹Department of Physics, University of Osnabrück, 49069 Osnabrück, Germany — ²International University Bremen, P.O. Box 750561, 28725 Bremen, Germany — ³Faculty of Physics, Babes-Bolyai University, 3400, Cluj-Napoca, Romania

New materials based on polyoxometalates (metal-oxygen clusters) are promising stages of development in nano/micro electronic applications that can lead to the emergence of a new technology. We have investigated the electronic and magnetic properties of the dimeric, transition metal substituted polyoxotungstates $Cs_n[M_4(H_2O)_{10}(\beta-XW_9O_{33})_2]$ ($n = 6, M = Fe^{3+}, Cr^{3+}, X = Sb^{III}; n = 8, M = Co^{2+}, Mn^{2+}, X = Se^{IV}$) synthesized by Ulrich Kortz at the IUB [1]. X-ray photoelectron spectroscopy (XPS) and X-ray emission spectroscopy (XES) measurements have been performed. Hybridization of the O 2p, M 3d and W 5d states close to the Fermi level was found. Magnetic measurements of $Cs_6[Fe_4(H_2O)_{10}(\beta-SbW_9O_{33})_2]$ show a magnetization of approximately $10 \mu_B/f.u.$ at $T = 4.2$ K and $B = 9$ T without saturation.

[1] Kortz *et al.*, Inorg. Chem. 2002, 41, 783-789

MA 20.150 Mo 14:00 Poster TU C

Corrosion of Nd-Fe-B magnets in aqueous environments — •MIHAELA RADA, ANNETT GEBERT, OLIVER GUTFLEISCH, and LUDWIG SCHULTZ — IFW Dresden, Postfach 27 0116, 01171

The corrosion properties of hot compacted $Nd_2Fe_{14}B/Fe$ (0 to 35 wt. %) nanocomposites (exhibiting remanence enhancement) produced from intensively milled powders and of polymer-bonded nanocrystalline magnets made from commercial rapidly quenched NdFeB-based powders with compositions varying from the Nd-rich to slightly Fe-rich range are evaluated in neutral and acidic aqueous media. The electrochemical properties of the magnets are discussed with respect to the behaviour of their single phases (Nd-rich phase, Fe, Fe_3B and $Nd_2Fe_{14}B$). Polymer-bonded magnets of different compositions have a significantly improved environmental resistance as compared to hot pressed magnets. Slight enrichment in Fe content and additions like Co and Nb improve their corrosion behaviour. For nanocomposites with increasing Fe content up to 35 wt. % decreasing corrosion rates as well as increasing passivation ability is detected. Effects of grain orientation on the corrosion rate are studied in detail for textured sintered magnets.

MA 20.151 Mo 14:00 Poster TU C

Oxidationsverhalten von Sm-Co-Permanentmagneten bis 500°C — •STEFAN KARDELKY, ANNETT GEBERT, OLIVER GUTFLEISCH und LUDWIG SCHULTZ — Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, PF 270116, 01171 Dresden

Die Kenntnis des Oxidationsverhaltens von $Sm(Co,Fe,Cu,Zr)_z$ Permanentmagneten des Typs Sm_2Co_{17} ist notwendig für die Einschätzung ihrer Stabilität unter Einsatzbedingungen. Gesinterte Magnete mit variieren-

dem Fe, Cu, Zr-Gehalt wurden hinsichtlich Oxidsschichtbildung bei verschiedenen Auslagerungstemperaturen und -zeiten in Luft und in O_2/Ar -Gemischen untersucht. Die Kinetik der Oxidschichtwachstumsprozesse wurden mittels TGA verfolgt. Die oxidierten Magnetoflächen wurden nachfolgend mit OM und REM sowie mittels GDOES charakterisiert. Anhand zeitabhängigen Massenänderungen wurden unter Anwendung bekannter Wachstumsgesetze parabolische Zunderkonstanten bestimmt, mit denen das Langzeitoxidationsverhalten vorhergesagt werden konnte. Durch Reduzierung des Fe- und Erhöhung des Cu, Zr-Gehaltes in der Zusammensetzung der Magnete werden sowohl magnetische Eigenschaften stabilisiert als auch Zunderkonstanten bei 500°C in Luft um bis zu 30 % gesenkt. Magnetische Kennwerte wurden nach Oxidationsversuchen in Luft bei 500°C bis 1000h bestimmt. Nach 600h Oxidation in Luft bei 500°C verminderte sich $(BH)_{max}$ auf 50 %. Durch elektrolytisches Aufbringen von bis zu 15 μm starken Ni Schichten wurde die Oxidationsgeschwindigkeit bei 500°C in Luft um bis zu 96,5 % reduziert, d.h. die Stabilität gegenüber Oxidation wurde deutlich verbessert.

MA 20.152 Mo 14:00 Poster TU C

AMR Sensor Array for the Detection of Defects in Aluminum Laser Welds — •KAI ALLWEINS and MARC VON KREUTZBRUCK — Institut für Angewandte Physik, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen

Increasing demands in material testing have led to growing interest for advanced and reliable electro-magnetic testing methods. We present eddy current measurements with an AMR sensor array for the detection of imperfections in aluminum laser welds used in automotive industry. Usually material defects in laser welds are micro-cracks as well as porosities with diameters often as small as 100 μm . Measurements of laser welds with a width of 1-2 mm in an AlMg3 aluminum alloy with a thickness of more than 1 mm were performed. The welds contain reference defects or unknown defects. The separation of defect signals from noise caused by the weld's surface texture required additional efforts in signal processing and simulations. Due to the field sensitivity of about 100 pT/ \sqrt{Hz} and high spatial resolution of the implemented AMR sensor array small porosities with a radius of 65 μm could be detected in a depth of up to 1 mm with a sufficiently high signal-to-noise ratio.

MA 20.153 Mo 14:00 Poster TU C

Magnetische Ortung und Klassifizierung von Luft- und Landfahrzeugen auf Flughäfen — •THOMAS HEUER, HAIBIN GAO und UWE HARTMANN — FR 7.2 Experimentalphysik, Universität des Saarlandes, Im Stadtwald, 66123 Saarbrücken

Angesichts der weltweit rapide steigenden Zahl von Flugbewegungen wird ein System benötigt, das die Ortung und Klassifizierung von Objekten auf einem Flughafen auch unter ungünstigen Witterungsbedingungen gewährleistet und somit die Voraussetzung für eine zügige und sichere Verkehrsabwicklung schafft. Ein neuartiges, im Rahmen des EU-Projektes "ISMAEL" zu entwickelndes System erfasst die durch die Präsenz von Luft- und Landfahrzeugen erzeugten Änderungen im Erdmagnetfeld. Es kann damit andere, auf Radar basierende Ortungssysteme ergänzen oder, insbesondere auf kleineren Flughäfen, vollständig ersetzen. Besondere Herausforderungen bei der Entwicklung dieses Systems stellen dabei der geringe Anteil ferromagnetischer Werkstoffe in Luftfahrzeugen sowie die Vielzahl starker Störsignale auf einem Flughafen dar. Schwerpunkte der Forschungstätigkeit sind daher neben der numerischen Simulation der zu erwartenden Signale und dem Vergleich mit tatsächlich gemessenen Werten die Optimierung der Sensoren hinsichtlich Empfindlichkeit und Zuverlässigkeit.

MA 20.154 Mo 14:00 Poster TU C

Modelling the Procopiu Effect — •J. VELLEUER, A. HACKL, and E. KISKER — Institut für Angewandte Physik, Heinrich-Heine Universität Düsseldorf, 40225 Düsseldorf

The Procopiu effect [1], used for very sensitive magnetic field sensing, manifests itself in the occurrence of an AC voltage on a solenoid wrapped around a softmagnetic wire, when an AC current is flowing through the wire and an external magnetic field (H_z) is applied. The magnitude of the voltage increases quasilinearly from very small values at $H_z=0$ until two maxima symmetrical to $H_z=0$ are observed at about the earth magnetic field strength. At the same time, the wire exhibits the giant magnetoimpedance (GMI) effect [2] which, at frequencies above about 500 kHz, also shows two maxima at some small magnetic field strength, also symmetrical to zero field. We are able to model the Procopiu effect quantitatively using only the magnetic material properties. Whereas

the maxima in the GMI effect are considered to arise from the coercive field of the softmagnetic wire, the maxima in the Procopiu voltage are shown to originate already from a non-hysteretic magnetization curve. This suggests that the Procopiu effect and the GMI effect arise from different shells of the wire, i.e. the former from the magnetic core and the latter from the outer shell as a consequence of the skin effect. [1] see, e.g.: J. J. Freijo, J. Appl. Phys. **85**, 5450 (1999) [2] see, e.g.: C. Bethke et al., Technisches Messen **70**, 12 (2003)

MA 20.155 Mo 14:00 Poster TU C

A Desktop NMR Cryogen free Magnet For 100 And 200Mhz — ●JEREMY GOOD — 30 Acton Park Industrial Estate, London W3 7QE, UK

Cryogenic have built a miniature helium and cryogen free magnet in a miniature cryostat with 5 ppm conformity at fields of 2.5 and 5 Tesla. The magnet is cooled by a small refrigerator to 4K without the use of liquid helium. The overall dimensions of the cryostat are 260mm high with a footprint 240 x 540mm. The workspace is a bore of 51mm but other sizes are practical in the same geometry. For the lower field the system is designed to run with a 1 Kilowatt air-cooled single-phase compressor making the magnet easy to use by non-specialists and to transport between locations. The magnet is intended for use in ESR as well as low field NMR experiments. It is thought to be the smallest High Field Superconductors NMR magnet yet built.

MA 20.156 Mo 14:00 Poster TU C

EPR Study of N@C₆₀ and P@C₆₀ in 1D Matrices — ●CH. SPUDAT¹, W. HARNEIT¹, B. NAYDENOV¹, M. SCHELOSKE¹, H.I. SÜSS², and J. HULLINGER² — ¹Institut für Experimentalphysik, Freie Universität Berlin, Arnimalle 14, 14159 Berlin, Germany — ²Dept. f. Chemie & Biochemie, Universität Bern, Freiestrasse 3, 3012 Bern, Switzerland

We will present our latest results towards the electron spin quantum computer (QC) based on the group V endohedral fullerenes N@C₆₀ and P@C₆₀ as qubits. These molecules are very suitable for QC purposes because of their very long relaxation times and the possibility of good scalability [1]. We show the dependence of the spin-spin relaxation of polycrystalline P@C₆₀ samples on the temperature and on spin concentration. At low temperatures and low concentrations, we found a value of $T_2 = 150 \mu s$, which is very long for molecular systems. We also managed to align our fullerenes in the perfectly one-dimensional channels of the organic crystal BrPOT (2,4,6-tris-(4-bromo-phenoxy)-1,3,5-triazine) as described in [2]. The inclusion lowers the symmetry of the fullerene cage and gives rise to a considerable zero-field splitting. This provides a way to selectively address the ($\pm 3/2$; $\pm 1/2$) and ($1/2$; $-1/2$) transitions, giving access to all internal spin degrees of freedom. The relaxation times of the corresponding transitions are also presented.

[1] W. Harneit, Phys. Rev. A **65** (2003) 032322

[2] H.I. Süss, M. Lutz, J. Hulliger, Cryst. Eng. Comm. **4** (2002) 610

MA 20.157 Mo 14:00 Poster TU C

Electronic and magnetic properties of a hexanuclear ferric wheel — ●HARALD NIEBER, KLAUS DOLL, and GERTRUD ZWICKNAGL — Institut für Mathematische Physik, TU Braunschweig, Mendelssohnstr. 3, D-38106 Braunschweig

The electronic and magnetic properties of the hexanuclear ferric wheel [LiFe₆(OCH₃)₁₂(dbm)₆]PF₆ have been studied with all-electron Hartree-Fock and full-potential density functional calculations. The best agreement for the magnetic exchange coupling is at the level of the B3LYP hybrid functional. The local density approximation and the gradient corrected functional PBE strongly overestimate the exchange coupling due to the too large delocalization of the *d*-orbitals. These findings are supported by results from the Mulliken population for the magnetic moments and the charge on the individual atoms.

MA 20.158 Mo 14:00 Poster TU C

Electronic and magnetic properties of multinuclear Ni(II) complexes — C. MENNERICH¹, ●C. GOLZE^{2,1}, M. BRÖCKELMANN^{1,2}, V. KATAEV², H.-H. KLAUSS¹, B. BÜCHNER², A. WOLTER¹, S. SÜLLOW¹, J. LITTERST¹, R. KLINGELER², S. DEMESHKO³, G. LEIBELING³, F. MEYER³, and D.-J. PRICE⁴ — ¹Institut für Metallphysik und Nukleare Festkörperphysik, TU Braunschweig — ²Leibniz-Institut für Festkörper- und Werkstofforschung, Dresden — ³Institut für Anorganische Chemie, U Göttingen — ⁴Department of Chemistry, Univ. of Glasgow, United Kingdom

We present thermodynamic and high field ESR studies of the magnetic behaviour of two newly synthesized Ni(II) S=1 molecular magnets. In Na₂Ni₂(C₂O₄)₃(H₂O)₂ Ni dimers are weakly coupled along one direction forming a S=1 two-leg spin ladder. Magnetic susceptibility data and results of tunable ESR at frequencies up to 600 GHz in fields up to 15 T enable the accurate determination of the magnetic interactions J_{rung} and J_{leg} , the local anisotropy parameters D and E as well as the estimate of the relative energies of the Ni orbital states. The measurements prove that this system is close to the dimer limit. In the tetranuclear Ni(II) complexes [L₂Ni₄(N₃)_{5-i}(O₂CR)_i] (ClO₄), i=2,4, three symmetric magnetic interaction paths are realized by azide groups. The magnetic susceptibility of these systems indicates an S=0 ground state. This is confirmed by a numerical analysis using a three- J approach and a uniaxial anisotropy D which reveals a combination of antiferromagnetic and ferromagnetic interactions between the individual metal ions. First ESR results on this system will be discussed as well.

MA 20.159 Mo 14:00 Poster TU C

Electronic and magnetic properties of Fe (II) based molecular magnets — ●F. GOUIDER¹, J. KREITLOW¹, D. BAABE¹, S. SÜLLOW¹, J. LITTERST¹, R. FEYERHERM², A. LOOSE², T. ISHIDA³, T. NOGAMI³, K. DOLL⁴, and H.-H. KLAUSS¹ — ¹Institut für Metallphysik und Nukleare Festkörperphysik, TU Braunschweig — ²Hahn-Meitner-Institut, 14109 Berlin — ³Dep. of Appl. Phys. and Chem., University Chofu, Tokyo 182-8585, Japan — ⁴Institut für Mathematische Physik, TU Braunschweig

We present Moessbauer spectroscopy studies on two Fe(II) S=2 based molecular magnets, FePM₂Cl₂ and FePMCl₂ (PM=N₂C₄H₄ = pyrimidine). In both compounds the pyrimidine molecule forms the magnetic exchange path. FePM₂Cl₂ crystallizes in a chiral lattice. Combined magnetization, Moessbauer spectroscopy, and powder neutron diffraction studies reveal that it is a canted antiferromagnet below $T_N=6.4$ K with an unusually large canting of the magnetic moments of 14° from their general antiferromagnetic alignment. This results in weak ferromagnetism with a ferromagnetic component of $\approx 1 \mu_B$ [1]. In FePMCl₂ anisotropic magnetic interactions are provided via the PM molecules and the Cl⁻ ions. This leads to a long range magnetic order below ≈ 11 K. Although neutron scattering results in an ordered moment of 3.2 μ_B the Moessbauer experiments reveal a strongly reduced magnetic hyperfine field of ≈ 4 T. These results are discussed in terms of the interplay of orbital and spin magnetic moments on the local Fe complexes. [1] R. Feyerherm et al., PRB **69** (2004) 134427.

MA 20.160 Mo 14:00 Poster TU C

Neutron Diffraction Studies of the Long-Range Magnetic Ordering in the Antiferromagnetic Quantum Chain System CuBr₂ — ●REINHARD K KREMER¹, MICHAEL BANKS¹, ARNDT SIMON¹, and BACHIR OULADDIAF² — ¹MPI-FKF, 70569 Stuttgart — ²ILL Grenoble, CEDEX 9

Historically, the binary CuBr₂ and the structurally similar CuCl₂ are among the very first systems the magnetic properties of which were analyzed in terms of a linear spin chain arrangements. Low-dimensional magnetism with typical signatures, e.g. a broad short-range ordering maxima in the susceptibility have been found. The antiferromagnetic (afm) intra-chain exchange parameters are significant (e.g. ≈ 320 K for CuBr₂), however, both systems are far from representing ideal one-dimensional magnets as must be concluded from the rather high transition temperatures to long-range ordering (e.g. 74 K for CuBr₂) indicating appreciable inter-chain coupling. To the best of our knowledge, the magnetic structures of CuBr₂ and CuCl₂ remained unsolved until now. We studied the afm ordering of CuBr₂ in detail by neutron powder diffraction using ILL's high flux powder diffractometer D20 in its high resolution option. Below T_N , two very weak additional reflections of magnetic origin were identified which can be indexed with a propagation vector (0,0.54,0) indicating an incommensurate antiferromagnetic structure. A first analysis assumes

a longitudinal amplitude modulation with moments ($\mu = 0.2 \mu_B$) oriented along (0,1,0). In the critical regime characteristic magnetoelastic anomalies are observed for the b lattice parameter and the monoclinic angle β .

MA 20.161 Mo 14:00 Poster TU C

EuGe: A system close to the transition from a ferro- to an antiferromagnetic state — ●JULIA FERSTL and CHRISTOPH GEIBEL — Max Planck Institut fuer Chemische Physik fester Stoffe, Noethnitzer Strasse: 40, 01187 Dresden

The Rare earth compound series RGe has attracted some attention because of the transition from a ferromagnetic state for light rare earth towards an antiferromagnetic state for heavy rare earth, the transition occurring in between Nd and Eu. However, for EuGe, beside structural data, only the susceptibility and a magnetization curve at low T have yet been reported [1]. From these data a divalent Eu state ordering antiferromagnetically below $T_N = 20$ K was inferred. In an attempt to synthesize EuFe₂Ge₂, we obtained EuGe single crystals. We present here the investigation of these single crystals by means of susceptibility, specific heat and resistivity measurements. Our results confirm a divalent Eu state, but indicate a more complex magnetic ordering behavior. Very pronounced anomalies in the specific heat and in the resistivity show that magnetic ordering occurs at a much higher temperature $T_N = 38$ K, while a pronounced anomaly in the susceptibility in low fields at 25 K, which likely corresponds to the anomaly seen in [1], indicate a further transition associated with a change in the magnetic structure. This complex magnetic behavior is probably related to the proximity to a ferromagnetic state, which is also evidenced by a ferromagnetic Curie-Weiss temperature $\theta_{CW} = +34$ K. [1] K.H.J. Buschow et al. Journal of Less-Common Metals, 139 (1988) 221-231

MA 20.162 Mo 14:00 Poster TU C

New clathrate-like compounds EuPd₅P₂ and EuPd₁₂P₅ — ●ULRIKE KÖHLER, SERGIJ BUDNYK, SILKE PASCHEN, FRANK STEGLICH, and YURI GRIN — MPI für Chemische Physik fester Stoffe, Noethnitzer Straße 40, 01187 Dresden

Many filled cage compounds are known to have low phonon thermal conductivities κ_{ph} . In Kondo insulators the hybridization between localized 4f states and a conduction band is held responsible for the formation of a narrow band gap at the Fermi level and hence for a semiconductor-like electrical resistivity ρ and a low electronic thermal conductivity κ_{el} . The strong energy dependence of the quasiparticle density of states near the Fermi level in these materials gives rise to high values of the thermopower S . Since a good thermoelectric material is characterized by a high thermoelectric figure of merit $ZT = TS^2/[\rho(\kappa_{ph} + \kappa_{el})]$, Kondo insulating filled cage compounds appear to be a promising class of new materials. In this contribution we present physical properties of the two newly discovered filled cage compounds EuPd₅P₂ and EuPd₁₂P₅ which crystallize in a novel clathrate-like structure. Both materials have a metal-like $\rho(T)$ and are therefore expected to show neither high $S(T)$ nor low $\kappa_{el}(T)$. The high temperature magnetic susceptibility χ is well described by a Curie-Weiss law with a full Eu²⁺ effective moment. Below 10 K both compounds order magnetically. The large Eu-Eu distance indicates that not the direct exchange interaction between the localized 4f moments but the RKKY interaction is responsible for the magnetic ordering.

Modifications of the compounds investigated here will be necessary to make them good thermoelectrics.

MA 20.163 Mo 14:00 Poster TU C

YbFe₄Sb₁₂: Divalent Ytterbium State and Itinerant Magnetism of the Skutterudite Host Structure — ●W. SCHNELLE, A. LEITHE-JASPER, H. ROSNER, M. SCHMIDT, M. BAENITZ, J.A. MYDOSHI, and Y. GRIN — Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

The filled skutterudite YbFe₄Sb₁₂ has been investigated by Maple et al. [1] and other groups [2] and its remarkable properties have been inter-

preted involving an intermediate valence state of Yb and heavy-fermion behaviour at low temperatures. The large linear term γ in the specific heat (≈ 140 mJ/molK²) and the 'S'-shape of the metallic resistivity have been presented as evidence for a Kondo effect and heavy electrons. However, the filled skutterudites $M\text{Fe}_4\text{Sb}_{12}$ with $M = \text{Na, K, Ca, Ba}$ [3] and La all display γ terms of 100-200 mJ/molK² and strongly curved resistivities $\rho(T)$, irrespective of their magnetic ground state. Also, their paramagnetic effective moments are quite similar and derive almost completely from the itinerant magnetism of the Fe₄Sb₁₂ host which is only slightly modified by the various filler atoms. Conclusively, X-ray absorption spectra (XANES) at the Yb L_{III} threshold demonstrate that Yb is in a divalent $4f^{14}$ state and thus YbFe₄Sb₁₂ can neither exhibit a Kondo effect nor show conventional heavy fermion behaviour.

[1] N.R.Dilley et al. Phys. Rev. B 58, 6287 (1998). S.V.Dordevic et al. Phys. Rev. Lett. 86, 684 (2001).

[2] see e.g. E.Bauer et al. Acta Phys. Polon. B 34, 595 (2003).

[3] A. Leithe-Jasper et al. Phys. Rev. B, in print (1 Dec 2004).

MA 20.164 Mo 14:00 Poster TU C

Electronic structure of NiO monolayer on Ag(100) — ●L. H. TJENG¹, C.-F. CHANG¹, S. ALTIERI², S. HEISE¹, M. W. HAVERKORT¹, Z. HU¹, S. V. STRELTSOV³, V. I. ANISIMOV³, H. H. HSIEH⁴, H.-J. LIN⁵, D.-J. HUANG⁵ und C.T. CHEN⁵ — ¹II. Physikalisches Institut, Universität zu Köln, Zùlpicher Str. 77, 50937 Köln, Germany — ²INFN, Modena, Italy — ³Institute of Metal Physics, Ekaterinburg, Russia — ⁴Chung Cheng Institute of Technology, Taiwan — ⁵NSRRC, Taiwan

We have investigated the electronic structure of a NiO monolayer deposited on top of a Ag(100) substrate. Using x-ray absorption spectroscopy we found that the Ni ions are in the 3d⁸ (2+) valence state, with one hole in a 3d_{3z²-r²} orbital and another in a 3d_{x²-y²}, very similar to bulk NiO. From the polarization dependence we observed nevertheless that the 3d_{3z²-r²} orbital in the NiO monolayer is somewhat less unoccupied than in bulk NiO and that there is a large 3d_{3z²-r²}-3d_{x²-y²} crystal field splitting. Our LDA+U calculations show that the unoccupied 3d_{3z²-r²} orbital is not pushed up so strongly above the Fermi level because in the monolayer there are no oxygens above or below it to hybridize with. This 3d_{3z²-r²} forms a band via the Ag sp-states, with a low energy tail extending below the Fermi level. This is confirmed by our photoemission data, which show a clear Fermi cut-off in the Ni 3d. In other words, the monolayer is metallic. Moreover, except for a rigid energy shift, the photoemission spectra of the NiO monolayer and bulk NiO look rather similar. We have more spectroscopic data to suggest that the NiO monolayer on Ag is actually a Kondo lattice system.

MA 20.165 Mo 14:00 Poster TU C

Spin versus orbital Kondo effect in electrostatically coupled double quantum dots — ●DANIEL BEZECNY and ALEXANDER L. CHUDNOVSKIY — 1. Institut für theoretische Physik, Uni Hamburg, Jungiusstr. 9, 20355 Hamburg

We consider the Kondo effect in strongly electrostatically coupled double quantum dots. The orbital structure of the electron wave function of a double dot crucially influences the transport properties if there is no energy cost to transfer an electron from one dot to the other. In that case the two degenerate states with the "last" electron either in the right or in the left dot can be associated with a spin-like degree of freedom that we call pseudo-spin. Resonant transfer of an electron corresponds to a flip of the pseudospin analogously to a spin flip in the Kondo effect. The process of a resonant pseudospin flip can induce a so called orbital (or pseudospin) Kondo effect quite similar to - and to a large extent independent of - the well-known (spin) Kondo effect. Varying the strength of the tunnel coupling between the reservoirs and each of the two dots allows a controllable change of the coupling symmetry of the Orbital Kondo effect without affecting the spin Kondo effect. Furthermore, the orbital Kondo effect can be suppressed by lifting the degeneracy of the energy levels of the left and right dot.

MA 21 Hauptvortrag Moshnyaga

Zeit: Dienstag 09:45–10:15

Raum: TU H1028

Hauptvortrag

MA 21.1 Di 09:45 TU H1028

Lattice strain and disorder effects in magnetotransport of manganite films — ●VASILY MOSHNYAGA — I. Physikalisches Institut, Universitaet Goettingen, Friedrich-Hund-Platz1, 37077 Goettingen

The properties of perovskite manganites are governed by complex phase diagram with a number of phase transitions as a function of doping level, temperature, pressure and magnetic field. Moreover charge-, spin- and lattice degrees of freedom can compete yielding to electronic phase separation (EPS). We studied magnetotransport in thin mangan-

ite films of La-(Ca or Sr)-Mn-O (L(CS)MO), prepared by a metalorganic aerosol deposition (MAD) technique. Layer-by-layer (LL) and 3D island film growth were realized by MAD, which results in different microstructure and magnetotransport. Nanocomposite L(CS)MO:MgO films were shown to be promising for tuning both intrinsic (CMR) and extrinsic (TMR) properties. In addition very large photoinduced resistivity and optical second harmonic generation were observed in LCMO films. These different effects are discussed in terms of lattice strain and disorder, which by modifying the double exchange and electron-lattice interaction on the nm-scale can control EPS in manganites.

MA 22 Magnetische dünne Schichten IV

Zeit: Dienstag 10:30–13:00

Raum: TU H1012

MA 22.1 Di 10:30 TU H1012

Element-specific characterization of Co₂MnGe/Au interfaces by XRMS — ●ANDRE BERGMANN, JOHANNES GRABIS, ALEXEI NEFEDOV, KURT WESTERHOLT, and HARTMUT ZABEL — Institut für Experimentalphysik IV, Ruhr-Universität Bochum

Sputtered superlattices of the Heusler compound Co₂MnGe with Au as spacer layer are studied by x-ray resonant magnetic reflectivity and diffuse scattering. Reflected intensities for both magnetic field directions in the longitudinal magneto-optical Kerr geometry were measured as a function of the photon energy at the first three superlattice reflections in the Co and Mn $L_{2,3}$ absorption edge regions. Both, intensities and the corresponding asymmetries are simulated within a magneto-optical approach in order to determine an element-specific magnetization depth profile. Magnetically dead layers of up to 1 nm thickness are found at the Co₂MnGe/Au interface explaining the relatively low magnetic moment observed in these systems. Resonant diffuse scattering yields information on the chemical and magnetic interface morphology. The in-plane correlation lengths of chemical and magnetic roughness are almost identical and correspond to the Co₂MnGe crystallite size.

MA 22.2 Di 10:45 TU H1012

Morphology, structure and magnetic properties of Ni_xMn_{1-x} and Ni_xMn_{1-x}/Co bilayers grown on Cu(001) — ●C. TIEG¹, S. WANG¹, W. KUCH^{1,2}, and J. KIRSCHNER¹ — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle — ²present address: Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin

Thin films of Ni_xMn_{1-x} were epitaxially grown by thermal evaporation on Cu(001) and studied with respect to their morphology, structure, and magnetic properties by means of electron diffraction techniques and magneto-optic Kerr effect measurements. A 2-dimensional growth mode has been verified for coverages up to 15 monolayers (ML) by the presence of MEED oscillations within the composition range of $0.4 < x < 1.0$. While chemically disordered Ni-rich and Mn-rich films exhibit a $p(1 \times 1)$ structure, films in the equiatomic region display a characteristic $c(2 \times 2)$ superstructure for thicknesses within the studied range of up to 18 ML that might be attributed to an ordered $L1_0$ phase as it is present in bulk NiMn. Furthermore, the interlayer spacing d was deduced from a kinematic analysis of LEED I(V) curves taken at thick Ni_xMn_{1-x} films (>10 ML). We obtain a continuously decreasing d from 1.92 ± 0.02 Å for highly Mn-rich films to 1.73 ± 0.02 Å for tetragonally distorted pure Ni films. The lattice constants of Ni_xMn_{1-x} and Cu(001) coincide at $x \approx 0.6$. Magnetic properties were studied for Ni_xMn_{1-x} films in contact with a ferromagnetic layer. The presence of antiferromagnetic order in equiatomic NiMn films at $T=300$ K above a certain thickness is indicated by a pronounced coercivity enhancement in Co/NiMn bilayers.

MA 22.3 Di 11:00 TU H1012

Electrical and magnetic effects in multi-ferroic (La,A)MnO₃ / PZT bilayers — ●C. THIELE¹, K. DÖRR¹, J.-W. KIM¹, W.-M. LIN², and L. SCHULTZ¹ — ¹IFW Dresden, PB 270116, 01171 Dresden — ²IFE, TU Dresden, Mommsenstr. 13, 01062 Dresden

Magnetic and electrical properties of conducting ferromagnetic manganites La_{1-x}A_xMnO₃ (A= Sr, Ca, Ce) crucially depend on the charge carrier density usually controlled by doping level x . Earlier it was sug-

gested to control epitaxial strain of thin manganite films using the piezoelectric effect of a ferroelectric Pb(Zr, Ti)O₃ (PZT) toplayer [1], however, an electrical field effect seems to be dominant in this type of bilayer structure. Off-axis pulsed laser deposition has been applied to epitaxially grow manganite/PZT bilayers. An electrical voltage applied to the PZT layer in bilayer structures leads to hysteretic modulation of the manganite layer resistance which has been studied in dependence on magnetic field, temperature and manganite layer thickness. The phenomenon is discussed in the framework of a field effect modulating the carrier density of the manganite. Further, magnetization, ferroelectrical polarization and piezoresponse measurements are shown.

This work is supported by DFG, FOR 520.

[1] H. Tabata et al., IEICE Trans. Electron. E80-C (1997) 918

MA 22.4 Di 11:15 TU H1012

Correlation of ferromagnetic resonance modes and domain structure in patterned ferromagnetic films — ●UTE QUEITSCH¹, JEFFREY MCCORD¹, RUDOLF SCHÄFER¹, LUDWIG SCHULTZ¹, KARSTEN ROTT², and HUBERT BRÜCKL² — ¹Leibniz Institut für Festkörper- und Werkstofforschung (IFW), Helmholtzstraße 20, 1069 Dresden — ²Universität Bielefeld, Lehrstuhl für Dünne Schichten und Nanostrukturen, Universitätsstrasse 25, 33615 Bielefeld

Understanding the high frequency (hf) magnetic response of patterned soft magnetic thin films is crucial for hf applications, e.g. integrated micro-inductors. Arrays of single and bi-layer Ni₈₁Fe₁₉ and CoZrTa thin film elements (100 μm x 50 μm x 80 nm) were fabricated. The hf response was characterized by pulsed inductive microwave magnetometry (PIMM) and directly compared to the magnetic domain structure, analyzed by magneto-optical Kerr microscopy in the longitudinal mode. By varying the magnetic field history different 'virgin' domain states were adjusted. Depending on the micromagnetic structure, characteristic changes in the hf response were observed. It was found that the presence of domains causes a drastic increase in the dominating ferromagnetic resonance frequency of the films due to an accompanied stiffening of its magnetization. With increasing domain density, a decrease in hf permeability for the same sample is observed. Domain wall effects during the dynamic remagnetization process lead to additional frequency modes in the sub-GHz range.

MA 22.5 Di 11:30 TU H1012

Ultrathin antiferromagnetic films on a ferromagnetic substrate: A first-principles study of Mn on Fe(001) — A. ERNST¹, ●J. HENK¹, P. BRUNO¹, and R. K. THAPA² — ¹MPI für Mikrostrukturphysik, Halle/S., Germany — ²Pachhunga University College, Mizoram University, India

The electronic and magnetic structures of Mn films with thicknesses of up to 12 monolayer on Fe(001) is investigated by means of first-principles calculations, with a focus on the thicker films. The Mn films show a layer-by-layer antiferromagnetic structure and couple antiferromagnetically to the Fe substrate. The magnetic moments at the Mn surface and at the Mn-Fe interface are significantly enhanced, as compared to the respective bulk values. Several surface states are found at the center of the two-dimensional Brillouin zone, some of which might explain recent experimental scanning-tunneling-spectroscopy results [1].

[1] T. K. Yamada, M. M. J. Bischoff, G. M. M. Heijnen, T. Mizoguchi, and H. van Kempen, Phys. Rev. Lett. (2003) **90** 056803.

MA 22.6 Di 11:45 TU H1012

Ferromagnetic Cr and antiferromagnetic Co: Unexpected magnetism of 3d transition-metal monolayers on W(001) — ●PAOLO FERRIANI¹, STEFAN HEINZE¹, GUSTAV BIHLMAYER², and STEFAN BLÜGEL² — ¹Institut für Angewandte Physik, Universität Hamburg, Jungiusstrasse 9a, 20355 Hamburg — ²Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

In the past, first-principles calculations of 3d transition-metal monolayers on (001) surfaces of non-magnetic metals have led to the conclusion that the early 3d metals V, Cr, and Mn possess a $c(2 \times 2)$ antiferromagnetic (AFM) ground state while Fe, Co, and Ni are ferromagnetic. For Fe on W(001), however, first-principles calculations so far remained non-conclusive while experiments could not find any magnetic order. Here, we present density-functional theory based calculations of 3d transition-metal monolayers on W(001) using the full-potential linearized augmented plane wave (FLAPW) method. Surprisingly, the normal trend is inverted, i.e. V, Cr and Mn are ferromagnetic while Fe and Co are $c(2 \times 2)$ antiferromagnetic on W(001). Ni is non-magnetic. Recently, the AFM ground state of Fe has been confirmed experimentally by spin-polarized scanning tunneling microscopy [1].

[1] A. Kubetzka, P. Ferriani, *et al.*, submitted for publication.

See also talk by A. Kubetzka *et al.* at this DPG meeting.

MA 22.7 Di 12:00 TU H1012

Reorientation of spin-density waves in Cr films induced by proximity effects of vanadium — ●H. ZABEL¹, E. KRAVTSOV¹, A. NEFEDOV¹, A. REMHOF¹, F. RADU¹, B. HJÖRVARSSON², A. HOSER³, and G.J. MCINTYRE⁴ — ¹Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — ²Department of Physics, Uppsala University, Box 530, S-75121 Uppsala, Sweden — ³Institut für Kristallographie, RWTH-Aachen, D-52056 Aachen, Germany — ⁴Institut Laue-Langevin, F-38042 Grenoble Cedex 9, France

The spin density wave (SDW) magnetism in Cr implies a periodic and usually incommensurate modulation of the magnetization vector in real space. In thin films, the SDW is confined and therefore the spontaneous formation of the SDW due to the Fermi surface nesting competes with hybridization effects of adjacent ferro- or paramagnetic layers, with interfacial structures (order and disorder), and with dimensionality effects (film thickness). We report on neutron scattering studies from proximity effects of neighbouring vanadium layers on the SDW in epitaxial Cr(001) films. We provide direct evidence for long-range effects from the V/Cr interface, leading to changes in the polarization and propagation direction of the SDW in rather thick Cr films. The Néel temperature is found to be affected by boundary conditions for the spin-density waves at V/Cr interfaces. - This work is supported by DFG-SFB 491: Magnetic Heterostructures.

MA 22.8 Di 12:15 TU H1012

MODIFICATION OF THE SPIN DENSITY WAVE OF CR IN FE/CR MULTILAYERS BY INSERTION OF SN — ●DIETER LOTT¹, DANICA SOLINA¹, MOHAMED ALMOKHTAR², KO MIBU³, JÖRG DUDEK⁴, WOLFGANG SCHMIDT⁵ und ANDREAS SCHREYER¹ — ¹GKSS Research Center, Max Planck Str.1, D-21502 Geesthacht, Germany — ²Physics Department, Assiut University, Assiut, Egypt — ³Research Center for Low Temperature and Materials Sciences, Kyoto University, Uji, Kyoto, 611-011, Japan — ⁴Institut für Experimentalphysik/Festkörperphysik, University Bochum, D-44780 Bochum, Germany — ⁵Institut Laue Langevin, 38042 Grenoble, France

Recently, the SDW behavior of Cr in Fe/Cr/Sn/Cr multilayers was

studied by Moessbauer spectroscopy [1]. The monolayer (ML) of Sn inserted into the Cr layers serves as a Moessbauer probe permitting the study of the magnetic local environment around Sn providing details about of the magnetic structure of Cr. In this work, complimentary neutron diffraction studies were carried out on a set of Fe/Cr(t) and Fe/Cr(t/2)/Sn(2Å)/Cr(t/2) multilayers with $t=80\text{Å}$ and $t=160\text{Å}$. Here, the magnetic order of the Cr layers was examined, systematically comparing the systems with and without Sn inserted in the Cr layers. The multilayers with Sn show drastic changes in the diffraction pattern for both Cr thicknesses. Using polarized neutron diffraction and reflectivity combined with the information obtained by SQUID measurements enable us to connect the spin orientation of the Cr and Fe moments to the changes in the SDW behavior. [1] M. Almokhtar *et al.*, Phys. Rev. B 66, 134401 (2002)

MA 22.9 Di 12:30 TU H1012

Strukturrechnungen zur Spindichtewelle von Cr in Fe/Cr/Sn/Cr — ●ALEXANDER GRÜNWARD, DIETER LOTT und ANDREAS SCHREYER — GKSS-Forschungszentrum Geesthacht, D-21502 Geesthacht

Das Verhalten der Spindichtewelle von Cr in Fe/Cr-Multilayern ist ein Gebiet intensiver Forschung. Kürzlich wurde gezeigt, dass das Einfügen einer zusätzlichen Monolage Zinn inmitten der Cr-Schicht zu deutlichen Modifikationen des SDW Verhaltens führt. Um diese Veränderungen qualitativ und quantitativ beschreiben zu können, wurden die durch unpolarisierte Neutronenbeugung gewonnenen Streubilder der Systeme Fe/Cr und Fe/Cr/Sn/Cr mittels kinetischer Streutheorie simuliert. Anhand dieser Strukturberechnungen lassen sich klare Aussagen über die Periode und die Phase der SDW sowie über die magnetische Korrelation machen. Dabei zeigt sich, dass die Erhöhung des Cr-Momentes an der Cr/Sn-Grenzfläche für die Phase der SDW von großer Bedeutung ist.

MA 22.10 Di 12:45 TU H1012

Charakterisierung der dynamischen Spinstruktur von Anisotropie-induzierten antiferromagnetisch gekoppelten Fe/Cr-Multilayern mit Hilfe von Kernresonanzstreuung in streifendem Einfall — ●KAI SCHLAGE¹, RALF RÖHLSBERGER², TORSTEN KLEIN¹ und OLAF LEUPOLD² — ¹Universität Rostock, August-Bebel-Strasse 55, 18055 Rostock — ²HASYLAB bei DESY, Notkestrasse 85, 22607 Hamburg

In diesem Experiment untersuchen wir die Austauschkopplung eines antiferromagnetisch gekoppelten Fe/Cr-Multilayers mit einer hartmagnetischen FePt-Schicht, die eine uniaxiale Anisotropie aufweist. Die Untersuchungsmethode ist die Kernresonanzstreuung in streifendem Einfall an dem Mössbauerisotop ⁵⁷Fe [1]. Die hartmagnetische Schicht induziert in den gesputterten, polykristallinen ⁵⁷Fe/Cr-Vielfachschichten eine magnetische Anisotropie. Diese ist Voraussetzung für das Auftreten von magnetischen Reorientierungsphänomenen wie dem bulk spin-flop [2,3]. Wir verwenden spekulare und off-spekulare Reflektometrie zur Detektierung des bulk spin-flops sowie zur Bestimmung der magnetischen Domänenstruktur in diesem neuartigen System. Zusätzlich ermöglicht die Kernresonanzstreuung an Probensystemen mit nur einer ⁵⁷Fe-Sensorschicht die direkte Bestimmung der dynamischen Magnetisierung von einzelnen Eisenschichten.

[1] R. Röhlberger, J. Bansmann, V. Senz, K. L. Jonas, A. Bettac, K. H. Meives-Broer und O. Leupold, Phys. Rev. B 67, 245412 (2003) [2] V. Lauter-Pasyuk *et al.*, Phys. Rev. Lett. 89, 127203 (2002) [3] U. K. Rößler und A. N. Bogdanov, Phys. Rev. B 69, 094405 (2004)

MA 23 Spinabhängiger Transport III

Zeit: Dienstag 10:30–13:00

Raum: TU H1028

MA 23.1 Di 10:30 TU H1028

Direct observation of current induced domain wall motion and wall spin structure modification — ●MATHIAS KLÄU¹, ULRICH RÜDIGER¹, PIERRE-OLIVIER JUBERT², ROLF ALLENSPACH², LAURENT VILA³, GIANCARLO FAINI³, C.A.F. VAZ⁴ und J.A.C. BLAND⁴ — ¹FB Physik, Universität Konstanz — ²IBM Zürich Laboratory, Rüschlikon, Switzerland — ³LPN-CNRS, Marcoussis, France — ⁴Cavendish Laboratory, University of Cambridge, UK

Novel approaches to the switching of magnetic nanostructures are currently heavily investigated. A promising approach is switching by

current-induced domain wall propagation (CIDP), where due to a spin torque effect, electrons transfer angular momentum to a head-to-head domain wall and thereby push it in the direction of the electron flow [1,2]. Here we use Spin-SEM to directly observe domain wall propagation in-situ in permalloy nanostructures induced by current pulses. We determine the propagation distances as a function of pulse height and pulse length for different types of domain walls (vortex, transverse). High resolution imaging allows us to image the nanoscale spin structure of the walls after and during the injection of currents and we observe that the current modifies the spin structure dramatically. Theoretically there are

different competing approaches for incorporating spin torque effects into micromagnetic calculations [3,4] and direct comparison with our results allow us to discriminate between these theories. [1] M. Kläui et al., Appl. Phys. Lett. 83, 105 (2003) [2] A. Yamaguchi et al., Phys. Rev. Lett. 92, 77205 (2004) [3] A. Thiaville et al., J. Appl. Phys. 95, 7049 (2004) [4] S. Zhang and Z. Li, cond-mat/0407174 (2004)

MA 23.2 Di 10:45 TU H1028

Magnetowiderstandsverhalten nanostrukturierter magnetischer Leiterbahnen mit einer gepinnten Domänenwand — ●CHRISTOPH HASSEL, MARIO BRANDS und GÜNTER DUMPICH — Experimentalphysik, AG Farle, Universität Duisburg-Essen (Standort Duisburg), Lotharstr. 1, 47048 Duisburg

Mittels Elektronenstrahlolithographie werden nanostrukturierte Co/Pt-Leiterbahnen hergestellt, die abschnittsweise aus schmalen und breiten Leiterbahnelementen bestehen. Da die Koerzitivfeldstärke von der Leiterbahnbreite abhängig ist, führt die verwendete Leiterbahngeometrie dazu, dass sich am Übergang zwischen den beiden Leiterbahnstücken eine einzelne Domänenwand bildet, wie magnetkraftmikroskopische Aufnahmen belegen. Magnetowiderstandsmessungen, die an diesen Strukturen vorgenommen wurden, spiegeln das Ummagnetisierungsverhalten der einzelnen Leiterbahnelemente wider und gestatten, den Widerstand eines einzelnen Domänenwandbereiches zu bestimmen. Es wird diskutiert, inwieweit es möglich ist, für diese Struktur Widerstandsbeiträge, die auf dem anisotropen Magnetowiderstand (AMR) beruhen, von Beiträgen des Domänenwandwiderstandes (DWR) zu trennen.

Diese Arbeit wird im Rahmen des SFB 491 gefördert.

MA 23.3 Di 11:00 TU H1028

Magnetisches Schaltverhalten von einzelnen, nanostrukturierten Kobalt-Leiterbahnen — ●O. POSTH, M. BRANDS und G. DUMPICH — Experimentalphysik, AG Farle, Universität Duisburg-Essen (Standort Duisburg), Lotharstr. 1, 47048 Duisburg

Es wurde der Magnetowiderstand von dünnen Co-Leiterbahnen bei tiefen Temperaturen untersucht. Die Co-Leiterbahnen sind mittels eines 3-Schritt Elektronenstrahlolithographieprozesses (EBL) mit nichtmagnetischen Kontakten versehen worden. Die Leiterbahnen oxidieren unter Atmosphäreinfluss oder wurden zum Schutz vor der Oxidation in-situ mit Kohlenstoff oder Platin abgedeckt.

Die Magnetowiderstandsmessungen zeigen in transversaler und vertikaler Geometrie einen negativen Magnetowiderstand, der auf dem anisotropen Magnetowiderstand (AMR) beruht. Mit Hilfe der longitudinalen Magnetowiderstandsmessung lassen sich in Abhängigkeit von Schichtdicke und Abdeckschicht verschiedene Umschaltprozesse unterscheiden. Das bei nicht abgedeckten Co-Leiterbahnen beobachtete Domänenwandpinning kann durch die verwendeten Abdeckschichten verhindert werden.

Diese Arbeit wird von der DFG im Rahmen des SFB 491 gefördert.

MA 23.4 Di 11:15 TU H1028

Disorder-induced resistive anomaly near ferromagnetic phase transitions — ●CARSTEN TIMM¹, M.E. RAIKH², and FELIX VON OPPEN¹ — ¹Institut für Theoretische Physik, Freie Universität Berlin — ²Department of Physics, University of Utah, Salt Lake City, U.S.A.

The resistive anomaly in disordered itinerant ferromagnets has a long history, dating back to the first observation by Gerlach in 1932. In 1968, Fisher and Langer proposed a theory for this anomaly based on anomalous scaling. We show that the resistivity $\rho(T)$ can exhibit a *stronger* singularity than predicted in that work. Close to the Curie temperature T_c the correlation length becomes large compared to the mean free path. Then, the quenched disorder is probed by *diffusive* carriers, which requires one to go beyond the Boltzmann description used in all previous works. Our approach combines ideas from the theory of random media and from mesoscopic physics. Specifically, we find that $d\rho/dT$ scales as $|T - T_c|^{-1/2}$ assuming Gaussian magnetic fluctuations. Our results are relevant for ferromagnets with low T_c , such as SrRuO₃ or diluted magnetic semiconductors, whose mobility near T_c is limited by disorder.

MA 23.5 Di 11:30 TU H1028

Grain-boundary transport in polycrystalline ferromagnetic manganites with varied T_C — ●R. B. GANGINENI, K. DÖRR, K. NENKOV, K. -H. MÜLLER, and L. SCHULTZ — IFW Dresden, PB 270116, 01171 Dresden

The grain-boundary magnetoresistance of several (non-textured) polycrystalline half-metallic manganites La_{0.7}A_{0.3}(Mn, B)O₃ (A = Sr, Pb, Ca;

B = Ti, Ta, W) due to spin-polarized second-order tunneling was systematically investigated. The dependence of electrical conductance $G(H)$ on larger applied magnetic fields ($\mu_0 H > 1$ T, above technical saturation of magnetization) can be described by a quadratic polynomial for all samples. La_{0.7}Sr_{0.3}MnO₃ and La_{0.6}Pb_{0.4}MnO₃ with high Curie temperatures T_C were found to show nearly linear field dependence of magnetoconductance, while other samples exhibit a more or less pronounced quadratic magnetoconductance term. Linear magnetoconductance in large magnetic fields up to 50 T indicates second-order tunneling and proves strong antiferromagnetic interactions of grain boundary magnetic moments [1]. Interestingly, the linear magnetoconductance term decreases systematically with increasing T_C for $150 \text{ K} < T_C < 365 \text{ K}$. [1] N. Kozlova et al., Physica B 346, 74 (2004)

MA 23.6 Di 11:45 TU H1028

Scanning laser microscopy studies of tunneling magnetoresistance in artificial La_{2/3}Ca_{1/3}MnO₃ grain boundaries — ●T. NACHTRAB¹, M. WAGENKNECHT¹, H. EITEL¹, M. ZAISER¹, R. KLEINER¹, D. KOELLE¹, J.-B. PHILIPP², and R. GROSS² — ¹Physikalisches Institut - Experimentalphysik II, Universität Tübingen, 72076 Tübingen — ²Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching

It is widely believed that an artificial grain boundary (GB) in a manganite film, made e.g. by growing the film on a bicrystal substrate, can act as a tunneling barrier for the spin polarized current below T_{Curie} . However, the TMR effect in these devices can be strongly influenced by the formation of magnetic microdomains along the GB.

By means of low temperature scanning laser microscopy (LTSLM), we imaged the tunneling conductance distribution along the GB in a La_{2/3}Ca_{1/3}MnO₃ film grown on a 24° bicrystal SrTiO₃ substrate. Our images can be interpreted as a map of the relative orientations of adjacent microdomains at both sides of the GB. Careful ramping of the applied magnetic field enables us to directly observe the growth of the magnetic microdomains at low temperature ($T \approx 10$ K). In addition, due to the spatial resolution of the LTSLM ($\approx 2 \mu\text{m}$), we are able to reconstruct the T dependence of the GB resistance, R_{GB} . It increases with T up to $T_{\text{max}} \approx 130$ K and then decreases. However, it remains at a relatively high level even above T_{Curie} (≈ 220 K). This gives strong evidence that the GB behaves as a barrier also in the paramagnetic phase of the manganite film suggesting a tunneling transport mechanism.

MA 23.7 Di 12:00 TU H1028

Magnetoresistance in CoFeHfO oxide films — ●YUANSU LUO, MARKUS ESSELING und KONRAD SAMWER — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

Oxide films [Co₅₅Fe₂₅Hf₂₀]_{1-x}O_x were prepared by reactive sputtering and characterized by XRD, magnetic and electrical measurements, including XPS analysis to determine the oxygen amount x . For $x < 0.1$, the films are homogeneous and amorphous, showing excellent soft magnetic properties. These films were used as magnetic electrode layers in magnetotunneling junctions to simplify the oxidation process for the barrier fabrication. For large x , a chemical phase separation occurs. The films consist of two interconnected amorphous phases with dominated atomic correlation Hf-O and Co-Co(Fe) and become paramagnetic-like and insulating at low temperatures. A large magnetoresistance (MR) effect which increases with x has been observed in these films. For $x=0.4$, the MR value is 12 % at RT and 22 % at 10 K (7 T). The effect is similar to that observed in granular systems and related to spin dependent scattering. The large MR effect at low temperatures could be attributed to spin dependent tunneling effect across the HfO_x phase.

Supported by DFG-project, SA 337/9-1

MA 23.8 Di 12:15 TU H1028

Local Anisotropic Magnetoresistance Simulations and Measurements — ●MARKUS BOLTE, MARCUS STEINER, ULRICH MERKT, and GUIDO MEIER — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

Understanding magnetoresistance effects in ferromagnetic nanostructures is prerequisite for the development of magnetoelectronic devices such as read-heads for magnetic storage media, magnetic random access memory cells, and prospective semiconductor/ferromagnet hybrid devices. A spatially resolved picture of magnetoresistance effects allows an accurate prediction and control of the behavior of such devices. We have extended the code of one of the standard micromagnetic simulation

frameworks, OOMMF, to simulate the influence of the local anisotropic magnetoresistance (AMR) on the total resistance of micrometer sized permalloy rectangles of varying thicknesses [1]. We compared the results with AMR-measurements done on permalloy ($\text{Ni}_{83}\text{Fe}_{17}$) samples with similar geometry. The simulated magnetization configurations and the concomitant magnetoresistances are in good agreement with the magnetic states observed in magnetic-force microscopy and resistance measurements. Finite-element calculations yield the local current density resulting from changes in resistance due to AMR [2].

[1] M. Steiner, C. Pels, M. Barthelmeß, M. Bolte, U. Merkt, and G. Meier, to be published.

[2] M. Holz, O. Kronenwerth, and D. Grundler, Phys. Rev. B **67**, 195312 (2003).

MA 23.9 Di 12:30 TU H1028

Field dependence of colossal magnetoresistance in magnetic fields up to 50 T — •N. KOZLOVA, K. DÖRR, K.-H. MÜLLER, P. REUTLER, R. KLINGELER, B. BÜCHNER, and L. SCHULTZ — IFW Dresden, Postfach 270116, 01171 Dresden

The magnetoresistance of $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ and $\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ epitaxial films and of a $\text{La}_{0.75}\text{Ca}_{0.25}\text{MnO}_3$ single crystal were investigated in pulsed magnetic fields up to 50 T over a wide temperature range. The Brillouin scaling model of Refs. [1] and [2] based on Mott hopping of electrons between magnetic clusters has been applied to analyze the magnetoresistance data. It has been shown that this model works well a)

in the paramagnetic state above T_C and b) in a low temperature window ($0.2 < T/T_C < 0.9$). Near the ferromagnetic transition temperature T_C systematic deviations, in particular in larger fields, indicate that the model fails there, since neither the field dependence of magnetization nor resistance follows a Brillouin function. The temperature-dependent average magnetic moment of clusters is similar for all of our samples, but differs essentially from that obtained earlier for half-doped manganites.

[1] P. Wagner et. al., Phys. Rev. B **55** (1997) 3699.

[2] P. Wagner et. al., Phys. Rev. Lett. **81** (1998) 3980.

MA 23.10 Di 12:45 TU H1028

Transport properties of PCMO in magnetic and electrical fields — •WILKO WESTHÄUSER und CHRISTIAN JOOSS — Institut für Materialphysik, Universität Göttingen

$\text{Pr}_{0.68}\text{Ca}_{0.32}\text{MnO}_3$ (PCMO) is very sensitive to certain external perturbations inducing a phase transition from a charge-ordered antiferromagnetic state to a charge-delocated ferromagnetic state. We investigate the electric field driven phase transition in comparison to the well-known colossal drop in resistance caused by an applied magnetic field (CMR) in several samples: poly-crystalline sintered pellets and epitaxial, laser-deposited thin films on single-crystalline SrTiO_3 - and MgO -substrates. In These samples we find significant differences in the metal-insulator (MI) transition which are due to strain and lattice defects. Evidences that the MI transition driven by electric fields is localized in a filamentary path are presented.

MA 24 Oberflächenmagnetismus

Zeit: Dienstag 10:30–12:30

Raum: TU A060

MA 24.1 Di 10:30 TU A060

Resonant x-ray emission applied to Mn-based Heusler alloys — •MAX THEODOR KUCHEL¹, JÜRGEN BRAUN¹, MARKUS DONATH¹, and MIKHAIL YABLONSKIKH² — ¹Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — ²Department of Physics and Engineering Physics, University of Saskatchewan, Canada

We present resonant x-ray emission spectra calculated for a series of different Mn-based Heusler alloys. The fully relativistic calculations are based on the well known Kramers-Heisenberg formula [1] which describes second order optical excitation processes. The initial, intermediate and final states appearing in this formula were derived by use of the tight-binding linear muffin-tin orbitals method [2]. Comparing our theoretical spectra with corresponding experimental data we found a good agreement.

[1] A. Kotani, Rev. Mod. Phys. **73**, 203 (2001)

[2] O. K. Andersen and O. Jepsen, Phys. Rev. Lett. **53**, 2571 (1984)

MA 24.2 Di 10:45 TU A060

The effect of chemical disorder on the empty electronic states of NiMnSb — •JÜRGEN BRAUN¹, HRISTO KOLEV¹, GEORGI RANGELOV¹, MARKUS DONATH¹, SVEN BORNEMAN², JAN MINAR², and HUBERT EBERT² — ¹Physikalisches Institut, Westfälische-Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — ²Institut für Physikalische Chemie, Ludwig-Maximilians-Universität München, Theresien Str. 37-41, 80333 München

The empty electronic states of the half-metallic semi Heusler alloy NiMnSb have been investigated by spin-resolved Appearance Potential Spectroscopy (SRAPS). Compared to fully relativistic SRAPS calculations our measurements reveal an unexpected low spin-polarization. To understand the physical origin of this discrepancy we performed a quantitative theoretical analysis of the influence of chemical disorder on the unoccupied density of states (DOS). Our theory describes the spectra as the self-convolution of the matrix-element weighted, orbitally-resolved unoccupied DOS, which was calculated by use of the ab-initio Coherent Potential Approximation (CPA) method.

MA 24.3 Di 11:00 TU A060

Ultrathin Ni films grown with O surfactant: Structure and Magnetism — •C. SORG, N. PONPANDIAN, A. SCHERZ, R. NÜNTHEL, T. GLEITSMANN, K. FABERSCHKE, and H. WENDE — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin-Dahlem, Germany

We have studied ultrathin Ni films grown on Cu(100) and Cu(110) with and without O surfactant using element specific XAS and XMCD at the O K edge as well as at the Ni $L_{2,3}$ edges [1]. The O surfactant improves the growth mode of these films towards a better layer-by-layer growth and leads to a reduced surface roughness [2]. Since the O surfactant reduces also the surface anisotropy energy, the spin reorientation transition is shifted to a lower Ni thickness on Cu(100) [3]. On the more open and anisotropic Cu(110) surface an out-of-plane phase exists only if O is present on the Ni films. By means of XAS, we give final evidence that no bulk-like NiO is formed and that the O stays on top of the Ni films. We observe a charge transfer from Ni to O states. With XMCD we investigate the Ni orbital and spin moments. On the Cu(100) surface the total Ni magnetization of thinner films is reduced compared to the bulk. In contrast, on Cu(110) we observe an enhancement which is mainly carried by the orbital moment. Finally, we determine an induced magnetic orbital moment of the oxygen parallel to the one of Ni by analyzing the XMCD at the O K edge. – Supported by BMBF (05 KS4 KEB 5).

[1] C. Sorg et al., Surf. Sci. **565**, 197 (2004).

[2] R. Nünthel et al., Surf. Sci. **531**, 53 (2003); *ibid.* **566-568**, 100 (2004).

[3] J. Hong et al., Phys. Rev. Lett. **92**, 147202 (2004).

MA 24.4 Di 11:15 TU A060

Tunable Magnetic Properties of Nanocrystalline Pd-Ni Alloy — •SADHAN GHOSH¹, CHRISTIAN LEMIER¹, JÖRG WEISSMÜLLER^{1,2}, and VISWANATH RAGHAVAN NADAR¹ — ¹Forschungszentrum Karlsruhe, Institut für Nanotechnologie, Karlsruhe — ²Fachrichtung Technische Physik, Universität des Saarlandes, 66041 Saarbrücken

Ferromagnetism is strongly related to the electronic structure density, therefore it is interesting to study how far one can modify the magnetic order of solids by changing their electron density. While this is usually done by alloying, one can also change the charge density reversibly by inducing space-charge regions at surfaces. This is particularly interesting in nanostructured materials, since the high surface to volume ratio maximizes the effect of the local property changes on the macroscopic materials behaviour [1]. It has been demonstrated that the polarized nanoporous metals exhibit large volumetric expansion and contraction in phase with the applied electrode potential [2]. In the present work, we report the variation of the magnetic moment of charged nanocrystalline Pd-Ni alloy, produced by the inert-gas condensation method, by in-situ magnetization experiments. We discuss the relative variation of charge-induced magnetization by changing the alloy composition as well as changing the electrochemical environment. [1] Gleiter H., Weissmüller J., Wollersheim O., Würschum R. Acta mater. **49** (2001), 737; [2] Weissmüller, J., Viswanath, R.N., Kramer, D., Zimmer, P., Würschum, R., Gleiter, H. Science **300** (2003), 312.

MA 24.5 Di 11:30 TU A060

Bias dependence of the spin polarized tunneling current between a ferromagnetic tip and antiferromagnetic surfaces — ●U. SCHLICKUM, C. L. GAO, W. WULFHEKEL, J. HENK, P. BRUNO, and J. KIRSCHNER — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle

In spin-polarized scanning tunneling microscopy (Sp-STM) measurements the spin dependent tunneling current is used to image magnetic structures on the nanometer scale. Spin sensitivity is achieved by the tunneling magnetoresistance effect, i.e. the tunneling current depends on the relative orientation of the magnetization of the tip and sample spin. Besides the possibility to image magnetic structures, this technique allows the investigation of the spin dependent tunneling through a well defined tunneling barrier (vacuum gap). In our contribution, we present Sp-STM measurements performed on ultra-thin antiferromagnetic Mn and Cr films on Fe(001). Both systems show a layer-wise antiferromagnetic order at the surfaces [1, 2]. We found that the size and the sign of the spin contrast, i.e. the difference in the tunneling current between oppositely spin polarized layers, depends on the bias voltage. For Cr, a strong increase of the spin contrast close to a spin polarized surface state was measured. For Mn, we observed, however, a rather complex dependence which can be explained with model calculations based on ab-initio band structures.

[1] U. Schlickum, N. Janke-Gilman, W. Wulfhekel, and J. Kirschner, Phys. Rev. Lett. 92, 107203 (2004). [2] D. T. Pierce, J. Unguris, R. J. Celotta, and M. D. Stiles, J. Magn. Mater. 200, 290 (1999).

MA 24.6 Di 11:45 TU A060

Temperature-dependent exchange splitting of image-potential states in front of a magnetic surface — ●MARTIN PICKEL¹, ANKE SCHMIDT², MARTIN WIEMHÖFER¹, MARKUS DONATH¹, and MARTIN WEINELT³ — ¹Physikalisches Institut, Universität Münster, Wilhelm-Klemm Str. 10, 48149 Münster — ²Lehrstuhl für Festkörperphysik, Staudtstr. 7, 91058 Erlangen — ³Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin

Electrons excited to image-potential states can be used as sensors for various surface properties. For example, an exchange-split bulk band-structure, leads to spin-dependent binding energies of the image-potential states [1]. This allows to study magnetic properties and related electron dynamics at ferromagnetic surfaces. By spin-resolved two-photon photoemission we studied ultrathin iron films on Cu(001). The exchange splitting of the image-potential states is directly resolved for the $n=1$ and $n=2$ states. With increasing temperature the splitting is reduced and vanishes at the Curie temperature. The decrease in spin polarization with increasing temperature is found to be proportional to the splitting. The linewidths of the image-potential states are spin dependent and indicate spin-dependent lifetimes. With increasing temperature the difference in linewidth declines in accordance to the lowering of the spin-splitting. This behaviour reflects the change in the electronic structure of the Fe films. The observed collapse of the exchange splitting with temperature and the temperature behaviour of the linewidths are discussed particularly with regard to the simple Stoner picture.

[1] F. Passek and M. Donath, Phys. Rev. Lett. 69, 1101 (1992)

MA 25 Kondo/Schwere-Fermionen

Zeit: Dienstag 12:30–13:00

Raum: TU A060

MA 25.1 Di 12:30 TU A060

The split personality of the 5f-electrons in uranium intermetallics — ●ARNO HIESS — ILL, Grenoble, France

Information on the interplay between superconductivity and magnetism is key to our understanding of a large variety of materials such as high-temperature and heavy-fermion superconductors. Of importance are some uranium-based intermetallic compounds, in which a co-existence of both phenomena is observed at low T . Inelastic neutron scattering offers the possibility to measure the wavevector (q) and energy (E) dependent magnetic response. Comparing the magnetic response observed for the heavy-fermion superconductor UBe₁₃, the magnetic superconductors UPd₂Al₃ and UNi₂Al₃ as well as for the itinerant antiferromagnet UGd₃ the unusual but intriguingly similar dynamic magnetic properties of such compounds are discussed. The magnetic response is structured in q - and E -space. It shows overdamped as well as propagating components, attributed to different degrees of freedom of 5f electrons. Furthermore, the

MA 24.7 Di 12:00 TU A060

Spin-polarized scanning tunneling microscopy of ultrathin Fe/Mo(110) films — ●J. PROKOP, A. KUKUNIN, and H.J. ELMERS — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudingerweg 7, D-55099 Mainz

We report on magnetic contrast observed by low-temperature (5 K) spin-resolved scanning tunnelling microscopy (SP-STM) of Fe nanowires deposited on a Mo(110) single crystal. Magnetic information is obtained from the conductivity map. Magnetic contrast is achieved using tungsten tips covered by Au/Co thin films. The W tips were flashed at ~ 2000 K, and subsequently covered by 10 ML thick Au and Co layers at RT. Due to the spin reorientation transition of Co films on Au an out-of-plane magnetic sensitivity is obtained for thin cobalt films, while for thicker Co coverages an in-plane magnetization component can be probed. The iron nanowires were prepared by step flow growth onto the Mo(110) substrate kept at 700 K during molecular beam epitaxy (MBE) in ultra high vacuum (UHV). We find that the 1 ML thick ferromagnetic Fe nanowires reveal a magnetization perpendicular to the surface [1]. Double layer (DL) nanowires show a perpendicular easy axis, too. Due to the dipolar coupling adjacent nanowires are mostly antiparallely magnetized. The domain wall width observed in DL stripes is ~ 3 nm, similar to the width observed in ML stripes [1]. The reorientation of the tip sensitivity axis was confirmed by SP-STM measurements of thicker Fe/Mo(110) films.

[1] M. Bode et al., Phys. Rev. Lett. 92, 067201 (2004).

MA 24.8 Di 12:15 TU A060

Growth and electronic properties of thick films and pyramidal islands of Dy/W(110) studied by STM/STS — ●LUIS BERBILBAUTISTA, STEFAN KRAUSE, TORBEN HÄNKE, MATTHIAS BODE, and ROLAND WIESENDANGER — Institut of Applied Physics, University of Hamburg, Jungiusstraße 11, Germany

The magnetic structure of bulk Dysprosium (Dy) exhibits two phase transitions with decreasing temperature T : from paramagnetic to helimagnetic at $T_N = 178$ K and from helimagnetic to ferromagnetic at $T_C = 85$ K [1]. The helimagnetic phase is particularly interesting as the turn angle between two adjacent basal (0001) planes Dy varies between 43° at T_N and 26° at T_C [2].

The magnetic structure of the Dy(0001) surface is basically unknown. Since it is almost impossible to clean Dy bulk crystals we have studied the growth and electronic structure of Dy films on W(110) by STM and STS, respectively. In agreement with Wegner *et al.* [3] our tunneling spectra are dominated by a double-peak structure which originates from an exchange-split d-derived surface state. The exchange splitting amounts to 500 meV at $T = 20$ K.

By an appropriate variation of the substrate temperature during growth stepped-pyramidal islands were prepared. These islands may be suitable for an investigation of the surface helimagnetic turn angle as numerous different atomic planes are exposed to the surface.

[1] D.R. Behrendt *et al.*, Phys. Rev. 109, 1544 (1958).

[2] M.K. Wilkinson *et al.*, J. Appl. Phys. 32, 48S (1961).

[3] D. Wegner *et al.*, to be published.

magnetic response in UPd₂Al₃ shows a T - and B -dependent behaviour that can be linked to the superconductivity. It reflects the characteristic properties of the electronic system and sheds light on the symmetry of the superconducting order parameter.

MA 25.2 Di 12:45 TU A060

Electronic transport properties of single crystalline UPt₂Si₂ — ●A. OTOP¹, R.W.A. HENDRIKX², J.A. MYDOSH^{2,3}, and S. SÜLLOW¹ — ¹IMNF, TU Braunschweig, Germany — ²Kamerlingh Onnes Laboratory, Leiden University, The Netherlands — ³Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

We present a detailed study of the transport properties of single crystalline tetragonal UPt₂Si₂, for which we recently established the presence of crystallographic disorder on the Pt/Si sublattice. We carried out resistivity (ρ), magnetoresistivity (MR) and Hall effect measurements (R_H) in the temperature range from 2 to 300 K and in magnetic fields up to

5.5 T. In this range we observe a very pronounced anisotropy between a and c axis behavior. While along the a axis we find a common heavy fermion metallic resistivity, along the c axis ρ is disorder dominated. From our MR data we extract the magnetic scattering component of the electronic transport properties. With our Hall effect data we establish

the metallicity for both crystallographic axes of our material. We discuss the relevance of the crystallographic disorder for the transport properties for this correlated electron material.

This work was supported by the DFG under Contract No. SU229/1-3.

MA 26 Hauptvorträge Fauth / Acet

Zeit: Dienstag 14:00–15:00

Raum: TU H1028

Hauptvortrag

MA 26.1 Di 14:00 TU H1028

A spectroscopic look at small particle magnetism from the atom to nanoscale solids — •KAI FAUTH — Physikalisches Institut der Univ. Würzburg, Am Hubland, 97074 Würzburg — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

The investigation of (sub-) nanoscale objects must take the interaction with their environment into consideration, since they have a high proportion of surface atoms. In order to understand the role of these interactions, in particular with respect to magnetic properties, interaction-free particles should be compared with the same particles in the presence of interactions. X-ray magnetic circular dichroism (XMCD) proves to be a highly versatile tool to tackle this question, since it combines several advantages such as element specificity, high sensitivity and the possibility to disentangle spin and orbital contributions to the magnetization.

The presentation will discuss realizations of the above scenario for both, atoms and small Co and Ni clusters deposited from a molecular beam and magnetic nanoparticles (Co, FePt) prepared by chemical means. In the case of small clusters the magnetic properties of matrix-isolated clusters in Argon films are compared to those which are observed when they are exposed to a markedly interacting substrate. For the case of magnetic nanoparticles it will be shown that using mild reactive plasma treatments, full control over the chemical state of the particle surface can be obtained while preserving the integrity of the layer structure. In this way, the role of stabilizing ligands as well as of surface oxide formation can be investigated.

Hauptvortrag

MA 26.2 Di 14:30 TU H1028

Magnetic instabilities in Fe_3C (cementite) particles observed with Fe K-edge x-ray circular dichroism under pressure — •MEHMET ACET — Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg

The atomic volume is a prime parameter that characterizes electronic properties of solids. Around the equilibrium volume, the electronic structure of a solid can be stable in a relatively broad volume range (20-25 percent) or it can be unstable with respect to an energetically lower lying electronic state by a few meV, when the atomic volume is varied by 3-5 percent. In magnetic solids, the instability of an electronic structure can be detected by probing the magnetic moment while varying the atomic separation by applying hydrostatic pressure. Such instabilities can be found in some 3d-transition metals and alloys incorporating Fe, Mn, and Co as well as in some rare-earth intermetallic compounds. In this report, we present results showing that magnetovolume instabilities can also be present in interstitial solids, specifically in Fe_3C (cementite), for which a rapid change in the magnetic moment is found from about $1.8 \mu_B$ to nearly vanishing values at pressures of about 8 GPa. We show that the Fe K-edge x-ray circular dichroism technique in conjunction with a diamond anvil cell is particularly useful for studying volume dependent magnetic instabilities in Fe alloys and compounds. We examine additionally the equation of state of Fe_3C to show that the rapid change in the magnetic moment is not associated with a structural transformation.

MA 27 Spindynamik II

Zeit: Dienstag 15:15–18:30

Raum: TU H1012

MA 27.1 Di 15:15 TU H1012

Micromagnetic Dissipation, Dispersion and Mode Conversion in thin Permalloy platelets — •MATTHIAS BUSS^{1,2}, THOMAS HAUG¹, MICHAEL R. SCHEINFELD³ und CHRISTIAN H. BACK¹ — ¹Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93040 Regensburg, Germany — ²Laboratorium für Festkörperphysik, Eidgenössische Technische Hochschule Zürich, CH-8093 Zürich, Switzerland — ³Simon Fraser University, 8888 University Drive, Burnaby BC V5A 1S6, Canada

Micron sized ferromagnetic permalloy disks exhibiting an in-plane ferromagnetic vortex structure are excited by a fast rise time perpendicular magnetic field pulse and their modal structure is analyzed. We find azimuthal and axial modes. By a Fourier filtering technique we can separate and analyze the time dependence of individual modes. Analysis of the experimental data demonstrates that the azimuthal modes damp more quickly than the axial modes. We interpret these results as mode conversion from low-frequency azimuthal modes to the fundamental mode which is higher in frequency, i.e. mode-mode coupling in a system with a single Landau-Lifshitz-Gilbert phenomenological damping constant. We present a method to extract the decay rates for different modes from a single average precession component. These measurements are the first clear demonstration that mode-mode coupling plays a significant role in magnetization dynamics, and, the data demonstrate how mode-conversion could be construed as damping.

MA 27.2 Di 15:30 TU H1012

Damping in thin ferromagnetic films — •H.T. NEMBACH¹, P. MARTIN PIMENTEL¹, M.C. WEBER¹, J. FASSBENDER², and B. HILLEBRANDS¹ — ¹Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, E.-Schroedinger-Str. 56, 67663 Kaiserslautern — ²Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Rossendorf, 01314 Dresden

The understanding of the damping processes of the magnetization dynamics is an important issue. Several different damping channels are proposed. Here the importance of magnon-magnon processes for the damping is investigated with a magneto-optical method. This method allows to determine the length of the magnetization vector and therefore gives an indication for magnon-magnon processes. Higher order magneto-optic effects are also taken into account, which allows the determination of the quadratic magneto-optic constant.

This work was supported by the DFG-Graduiertenkolleg 792 and the EU-RTN ULTRASWITCH network (HPRN-CT-2002-00318).

MA 27.3 Di 15:45 TU H1012

Damping of ultrafast spin dynamics in nanostructures: An ab-initio study — •DANIEL STEIAUF and MANFRED FÄHNLE — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany

Based on the model of Kamberský [1] we calculated the matrix $\underline{a}(\mathbf{M})$ entering the damping term $\mathbf{M} \times (\underline{a}(\mathbf{M}) \cdot d\mathbf{M}/dt)$ in a generalized Landau-Lifshitz-Gilbert equation by the ab-initio electron theory for bulk materials, atomic monolayers and monatomic wires of Fe, Co and Ni. It turns out that in the monolayers and monatomic wires the damping depends extremely sensitively on the momentary orientation of the magnetization and even vanishes for various orientations. We underpin these surprising numerical results by group-theoretical considerations. This discovery represents an additional option for the optimization of the switching behaviour of nanostructured magnets by choosing a trajectory of the magnetization vector which exhibits the desired properties of the damping.

[1] V. Kamberský, Canadian J. Phys. **48**, 2906 (1970).

MA 27.4 Di 16:00 TU H1012

Limitations of the Landau-Lifshitz-Equation and spin-pump effects in magnetic nanostructures — ●K. LENZ¹, E. KOSUBEK¹, T. TOLIŃSKI², K. BABERSCHKE¹, and A. JANOSSY³ — ¹Inst. f. Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — ²Institute of Molecular Physics, PAS; Smoluchowskiego 17, 60-179 Poznań, Poland — ³Department of Experimental Physics, Institute of Physics, Budapest University of Technology and Economics, 1521 Budapest, Hungary

Two mechanisms have been the topic of recent discussions concerning the precessional damping at interfaces of ferromagnetic to nonmagnetic materials: (i) The magnon-magnon scattering, with origin in surface or interface defects. (ii) The spin-pump effect, i.e. the transfer of angular momentum from the precessing magnetization excited by ferromagnetic resonance to the conduction electrons of a non-magnetic layer. The commonly used Landau-Lifshitz-Gilbert equation is insufficient to describe transverse scattering within magnetic excitations. In addition to previous results [1] we present FMR data up to 230 GHz showing the importance of two-magnon scattering. Secondly, the linewidth analysis of Ni/Cu/Ni trilayer FMR for parallel and perpendicular alignment of the Ni magnetization shows distinct narrowing as function of the orientation of the external field, which will be discussed in terms of spin-pump effects [2].

Supported by DFG (Sfb 290, TP A2).

[1] J. Lindner *et al.*, Phys. Rev. B **68**, 060102(R) (2003)

[2] K. Lenz *et al.*, Phys. Rev. B **69**, 144422 (2004)

MA 27.5 Di 16:15 TU H1012

Dynamic losses and domain refinement in nanocrystalline tape wound cores — ●SYBILLE FLOHRER¹, RUDOLF SCHÄFER¹, JEFFREY MCCORD¹, STEFAN ROTH¹, GISELHER HERZER² and LUDWIG SCHULTZ¹ — ¹Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstraße 20, D-01069 Dresden, Germany — ²VACUUMSCHMELZE GmbH & Co. KG, Grüner Weg 37, D-63450 Hanau, Germany

The analysis of dynamic magnetization processes is the basis for the understanding of energy loss mechanisms in magnetic materials. Stroboscopic Kerr-microscopy observations on a variety of nanocrystalline Fe₇₃Cu₁Nb₃Si₁₆B₇ tape wound cores with different strengths of the induced longitudinal anisotropy are presented. In the frequency range from the quasi-static case up to 10 kHz domain refinement is distinctive. The correlation between domain refinement, the strength of the induced anisotropy, and the cycle losses is studied. The strongest wall multiplication is observed in the cores with the weakest induced anisotropy, where the wide domains even decay into a patchy pattern at elevated frequencies. The arising of the patchy domains is discussed in terms of the induction rate and the influence of residual anisotropies.

MA 27.6 Di 16:30 TU H1012

FMR study of thin Fe layers grown on hexagonal GaN — ●MATTHIAS BUCHMEIER¹, RALPH MEIJERS², RAFFAELLA CALARCO², and DANIEL E. BÜRGLER¹ — ¹Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich — ²Institut für Schichten und Grenzflächen, Forschungszentrum Jülich GmbH, 52425 Jülich

Fe films with thicknesses between 5 nm and 50 nm have been prepared by MBE on top of GaN(0001) substrates. XRD and LEED results suggest the growth in crystallographic Fe(110) domains with three different orientations. The magnetic properties have been investigated by in-plane angle-dependent FMR at frequencies from 4.5 GHz to 15.5 GHz. All samples show a weak thickness-independent hexagonal in-plane anisotropy with hard-axis saturation field of 8 mT. The FMR linewidth versus frequency curves are linear with no zero-frequency offset indicating a good homogeneity of the magnetic properties over the sample area. However the effective damping parameter α shows a pronounced anisotropy and thickness dependence, with enhanced damping along the hard-axis and for thicker layers. We suggest that the additional damping can be explained by two-magnon scattering at defects which are due to the triple domain formation.

MA 27.7 Di 16:45 TU H1012

Modifikation der magnetischen Dämpfung in Permalloy-Schichten durch Cr-Implantation — ●J. FASSBENDER¹, J. MCCORD², M. WEISHEIT² und R. MATTHEIS³ — ¹FZ Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, 01314 Dresden — ²IFW Dresden, Institut für Metallische Werkstoffe, 01069 Dresden — ³Institut für Physikalische Hochtechnologie e. V. Jena, 07745 Jena

Das magnetische Dämpfungsverhalten, die Curie-Temperatur und die uniaxiale magnetische Anisotropie von 20 nm dicken Permalloy-Schichten wurde mittels Cr-Implantation modifiziert. Die Implantation wurde bei 30 keV Beschleunigungsspannung im Dosisbereich zwischen 2×10^{15} und 2×10^{16} Ionen/cm² durchgeführt. Daraus resultiert ein Implantationsprofil mit einer mittleren Konzentration an Cr innerhalb der Permalloy-Schicht von 1 bis 10 %. Bei einer mittleren Konzentration von ca. 7% wird die Curie-Temperatur der Permalloy-Schicht auf Raumtemperatur abgesenkt. Damit einher geht eine leichte Verringerung der uniaxialen magnetischen Anisotropie. PIMM-Messungen ("pulsed inductive microwave magnetometry") zeigen jedoch eine starke Vergrößerung des magnetischen Dämpfungsverhaltens durch die Cr-Implantation. Die möglichen Ursachen dieser Erhöhung werden diskutiert.

MA 27.8 Di 17:00 TU H1012

Angle dependent switching of spherically shaped nanostructures — ●TILL C. ULBRICH¹, ILDICO L. GUHR¹, DIETER SÜSS², TOMAS SCHREFL², DENIS MAKAROV³, GÜNTER SCHATZ¹, and MANFRED ALBRECHT¹ — ¹University of Konstanz, Department of Physics, 78457 Konstanz, Germany — ²Vienna University of Technology, A-1040 Wien, Austria — ³Taras Shevchenko University, 01033 Kiev, Ukraine

Co/Pd multilayer films provide uniaxial magnetic anisotropy K_u mainly generated by interface anisotropy. The strength and orientation of K_u depends strongly on the individual Co and Pd layer thicknesses. By evaporating of a Co/Pd multilayer film onto a monolayer of self-assembled polystyrene nanoparticles a novel type of magnetic nanostructures is formed on top of the spheres. Due to the spherical shape a spread in anisotropy orientation is present in the magnetic nanostructures. Furthermore, the strength of the anisotropy varies across the nanostructure due to the changing Co layer thickness. These variations have a drastic impact on the switching mechanism which differs remarkably from a Stoner-Wohlfahrt behavior expected for a single domain particle. Here we present first results on the angle dependent switching using nanospheres in the size range of 50 to 310 nm investigated by focused MOKE and MFM. These results were compared to micromagnetic simulations clearly revealing the importance of the local variation of anisotropy induced by the spherical shape of the nanostructures.

This project is funded by the DFG through the SFB 513 A8 and the Emmy-Noether program at the University of Konstanz.

MA 27.9 Di 17:15 TU H1012

Current-induced precessional magnetization reversal — ●HANS WERNER SCHUMACHER¹, CLAUDE CHAPPERT², RICARDO C. SOUSA³, and PAULO P. FREITAS³ — ¹Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig, Germany — ²Institut d'Electronique Fondamentale, UMR 8622, CNRS, Université Paris Sud, Bât. 220, 91405 Orsay, France — ³Instituto de Engenharia de Sistemas e Computadores, Rua Alves Redol, 9, 1 Dt., P-1000 Lisboa, Portugal

We report magnetization reversal in microscopic current-in-plane spin valves by ultra short current pulses through the device. Current densities of the order of 1011 A/m² with pulse durations as short as 120 ps reliably and reversibly switch the cells free-layer magnetization. Variations of the pulse parameters and of an easy axis bias field reveal the full signature of precessional switching, which is triggered by the transverse magnetic field generated by the device current. This current switching mode allows for the design of a two-terminal nonvolatile magnetic memory cell combining ultra fast access times and high magnetoresistive readout. The possible scaling of such memory cells towards smaller lateral dimensions is discussed.

MA 27.10 Di 17:30 TU H1012

Small and large angle precession in exchange biased bilayers — ●MARKUS C. WEBER¹, HANS NEMBACH¹, BURKARD HILLEBRANDS¹, and JÜRGEN FASSBENDER² — ¹Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — ²Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Rossendorf, 01314 Dresden, Germany

Small and large angle excitations in exchange bias systems have been investigated in real time by means of all-optical pump-probe experiments. Due to an increased spin temperature upon photoexcitation, an unpinning of the interfacial exchange coupling takes place resulting in a collapse of the unidirectional anisotropy. In terms of an internal pulse field the excess energy of the spin system leads to the excitation of a high frequency precessional response. The magnitude of the internal pulse field can be controlled by the absorbed photons [1]. Hence, the precessional motion depending on the precession angle can be investigated. The extracted Gilbert parameter does not depend on the magnitude of the internal pulse field. Both small and large angle precession can be modeled within the Landau-Lifshitz-Gilbert framework. Employing the antiferromagnetic thickness dependence of the exchange bias field, the exchange bias field dependence of the Gilbert parameter was investigated. The dissipation rate increases linearly with the exchange bias field magnitude which can be understood taking local fluctuations of the interfacial exchange coupling as an additional dissipation mechanism into account [2].

[1] M. C. Weber et al., Phys. Rev. B, submitted. [2] M.C. Weber et al., J. Appl. Phys., in press.

MA 27.11 Di 17:45 TU H1012

Ultrafast direct writing schemes for SAF MRAM cells — ●H.T. NEMBACH, C. BAYER, M.C. WEBER, P. MARTIN PIMENTEL, P.A. BECK, B. LEVEN, and B. HILLEBRANDS — Fachbereich Physik und Forschungsschwerpunkt MINAS, E.-Schroedinger-Str. 56, Technische Universität Kaiserslautern, 67663 Kaiserslautern

Magnetic random access memory (MRAM) will be essential for future data storage. Two important issues, which still need to be improved, are access time and insensitivity against parameter variations, as for instance pulse length and amplitude. Recently a new switching scheme has been introduced for a 4Mbit MRAM demonstrator using a toggle mode for switching [1]. Here we present two direct writing schemes for such a so-called Savtchenko-type MRAM [2]. These writing schemes using two orthogonally oriented bipolar and unipolar magnetic field pulses with time delay allow for ultrafast direct writing with high stability against half select switching. The numerical simulations are based on the Stoner Wohlfarth model and a Runge Kutta integration of the Landau-Lifshitz and Gilbert equation.

This work was supported by the DFG-Graduiertenkolleg 792, the Studienstiftung des Deutschen Volkes, and the EU-RTN ULTRASWITCH network (HPRN-CT-2002-00318).

[1] Savtchenko et al., US Patent 6,545,906 B1, Apr. 8 (2003).

[2] H. T. Nembach et al, submitted to APL.

MA 28 Magnetische Partikel/Cluster I

Zeit: Dienstag 15:15–18:30

Raum: TU H1028

MA 28.1 Di 15:15 TU H1028

Magnetic and spectroscopic properties of deposited transition metal clusters — ●S. BORNEMANN, J. MINÁR, and H. EBERT — Dep. Chemie, LMU, Butenandtstr. 5-13, 81377 München, Germany

The fully relativistic spin-polarized KKR method has been used to study the magnetic and spectroscopic properties for supported clusters. For a variety of clusters supported on various transition metal substrates it is shown that the magnetic properties depend on several different parameters such as substrate type, cluster size as well as shape etc. This applies especially if one considers properties caused by spin-orbit coupling like the X-ray magnetic circular dichroism (XMCD). In line with recent experimental findings a very pronounced magnetic circular dichroism in X-ray absorption is found for Co-clusters on Pt(111). The results for the XMCD spectra and their connection with the spin, orbital and spin dipolar moments will be discussed on the basis of the so-called sum rules. Furthermore, theoretical results for FePt-clusters on Cu(001), Ag(001) and Au(001) are shown as the bulk material of FePt is well known for having a large magnetic anisotropy.

MA 28.2 Di 15:30 TU H1028

Elektronenkorrelation in Fe Clustern: Einfluß auf Struktur und Magnetismus — ●GEORG ROLLMANN, SANJUBALA SAHOO und PETER ENTEL — Theoretische Tieftemperaturphysik, Universität Duisburg-Essen, Lotharstr. 1, D-47048 Duisburg

MA 27.12 Di 18:00 TU H1012

Dynamics of magnetic domain wall motion: Dependence on wall energy, mobility, and Zeeman energy — ●K. FUKUMOTO¹, W. KUCH¹, J. VOGEL², J. CAMARERO³, S. PIZZINI², F. ROMANENS², M. BONFIM², A. FONTAINE², and J. KIRSCHNER¹ — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — ²Laboratoire Louis Néel, CNRS, 25 avenue des Martyrs, B. P. 166, F-38042 Grenoble Cedex 9, France — ³Dpto. Física de la Materia Condensada, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

Nowadays the response time of magnetic recording devices is going down to the ns range. For the fast switching of magnetic trilayered systems it is important to know the factors influencing the speed of domain nucleation and subsequent domain wall propagation. We studied magnetic domain nucleation and wall motion in the permalloy layer of a magnetic-tunnel-junction like system by a novel combination of x-ray magnetic circular dichroism, photoelectron emission microscopy, and stroboscopic pump-probe technique. The expansion of micron-sized magnetic domains was followed with ns time resolution for various amplitudes of the external field. Since these applied external fields were well above the static coercive field, viscous wall motion was observed, in which the wall velocity is a linear function of the external field. The onset of domain expansion was observed to take place after the beginning of the pulse, with a delay depending on the pulse amplitude. This apparent delay in domain nucleation can be understood taking into account the domain wall energy, causing a lower domain wall speed when the domains are small.

MA 27.13 Di 18:15 TU H1012

AC-driven Domain Walls in Random Media — ●ANDREAS GLATZ¹, THOMAS NATTERMANN¹, and VALERY POKROVSKY² — ¹Institut für theoretische Physik, Universität zu Köln, Zùlpicher Str. 77, 50937 Köln — ²Department of Physics, Texas A&M University, College Station, Texas 77843-4242

The viscous motion of an interface driven non-adiabatically by an *ac external field* of frequency ω_0 in a random medium is considered. The velocity exhibits a smeared depinning transition showing a *double hysteresis* in the case when the amplitude of the external field is larger than the depinning field. This hysteresis is absent in the adiabatic case $\omega_0 \rightarrow 0$. Using scaling arguments and an approximate renormalization group calculation we explain the main characteristics of the hysteresis loop. In the low frequency limit these can be expressed in terms of the depinning threshold and the critical exponents of the adiabatic case. If the amplitude is smaller than the depinning field, also the avalanche motion of the interface has to be taken into account leading to a pronounced effect in the velocity hysteresis.

Über die Eigenschaften kleinster magnetischer Cluster ist von experimenteller Seite häufig nur wenig bekannt, so daß ein Großteil der zur Zeit verfügbaren Information oftmals aus numerischen Untersuchungen stammt. Die im Rahmen der Dichtefunktionaltheorie (DFT) gefundenen Grundzustände von Fe Clustern sind von starken Jahn-Teller-Verzerrungen sowie kollinearen, ferromagnetischen Momenten geprägt. Ergebnisse hochgenauer quantenchemischer Rechnungen legen jedoch die Vermutung nahe, daß sowohl magnetische, als auch strukturelle Eigenschaften durch die reine DFT nicht richtig wiedergegeben werden.

Dies wird durch Ergebnisse der von uns durchgeführten Rechnungen im Rahmen der DFT + *U* Methode, bei der intra-atomare Korrelationseffekte durch einen Hubbard-artigen Term berücksichtigt werden, bestätigt. Wir finden eine Erhöhung der magnetischen Momente schon bei kleinen Werten für *U*, verbunden mit einer Volumenvergrößerung sowie einem Rückgang der geometrischen Verzerrung, und führen dies auf Änderungen in der elektronischen Struktur der Cluster zurück.

MA 28.3 Di 15:45 TU H1028

Temperature Dependence of Magnetic Properties of Small Ferromagnetic Clusters — ●SVETLANA POLESYA¹, SVEN BORNEMANN¹, JAN MINÁR¹, HUBERT EBERT¹, and ONDREJ ŠIPR² — ¹Dept. Chemie und Biochemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany — ²Institute of Physics Acad. of Sci. of the Czech Republic, Cukrovarnicka 10, Praha 6 162 53, Czech Republic

The temperature dependence of the magnetic properties of small ferromagnetic clusters has been studied within the extended classical Heisenberg model using Monte-Carlo simulations. The exchange coupling constants were obtained from *ab initio* spin-polarized KKR calculations of the electronic structure. Results of calculations for Co clusters both unsupported and deposited on Pt(111) surface will be presented. In particular the influence of the spin-orbit induced anisotropy on their thermodynamic properties will be discussed. The peculiarities of the cluster electronic structure lead to a nonmonotonical size dependent Curie temperature for small Fe, Co and FePt clusters. The use of exchange coupling constants taken from bulk calculations on the other hand results in a monotonous increase of the Curie temperature.

MA 28.4 Di 16:00 TU H1028

Magnetic moments of Co clusters on Au(111) — ●JÁN MINÁR¹, O. ŠÍP², H. EBERT¹, and V. POPESCU¹ — ¹Dep. Chemie, LMU, Butenandtstr. 5-13, 81377 München, Germany — ²Institute of Physics AS CR, Cukrovarnicka 10, Praha, Czech Republic

Generally, magnetic moments of atoms at surfaces and interfaces are larger than magnetic moments of these atoms in the bulk. This property opens a number of interesting topics for fundamental research and has a great potential for industrial applications as well. Recently a lot of experimental effort focused on studying magnetism of Co clusters on Au(111) [1]. These clusters are self-assembled at the elbows of the Au(111) herringbone reconstruction and attain a two-atomic-layers height for a broad range of coverages. In order to assess various contributions to magnetism of these systems, we performed a series of fully relativistic *ab-initio* calculations of electronic and magnetic structure of Co monolayer and bilayer and of Co_n clusters (n=1-10) on Au(111), employing the spin-polarized tight-binding multiple-scattering formalism [2]. By comparing our theoretical results for different systems one with another and with available experimental data, general conclusions about the nature of magnetism of Co clusters on Au(111) can be drawn.

[1] A. Dürr et al., Phys. Rev. B 59, R701 (1999); T. Koide et al., Phys. Rev. Lett. 87, 257201 (2001); N. Spiridis et al., Surf. Sci. 507-510, 546 (2002)

[2] R. Zeller et al., Phys. Rev. B 52, 8807 (1995)

MA 28.5 Di 16:15 TU H1028

Mass filtered magnetic FeCo clusters — ●FURKAN BULUT¹, RENATE KERSTIN GEBHARDT¹, JOACHIM BANSMANN², ARMIN KLEIBERT², RALF METHLING², KARL-HEINZ MEIWES-BROER², and MATHIAS GETZLAFF¹ — ¹Institut für Angewandte Physik, Uni Düsseldorf — ²Fachbereich Physik, Uni Rostock

FeCo is a binary alloy with a large magnetic moment. Therefore FeCo clusters are promising candidates for thin film magnetic storage devices. Such clusters are produced by means of a continuously working arc cluster ion source (ACIS). A subsequent electrostatic quadrupole acts as mass filtering element of the alloy clusters. Typical diameters are between 6 and 12 nm. The clusters are deposited on ferromagnetic Ni/W(110)-surfaces under UHV conditions. AFM measurements prove that the height of the clusters is less than the diameter of free particles that is probably caused by particle-support interactions. Element specific magnetic studies were performed by means of X-ray magnetic circular dichroism (XMCD) at BESSY. We will also discuss saturation effects which have to be taken into account when applying sum rules for spin and orbital moment calculations.

MA 28.6 Di 16:30 TU H1028

Strukturelle Charakterisierung von in der Gasphase hergestellten FePt-Nanopartikeln — ●OLGA DMITRIEVA, JOCHEN KÄSTNER und GÜNTER DUMPICH — Experimentalphysik, AG Farle, Universität Duisburg-Essen (Standort Duisburg), Lotharstrasse 1, 47057 Duisburg

Untersucht werden strukturelle Eigenschaften von FePt-Nanopartikeln, die mittels Sputtern und anschließendem Tempern in der Gasphase hergestellt werden. Es zeigt sich, dass die kristalline Struktur und Morphologie der Partikel vom Sputterdruck und der Sintertemperatur abhängt. Mit hochauflösender Transmissionselektronenmikroskopie (HRTEM) wird festgestellt, dass bei einem Sputterdruck von 0,5 mbar monodisperse, thermisch stabile ikosaedrische Partikel entstehen. Bei höherem Druck bis 2 mbar entstehen dagegen polydisperse Nanopartikel, die teilweise eine geordnete, durch hohe magnetokristalline Anisotropie geprägte L1₀-Phase bilden. Da die Ordnungseinstellung auf Volumendiffusion beruht, wird versucht, die Anzahl der Leerstellen während der Partikelherstellung durch Zugabe von Stickstoff im Sputtergas zu

erhöhen. Erste Ergebnisse über den Einfluss von Stickstoff auf die strukturellen und magnetischen Eigenschaften der FePt-Nanopartikel werden dargestellt und diskutiert.

Gefördert aus Mitteln der DFG im Rahmen des SFB 445.

MA 28.7 Di 16:45 TU H1028

Ionenstrahlinduzierte Strukturänderungen in FePt Nanopartikeln — ●B. RELINGHAUS¹, O. DMITRIEVA², M.O. LIEDKE^{3,4}, L. SCHULTZ¹ und J. FASSBENDER⁴ — ¹IFW Dresden, Institut für Metallische Werkstoffe, 01069 Dresden — ²Institut für Physik, AG Farle, Universität Duisburg-Essen, 47048 Duisburg — ³Fachbereich Physik, TU Kaiserslautern, 67663 Kaiserslautern — ⁴FZ Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, 01314 Dresden

Monodisperse, vielfach verzwilligte FePt Nanopartikel mit ikosaedrischer Struktur und Konzentrationen im Bereich der stöchiometrischen Zusammensetzung wurden durch DC-Sputtern in der Gasphase hergestellt. Die ikosaedrische Struktur der Partikel hat sich dabei als äußerst stabil erwiesen, und weder thermisches Anlassen im Fluge noch nach der Deposition führt zur Einstellung der magnetisch hochanisotropen, chemisch geordneten tetragonalen L1₀-Gleichgewichtsstruktur [1]. Eine Bestrahlung dieser Teilchen durch 5 keV He-Ionen bei Fluenzen von $f > 10^{17}$ Ionen/cm² hingegen führt zur Umwandlung in die kfz Struktur. Obwohl die Ionenbestrahlung die Versinterung benachbart liegender Partikel initiiert und somit eine erhöhte Diffusion aufgrund einer temporär erhöhten Defektkonzentration belegt, wird die Einstellung der L1₀-Phase nicht beobachtet. Die Ergebnisse werden durch kinetisch bedingte Modifikationen der thermodynamischen Gleichgewichtsphasen erklärt.

[1] S. Stappert, B. Rellinghaus, M. Acet, and E.F. Wassermann, Proc. Mat. Res. Soc. Vol. 704, 73 (2002); S. Stappert, B. Rellinghaus, M. Acet, and E.F. Wassermann, J. Cryst. Growth 252, 440 (2003).

Gefördert durch die DFG im Rahmen des SFB 445.

MA 28.8 Di 17:00 TU H1028

Temperaturabhängige effektive magnetische Anisotropie in Fe₇₀Pt₃₀-Nanopartikeln — ●C. ANTONIAK, J. LINDNER und M. FARLE — Experimentalphysik - AG Farle, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg

Chemisch ungeordnete monodisperse Fe₇₀Pt₃₀-Nanopartikel mit einem Durchmesser von (2.3 ± 0.3) nm wurden mittels ferromagnetischer Resonanz (FMR) und SQUID-Magnetometrie zwischen 4.2K und 370K untersucht. Wir finden, dass der im Vergleich zu bulk-Legierungen um eine Zehnerpotenz erhöhte Wert der effektiven Anisotropie-Konstanten $K_{eff} = (8.4 \pm 0.9) \times 10^5$ J/m³ bei 23K stark mit steigender Temperatur abfällt und bei Zimmertemperatur weniger als 10% dieses Wertes beträgt. Die Erhöhung kann mithilfe eines einfachen Modells durch die Oxidhülle erklärt werden.

Quantitative Simulationen der magnet. Daten bestätigen das Ergebnis und zeigen die Notwendigkeit, auch in superparamagnetischen Partikel-Systemen die Temperaturabhängigkeit der magnet. Anisotropie zu berücksichtigen.

Unterstützt durch die Europäische Gemeinschaft (HPRN-1999-00150) und die Deutsche Forschungsgemeinschaft, SFB 445.

MA 28.9 Di 17:15 TU H1028

Gitterdehnung in kolloidalen Fe_xPt_{1-x}-Nanopartikeln mit 3 nm Durchmesser — ●ANASTASSIA TROUNOVA, MARINA SPASOVA und MICHAEL FARLE — Experimentalphysik-AG Farle, Universität Duisburg-Essen, 47048 Duisburg

Chemisch synthetisierte kolloidale Fe_xPt_{1-x}-Nanopartikel ($0.4 \leq x \leq 0.6$), die sowohl in Hexan als auch in Wasser [1] dispergiert sind, wurden mittels hochauflösender Transmissionselektronenmikroskopie strukturell und chemisch charakterisiert. Zunächst konnte gezeigt werden, dass durch fünfmalige Sedimentationsfraktionierung die Monodispersität der frisch präparierten Partikel mit einem mittleren Durchmesser von 3 nm wesentlich erhöht werden kann (Standardabweichung $\sigma = 8\%$). Wir finden eine lineare Vergrößerung der Gitterkonstante der chemisch ungeordneten Partikel als Funktion der Pt-Konzentration. Gegenüber dem Volumenverhalten sind die Gitterkonstanten der Nanopartikel um ca. 2 – 3% gedehnt. Dieses Verhalten wird semi-quantitativ durch die auf das Gitter ausgeübten Spannungen erklärt, welche aufgrund der bekannten Oberflächenoxidation in den kolloidalen Partikeln auftreten. [1] V. Salgueirino-Maceira et al., Langmuir 20, 6946 (2004)

Unterstützt durch Sonderforschungsbereich 445 und Europäische Union, RTN-00150.

MA 28.10 Di 17:30 TU H1028

Monte Carlo Simulations of Thermodynamic Properties of FePt Nanoparticles — ●MICHAEL MÜLLER and KARSTEN ALBE — TU Darmstadt, FB Materialwissenschaft, Petersenstr. 23, 64287 Darmstadt

To date, a number of experimental routes for synthesizing FePt nanoparticles have been developed. In many cases, the disordered fcc phase instead of the desired L10 ordered phase is obtained even at low temperatures and it is still unclear whether this is due to kinetic or thermodynamic reasons. Therefore, a detailed investigation of the thermodynamic properties of nanoalloys as a function of particle size, temperature and composition can provide important information.

In our work we have chosen a lattice Monte-Carlo model combined with a spin-1/2 Ising model including nearest and next nearest neighbor interactions. The parameters of the model were fitted to the FePt bulk phase diagram and experimental data on Pt surface segregation. By using this model, we have systematically explored the influence of particle size and chemical composition on the ordering temperature as well as the segregation of Fe and Pt in ordered particles. In general, we find no evidence for a considerable decrease of the ordering temperature with particle size. On the other hand, a lowering of the ordering temperature with increasing deviation from stoichiometry could clearly be observed. This effect was found to be strongly asymmetric with respect to compositions enriched with Fe or Pt, which can be explained by differences in the segregation behaviors of the two elements at the surface.

MA 28.11 Di 17:45 TU H1028

Frequenzabhängige Ferromagnetische Resonanz an CoPt₃ Nanopartikeln — ●CHRISTIAN RAEDER¹, MARINA SPASOVA¹, JÜRGEN LINDNER¹, MICHAEL FARLE¹, ELENA SHEVCHENKO², HORST WEL-
LER², RATISLAV MALYCH³ und ZDENEK FRAIT³ — ¹Fachbereich Physik, Experimentalphysik AG Farle, Universität Duisburg-Essen, Lothar-
str. 1, 47048 Duisburg — ²Institut für physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg — ³Institute of Physics, Academy of Sciences, Na Slovance 2, 18221 Prague 8, Czech Republic

Kolloidale CoPt₃ Nanopartikel mit einem Durchmesser von 4 nm, in hoher Verdünnung eingebettet in ein Polymer, wurden mittels Transmissionselektronenmikroskopie (TEM) und ferromagnetischer Resonanz (FMR) untersucht. Es liegt eine ungeordnete fcc-Phase vor. Die Partikel haben gegenüber dem Volumenmaterial eine um 3% vergrößerte Gitterkonstante von $a=0.393 \pm 0.005$ nm. Die Blocking-Temperatur beträgt $T_B=12$ Kelvin. Das aus dem g -Faktor berechnete Verhältnis aus Bahn- und Spinnmoment beträgt $\mu_L/\mu_S=0.113 \pm 0.006$. Durch Analyse der Linienspektren der FMR Spektren ($T=300$ K) wurde ein stark erhöhter Gilbert Damping Parameter bestimmt: $G=32 \pm 2$ GHz gegenüber bulk Cohcp: $G=0.1$ GHz. Unterstützt durch EU Netzwerk RTN-CT-1999-00150.

MA 28.12 Di 18:00 TU H1028

Experimentelle Untersuchung und theoretische Modellierung des Relaxationsverhaltens von Fe₃O₄-Nanoteilchen für die Magnetorelaxometrie — ●FRANK LUDWIG, SASCHA MÄUSELEIN, ERIK HEIM und MEINHARD SCHILLING — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-
Str. 66, D-38106 Braunschweig

Die Magnetorelaxometrie (MRX) ist ein vielversprechendes Verfahren für die Detektion von Biomolekülen. Dabei werden die Zielmoleküle spezifisch über Antikörper an superparamagnetische Nanoteilchen gebunden, deren Relaxation nach Abschalten eines Magnetisierungsfeldes analysiert wird. Dabei unterscheidet sich das Relaxationsverhalten gebundener und ungebundener magnetischer Marker, so dass im Gegensatz zu anderen Verfahren keine Auswaschschritte ungebundener Marker erforderlich sind.

Wir haben das Relaxationsverhalten magnetischer Fe₃O₄-Nanoteilchen verschiedener Hersteller als Funktion der Magnetisierungszeit und der Magnetisierungsfeldstärke für verschiedene Konzentrationen in Lösung als auch im gefriergetrockneten Zustand untersucht. Es zeigt sich, dass die bisher für die Analyse von MRX-Messungen verwendeten Modelle nur für einen sehr begrenzten Parameterbereich gelten.

Gefördert durch die DFG über den SFB 578.

MA 28.13 Di 18:15 TU H1028

Preparation and properties of thin magnetic metal-polymer nanocomposite films — ●HENRY GREVE¹, ABHIJIT BISWAS², CHRISTIAN POCHSTEIN¹, ULRICH SCHÜRMAN¹, VLADIMIR ZAPOROJTCHE¹, FRANZ FAUPEL¹, MICHAEL FROMMBERGER³, and ECKHARD QUANDT³ — ¹Chair for Multicomponent Materials, Faculty of Engineering, CAU Kiel, Kaiserstr. 2, 24143 Kiel — ²Institute for Shock Physics, Washington State University Spokane, U.S.A. — ³Smart Materials Group, CAESAR, 53175 Bonn

Thin composite films consisting of a magnetic material inside an insulating polymer matrix show very fascinating properties and may be applied in different areas ranging from high density hard disc storage to inductive components useable up and beyond the GHz barrier. We prepared metal-polymer composite films by vapor phase co-deposition. The film structure was characterized by profilometry, EDX and TEM. Depending on deposition parameters and materials we either observe metal clusters or nanocolumns inside a polymer matrix. The cluster nanocomposites are considered to be ideal for high frequency applications due to minimized eddy current losses and a high ferromagnetic resonance frequency. The columnar nanocomposite shows vertically aligned columns of 5-8 nm diameter. Due to small dimensions of the columns and their high shape anisotropy they are promising candidates for high density data storage.

MA 29 Magnetische Materialien

Zeit: Dienstag 15:15–18:45

Raum: TU A060

MA 29.1 Di 15:15 TU A060

ZnO-based diluted magnetic semiconductors — ●ALEXEI NEFEDOV¹, NUMAN AKDOGAN¹, HARTMUT ZABEL¹, and HANS-WERNER BECKER² — ¹Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — ²Ionenstrahlenphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Diluted magnetic semiconductors (DMS) have attracted much interest in recent years because of the possibility to utilize both, the charge and spin degrees of freedom in a single substance. Therefore, there is a strong interest to synthesize a ferromagnetic DMS whose Curie temperature is above room temperature. Since it was predicted that 3d transition metal atoms can order ferromagnetically in the ZnO matrix, further investigations on the feasibility of ZnO-based DMSs are of great interest. We report on studies of the magnetic properties of ZnO films doped with Co, Mn and Fe using ion implantation techniques. Data obtained by MOKE, SQUID, and x-ray resonant magnetic scattering (XRMS) will be presented. The Curie temperature dependence of ZnO-based DMS on different parameters (implantation dose, structural quality, annealing) will be reported. This work is supported by BMBF through the project 03ZAE8BO.N.A. acknowledges a fellowship through the International MPI Research School "SurMat".

MA 29.2 Di 15:30 TU A060

The minority gap in half-metallic ferromagnets — ●HEM C. KANDPAL, GERHARD H. FECHER, CLAUDIA FELSER, and GERD SCHÖNHENSE — Johannes Gutenberg - Universität, 55099 Mainz, Germany

Half-metallic ferromagnets like the full Heusler compounds with formula X_2YZ are supposed to show an integer value for the total magnetic moment. SCF calculations reveal, however, in certain cases of $X = \text{Co}$ based compounds, non-integer values in contrast to experiments. Co_2YSi with $Y = \text{Mn, Fe}$ are of particular interest because of their high T_C . In order to explain deviations of the magnetic moment calculated for such compounds, the dependency of the minority gap on the lattice parameter was studied by using FLAPW calculations. The minimum total energy (relaxed structure) of Co_2FeSi is found for the experimental lattice parameter. But, the relaxed structure does not show half metallic ferromagnetic behavior. However, if we increase the relaxed lattice constant by +8%, it shows half-metallic ferromagnetism and a magnetic moment equal to $6\mu_B$ in accordance to the experimental value. While Co_2MnSi is a half metallic ferromagnet for the experimental lattice constant, the size of the minority gap still depends on the lattice parameter used in the calculations. Recently there is an increased interest in thin films of the Heusler compounds. In this situation, the lattice parameter may be changed if the thin films consist of strained layers. Therefore, one may

observe experimentally different results with respect to the width of the gap and magnetic moments compared to bulk samples.

(This work is funded by the DFG in FG 559.)

MA 29.3 Di 15:45 TU A060

Magnetic and structural characteristics of epitaxial Ge(Mn,Fe) diluted films — ●HEIKO BRAAK, R.R. GAREEV, D. RATA, D.E. BÜRLER, P.A. GRÜNBERG, and C.M. SCHNEIDER — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Novel Germanium-based Ge(Co,Mn) diluted magnetic semiconductor recently attracted attention due to their high Curie temperature ($T_C \approx 270\text{K}$) and the possibility of straightforward integration into Si- and Ge-based technologies [1]. We prepare 100 nm-thick, epitaxial $\text{Ge}_{100-(x+y)}(\text{Mn}_x\text{Fe}_y)$ films with Mn and Fe concentrations of several at. % by growing Ge, Fe, and Mn separately layer-wise at elevated temperature. From depth profiling with secondary ion mass spectrometry (SIMS) after annealing we find a homogenous distribution of Fe and Mn across the sample. The layered structure is gone.

We measure saturation magnetization m_S versus temperature curves for a variety of (x, y) combinations with a SQUID magnetometer and find for fixed temperatures a non-trivial dependence of m_S on x and y . Within a certain window in the (x, y) parameter space $\text{Ge}_{100-(x+y)}(\text{Mn}_x\text{Fe}_y)$ exhibits a T_C of 350K and $m_S \approx 10 \text{ emu/cm}^2$ at room temperature.

The temperature dependence of the remanent magnetization shows a curve composed of magnetic contributions with different phase-transition temperatures. The XRD-data gives evidence that our samples contains different clusters.

[1] F. Tsui, L. He, L. Ma, A. Tkachuk, Y. S. Chu, K. Nakajima, and T. Chikyow, Phys. Rev. Lett. **91**, 177203 (2003).

MA 29.4 Di 16:00 TU A060

Doped semi-conductors as HMF materials: $\text{CoTi}_{1-x}\text{Fe}_x\text{Sb}$ — ●KRISTIAN KROTH, GERHARD H. FECHER, VADIM KSENOFONTOV, CLAUDIA FELSER, and GERD SCHÖNHENSE — Johannes Gutenberg - Universität, 55099 Mainz, Germany

CoTiSb is known to be a semiconducting half Heusler compound. Doping by Fe is expected to result in ferromagnetic order. It was found that Ti can be replaced by up to 5% Fe while its crystal structure still remains $C1_b$, which was proved by X-ray powder diffraction and Mößbauer spectroscopy. SQUID magnetometry revealed a magnetic moment of $0.2\mu_B$ per formula unit. SCF calculations using the KKR-CPA method predict a half metallic ferromagnetic character with only Fe atoms contributing to the total magnetization of the alloy. This is in agreement to experiments using XMCD at $L_{2,3}$ edges to determine the atomic resolved contribution of the 3d metals to the magnetic moment.

An alternative way of synthesis, besides arc-melting of the four components, had been tried out by Fe ion implantation into an arc-melted CoTiSb sample. Surface investigations of such samples were carried out by XAS-PEEM and Nano-ESCA devices in order to examine the spatial distribution of the elements.

MA 29.5 Di 16:15 TU A060

Co_2FeSi : A half metallic full Heusler compound with high Curie temperature — ●SABINE WURMEHL¹, GERHARD H. FECHER¹, VADIM KSENOFONTOV¹, HONG-JI LIN², HANS-JOACHIM ELMERS¹, and CLAUDIA FELSER¹ — ¹Johannes Gutenberg - Universität, 55099 Mainz, Germany — ²NSRRC, Hsinchu 30077, Taiwan

Co_2FeSi crystallizes in the ordered $L2_1$ structure as proofed by X-ray diffraction. Mößbauer spectroscopy exhibits a single site for the Fe atom indicating a high local order in the samples. Magnetic hysteresis was measured by SQUID from 5K to 775K revealing a magnetic moment of $6\mu_B$ at low temperature. This value of the magnetic moment is in agreement with the Slater-Pauling rule for half metallic ferromagnets. Plotting the Curie temperature of Co_2 based Heusler compounds versus magnetic moment suggests that Co_2FeSi will have one of the highest magnetic transition temperatures. Here, the Curie temperature was measured with DTA to be about 1030K. Magnetic circular dichroism spectra excited by soft X-rays (XMCD) were taken to determine the element specific magnetic moments of Co and Fe. The electronic and magnetic structure of the compound was calculated self-consistently by means of different methods. These SCF calculations revealed the measured magnetic moment and a half metallic ferromagnetic character only if an appropriate lattice parameter was used.

(This work is funded by the DFG in FG 559.)

MA 29.6 Di 16:30 TU A060

Untersuchung der magnetischen Eigenschaften und der martensitischen Umwandlung im Heusler-System Ni-Mn-Sn — ●T. KRENKE¹, M. ACET¹, E.F. WASSERMANN¹, X. MOYA², LL. MAÑOSA² und A. PLANES² — ¹Fachbereich Physik, Experimentalphysik, Universität Duisburg-Essen, Campus Duisburg, Lotharstrasse 1, 47048 Duisburg — ²Facultat de Física, Universitat de Barcelona, Diagonal 647, E-08028 Barcelona, Catalonia, Spain

Es wurden die magnetischen Eigenschaften und die martensitische Umwandlung der Legierungsreihe $\text{Ni}_{0.50}\text{Mn}_{0.50-x}\text{Sn}_x$ in einem Konzentrationsbereich $0.05 \leq x \leq 0.25$ studiert. Es zeigt sich, dass, ausgehend von der stöchiometrischen Zusammensetzung Ni_2MnSn , bis zu einer Konzentration $x = 0.13$ der ferromagnetische Zustand erhalten bleibt. Die martensitische Umwandlung erfolgt in einem Konzentrationsbereich von $x = 0.05$ bis $x = 0.15$, wobei als Funktion der Zusammensetzung sowohl die unmodulierte $L1_0$ -Phase als auch verschiedene modulierte martensitische Phasen beobachtet werden. Es existiert demnach ein Koexistenzgebiet von Ferromagnetismus und martensitischer Umwandlung. Für $x = 0.15$ ist die Martensit-Starttemperatur M_s kleiner als die Curie-Temperatur des Martensits T_c^M . In der Temperaturabhängigkeit der Magnetisierung beobachtet man während der martensitischen Umwandlung einen charakteristischen Verlauf. Zuvor wurde anhand des verwandten Systems Ni-Mn-Ga bereits gezeigt, dass diese eindeutige Hinweise für das Auftreten des magnetischen Formgedächtnis-Effektes sind. In Ni-Mn-Sn-Legierungen sollte daher ebenfalls der magnetische Formgedächtnis-Effekt zu beobachten sein.

MA 29.7 Di 16:45 TU A060

Adjusting the crystal structure of NiMnGa ferromagnetic shape memory alloys — ●UWE GAITZSCH, STEFAN ROTH, NORBERT MATTERN, BERND RELLINGHAUS, and LUDWIG SCHULTZ — IFW Dresden, Helmholtzstr. 20, 01069 Dresden

The intermetallic phase Ni_2MnGa is known to exhibit large magnetic field induced strain (MFIS) due to magnetically driven rearrangements of martensitic variants within a wide compositional range. Samples of $\text{Ni}_{100-x-y}\text{Mn}_x\text{Ga}_y$ with $(x,y) = (26,22)$ and $(x,y) = (30,20)$ were prepared by arc or induction melting of the elements in Argon. Se (0,1%) was added to one of the samples to investigate phase stabilizing effects. Annealing at and below the ordering temperature ($B2$ - $L2_1$ type, roughly 750°C) followed by water quenching was found to have an influence on the structure of the martensitic phase, which forms between 50°C and 100°C as determined by DSC. X-ray diffraction was used to characterize the structure: In ball milled powder samples, the structure was found to be tetragonal for $(x,y) = (26,22)$ and orthorhombic with some monoclinic distortion for $(x,y) = (30,20)$ thereby indicating the seven-layered (7M) type of martensite. The magnetic anisotropy field was measured using the singular point detection technique. Compression tests up to 150 MPa resulted in persistent deformations. Whereas it was possible to recover the original shape by thermal treatments, magnetically induced recovery was not achieved in fields up to 2 T.

MA 29.8 Di 17:00 TU A060

Melt-spun $\text{LaFe}_{13-x}\text{Si}_x$ ribbons with large magnetic entropy change — ●ARU YAN, KARL-HARTMUT MÜLLER, and OLIVER GUTFLEISCH — Leibniz Institute of Solid State and Materials Research Dresden, Institute of Metallic Materials, P.O. Box 270016, D-01171 Dresden, Germany

$\text{LaFe}_{13-x}\text{Si}_x$ ($X=1, 1.8$) compounds were prepared by melt-spinning and their structure and magnetic entropy change were investigated. The 1:13 phase with cubic NaZn_{13} -type structure is obtained by a very short time annealing (1000 - $1050^\circ\text{C}/1\text{h}$) in melt-spun-type materials, which, in contrast, requires a very long time annealing at high temperature to develop in the bulk alloy. More importantly, a very large value of magnetic entropy change, 31 J/kg K , was obtained in $\text{LaFe}_{11.8}\text{Si}_{1.2}$ ribbons at 201 K under 5 T, which is much higher than that reported in the bulk alloys in this temperature range ($\text{LaFe}_{11.44}\text{Si}_{1.56}$, 23 J/kg K at 195 K). Further analysis confirms the occurrence of a typical first-order field-induced transition and a more homogenous element distribution resulting from the very high cooling rate in the $\text{LaFe}_{11.8}\text{Si}_{1.2}$ ribbons. With increasing Si concentration, the Curie temperatures are increased, while the maximum magnetic entropy changes are decreased due to weakening or disappearance of the first-order magnetic phase transition. The large value of magnetic entropy change and much reduced annealing programme make the melt-spun-type materials more appropriate for magnetic refrigerant applications, compared with conventional bulk alloys.

MA 29.9 Di 17:15 TU A060

Influence of melt convection on microstructure evolution of Nd-Fe-B alloys using forced crucible rotation technique — ●KAUSHIK BISWAS¹, REGINA HERMANN¹, OCTAVIAN FILIP¹, JOCHEN WERNER¹, GUNTHER GERBETH², and JANIS PRIEDE² — ¹Institute for Solid State and Materials Research (IFW) Dresden — ²Forschungszentrum Rossendorf e.V., Dresden

The forced crucible rotation technique has been applied to the solidification of Nd-Fe-B alloys. Specially sealed samples were subjected to well-defined forced rotation during induction heating and solidification. The resulting microstructure of the Nd-Fe-B alloys in consideration of melt convection has been investigated using scanning electron probe microscopy. The determination of the α -Fe volume fraction by measuring the magnetic moment in a vibrating sample magnetometer (VSM) resulted in a distinct reduction of the α -Fe volume fraction in samples with high crucible rotation frequencies. Furthermore, a new category of experiment has been started where a tailored magnetic field was applied in order to study the microstructure evolution due to an enhancement or suppression of the melt convection by additional alternating magnetic fields.

MA 29.10 Di 17:30 TU A060

TEXTURE IN FINE GRAINED NdFeB PERMANENT MAGNETS — ●KIRILL KHLOPKOV, OLIVER GUTFLEISCH, DIETRICH HINZ, KARL-HARTMUT MÜLLER, and LUDWIG SCHULTZ — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Melt-spun die-upset NdFeB magnets represent a nearly ideal system for the systematic study of texture in relation to the magnetic properties and the magnetic microstructure since various degrees of texture can be easily adjusted by hot deformation (die-upsetting to various strains or different height reductions). The degree of texture has been defined as the ratio between the respective remanent magnetisations measured in the two directions, perpendicular and parallel to the deformation direction. For the magnet with the highest degree of texture a local texture analysis using electron back scatter diffraction (EBSD) has been performed. Magnetic force microscopy (MFM) has been used to examine the dependence of magnetic microstructure on texture in the thermally and dc-demagnetised states. A very fine contrast on a scale of 300 nm can be resolved with MFM even in isotropic magnets. Magnets with higher degree of texture show broad and well-pronounced interaction domains. The phase shift of the MFM cantilever increases linearly with the width of interaction domains. Two types of magnetic microstructure (regions with fine contrast and interaction domains extension over more than 2 microns) have been observed in the dc-demagnetised state. The dependence of these cooperative phenomena on texture is discussed. This work was supported by SFB463.

MA 29.11 Di 17:45 TU A060

Magnetization of bulk $\text{SmCo}_{5-x}\text{Cu}_x$ ($x \approx 2.5$) in high pulsed fields — ●P. KERSCHL¹, A. HANDSTEIN¹, K. KHLOPKOV¹, O. GUTFLEISCH¹, R. GRÖSSINGER², K.-H. MÜLLER¹, and L. SCHULTZ¹ — ¹IFW Dresden, Institut für Metallische Werkstoffe, PF 270116, D-01171 Dresden, Germany — ²TU Wien, Institut für Festkörperphysik, Wiedner Hauptstr. 8-10, A-1040, Wien, Austria

The substitution of Co by Cu in SmCo_5 is known to cause a considerably large coercivity JH_c in this material even in the as-cast state. In this study the phase composition and microstructure have been investigated by XRD, SEM and EDX analysis. Induction melted samples of $\text{SmCo}_{5-x}\text{Cu}_x$ ($x = 2.5, 3$) show a phase separation within the 1:5 structure exhibiting different Sm/(Co,Cu) ratios. Magnetization measurements were performed in a pulsed high-field facility up to 50 T with a rise time of about 8.5 ms. A jump from low to high magnetization state in an increasing external field at the transition field H_u is observed in the samples with $x = 2.5$ and 3. The values of JH_c and H_u increase with decreasing temperature and with increasing field sweep rate. High coercivities up to about $\mu_0 JH_c \approx 30$ T and high transition fields $\mu_0 H_u$ reaching 45 T at 4.2 K for $x = 3$ are observed. Indications for the connection between the high field transition at H_u and the observed microstructure

are presented. The influence of the field changing rate on the observed coercivity is discussed with respect to a possible pinning mechanism. *This work was supported by the BMBF project 03SC5DRE.*

MA 29.12 Di 18:00 TU A060

Magnetic properties of single crystalline RE_2PdSi_3 intermetallic compounds. — ●IRINA MAZILU¹, WOLFGANG LÖSER¹, GÜNTER BEHR¹, MATTHIAS FRONTZEK², E.V. SAMPATHKUMARAN³, and LUDWIG SCHULTZ¹ — ¹Leibniz-Institut für Festkörper- und Werkstofforschung Dresden, PF 27 01 16, D-01171 Dresden — ²Institut für Festkörperphysik, Technische Universität Dresden, D- 01062 Dresden — ³TIFR Mumbai, Homi Bhabha Road, Colaba, Mumbai-400005, India

Rare Earth (RE)-Transition Metal-Silicides are of interest for their magnetic and magnetoelectric properties and complex magnetic ordering phenomena. RE_2PdSi_3 intermetallic compounds exhibit a hexagonal AlB_2 type crystal structure. Single crystals of compounds with various rare earth elements $\text{RE} = \text{Tb, Dy, Ho, Er, Gd, Tm}$ were grown by a floating zone method. The magnetic measurements on samples with different crystallographic orientation revealed magnetic ordering transitions between 2 and 23 K. The considerable anisotropy of susceptibility and magnetization primarily depends on the orbital shape of the rare earth element. The anisotropy of electrical conductivity as function of the temperature is less pronounced but related to the magnetic order. Some compounds, display an anisotropic giant magnetoresistance with significant differences of the field dependence below and above the magnetic ordering transition temperature. (Supported by DFG/SFB 463.)

MA 29.13 Di 18:15 TU A060

Structural and magnetic properties of the solid solution series $\text{Sr}_2\text{FeRe}_{1-x}\text{Sb}_x\text{O}_6$ — ●ALEXANDRA JUNG, VADIM KSENOFONTOV, SERGEY REIMAN, GERHARD H. FECHER, CLAUDIA FELSER, and WOLFGANG TREMEL — Johannes Gutenberg - Universität, 55099 Mainz, Germany

Structural and magnetic studies of doped double perovskites $\text{Sr}_2\text{Fe}_{1-x}\text{M}_x\text{ReO}_6$ ($0 < x < 1$, $\text{M} = \text{Zn, Cr}$) revealed a strong magnetic interaction between Fe and Re sublattices which leads to a ferrimagnetic phase. A transformation from FERRImagnetic to FERROMagnetic order was observed at high Zn content. In this study, the effect of Sb dilution on the magnetic properties of $\text{Sr}_2\text{FeRe}_{1-x}\text{Sb}_x\text{O}_6$ are exploited. X-ray powder diffraction points that all substituted samples adopt the same double perovskite structure like the original undoped compound with $x = 0$. Magnetic measurements of $\text{Sr}_2\text{FeRe}_{1-x}\text{Sb}_x\text{O}_6$ ($\approx 0.5 < x < 1$) indicate transformation to an antiferromagnetic phase, which was proved by ⁵⁷Fe magnetic field Mößbauer spectroscopy. Application of ¹²¹Sb Mößbauer spectroscopy reveals the features of magnetic exchange within the Re sublattice.

(This work is funded by the DFG in FG 559.)

MA 29.14 Di 18:30 TU A060

Untersuchung des Einflusses formanisotroper magnetischer Partikel im Submikrometerbereich auf die mechanischen Eigenschaften eines Ferrogels — ●STEFAN MONZ, ANDREAS TSCHÖPE und RAINER BIRNINGER — 7.3 Technische Physik, Universität des Saarlandes, Geb. 43B, D-66123 Saarbrücken

Durch den Einbau magnetischer Nanopartikel in ein Hydrogel ist es möglich, ein magnetfeldsensitives Kompositmaterial (Ferrogel) herzustellen. Während bisher vorwiegend sphärische Magnetpartikel verwendet werden, sollen hier magnetische Partikel mit starker Formanisotropie in einem Hydrogel dispergiert werden. Diese ferromagnetischen Partikel werden im Gegensatz zu den sphärischen, superparamagnetischen Teilchen eine starke Wechselwirkung mit homogenen Magnetfeldern erfahren. Das mechanische Gleichgewicht zwischen den durch Magnetfelder induzierten Drehmomenten und den lokalen elastischen Kräften des Hydrogelnetzwerks bedingt eine Kopplung der mechanischen und magnetischen Eigenschaften. In diesem Vortrag wird über die Synthese dieser Teilchen berichtet. Außerdem werden erste Untersuchungen bezüglich des Einflusses dieser Partikel auf die mechanischen Eigenschaften des Hydrogels vorgestellt.

MA 30 Hauptvorträge Schilling / Vedmedenko

Zeit: Mittwoch 09:45–10:45

Raum: TU H1028

Hauptvortrag

MA 30.1 Mi 09:45 TU H1028

Proteine und Patienten - Neue Anwendungen der höchstempfindlichen Magnetfeldsensorik — ●MEINHARD SCHILLING — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Str. 66, 38106 Braunschweig

In den letzten Jahren sind sehr große Fortschritte bei magnetischen Sensoren und darauf basierenden Messverfahren erreicht worden. Neben den supraleitenden Quanteninterferometern im Betrieb bei tiefen Temperaturen sind mehrere andere Sensortypen entwickelt worden, die im Betrieb bei Raumtemperatur für viele Anwendungen eine ebenso rauscharme Alternative darstellen.

Über diese neuen Konzepte und ihre Anwendungen, insbesondere in den Lebenswissenschaften und der Medizin, wird ein Überblick gegeben.

Hauptvortrag

MA 30.2 Mi 10:15 TU H1028

Theorie der magnetischen Strukturbildung in Nanoteilchen und Nanoarrays — ●E. Y. VEDMEDENKO — Universität Hamburg, JAP, Jungiusstr. 11, 20355 Hamburg — Trägerin des Hertha-Sponer-Preises

Die Konfiguration der magnetischen Momente in einzelnen Nanomagneten und Nanoarrays bestimmt fundamentale physikalische Eigenschaften dieser Nanobjekte. Deswegen spielt das Verständnis der Anordnung magnetischer Momente auf atomarer Skala eine Schlüsselrolle für Systeme reduzierter Dimensionen.

Durch eine Kombination analytischer Rechnungen mit Computersimulationen konnten wir zeigen, dass die atomare Körnigkeit zu wichtigen neuen Effekten in Nanomagneten führt, z.B. nichtkollinearem Magnetismus [1, 2] und anisotroper Orientierung von magnetischen

Domänenwänden [3]. In guter Übereinstimmung mit den Experimenten konnten wir demonstrieren, dass die Orientierung der Domänenwände in ferromagnetischen ultradünnen (Dicke von zwei atomaren Lagen) Nanostrukturen nicht nur - wie noch bis vor wenigen Jahren angenommen - mit der Form- und Kristallanisotropie zusammenhängt, sondern von der Austauschenergie und der Gitterstruktur bestimmt wird [3]. Einer der Gründe dafür ist eine Verringerung der magnetostatischen Energie in Nanostrukturen mit einer Dicke von wenigen Monolagen. Damit liesse sich ein neuer Effekt, die grössenabhängige Spinreorientierung, vorherzusagen [4]. In der letzten Zeit haben wir ein allgemeines Verfahren zur Berechnung von Multipolmomenten polarisierter Nanoteilchen entwickelt [5]. Wir zeigen, dass polarisierte Nanoteilchen mit axialer Symmetrie Multipolmomente höherer Ordnung besitzen. Die starke multipolare Wechselwirkung führt zur Bildung neuer magnetischer Überstrukturen. Die Symmetrie dieser Strukturen hängt mit der Ordnung der Multipolmomente und der des Gitters zusammen und ermöglicht es, einige experimentelle Phänomene zu erklären.

(1) E. Y. Vedmedenko, H.P. Oepen, and J. Kirschner, Phys. Rev. Lett. 90, 137203 (2003).

(2) E. Y. Vedmedenko, U. G. Grimm, and R. Wiesendanger, Phys. Rev. Lett. 93, 76407 (2004).

(3) E.Y. Vedmedenko, A. Kubetzka, K. von Bergmann, O. Pietzsch, M. Bode, H.P. Oepen, J. Kirschner and R. Wiesendanger, Phys. Rev. Lett. 92, 077207 (2004).

(4) E. Y. Vedmedenko, H.P. Oepen, and J. Kirschner, Phys. Rev. B 67, 012409 (2003).

(5) N. Mikuszeit, E. Y. Vedmedenko, and H. P. Oepen, J. Phys. C: Cond. Matter., 16, 9037(2004).

MA 31 Magnetische Partikel/Cluster II

Zeit: Mittwoch 11:00–13:15

Raum: TU H1012

MA 31.1 Mi 11:00 TU H1012

Electronic and Magnetic Properties of Arrays of well-separated fct FePt Nanoparticles Prepared using a Micellar Technique

— A. ETHIRAJAN¹, ●H.-G. BOYEN¹, U. WIEDWALD¹, F. WEIGL¹, G. KÄSTLE¹, P. ZIEMANN¹, K. FAUTH², M. HESSLER², M. BÜTTNER³, A. ROMANYUK³ und P. OELHAFEN³ — ¹Abteilung Festkörperphysik, Universität Ulm, D-89069 Ulm — ²Experimentelle Physik IV, Universität Würzburg, Am Hubland, D-97074 Würzburg — ³Institut für Physik, Universität Basel, Klingelbergstr. 82, CH-4056 Basel

Arrays of colloidal FePt nanoparticles generally need to be annealed to elevated temperatures in order to achieve the desired, magnetically attractive, fct phase. Such heat treatment, however, is likely to result in the formation of larger agglomerates due to very small interparticle distances (few nanometers) of the as-deposited particle ensembles. Here, we present a new method allowing to prepare arrays of well separated and chemically pure FePt nanoparticles (diameter about 10 nm, interparticle distance about 100nm). These dots are synthesized by exploiting the selforganization of metal salt-loaded diblock copolymer reverse micells, followed by a plasma-induced removal of the polymer matrix after deposition of a micellar monolayer on a silicon substrate, leading to metallic nanodots in the chemically disordered fcc phase. These dots are then annealed to 650°C for 2 hours yielding the fct phase without any indication for sintering. X-ray induced photoelectron spectroscopy (XPS) and X-ray Magnetic Circular Dichroism (XMCD) are used to study the electronic and magnetic properties in detail after the different preparational steps. First results will be presented.

MA 31.2 Mi 11:15 TU H1012

Magnetic properties of Ni/Ni-oxide core-shell — ●V. SCHNEIDER¹, A. TILLMANN², A. REINHOLDT¹, T. WEIRICH³, and U. KREIBIG¹ — ¹I. Phys. Inst. I.a, RWTH Aachen, Postfach 52056 — ²II. Phys. Inst. II.a, RWTH Aachen, Hüskensweg, 52074 Aachen — ³GFE, RWTH Aachen, Ahornstr. 55, 52074 Aachen

Nickel/Nickel-oxide core-shell nanoparticles are, at present, of great interest concerning medical applications and data storage devices.

Nanoparticles were produced by laser evaporation and adiabatic ex-

pansion. They were deposited on substrates and subsequently oxidized in-situ at a temperature up to 400°C forming oxide shells.

This talk will present structural and magnetic analysis on those particles including detailed Energy Filtered Transmission Electron Microscopy (EFTEM) and High Resolution Transmission Electron Microscopy (HRTEM). Magnetic hysteresis measurements were performed by SQUID. Results of samples with three different states of oxidation are discussed and their hysteresis including the observed exchange bias are interpreted.

MA 31.3 Mi 11:30 TU H1012

Selbstorganisierte Eisennanoketten: Elektrische und Magnetische Eigenschaften — ●HARTMUT WIGGERS¹, TIM PATRICK HÜLSER^{1,2}, JÖRG KNIPPING¹ und AXEL LORKE² — ¹Institut für Verbrennung und Gasdynamik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg — ²Laboratorium für Festkörperphysik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg

Ferromagnetische Eisen-Nanopartikel mit einem Durchmesser von 35 nm können durch Gasphasenpyrolyse von $Fe(CO)_5$ in einem Heisswandreaktor hergestellt werden. Die Partikelagglomeration wird von magnetischen Wechselwirkungen bestimmt und führt zur Bildung von bis zu 300 μm langen Eisenketten. Durch kontrollierte Oxidation lassen sich diese Nanodrähte mit einer 3-4 nm dicken schützenden Oxidhülle umgeben. HRTEM und EELS Untersuchungen liefern detaillierte Informationen über Morphologie, Struktur und chemischer Zusammensetzung des Materials.

Impedanz Spektroskopie an einzelnen, ca. 20 μm langen, Nanodrähten zeigt sowohl ohm'sche als auch kapazitive Impedanzbeiträge. Daraus lässt sich ein spezifischer Widerstand von $\rho = 3,2 \times 10^{-5} \Omega\text{m}$ bestimmen. Magnetische Messungen mittels SQUID Magnetometrie ergeben eine Sättigungsmagnetisierung von 160 emu/g. Impedanz Spektroskopie unter reduzierender H_2 -Atmosphäre an kompaktiertem Material belegt ohm'sches Verhalten. Mittels REM wird Sinterverhalten nachgewiesen.

MA 31.4 Mi 11:45 TU H1012

Molekulardynamik-Simulationen dipolarer magnetischer Nanopartikel — •ALFRED HUCHT, STEPHAN BUSCHMANN und PETER ENTEL — Theoretische Physik, Universität Duisburg-Essen und SFB 445, 47048 Duisburg

Neue Untersuchungen an Fe- und Ni-Nanopartikeln aus der Gasphase zeigen, dass diese sich unter bestimmten Bedingungen in Form langer Ketten anordnen [1]. Es wird angenommen, dass die Dipolwechselwirkung zwischen den magnetischen Nanopartikeln Ursache für die Kettenbildung ist.

Wir untersuchen die Dynamik und Thermodynamik dipolarer magnetischer Nanopartikel mit Molekulardynamik-Simulationen und analysieren den Einfluss u. a. von magnetischem Moment, Partikelgröße, Temperatur und äußerem Magnetfeld auf das System. Weiterhin ergeben sich interessante Effekte bei Berücksichtigung des quantenmechanischen Spindrehimpulses zusätzlich zum Massendrehimpuls der Partikel.

[1] J. Knipping *et. al.*, *Nanotechnology* 15, 1665 (2004).

MA 31.5 Mi 12:00 TU H1012

Classifying magnetic interactions in nanoparticle assemblies using Cole-Cole plots — •OLEG PETRACIC¹, ANDREAS GLATZ², SUBHANKAR BEDANTA¹, XI CHEN¹, and WOLFGANG KLEEMANN¹ — ¹Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany — ²Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany

Studying the magnetic ac susceptibility, $\chi = \chi' - i\chi''$, of nanoparticle assemblies leads to important conclusions about the role of inter-particle interactions. We demonstrate that the Cole-Cole plot, χ'' vs. χ' , can be used as a tool for classifying the magnetic behavior of interacting or non-interacting nanoparticles. Distinguishing non-interacting superparamagnetic from collective behavior like in the superspin glass or superferromagnetic state is easily possible. We performed measurements of the magnetization hysteresis and ac susceptibility on the granular multilayer $[\text{Co}_{80}\text{Fe}_{20}/\text{Al}_2\text{O}_3]_n$. The results are successfully compared to simulations within two approaches for a driven domain wall in random media.

MA 31.6 Mi 12:15 TU H1012

Polarized Neutron Reflectometry and magnetometry studies on granular multilayers — •SUBHANKAR BEDANTA¹, EMMANUEL KENTZINGER², OLEG PETRACIC¹, WOLFGANG KLEEMANN¹, ULRICH RÜCKER², AMITESH PAUL², THOMAS BRÜCKEL², S. CARDOSO³, and P. P. FREITAS³ — ¹Angewandte Physik, Universität Duisburg-Essen, D-47048 Duisburg, Germany — ²Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich, Germany — ³INESC, Rua Alves Redol 9-1, 1000, Lisbon, Portugal

Polarized neutron reflectivity (PNR) and magnetometry studies have been performed on the granular multilayers $[\text{Co}_{80}\text{Fe}_{20}(t_n)/\text{Al}_2\text{O}_3(3\text{nm})]_{10}$ for two different nominal thicknesses $t_n = 1.3$ nm (non-percolating superferromagnet) and $t_n = 1.6$ nm (percolating ferromagnet). The ac-susceptibility components measured as a function of frequency, temperature and field amplitudes show similar results as obtained from recent simulations. They hint at sliding and switching regimes of pinned domain walls. This is also confirmed by PNR measurements of the slowly relaxing magnetization reversal, which does not show any spin flip scattering. For the percolated sample fast relaxation is found, which is accompanied by two enhanced satellites around the first Bragg peak. This is probably due to an oscillating magnetization between FeCo layers with a period of five bilayers along the multilayer stack.

MA 31.7 Mi 12:30 TU H1012

Transport und Positionierung von Biomolekülen mit magnetischen Markern — •MICHAEL PANHORST¹, PAUL-BERTRAM KAMP², JÖRG SCHOTTER¹, GÜNTER REISS¹ und HUBERT BRÜCKL¹ — ¹Fakultät für Physik, Universität Bielefeld, Universitätsstr. 25, D-33615 Bielefeld — ²Fakultät für Biologie, Universität Bielefeld

Kommerziell erhältliche magnetische Marker werden in verschiedenen biomedizinischen Anwendungen genutzt. Die Marker gibt es je nach Anwendung in unterschiedlichen Konfigurationen (Größe, Matrix, Oberflächenfunktionalisierung, magnetische Eigenschaften ...). Diese magnetischen Marker und damit auch die angebotenen Biomoleküle, können über externe Magnetfelder manipuliert werden.

Ein on-chip Manipulationssystem wurde entwickelt, das den Transport von magnetischen Markern und eine genaue Positionierung auf der Chipoberfläche erlaubt. Dazu werden Gold-Leiterbahnen auf einem Si-Wafer mit optischer Lithographie strukturiert und mit 100 nm SiO_2 abgedeckt. Ströme bis zu 100 mA durch die Leiterbahnen erzeugen dabei Magnetfelder, durch die die paramagnetischen Marker magnetisiert und ausgerichtet werden. Die Marker folgen dem Gradienten zum nächsten lokalen Maximum des Magnetfeldes.

Durch ein spezielles Design der Leiterbahnen können magnetische Marker (Durchmesser: $1,5 \mu\text{m}$) exakt auf einem $2 \times 2 \mu\text{m}^2$ großen Sensor positioniert werden. Mit der Untersuchung von Bindungskräften zwischen zwei Biomolekülen (gezeigt am Beispiel von Streptavidin-Biotin und Avidin-Biotin) wird eine weitere Anwendung dieses Manipulationssystems vorgestellt.

MA 31.8 Mi 12:45 TU H1012

Magnetic susceptibility of magnetite nanoparticles in biological environments — •JIANDONG WEI and UWE HARTMANN — Experimental Physics Department, University of Saarbruecken, Saarbruecken, Germany

Biogenic magnetite (Fe_3O_4) has been found in a wide range of organisms, such as magnetotactic bacteria and homing pigeons. Magnetite nanoparticles are assumed to play a key role in the detection of the geomagnetic field and are the basis for several magnetoreception hypotheses. However, the susceptibility of the particles as an important property is not very well defined. On the other hand this quantity largely determines the plausibility of those hypotheses. Magnetite nanoparticles from bacteria and particles similar to those found in pigeons have been investigated. The static and dynamic magnetic behavior found in experiments provides a solid base for further theoretical work. The particle size and environmental dependence of the magnetic susceptibility were the main targets of the analysis. The work is supported by DFG.

MA 31.9 Mi 13:00 TU H1012

Nature of ^3He Nuclear-Spin Relaxation on Glass — •IOURI SOBOLEV¹, WERNER HEIL¹, ERNST OTTEN¹, JOERG SCHMIEDESKAMP¹, WOLFGANG KILLIAN², HERBERT RINNEBERG², THORSTEN SANDER-THOEMMES², FRANK SEIFERT², REINHARD KREMER³, and ARNDT SIMON³ — ¹Institut fuer Physik, Mainz — ²PTB Berlin — ³MPI fuer Festkoerperforschung, Stuttgart

Relaxation free storage and transport of hyperpolarised ^3He gas is a prerequisite for its use as contrast agent in MR imaging of the human lungs. Normally the spin-polarised gas is stored in aluminosilicate glass vessels but relaxation times $T_1 > 100$ h are demanded if one thinks of a central production facility and a distribution network of hyperpolarised gas to the clinics. The nature of ^3He relaxation on glasses was investigated quantitatively and will be presented: Using iron-free aluminosilicate glass cells where paramagnetic impurities are less than 30 ppm, the main source of wall relaxation is due to ferromagnetic sites. By means of a SQUID gradiometer the T_1 -hysteresis of bare glass cells was studied. Furthermore, using arrays of SQUIDS, the location of ferromagnetic sites within the cell wall was traced. A numerical MC-simulation of spin-relaxation of ^3He atoms diffusing near ferromagnetic sites reproduces the experimental findings. Finally, the ferromagnetic-site induced wall relaxation could be eliminated by means of an appropriate degaussing procedure resulting in measured T_1 relaxation times of up to 200 h.

MA 32 Mikro- und nanostrukturierte magn. Materialien II

Zeit: Mittwoch 11:00–13:15

Raum: TU H1028

MA 32.1 Mi 11:00 TU H1028

Anisotropy and Magnetic Microstructure of Monodisperse FePt Nanoparticles. — ●KEIR FOSTER¹, JÖRG WEISSMÜLLER^{1,2}, BALAJI GOPALAN¹, HARALD RÖSNER¹, and JOACHIM KOHLBRECHER³ — ¹Institute for Nanotechnology, Forschungszentrum Karlsruhe, Postfach 3640, D 76021 Karlsruhe, Germany — ²Universität des Saarlandes, Im Stadtwald, PO Box 15 11 50, D 66041 Saarbrücken, Germany — ³Laboratory for Neutron Scattering, PSI, CH 5232, Villigen, Switzerland

The magnetic anisotropy and magnetic microstructure of 4nm fcc alloy FePt nanoparticles coated with an organic shell were investigated using small-angle neutron scattering (SANS). Measurements were performed in conjunction with more standard magnetic characterization techniques, including vibrating sample magnetometry and AC susceptibility. The average particle size and size distribution were determined from transmission electron microscopy and small-angle X-ray scattering. For a ferromagnetic material it is expected that the SANS scattering intensity varies as a function of the angle α between the magnetization vector M and the scattering vector q as $\sin^2 \alpha$. To enhance this magnetic component of the scattering, measurements were made with polarized neutrons. From the field dependence of the SANS cross-sections, above and below the superparamagnetic blocking temperature (T_B), quantitative information about the magnitude and spatial variation of the magnetic anisotropy field perturbing the system and of the anisotropy of the individual particles themselves respectively is derived.

MA 32.2 Mi 11:15 TU H1028

Synthese Magnetischer Hohlkugeln mit μm -Durchmesser — ●ARNOLD SCHLACHTER, MARINA SPASOVA und MICHAEL FARLE — Fachbereich Physik, Experimentalphysik-AG Farle, Universität Duisburg-Essen

Mit der Layer-by-Layer Methode wurden Kern-Hülle Partikel mit einem Gesamtdurchmesser im Submikrometerbereich hergestellt [1]. Diese besitzen einen Polystyrol-Kern von 590 bzw. 640 nm und eine Schale bestehend aus superparamagnetischen Magnetit- bzw. Manganferrit-Nanopartikeln mit einem Durchmesser von 12 nm. Es konnten geschlossene Schalen mit einer Dicke von 30 bis 180 nm hergestellt werden. Mit Hilfe eines induktiv gekoppelten Plasmas wurde der Polystyrolkern komplett entfernt, wodurch stabile magnetische Hohlkugeln auf unterschiedlichen Substraten hergestellt wurden. Die Hohlkugeln konnten anschließend in Wasser suspendiert werden. Die Struktur und Zusammensetzung der Hohlkugeln wurde mit Elektronenmikroskopie (SEM, TEM) und EDX-Linescans analysiert. Unterstützt durch die DFG, SFB 445.

[1] F.Caruso, M.Spasova, A.Susha, M.Giersig, R.A.Caruso, Chem. Mater. 13, (2001), 109

MA 32.3 Mi 11:30 TU H1028

Magnetic Properties of Cobalt/Polymer Composite Nanotubes — ●KORNELIUS NIELSCH¹, FERNANDO J. CASTAÑO², SVEN MATTHIAS¹, WOO LEE¹, RAMKUMAR KRISHNAN², and CAROLINE A. ROSS² — ¹Max Planck Institute of Microstructure Physics, Halle, Germany — ²Massachusetts Institute of Technology, Cambridge, MA, USA

In the present work we report on a novel approach for the fabrication of ferromagnetic nanotubes and present results concerning the magnetic properties of Co nanotubes. The pores surfaces in porous alumina membranes patterned by imprint lithography and macroporous silicon membranes are wetted with a polystyrene layer containing a metallo-organic precursor with a thickness of 40 to 70 nm. During an annealing process at 180 C for 24 h, a cobalt thin-film forms at the oxide pore-wall/polymer interface. The decomposition of the precursor leads to the formation of thin-walled magnetic tubes with diameters of 160 to 520 nm and wall thicknesses of 1 to 5 nm. Magnetic measurements at room temperature and 5 K show that the tubes have a lower saturation field parallel to their axes, while the in-plane direction is a harder axis. The magnetic properties on varying the wall thickness and diameter of the nanotubes will be discussed. This synthesis method is not limited to Co. We have also precipitated metallic Fe and Ni nanotubes based on polymer wetting of porous templates.

MA 32.4 Mi 11:45 TU H1028

Magnetic frustration in coupled ferromagnetic ring structures — ●VOLKER ROSE¹, HARALD IBACH¹, VITALI METLUSHKO², SEOK-HWAN CHUNG³, AXEL HOFFMANN³, and SAM D. BADER³ — ¹Forschungszentrum Jülich (ISG3), Germany — ²University of Illinois, Chicago, USA — ³Argonne National Laboratory (MSD), USA

It is well known that patterned soft magnetic ring structures can exhibit a magnetic vortex state. When two rings interact, i.e., through direct contact, then it is expected that the vortex states have opposite chiralities. Thus, if three rings are interacting there is an obvious frustration between the magnetic states. We have fabricated isolated and contiguous arrays of rings using e-beam lithography and lift-off, with diameters of 1-4 μm and ring widths of 0.2-1.8 μm made of permalloy thin films with a thickness of 15 nm. Their field dependent magnetization was investigated with magnetic force microscopy (MFM) and magneto-optical Kerr effect (MOKE) accompanied by micromagnetic simulations. Generally, in the case of isolated rings the magnetization predominately follows the circumference resulting in a flux-close vortex state. In case of a three ring structure two transitions are observed. One from a high-magnetic-moment state obtained after relaxing the field from saturation to the low-magnetic-moment state, indicating the magnetic frustration of one ring in presence of two rings in vortex state. The second transition belongs to the reverse high-magnetic-moment state. Work at ANL was supported by US DOE-BUS

MA 32.5 Mi 12:00 TU H1028

Dreidimensionale Magnetisierungsstrukturen in Fe/Mo(110)-Inseln — ●R. HERTEL^{1,2}, O. FRUCHART³, S. CHERIFI³, P.-O. JUBERT^{3,4}, A. LOCATELLI⁵ und S. HEUN⁵ — ¹Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich — ²Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle — ³Laboratoire Louis Néel, CNRS, BP166, F-38042 Grenoble Cedex 9, Frankreich — ⁴IBM Research, Zürich Research Laboratory, CH-8803 Rüschlikon, Schweiz — ⁵Sincrotrone ELETTRA, I-34012 Basovizza, Trieste, Italien

Mittels zirkularem magnetischen Röntgendiffraktions in Verbindung mit Photoelektronen-Emissionsmikroskopie (XMCD-PEEM) wurde die Magnetisierungsverteilung in einer großen Anzahl mesoskopischer Fe Inseln untersucht. Die Fe Inseln wurden auf einem Mo(110)-Substrat durch selbstorganisiertes Wachstum hergestellt. Sie sind bis zu ca. 2,5 μm groß, bis zu ca. 250 nm dick und haben eine charakteristische hexagonale Form mit geneigten Randflächen und atomar glatten Oberflächen. Die XMCD-PEEM Untersuchungen zeigen unerwartete, stark asymmetrische Magnetisierungsverteilungen an der Probenoberfläche. Erst die Verwendung präziser mikromagnetischer finite-Elemente Simulationen ermöglicht ein Verständnis der zu Grunde liegenden komplexen Magnetisierungsverteilung. Die Simulationen zeigen, dass die beobachteten Strukturen signifikant von der Schichtdicke, jedoch nur in geringem Maße von der Probenform beeinflusst werden. Die in Dünnschichtelementen wohlbekannte Landaustuktur weist bei dieser Schichtdicke interessante Besonderheiten auf.

MA 32.6 Mi 12:15 TU H1028

Bragg-MOKE, Vector MOKE, ROTMOKE: The magnetic reversal of microstructured patterns — ●ANDREAS WESTPHALEN, KATHARINA THEIS-BRÖHL, and HARTMUT ZABEL — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

The Bragg MOKE technique extends the information of standard MOKE measurements by making use of diffraction from regular arrays of magnetic microstructures. The n th order diffraction spot is particularly sensitive to the n th order Fourier component of the magnetisation distribution. The orientation of the magnetisation vector during the reversal process is studied with Vector MOKE. The orientation is obtained through the determination of two orthogonal magnetisation components as a function of the external field. The ROTMOKE method, where the Kerr-angle is measured as a function of a rotating field, enables the quantitative determination of the Voigt effect contribution to the longitudinal Kerr effect. Here we have explored the properties of all three techniques for the investigation of regular arrays of magnetic microstructures. The samples under investigation are microstructured patterns of Fe and Co,

which display a variety of different magnetic reversal mechanisms. We have found that the combination of the three techniques gives a deeper understanding of the magnetic reversal process. We acknowledge financial support through SFB 491.

MA 32.7 Mi 12:30 TU H1028

Magnetic domain walls in T-shaped permalloy microstructures — ●THOMAS HAUG¹, JÖRG RAABE², STEFAN HEUN³, ANDREA LOCATELLI⁴, and CHRISTIAN H. BACK¹ — ¹Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany — ²Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — ³TASC-INFM Laboratory, 34012 Basovizza, Trieste, Italy — ⁴Elettra Synchrotron Light Source, 34012 Basovizza, Trieste, Italy

The magnetic domain configuration of 20 nm thick T-shaped permalloy structures has been observed using a photo emission electron microscope and X-ray magnetic dichroism. The shape of the structures allows us to analyse 90° Néel walls in the contact region. We measure the wall width out of the magnetic images and look at its dependence on the contact width. The results are compared to micromagnetic simulations. We find a decrease in domain wall width with decreasing contact dimensions as expected by theory and in good agreement with our micromagnetic simulations.

MA 32.8 Mi 12:45 TU H1028

Shining light on magnetic microstructures — ●ARNDT REMHOF, CENGİZ BIRCAN, ANDREAS WESTPHALEN, JOHANNES GRABIS, ALEXEI NEFEDOV, and HARTMUT ZABEL — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

The increasing interest in micro- and nanomagnetism requires new instruments to examine the collective behavior of laterally structured ferromagnetic thin films. We demonstrate the possibility to extend the established Bragg-MOKE technique, which measures the Kerr effect on off-specular diffracted polarized laser light to soft x-rays. The shorter

wavelength, which allows to investigate smaller structures, and the element selectivity of the resonant scattering make soft x-rays an attractive tool to study patterned ferromagnetic heterostructures. We illustrate this technique on permalloy islands and on exchange biased iron islands on CoO as two model systems. The results so far are in agreement with other experimental techniques and show the feasibility of off-specular resonant magnetic soft x-ray scattering. This work was founded by SFB491 and by the BMBF under contract 03ZAE8BO.

MA 32.9 Mi 13:00 TU H1028

Theory of polarized neutron diffraction from nano-patterned magnetic films — ●BORIS P. TOPERVERG, KATHARINA THEISBRÖHL, and HARTMUT ZABEL — Department of Experimental and Solid State Physics, Ruhr-University Bochum, 44780 Bochum

At grazing incidence the projection of the neutron coherence length onto the surface plane is greatly extended. Therefore the Bragg diffraction from lateral patterns with nano- and submicron periods is readily observable experimentally. However, due to strong optical effects, e.g. specular reflection and refraction, the Born approximation fails to correctly describe diffracted signal. The Distorted Wave Born Approximation (DWBA) is shown to be well suitable to the problem over a very broad, but still limited range of lateral scales. One of the limitations is related to the crossover between the period and the lateral projection of the coherence length (LPCL). If they are comparable than the Bragg diffraction cannot be resolved from specular reflection. If the period is greater than LPCL than each of structural elements reflects independently and no Bragg diffraction occurs. DWBA may also fail even if the period is relatively small, but the lateral modulation of the optical potential due to individual elements is so strong that it cannot be treated as a perturbation. A set of alternative methods to treat this situation are suggested. Specific aspects of DWBA application to the case of polarized neutrons is discussed in view of resolving magnetic arrangement within and between the structural elements. We acknowledge funding by DFG, Mercator Visiting Professorship and SFB 491, and BMBF 03ZAE8BO.

MA 33 Messmethoden, Anisotropie, Spinelektronik/Spininjektion

Zeit: Mittwoch 11:00–13:15

Raum: TU EMH225

MA 33.1 Mi 11:00 TU EMH225

Magnetrelaxometrie an magnetischen Nanoteilchen mit gradiometrischer Fluxgate-Anordnung — ●E. HEIM, S. MÄUSELEIN, F. LUDWIG und M. SCHILLING — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Str. 66, 38106 Braunschweig

Die Magnetrelaxometrie mit magnetischen Nanoteilchen ist ein aussichtsreiches Verfahren in der Bioanalytik zur Konzentrationsbestimmung von Biomolekülen. Wir untersuchen die Relaxation biologisch funktionalisierter Nanoteilchen aus Magnetit (Fe_3O_4) mit Durchmessern unter 20 nm, die bei Raumtemperatur superparamagnetische Eigenschaften zeigen. Die Teilchen können nach zwei grundsätzlichen Mechanismen relaxieren. Bei der Brownschen Relaxation retort das Nanoteilchen größenabhängig im Medium und bei der Néel-Relaxation rotiert das innere magnetische Moment.

In unserem neuen Messaufbau verwenden wir eine 3-achsige Helmholtz-Spule, um die Probe homogen zu magnetisieren. Zwei Fluxgate-Magnetometer sind gradiometrisch im homogenen Feld um die Probe herum angeordnet. Dieser neue gradiometrische Messaufbau bewirkt eine um den Faktor 2 höhere Empfindlichkeit und ermöglicht durch die Störfeldunterdrückung die Konzentrationsbestimmung in ungeschirmter Umgebung.

Gefördert durch die DFG über den SFB 578.

MA 33.2 Mi 11:15 TU EMH225

Rauscharme Fluxgate-Sensoren mit Modulationsfrequenzen bis zu 1MHz — ●R. PIEL, F. LUDWIG und M. SCHILLING — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU-Braunschweig, Hans-Sommer-Str. 66, D-38106 Braunschweig

Fluxgates werden üblicherweise mit Anregungsfrequenzen von einigen kHz betrieben. Dabei wird das Gesamttrauschen des Sensors vorwiegend durch die Auswertelektronik bestimmt. Mit der Erhöhung der Modulationsfrequenz ist eine Erhöhung der Empfindlichkeit verbunden, die eine Reduktion des Beitrages der Elektronik zum Sensorrauschen ermöglicht.

Weiterhin erlaubt die hohe Modulationsfrequenz eine höhere Messbandbreite, die zu einer Verbesserung des dynamischen Verhaltens führt.

Zur Optimierung wurden Betriebselektronik und Fluxgate-Spulen in PSPICE simuliert. Desweiteren wurden Anregungsspule und Detektionsspule auf ihre Eignung für diese Frequenzen überprüft. Es zeigte sich, dass die hohe Anregungsfrequenz im Bereich der Eigenfrequenz der bisher verwendeten, drahtgewickelten Spulen liegt. Dies erfordert eine Anpassung der Fluxgate-Spulen. Die mit der neuentwickelten Elektronik gemessenen Sensoreigenschaften, wie Empfindlichkeit, Rauschen und Dynamik werden präsentiert.

MA 33.3 Mi 11:30 TU EMH225

Magnetische Anisotropie und orbitales Moment in Nickel — THORSTEN OHM¹, STEFAN WEISER¹, WERNER WEBER¹, ●JÖRG BÜNEMANN² und FLORIAN GEBHARD² — ¹Institut für Physik, Universität Dortmund, 44221 Dortmund — ²Fachbereich Physik, Philipps-Universität Marburg, 35032 Marburg

Die Gutzwiller-Theorie ist eine neue Methode zur Untersuchung der elektronischen Eigenschaften von Metallen mit starken lokalen Coulomb-Wechselwirkungen. Sie erwies sich bereits als sehr erfolgreich bei der Beschreibung der Quasi-Teilchen Bandstruktur von elementarem Nickel [1]. In unsere neueren Rechnungen haben wir nun auch die Spin-Bahn-Kopplung in Nickel einbezogen. Wir finden in folgenden Punkten eine sehr gute Übereinstimmung mit dem Experiment: (i) die magnetische Vorzugsrichtung ist (111), (ii) das orbitale Moment beträgt $\approx 0.05\mu_B$, (iii) bei einer kontinuierlichen Drehung des Moment mit Hilfe eines äußeren Magnetfeldes in die (001)-Richtung ergibt sich bei einem bestimmten Winkel eine Änderung der Fermiflächentopologie am X-Punkt [2]. Deutliche Abweichungen finden wir zwischen unseren Ergebnissen und de-Haas-van-Alphen Daten. Wir vermuten, daß diese auf einer fehlerhaften Auswertung der experimentellen Rohdaten beruhen und regen daher eine Wiederholung solcher Experimente an.

[1] J. Bünnemann et. al., Europhys. Lett. **61**, 667 (2003)

[2] R. Gersdorf und G. Aubert, Physica B **95**, 135 (1978)

MA 33.4 Mi 11:45 TU EMH225

Reversible H-induced switching of the magnetic easy axis in Ni monolayers and structural relaxation — ●J. KIRSCHNER¹, D. SANDER¹, W. PAN¹, S. OUAZI¹, W. MEYER², M. KRAUSE², ST. MÜLLER², L. HAMMER², and K. HEINZ² — ¹Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle / Saale — ²Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen

A reversible switching of the easy axis of magnetization for Ni on Cu(100) from in-plane to out-of-plane is found by changing the partial pressure of hydrogen in the gas phase around the sample. A quantitative low-energy electron diffraction (LEED) study of the diffracted intensity versus electron energy ($I(E)$) shows that the H-induced spin reorientation transition (SRT) is accompanied by a relaxation of the tetragonal distortion of the topmost Ni layer upon H-adsorption. The orientation switch to perpendicular to the surface comes with a relaxation of the topmost layer spacing upon H-adsorption from 1.675 Å to 1.770 Å. We propose that the H-induced structural change drives the SRT via a corresponding quenching of the orbital moment, which reduces the magnetic surface anisotropy. These results support recent ab initio calculations of both structure and magnetic anisotropy of this system [2].

[1] D. Sander et al., Phys. Rev. Lett. (2004) in press. [2] F. Máca et al., J. Magn. Magn. Mater. **272-276**, 1194 (2004).

MA 33.5 Mi 12:00 TU EMH225

Percolation limits the Curie temperature of Dilute Magnetic Semiconductors — ●PETER H. DEDERICHS¹, KAZUNORI SATO^{1,2}, BRAHIM BELHADJI¹, and HIROSHI KATAYAMA-YOSHIDA² — ¹Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich — ²ISIR, Physics Department, University of Osaka, Japan

We present detailed ab-initio calculations for the electronic and magnetic properties of dilute magnetic semiconductors (DMS), using the KKR-CPA method. The exchange coupling constants J_{ij} between two magnetic impurities are calculated by embedding the impurities in the CPA medium and using the Lichtenstein formula. Two types of DMS can be distinguished: (i) DMS with the d states deep in the valence band, like e.g. (Ga,Mn)As and (Ga,Mn)Sb. Here the exchange interaction is dominated by p-d (“kinetic”) exchange and is long ranged. (ii) DMS with impurity d-bands in the gap, like e.g. (Ga,Mn)N and (Zn,Cr)Te. In this case the exchange interaction is dominated by double exchange and is short ranged. Using Monte Carlo methods and Binder’s cumulant expression we calculate the Curie temperatures for a series of magnetic semiconductors, with the J_{ij} calculated in LDA and LDA+U. We find that for short ranged interactions, in particular for (Ga,Mn)N, the Curie temperature is strongly reduced from the very high values obtained in the mean field approximation. The physical reason is that, for small concentrations of Mn, percolation cannot be achieved by the strong nearest neighbour interaction. Even for (Ga,Mn)As, where the interaction is longer ranged, the mean field values are reduced by a factor of two. Thus percolation is a serious obstacle to high Curie temperatures in DMS.

MA 33.6 Mi 12:15 TU EMH225

Ferromagnetische Ordnung oberhalb Raumtemperatur in TiO₂ durch Mn-Implantation — ●D. MENZEL, I. JURSIĆ und J. SCHÖNES — Institut für Halbleiterphysik und Optik, TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig

Dünne TiO₂-Filme auf Quarzsubstrat sowie einkristalline TiO₂-Substrate wurden mit Mn-Ionen implantiert. Auf diese Weise konnte Mn-dotiertes TiO₂ erstmalig ohne Risiko der Cluster-Bildung hergestellt werden. Sowohl die Filme als auch der implantierte Anteil der Volumenproben ordnen ferromagnetisch oberhalb Raumtemperatur mit einem magnetischen Moment von 0.41 μ_B pro Mn-Atom. Die Curie-Temperatur konnte bei einer Mn-Konzentration von 7% zu 680 K abgeschätzt werden. Nach einem Temperungsprozess unter Sauerstoff-

atmosphäre nimmt die Magnetisierung ab, was einer Reduzierung des Sauerstoffdefizits im TiO₂ und einer damit verbundenen Erhöhung der Elektronenkonzentration zugeschrieben wird. Dieses spricht für indirekten magnetischen Austausch, der über freie Elektronen vermittelt wird, wie es bereits für Co-dotiertes TiO₂ vorgeschlagen wurde [1]. Die Rolle von Mn auf Zwischengitter- sowie Substitutionsplätzen für den Magnetismus wird diskutiert.

[1] L. A. Balagurov et al., JETP Letters **79**, 98 (2004)

MA 33.7 Mi 12:30 TU EMH225

Magnetic Properties of Gd-doped EuO Thin Films — ●R. SUTARTO¹, H. OTT¹, S. HEISE¹, H.-H. HSIEH², H.-J. LIN², C.T. CHEN², and L.H. TJENG¹ — ¹II. Physikalisches Institut, Universität zu Köln — ²NSRRC, Hsinchu, Taiwan

We have successfully grown Gd-doped EuO thin films at different doping levels from 2 to 20% using molecular beam epitaxy (MBE). Soft x-ray magnetic circular dichroism (XMCD) measurements at the Eu $M_{4,5}$ -edges indicate a strong enhancement of the Curie temperature compared to $T_c = 69$ K for undoped EuO. We found a maximum T_c of 180 K at Gd-doping level 4-5%. This enhancement of T_c was further observed in the exchange splitting in the O 1s XAS spectra. Gd- $M_{4,5}$ XMCD spectra reveal that Eu and Gd spins align parallel at all doping levels.

MA 33.8 Mi 12:45 TU EMH225

Half-Metallic and Metallic Phases of Magnetite probed by Raman Spectroscopy — ●MARTIN FRIÁK¹, ARNO SCHINDLMAYR^{1,2} und MATTHIAS SCHEFFLER¹ — ¹Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin-Dahlem, Germany — ²Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

Half-metals, which are metallic in only one spin channel and can thus sustain ideal 100% polarized currents, are excellent candidates for future spintronics technologies. Factors like strain may destroy this desirable property, but as the spin polarization is difficult to measure directly, there are so far no comprehensive data. We therefore studied thermodynamic properties that are more readily accessible by spectroscopy and can be probed to distinguish the half-metallic and metallic phases. For magnetite we identify the A_{1g} Raman-active phonon mode as a possible indicator. Our density-functional theory (DFT-GGA) calculations, employing the all-electron FLAPW method, predict the mode frequency under equilibrium conditions in good agreement with experiments and also reproduce the observed kink in the frequency as a function of applied pressure around 15 GPa. We explain this behavior as a direct consequence of the strain-induced half-metal to metal transition, which changes the lattice dynamics. Explicit boundaries for the half-metallic phase of magnetite are given for different forms of strain.

MA 33.9 Mi 13:00 TU EMH225

Magnetic tunneling junctions with the Co₂Cr_{0.6}Fe_{0.4}Al Heusler compound — ●ANDRÉS CONCA, MARTIN JOURDAN, GERHARD JAKOB, and HERMANN ADRIAN — Institut für Physik, Johannes Gutenberg Universität, Staudinger Weg 7, 55128, Mainz, Germany.

The use of half metallic electrodes in magnetic tunnelling junctions (MTJ's) will result in a large increase of the TMR ratio. We used the full Heusler alloy Co₂Cr_{0.6}Fe_{0.4}Al as bottom electrode for MTJ's. This compound is expected to show half metallicity.

The junctions were deposited in a chamber with a base pressure of $3.0 \cdot 10^{-8}$ mbar by dc magnetron sputtering using metallic shadow masks with Co as counter electrode and AlO_x as barrier. We present measurements of the magnetoresistive differential conductivity between 4 and 300K. The properties of the barrier are analyzed by applying the Simmons model to the bias dependent differential conductivity. Magnetic properties of the junctions were analyzed by VSM, SQUID and Kerr effect methods.