Section Magnetism
Fachverband Magnetismus (MA)

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Overview of Invited Talks and Sessions

(lecture rooms H10, H22, H23, and H5; Poster A)

Invited Talks

MA 1.1	Mon	9:30–10:00	H10	**Magnetovolume effects in $L1_0$ Fe-Pt alloys** — •Julia Lyubina, Ingo Opahle, Manuel Richter, Olivier Isnard, Oliver Gutfleisch, Karl-Hartmut Müller, Ludwig Schultz
MA 5.1	Mon	14:00–14:30	H10	**Novel magnetoresistive effect in organic semiconductors** — •Ralph Paetzold, Manfred Ruehrig, Joachim Wecker
MA 5.2	Mon	14:30–15:00	H10	**Structural and magnetic properties of transition metal nanoparticles from first principles** — •Markus Ernst Gruner, Georg Rollmann, Alfred Hucht, Peter Entel
MA 14.1	Tue	14:00–14:30	H10	**Controlling magnetism and self-organization of adatoms on surfaces by using quantum interferences** — •Patrick Bruno, Valeri Stepanyuk, Nikolay Negulyaev, Larissa Niebergall
MA 14.2	Tue	14:30–15:00	H10	**XMCD in TM Oxides: Are there hidden orbital moments in magnetite?** — •Eberhard Goering
MA 16.1	Wed	14:00–14:30	H10	**Out of plane steady-state precession for the 'perpendicular polarizer-planar free layer' spin torque oscillator** — •Ursula Ebels, Dimitri Houssameddine, Bertrand Delaet, Bernard Rodmacq, Ioana Firastrau, Fabienne Ponthenier, Magali Brunet, Christophe Thirion, Jean-Philipe Michel, Liliana Prejbeanu-Buda, Marie-Claire Cyrille, Bernard Dieny
MA 16.2	Wed	14:30–15:00	H10	**Multifunctional Ni-Mn-based shape memory alloys** — •Lluis Manosa, Xavier Moya, Antoni Planes, Seda Aksoy, Thorsten Krenke, Mehmet Acet, Eberhard Wassermann
MA 21.1	Thu	9:30–10:00	H10	**To Be Announced.** *(Talk by Zachary Fisk was withdrawn.)* — •XXX XXX
MA 22.1	Thu	10:15–10:45	H10	**Thermal properties of magnets from *ab initio*.** — •Jürgen Kübler
MA 22.2	Thu	10:45–11:15	H10	**Highly spin-polarized tunneling in fully epitaxial magnetic tunnel junctions with a Co-based full-Heusler alloy thin film and a MgO barrier** — •Masafumi Yamamoto, Takao Marukame, Takayuki Ishikawa, Ken-ichi Matsuda, Tetsuya Uemura
MA 22.3	Thu	11:15–11:45	H10	**giant tunnel magnetoresistance at room temperature using Co2Fe(SiAl) full Heusler alloy electrodes** — •koichiro inomata, naomichi ikeda, nobuki tezuka
MA 22.4	Thu	11:45–12:15	H10	**First-principles study of ferromagnetic Heusler alloys: an overview** — •Silvia Picozzi
MA 25.1	Thu	14:00–14:30	H10	**Magnetische Wechselwirkungen in nanokristallinen Ferromagneten: Untersuchungen mit Neutronenstreuung** — •Andreas Michels
MA 25.2	Thu	14:30–15:00	H10	**Strain induced ferromagnetic order in undoped $LaCoO_3$ thin films** — •Dirk Fuchs, Christian Pinta, Thorsten Schwarz, Peter Scheiss, Peter Nagel, Stefan Schuppler, Rudolf Schneider, Michael Merz, Georg Roth, Hilbert von Löhneysen

MA 30.1	Fri	10:15–10:45	H10	**Response of plants and animals to magnetic fields with cryptochrome, a field sensitive blue light photoreceptor** — •Margaret Ahmad, Paul Galland, Thorsten Ritz, Roswitha Wiltschko, Wolfgang Wiltschko

Invited talks of the joint symposium SYSS

See SYSS for the full program of the Symposium.

SYSS 1.1	Mon	9:30–10:00	H1	**Generating and manipulating spins in semiconductors** — •David Awschalom
SYSS 1.2	Mon	10:00–10:20	H1	**Spin noise spectroscopy and spin dynamics in semiconductors** — •Michael Oestreich, Michael Römer, Stefanie Döhrmann, Stefan Oertel, Daniel Hägele, Jens Hübner
SYSS 1.3	Mon	10:20–10:40	H1	**Spin-orbit interaction in Si quantum wells** — •Wolfgang Jantsch, Hans Malissa, Zbyslaw Wilamowski
SYSS 1.4	Mon	10:40–11:00	H1	**Driven coherent oscillations of a single electron spin in a quantum dot** — •Frank Koppens, Christo Buizert, Klaas-Jan Tielrooij, Ivo Vink, Katja Nowack, Tristan Meunier, Leo Kouwenhoven, Lieven Vandersypen
SYSS 1.5	Mon	11:00–11:20	H1	**Electrical spin injection and detection in semiconductors** — •Paul Crowell
SYSS 1.6	Mon	11:20–11:40	H1	**A microscopic view of the magnetism in magnetic semiconductors** *(replaces the contribution by N. Samarth)* — •Michael Flatté
SYSS 1.7	Mon	11:40–12:00	H1	**Tailoring ferromagnetism in bulk semiconductors and quantum dots** — •Igor Zutic
SYSS 1.8	Mon	12:00–12:20	H1	**Tunnel Anisotropic Magneto Resistance - TAMR** — •Laurens Molenkamp
SYSS 1.9	Mon	12:20–12:40	H1	**Electric field controlled spintronic effects based on spin-orbit coupling** — •Tomas Jungwirth
SYSS 1.10	Mon	12:40–13:00	H1	**Zero-bias spin separation in semiconductor heterostructures** — •Sergey Ganichev

Sessions

MA 1.1–1.1	Mon	9:30–10:00	H10	**Invited Talk Lyubina**
MA 2.1–2.11	Mon	10:15–13:00	H10	**Magnetic Particles/Clusters I**
MA 3.1–3.11	Mon	10:15–13:00	H22	**Magnetic Materials I**
MA 4.1–4.12	Mon	10:15–13:15	H23	**Electron Theory of Magnetism**
MA 5.1–5.2	Mon	14:00–15:00	H10	**Invited Talks Pätzold / Gruner**
MA 6.1–6.7	Mon	15:15–17:00	H10	**Magnetic Particles/Clusters II**
MA 7.1–7.6	Mon	17:00–18:30	H10	**Micromagnetism/Computational Magnetics**
MA 8.1–8.8	Mon	15:15–17:15	H22	**Magnetic Materials II**
MA 9.1–9.5	Mon	17:15–18:30	H22	**Anisotropy/Magnetoelasticity**
MA 10.1–10.15	Mon	15:15–19:00	H23	**Spinelectronics/Spininjection in Heterostructures**
MA 11.1–11.11	Tue	10:15–13:00	H10	**Magnetic Thin Films I**
MA 12.1–12.11	Tue	10:15–13:00	H22	**Spindependent Transport I**
MA 13.1–13.12	Tue	10:15–13:15	H5	**Spinstructures and magnetic Phase Transitions**
MA 14.1–14.2	Tue	14:00–15:00	H10	**Invited Talks (joint seesion with O) Bruno / Göring**
MA 15.1–15.156	Tue	15:00–19:00	Poster A	**Poster:ThinFilms(1-33),Transp.(34-49),ExchBias(50-56), Spindynamics(57-70),Micro-nanostr.Mat.(71-82), Particles/Clust.(83-88), Mag.Imag./Surface(89-96), Spinelectronics(97-109), Theory/Micromag.(110-116), Spinstruct/Phasetr.(117-128),Magn.Mat.(129-139), Aniso.+Measuring(140-145), MolMag.(146-152), MSMA(153-156)**
MA 16.1–16.2	Wed	14:00–15:00	H10	**Invited Talks Ebels / Manosa**
MA 17.1–17.16	Wed	15:15–19:15	H10	**Magnetic Shape Memory Alloys**
MA 18.1–18.13	Wed	15:15–18:30	H22	**Spindependent Transport II**
MA 19.1–19.15	Wed	15:15–19:00	H23	**Spin-Dynamics/Switching I**

MA 20.1–20.14	Wed	15:15–18:45	H5	**Magnetic Thin Films II**
MA 21.1–21.1	Thu	9:30–10:00	H10	**Invited Talk (joint session with TT)**
MA 22.1–22.8	Thu	10:15–13:15	H10	**FV intern Symposium: "Heusler Alloys"** **Invited Talks Kübler/Yamamoto/Inomata/Silvia Picozzi**
MA 23.1–23.10	Thu	10:15–12:45	H22	**Micro- and Nanostructured Magnetic Materials I**
MA 24.1–24.10	Thu	10:15–12:45	H23	**Spindynamics / Switching II**
MA 25.1–25.2	Thu	14:00–15:00	H10	**Invited Talks Michels / Fuchs**
MA 26.1–26.13	Thu	15:15–18:30	H10	**Exchange Bias**
MA 27.1–27.13	Thu	15:15–18:30	H22	**Micro- and Nanostructured Magnetic Materials II**
MA 28.1–28.15	Thu	15:15–19:00	H23	**Surface Magnetism**
MA 29.1–29.5	Thu	15:15–16:30	H5	**Magnetic Measuring Methods / Sensors / Actuators**
MA 30.1–30.1	Fri	10:15–10:45	H10	**Invited Talk Margaret Ahmad**
MA 31.1–31.7	Fri	11:00–12:45	H10	**Bio- and Molecular Magnetism**
MA 32.1–32.8	Fri	11:00–13:00	H22	**Magnetic Imaging**
MA 33.1–33.8	Fri	11:00–13:00	H23	**Spindynamics / Switching III**

Annual General Meeting of the Section Magnetism

Donnerstag 19:00–20:00 H10

- Bericht des Sprechers
- Wahl des FV Vorsitzenden
- Verschiedenes

MA 1: Invited Talk Lyubina

Time: Monday 9:30–10:00 Location: H10

Invited Talk MA 1.1 Mon 9:30 H10

Magnetovolume effects in $L1_0$ Fe-Pt alloys — •Julia Lyubina[1], Ingo Opahle[1], Manuel Richter[1], Olivier Isnard[2], Oliver Gutfleisch[1], Karl-Hartmut Müller[1], and Ludwig Schultz[1] — [1]IFW Dresden, P.O. Box 270016, D-01171 Dresden, Germany — [2]Laboratoire de Cristallographie, CNRS, Université J. Fourier Grenoble and Institut Laue-Langevin, 38042 Grenoble cedex 9, France

FePt alloys have recently attracted considerable attention as candidates for ultra-high-density magnetic storage media and as materials for special permanent magnet applications. The excellent magnetic properties of these alloys are associated with the ordered $L1_0$ FePt phase. Both experimental data and theoretical calculations indicate a correlation between the degree of order within the $L1_0$ phase and fundamental properties, such as magnetocrystalline anisotropy and Curie temperature. In contrast, the saturation magnetisation of the $L1_0$ phase was reported to be largely independent of the degree of order at a fixed composition. In this work, we report on a combined neutron powder diffraction and density functional study of ordered and partially ordered $Fe_{100-x}Pt_x$ (x = 41-52) alloys prepared by mechanical alloying at 77 K and subsequent heat treatment. For alloys with almost perfect $L1_0$-type long-range order the experimental value of the Fe magnetic moment was determined to be 2.8 ± 0.1 μ_B. It is shown that the Fe moment drops with increasing Fe content, but is less sensitive to the degree of order.

MA 2: Magnetic Particles/Clusters I

Time: Monday 10:15–13:00 Location: H10

MA 2.1 Mon 10:15 H10

Magnetrelaxometrie superparamagnetischer Fe_3O_4-Nanoteilchen für die Charakterisierung von Hydrogelen — •Erik Heim[1], Steffen Harling[2], Frank Ludwig[1], Henning Menzel[2] und Meinhard Schilling[1] — [1]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Straße 66, D-38106 Braunschweig, Germany — [2]Institut für Technische Chemie, TU Braunschweig, Hans-Sommer-Straße 10, D-38106 Braunschweig, Germany

Die Anwendung der Magnetrelaxometrie (MRX) beruht auf dem unterschiedlichen Relaxationsverhalten von frei beweglichen und gebundenen superparamagnetischen Nanoteilchen (MNPs). In unserem Versuchsaufbau werden die magnetischen Streufelder einer mit magnetischen Nanoteilchen dispergierten Probe mit Fluxgate-Magnetometern gemessen. Eine wesentliche Eigenschaft der Magnetrelaxometrie ist die Möglichkeit, das magnetische Signal auch von undurchsichtigen Proben zu messen. Diese Eigenschaft wird hier erstmals zur Charakterisierung von Hydrogelen ausgenutzt, die als zeitgesteuerte Medikamentendepots zum Einsatz kommen sollen. Die verwendeten Fe_3O_4-MNPs weisen eine ähnliche Größe wie die einzubettenden Wirkstoffe auf und können daher als Sonden eingesetzt werden, die Informationen aus dem Inneren des Hydrogels während der photoinduzierten Hydrogelbildung liefern. Somit lassen sich Einbettungskapazitäten und Vernetzungdynamiken bei der Herstellung von Hydrogelen untersuchen.

Gefördert durch die DFG über SFB 578.

MA 2.2 Mon 10:30 H10

Magnetic properties of biofunctional dextran-magnetite composite particles — •Martin Loichen, Juliane Issle, and Uwe Hartmann — Universität des Saarlandes, Institut für Experimentalphysik, AG Prof. Dr. U. Hartmann, 66123 Saarbrücken, Germany

Superparamagnetic magnetite particles embedded in a dextran matrix constitute spherical particles of a diameter of 100 to 500 nm. They are used to subject cells to specific proteins. For this purpose the composite particles are equipped at the surface with certain reactive groups allowing the binding of the respective proteins. The particles are then deposited on magnetic or nonmagnetic surfaces on which subsequently the cells are grown. The magnetic properties of the composite particles were studied in a liquid and solid environment by magnetometry. Furthermore the microscopic properties of the particles were investigated by electron microscopy, atomic and magnetic force microscopy. The results show how the individual 10 nm magnetite particles interact and together constitute the properties of the individual composite particles. The results are of importance in order to optimize the behavior of the composite particles under the influence of external magnetic fields.

MA 2.3 Mon 10:45 H10

Simulation of magnetic beads in on-chip structures — •Alexander Weddemann, Simone Herth, Michael Schilling, Andreas Hütten und Günter Reiss — Bielefeld University, Universitätsstraße 25, D-33615 Bielefeld, Germany

In this work the behaviour of particles with a permanent magnetic moment, so called magnetic beads, in a micro channel system under the influence of hydrodynamic and electrodynamic interactions is discussed. The particle density within the fluid is therefore assumed to be small enough to neglect particle dipole-dipole-interactions.

The geometry of the micro channels is chosen so as to avoid turbulence. In that case the force on the particles due to viscosity of the fluid is given by Stokes Drag Law. A micro channel system was constructed, to allow guiding nanoparticles with the help of two flow currents, if there is no magnetic gradient field applied. With the help of an additional inhomogeneous magnetic field, it is shown that such geometry can be used to separate magnetic particles in respect to their magnetic moment. Magnetic field design is being discussed and the resulting magnetic fields for several current geometries have been simulated. In addition further applications will be shown:

1) the possiblity to measure the viscosity of the carrier liquid
2) a way to separate biomolecules for certain properties e.g. size

MA 2.4 Mon 11:00 H10

Magnetische Nanopartikel-Aggregate aus dem sensorischen System von Lachsen — •Yvonne Brill[1], Jiandong Wei[1], Ivo Knittel[1], Joris Peters[2], Gabriela Maris[2], Sylvia Speller[2] und Uwe Hartmann[2] — [1]Fachbereich Experimentalphysik, Im Stadtwald, Geb. C6.3, 66041 Saarbrücken — [2]Experimental Solid State Physics II, Toernooiveld 1, University of Nijmegen, 6525 ED Nijmegen, Netherlands

Bestimmte Aggregate aus Magnetitteilchen, die vermutlich in bestimmten Sensorzellen angesiedelt sind, bilden die Basis des magnetischen Orientierungssinns des Lachses. Die Aggregate wurden in einem schonenden Verfahren isoliert und mit Magnetokraftmikroskopie im variablen Magnetfeld studiert. Die MFM-Bilder können mit Hilfe einfacher Modelle auf der Basis rein dipolar gekoppelter magnetischer Momente verstanden werden. Es wird angenommen, dass die magnetischen Momente der einzelnen Magnetitteilchen eines Clusters von Magnetit-Nanoteilchen ungeordnete Ketten bilden. Aus einer solchen Struktur resultiert, wie beobachtet, eine hohe tangentiale Suszeptibilität, verbunden mit einem niedrigen magnetischen Gesamtmoment des Clusters in Remanenz.

MA 2.5 Mon 11:15 H10

The origin of ferromagnetism in ^{57}Fe ion-implanted Silicon Carbide — •Frank Stromberg[1], Werner Keune[1], Heiko Wende[1], and Helfried Reuther[2] — [1]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 65, D-47048 Duisburg, Germany — [2]Institut für Ionenstrahlphysik, Forschungszentrum Rossendorf, Bautzner Landstrasse 128, D-01328 Dresden, Germany

Semiconducting single crystals of the 6H-polytype of SiC were implanted with ^{57}Fe ions with nominal doses starting from $1x10^{16}cm^{-2}$ up to a highest dose of $2x10^{17}cm^{-2}$ at energies of 100 keV and 200 keV in order to produce a diluted magnetic semiconductor (DMS). After subsequent rapid thermal annealing at 1000°C the samples were investigated by x-ray diffraction (XRD), high-resolution cross-sectional transmission electron microscopy (HRTEM), superconducting quan-

tum interference device (SQUID) and ^{57}Fe conversion electron Mössbauer spectroscopy (CEMS) at room temperature and 4.2 K. Our results prove unambigously that the main reason for the ferromagnetism in ^{57}Fe ion-implanted Silicon Carbide is the formation of epitaxial superparamagnetic Fe_3Si clusters which occurs for Fe concentrations above 3%. For the lowest dose of $1x10^{16}cm^{-2}$ we find evidence of ferromagntism below 20 K via a weak magnetic hyperfine interaction. We propose that the possibility exists to obtain a real DMS in Fe-implanted SiC for Fe concentraions in the range of 1-3%.

MA 2.6 Mon 11:30 H10

Morphology and magnetism of compact surface-supported metal clusters — •Violetta Sessi, Jian Zhang, Jan Honolka, Axel Enders, and Klaus Kern — Max Planck Institute for Solid State Reaserch, Stuttgart, Germany

We study small, compact metal clusters fabricated by buffer layer assisted growth. With this method the clusters are formed by thermal evaporation onto the substrate surface which is covered by a noble gas buffer layer. The clusters are then brought into contact with the substrate by thermal desorption of the buffer layer. We will present a systematic STM and XMCD investigation of clusters formed under the same experimental conditions on different substrates, such as Cu(100), Ag(111) and Rh(111). We find that although the clusters form on the noble gas buffer layer, their final shape after making contact does depend on the substrates. The pronounced cluster mobility leads to cluster growth, bunching and step decoration on Cu or Ag substrates, but not on Rh. Moreover the islands are spherical on both Cu and Ag but flat on Rh. Diffusion and wetting of the substrate determine the final shape, size and clusters distribution upon contact with the surface. XMCD measurements are presented showing that also the magnetic properties of the clusters, such as anisotropy and blocking temperature, are determined by cluster-substrate interaction.

MA 2.7 Mon 11:45 H10

Magnetic anisotropy of two-dimensional Co nanostructures deposited on the Pt(111) surface — •Sven Bornemann[1], Jan Minar[1], Julie Staunton[2], and Hubert Ebert[1] — [1]Department Chemie, LMU München, Germany — [2]Department of Physics, University of Warwick, United Kingdom

In recent years, magnetic nanostructures on surfaces have been the subject of intense research activities which are driven by fundamental as well as practical interests. One of the central questions for future applications is how the magnetic properties like magnetic moments, exchange coupling and magnetic anisotropy evolve in between single magnetic adatoms and submonolayer magnetic particle arrays.

We applied the fully relativistic spin-polarized KKR method to investigate the magnetic anisotropy energy (MAE) of a variety of Co clusters deposited on the Pt(111) surface. Hereby, we focussed on the evolution of the MAE and other magnetic properties and their convergence to the corresponding monolayer values when going from a single Co adatom to nanostructures with more than 100 atoms. Furthermore we also studied how the MAE will change by introducing heteroatoms like Fe or Ru at the perimeter of these Co structures. All MAE results were obtained by calculating the magnetic torque directly from the electronic structure rather than taking energy differences. We resolved the MAE contributions for inequivalent atoms and will discuss the effect of the induced MAE within the Pt substrate.

MA 2.8 Mon 12:00 H10

Magnetic Anisotropy of fcc and $L1_0$ ordered FePt nanoparticles — •Ulf Wiedwald[1], Andreas Klimmer[1], Luyang Han[1], Birgit Kern[1], Kai Fauth[2], Hans-Gerd Boyen[1], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm — [2]Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, 70569 Stuttgart

FePt alloy nanoparticles exhibit huge magnetic anisotropy energy in the chemically ordered $L1_0$ phase. This ordered phase is typically obtained by annealing the as-prepared chemically disordered fcc FePt nanoparticles at 600-800°C. Such fcc FePt nanoparticles can also be fabricated by a micellar technique resulting in regular arrays on various substrates. This approach offers the advantage that the interparticle distance can be tuned between 20-100 nm allowing to completely suppress particle agglomeration during the annealing induced transformation into the $L1_0$ phase. Moreover, the particles are magnetically decoupled. We investigated the formation of the $L1_0$ phase for 3-10 nm FePt particles as a function of the annealing temperature and time. For this purpose, the structural transformation is tracked by magnetic hysteresis loops taken at various temperatures after each annealing step. In case of 9 nm particles we observe a coercive field of $\mu_0 H = 0.2$ T at 340 K. For particles smaller than 6 nm preliminary results indicate an at least impeded structural transformation.

MA 2.9 Mon 12:15 H10

Finite Size Effects in ultrathin hard magnetic FePt Films — •Felix Kurth, Martin Weisheit, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, P. O. Box 270116, 01171 Dresden

$L1_0$ ordered FePt is considered a promising material as a candidate for future ultra-high density perpendicular magnetic recording media. In this talk the focus will be on the effect of the reduced size on ordering and hard magnetic properties of epitaxial FePt nanogranular films in the thickness range from 0.5 to 10 nm grown on MgO(100). 10 nm thick films reach a coercivity up to 7.3 T at room temperature. The influence of a reduced size on the heat absorption and magnetic properties as well as on composition are examined. The understanding of these finite size effects allows to reduce the thickness significantly resulting in highly ordered particles ($\mu_0 H_C = 5.5$ T at 10 K), but with superparamagnetic behaviour at room temperature.

MA 2.10 Mon 12:30 H10

First-principles studies on binary transition metal clusters — •Sanjubala Sahoo, Georg Rollmann, and Peter Entel — Physics Department, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany

The structural and magnetic properties of $Fe_{1-n}X_n$ (where, X = Ni, Co, Pt and n = total number of atoms) and Co-Pt binary clusters with 13 and 55 atoms have been performed using density functional theory and generalised gradient approximation. For each composition of the binary systems with icosahedron geometry, several cluster configurations are structurally optimised by conjugate gradient method. The configurational energy analysis for Fe-Ni clusters suggests a segregation tendency of Ni atoms towards the surface of the cluster, while for Fe-Co system, the Co atom is positioned towards the interior of the cluster. However, this behaviour is not consistent for 13 atom icosahedral clusters of Fe-Pt and Co-Pt. The mixing energies for the binary systems are calculated. The mixing energy versus composition of Fe-Ni icosahedron cluster is compared with the bulk alloy, which shows similar trend.

MA 2.11 Mon 12:45 H10

Magnetic moments in Fe_xPt_{100-x} nanoparticles vs. bulk — •Kai Fauth — MPI für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart, Germany

Due to its strong magnetocrystalline anisotropy FePt is actively being investigated as a potential material for ultrahigh density magnetic data storage. A survey is given on various approaches to generate appropriate nanoscale Fe_xPt_{100-x} particles and their magnetic properties in terms of magnetization and magnetic anisotropy are given as a function of alloy composition. Quite generally we find considerably reduced magnetic moments in sub 10 nm Fe_xPt_{100-x} nanoparticles compared to those determined for epitaxially grown films of corresponding stoichiometry. We discuss mechanisms such as surface magnetic anisotropy and surface segregation as posible sources of our experimental findings.

MA 3: Magnetic Materials I

Time: Monday 10:15–13:00 Location: H22

MA 3.1 Mon 10:15 H22

Melt-spun MnFe(P,Ge,Si) as a giant magnetocaloric material — •Oliver Gutfleisch, Wei Zhang, Julia Lyubina, and Ludwig Schultz — Leibniz Institute of Solid State and Materials Research Dresden (IFW Dresden), Institute of Metallic Materials, P.O. Box 270016, D-01171 Dresden, Germany

The giant magnetocaloric effect was studied in Mn1.1Fe0.9P0.8-xSixGe0.2 (x=0.1, 0.12, 0.13, 0.14) and Mn1.1Fe0.9P0.85-xSixGe0.15 (x=0.18, 0.2, 0.22) melt-spun ribbons. Thermal, structural and magnetic properties were investigated by SQUID, PPMS, XRD and SEM. The dependence of Curie-temperature, thermal and magnetic hysteresis, crystal lattice parameters and magnetic entropy changes on composition are described. It is demonstrated that melt-spinning [1,2] is a efficient and very simple processing route for MnFe(P,Ge,Si)-type materials, i.e. arsenic free Fe2P-type alloys [3], exhibiting large values of magnetic entropy change (|deltaS(m)|=45J/kgK) with very small magnetic hysteresis near room temperature.

[1] O. Gutfleisch et al., J. Appl. Phys. 97 (2005) 10M305. [2] A. Yan, et al., J. Appl. Phys. 99 (2006) 08K903. [3] D.T. Cam Thanh et al., J. Appl. Phys. 99 (2006) 08Q107.

MA 3.2 Mon 10:30 H22

Investigation of $Rb_4(O_2)_3$, a predicted Halfmetallic Ferromagnet — •Jürgen Winterlik[1], Gerhard H. Fecher[1], Claudia Felser[1], Martin Jansen[2], Claus Muehle[2], and Franziska Emmerling[3] — [1]Johannes-Gutenberg-Universität Mainz — [2]MPI Stuttgart — [3]BAM Berlin

The black colour of Rubidium Sesquioxide $Rb_4(O_2)_3$, an alkali oxide containing two superoxide anions and one peroxide anion, indicates an exceptional electronic structure compared to similar substances. Band structure calculations gave advice that $Rb_4(O_2)_3$ might be an anionogenic halfmetallic ferromagnet with magnetism based on oxygen-2p-electrons.

Neutron diffraction measurements reveal that the substance crystallises in the cubic space group I-43d. Magnetic measurements of the substance, performed by SQUID magnetometry, show dominating antiferromagnetic interactions with indications of a frustrated system due to thermal hysteresis and lack of saturation. An effective moment of 1.95 μ_B matches the expected value of 2 μ_B quite well. The experimental data are compared to electronic structure calculations.

MA 3.3 Mon 10:45 H22

Non-adiabatic spin dynamics in thin magnetic films — •Pawel Buczek, Arthur Ernst, Leonid Sandratskii, and Patrick Bruno — Max Planck Institute of Microstructure Physics

The thermal properties of magnetic materials are essentially influenced by the spectrum of spin fluctuations (magnons and Stoner excitations), both in bulk materials and in the systems with reduced dimensionality, e.g. films.

For small wave-length excitations, it is crucial to treat both the magnons and Stoner excitations dynamically, on an equal footing, especially in systems with reduced dimensionality. The most reliable way to consider magnon properties is by the computation of frequency-dependent magnetic susceptibility.

In our project the ground state of a magnetic film is generated by means of layered KKR Green's function method. Subsequently, the magnetic susceptibility is constructed in a two-step procedure. First, an auto-convolution of the KKR Green's function (non-enhanced susceptibility) is constructed. In the next step, true susceptibility is obtained through a solution of a selfconsistent integral equation, originating from the time dependent DFT. Layered KKR has the advantage of yielding realistic band structure; also the relaxations of the film crystalline structure in the direction perpendicular to its surface can be taken into account.

In the presentation the fundamentals of the method will be discussed along with several preliminary results on magnetic excitations in bulk Fe and its thin films.

MA 3.4 Mon 11:00 H22

Bestimmung der Ordnungsparameter in epitaktischen Fe_3Si-Filmen auf MgO(001) mittels Mössbauerspektroskopie — •Natalia Utochkina[1], Marco Walterfang[2], Werner Keune[1] und Heiko Wende[1] — [1]Fachbereich Physik, Universität Duisburg-Essen, D-47048 Duisburg — [2]ACCESS e.V. Materials & Processes, D-52072 Aachen

Fe_3Si-Legierungen sind aufgrund ihrer hohen Spinpolarisation für das sich schnell entwickelnde neue Gebiet der Spinelektronik und Magnetoelektronik interessant geworden. Epitaktische Fe_3Si-Filme auf MgO(001) wurden durch Koverdampfen im UHV bei verschiedenen Wachstums- (T_S-) und Anlass- (T_A-) Temperaturen präpariert und mittels Röntgenbeugung untersucht. Es wurde eine Gitterplatz-Besetzungsanalyse von Fe-Atomen mittels ^{57}Fe-CEMS durchgeführt. Die atomaren Nachbarkonfigurationen und Nahordnungsparameter α_1 und α_2 ergaben sich aus der Analyse der verschiedenen spektralen Sextett-Komponenten hinsichtlich magnetischem Hyperfeinfeld und relativer Intensität. Um die langreichweitigen Ordnungsparameter S zu bestimmen, wurden mittels Computersimulation willkürliche Abweichungen von der idealen $D0_3$-Struktur bei 25 at.% Si und dadurch gewünschte Werte der Si-Konzentration und des Ordnungsgrades erzeugt. Der Vergleich der Simulation mit den Mössbauer-Resultaten ergab die Ordungsparameter S($D0_3$) und S(B2). Die höchste Ordnung (α_1=-0.33, α_2=-0.32, S(D03)=0.99, S(B2)=0.66) wurde bei T_S=250 °C und T_A=600 °C beobachtet.

Gefördert durch die DFG (SFB 491).

MA 3.5 Mon 11:15 H22

Interfacial features of $La_{0.7}Sr_{0.3}MnO_3$ probed by scanning tunneling microscopy — •Lakshamana Sudheendra, Markus Esseling, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I. Physikalisches Insitut, Friedrich-Hund-Platz-1, 37077, Göttingen, Germany

We present scanning tunneling microscopy (STM) and spectroscopy (STS) studies on artificial grain boundary (GB) resulting from the growth of Sr-substituted manganite on MgO bicrystal substrate. The width of the GB-the region between the two crystals- was found to be around 20-30 nm, wherein unusual structural and electronic features were observed in the topography and spectroscopy. Within the GB, structural features running parallel to the grain boundary were detected, which originate probably due to relaxation of stress. Tunneling conductivity within the GB at room temperature was found to be insulating-like, and could be strongly increased through the interaction between the tip and film. The puzzle of sharp [1] versus diffused [2] electronic phase separation between two different electronic phases appears to be linked to domains/antiphase boundaries versus disorder/strain.

[1]. Ch. Renner et al., Nature, 416, 518 (2002).

[2]. T. Becker et al., Phys. Rev. Lett. 89, 237203 (2002).

Acknowledgement: We acknowledge the support of DFG-SFB 602 TP A2 and the Leibniz program.

MA 3.6 Mon 11:30 H22

Bulk sensitive photo emission spectroscopy of $C1_b$ compounds — •Benjamin Balke[1], Gerhard H. Fecher[1], Andrei Gloskovskii[1], Joachim Barth[1], Claudia Felser[1], Franz Schäfers[2], Marcel Mertin[2], Wolfgang Eberhardt[2], Sven Mähl[3], and Oliver Schaff[3] — [1]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg - Universität Mainz, Germany — [2]BESSY GmbH, Albert-Einstein-Straße 15, 12489 Berlin, Germany — [3]SPECS GmbH, Voltastraße 5, 13355 Berlin, Germany

This work reports about bulk-sensitive, high energy photoelectron spectroscopy from the valence band of CoTiSb excited by photons from 1.2 to 5 keV energy. The high energy photoelectron spectra were taken at the KMC-1 high energy beamline of BESSY II employing the recently developed Phoibos 225 HV analyser. The measurements show a good agreement to calculations of the electronic structure using the LDA scheme. It is shown that the high energy spectra reveal the bulk electronic structure better compared to low energy XPS spectra.

MA 3.7 Mon 11:45 H22

Magnetic order in highly oriented graphite irradiated with protons at low temperatures — •Jose Barzola-Quiquia[1], Martin Rothermel[2], Annette Setzer[1], Pablo Esquinazi[1], and Tilman Butz[2] — [1]Division of Superconductivity and Magnetism, Institute for Experimental Physics II, University of Leipzig, Linnéstr. 5, 04103

Leipzig, Germany — [2]Division of Nuclear Solid State Physics, Institute for Experimental Physics II, University of Leipzig, Linnéstrasse 5, 04103 Leipzig, Germany

In this contribution we compare the magnetic properties of graphite samples proton irradiated at room and low (T=110K) temperatures. An array of 160x160 spots of micrometer size were proton irradiated with fluence of $\sim$1nC/μm^2 in highly oriented graphite samples, two of them at low and one at room temperature. Special sample holders, which enable irradiation and SQUID measurements without any sample handling, allow us to study with high accuracy the changes produced by the irradiation on the magnetic properties. SQUID measurements reveal clear differences between the low and room temperatures irradiations. The samples irradiated at low temperature show larger ferromagnetic contribution. From the temperature dependence of the ferromagnetic contribution we obtain a Curie temperature of the order of 400K for the micrometer size irradiated spots. The total amount of magnetic impurities, measured in situ and during irradiation, is below 0.3 ppm and cannot explain the observed magnetic order. Our results confirmed previous results published earlier in Phys..Rev.Lett. **91**, 227201 (2003).

MA 3.8 Mon 12:00 H22

Bulk and surface magnetism in $Na_{0.75}CoO2$: why is Luttinger's theorem violated? — •Michelle Johannes[1], Igor Mazin[1], and George Sawatzky[2] — [1]Naval Research Laboratory, Washington, D.C. USA — [2]University of British Columbia, Vancouver, Canada

The properties of Na_xCoO_2 vary substantially with the sodium concentration, x. Though strong spin fluctuations are proposed to exist throughout the full range of sodium, long range magnetic order sets in only at low hole concentration (x $\sim$ 0.7). Also around this doping, ARPES results show substantial disagreement with Luttinger's theorem (LT). We show that this is definitively not the result of deviations from two-dimensionality and propose that the two effects (magnetism and violation of LT) are related. We present a careful analysis of the various possible terminations of a cleaved surface of $Na_{0.75}CoO_2$, and conclude that the observed Fermi surfaces are inconsistent with ANY physically possible bulk system. We suggest surface layer magnetism as a possible explanation for the discrepancy between Fermi surface size and electron count.

MA 3.9 Mon 12:15 H22

Unexpectedly Strong Magnetic Coupling in Rare Earth Borides — •Takao Mori[1,2] and Yuri Grin[2] — [1]National Institute for Materials Science, Nanoscale Materials Center, Namiki 1-1, Tsukuba, 305-0044, Japan — [2]Max Planck Institute for Chemical Physics of Solids, Noethnitzer Str. 40, 01187 Dresden, Germany

The magnetism of rare earth borides like REB_4, REB_6, and REB_{12} has attracted a lot of interest over the years. These compounds are all good metals in the case of trivalent rare earth elements and their magnetic coupling has basically been described by the Ruderman-Kittel-Kasuya-Yoshida (RKKY) mechanism. As an emerging new phenomenon, it has been found that borides which contain the B_{12} icosahedra as a structural building block can exhibit unexpectedly strong magnetic interactions despite being relatively magnetically dilute insulators (e.g. T_N = 17 K for TbB_{50} and T_f = 29 K for $HoB_{17}CN$) [1-3]. We report on a new phase discovered in a series of homologous rare earth boron carbonitride compounds which have a particular triangular configuration of the rare earth atoms. The dynamical properties investigation of $HoB_{22}C_2N$ has previously indicated that it is a two-dimensional spin glass. Magnetic and thermoelectric properties of this series of compounds are presented.

[1] T. Mori and T. Tanaka, J. Phys. Soc. Jpn. **68** 2033 (1999). [2] T. Mori and H. Mamiya, Phys. Rev. B **68**, 214422 (2003). [3] T. Mori, J. Appl. Phys. **95**, 7204 (2004).

MA 3.10 Mon 12:30 H22

The antiferromagnetic ground state on 2D kagomé lattices in Y0.5Ca0.5BaCo4O7 — •Martin Valldor[1] and Werner Schweika[2] — [1]II. Phys. Inst., Zülpicher Str. 77, D-50937 Köln — [2]Institut für Festkörperforschung, FZ Jülich, D-52425 Jülich

The compound Y0.5Ca0.5BaCo4O7 contains a net of tetrahedrally coordinated Co, similar to that in the wurtzite type structure. The transition metal sublattice forms perfect kagomé type layers and the intralayer coupling is much stronger than any inter-layer interaction, giving low-dimensional magnetism. Frustration and an unusual spin state of the inter-layers Co cause the layers to magnetically decouple. The susceptibility measurements indicate strong antiferromagnetic coupling between spins [1], but the magnetic part of neutron diffraction data, separated through polarization, shows no long-range order down to 1.2 K [2]. The observed diffuse peak indicates an ordering tendency towards a staggered chiral ground state, a spin structure of Heisenberg spins in layers called V3xV3. This coplanar spin structure exhibits a degeneracy with local chiral disorder even at very low temperatures. Studies of this complex, highly frustrated magnetic state give clues to unique spin ordering effects close to their ground state.

[1] M.Valldor Solid State Sciences 8 (2006) 1272-1280
[2] W.Schweika, M.Valldor, P. Lemmens submitted to PRL (2006)

MA 3.11 Mon 12:45 H22

High-temperature magnetic order in an aromatic polyimide — Jose Barzola-Quiquia[1], •Pablo Esquinazi[1], Annette Setzer[1], Michael Ziese[1], Martin Rothermel[2], Daniel Spemann[2], and Tilman Butz[2] — [1]Division of Superconductivity and Magnetism, Institute for Experimental Physics II, University of Leipzig, Linnéstr. 5, 04103 Leipzig, Germany — [2]Division of Nuclear Solid State Physics, Institute for Experimental Physics II, University of Leipzig, Linnéstr. 5, 04103 Leipzig, Germany

We have studied the temperature and magnetic field dependence of the magnetization of polyimide foils in the as-received state, after annealing at temperatures $T \leq 1000$C and after proton irradiation. The temperature and field dependence depend strongly on the sample initial, annealing as well as on the irradiation conditions. Added to a diamagnetic signal our results provide clear evidence for ferromagnetism and paramagnetism due to different multiplets contributions. The very low magnetic impurity concentration (below 0.5ppm) cannot explain the observed behavior as well as the ferromagnetic and paramagnetic values. The Curie temperature of the ferromagnetic contribution reaches values of the order 800 K upon annealing. The overall results indicate that metal-free polyimides are interesting objects for basic research with potential applications in the area of magnetism.

MA 4: Electron Theory of Magnetism

Time: Monday 10:15–13:15 Location: H23

MA 4.1 Mon 10:15 H23

Magnetic EXAFS on Fe/Ag(100): Experiment and Theory — •J. Kurde[1], N. Ponpandian[1], J. Luo[1], C. Sorg[1], K. Baberschke[1], and H. Wende[1,2] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin-Dahlem, Germany — [2]Angewandte Physik, Fachbereich Physik, Universität Duisburg-Essen, Lotharstr. 1, D-47048 Duisburg, Germany

The $L_{2,3}$ edges of a bcc iron film (13 ML) on Ag(100) have been investigated with magnetic EXAFS (MEXAFS). The absorption spectra were recorded in a k range up to 12 Å^{-1}. The normal or spin-averaged EXAFS confirmes clearly a bcc structure. The well known differences [1] of the spin-averaged and magnetic spectra are observed. Beyond this significant intensities for distances larger than 6 Å in the Fourier transform of the magnetic signal are seen and analysed. To achieve a more fundamental understanding of the spin-selective scattering phenomena that determine the MEXAFS, we applied two theoretical models: 1) *ab initio* calculations and 2) the rigid band model [2]. From 1) we can identify each contributing scattering path. Method 2) works surprisingly good, since we can clearly reproduce the observed structures. Hence, one can describe the magnetic scattering by a spin-dependend shift of the scattering potential due to exchange coupling, which can be modeled by the energy-shifted EXAFS spectra. Supported by BMBF (05 KS4 KEB 5).

[1] H. Wende *et al.*, J. Synch. Rad. 6, 696 – 698 (1999)
[2] H. Wende, Rep. Prog. Phys. 67, 2105-2181 (2004)

MA 4.2 Mon 10:30 H23

Relativistic formulation of the Korringa-Kohn-Rostoker nonlocal coherent-potential approximation — •Diemo D. Ködderitzsch[1], Hubert Ebert[1], and Derwyn Rowlands[2] — [1]Ludwig-Maximilians-Universität München, Department Chemie und Biochemie, Physikalische Chemie — [2]H. H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, United Kingdom

For years the Korringa-Kohn-Rostoker (KKR) coherent-potential approximation (CPA) has been widely and successfully used to describe the electronic structure of disordered systems like alloys. As a single-site mean field theory the CPA is not able to describe short-range order (e.g. clustering) effects. The recently introduced [1] KKR nonlocal coherent-potential approximation (KKR-NLCPA) provides a sound basis for systematically including important environmental effects within an *ab initio* description of disordered systems.

Here we propose a fully relativistic formulation of the KKR-NLCPA which is designed for the treatment of magnetically-ordered alloys. Crucial to its implementation is a reformulation of the basic algorithm and a symmetrisation of the fundamental coarse-graining procedure, which we describe in detail. As a first application of the approach we study the electronic and magnetic properties of the ferromagnetic FePt system.

[1] D.A. Rowlands, J. Phys.: Condensed Matter **16**, 3179, (2006) and references therein; D.A. Rowlands, J.B. Staunton, and B.L.Györffy. Phys. Rev. **B67**, 115109 (2003).

MA 4.3 Mon 10:45 H23

Recent developments in the theory of angle-resolved photoemission (UPS and XPS) — Jan Minar[1], •Juergen Braun[2], and Hubert Ebert[1] — [1]Dep. Chemie und Biochemie, Physikalische Chemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany — [2]Inst. f. Mathematik, Universität Hildesheim, Germany

Recent developments and improvements in the resolution of angle-resolved photoemission experiments in the UPS as well as in the XPS regime require an improved (or revised) theoretical description of the photoemission process based on the one-step model. In particular, in several earlies studies the measured spectra were described either within a single particle approach based on DFT(LSDA) including matrix elements effects or by sophisticated many-body approaches neglecting these effects. In our analysis [1], we combined for the first time electronic correlations with matrix elements effects to achieve an improved interpretation of photoemission data from Ni and Fe. This has been done by means of a combined fully-relativistic self-consistent LSDA+DMFT approach [2].

In the second part we present the results for angle-resolved photoemission of Ag in the soft X-ray range. In particular $k_{\|}$ and photon momentum transfer effects, which are often neglected in the high energy photoemission, are discussed in detail.[3]

1. J. Braun et al., Phys. Rev. Lett 97, 227601 (2006)
2. J. Minár et al., Phys. Rev. B 72, 45125 (2005)
3. F. Venturini, J. Phys.: Cond. Matt., submitted (2006)

MA 4.4 Mon 11:00 H23

Residual resistance calculations of $Ga_{1-x}Mn_xAs$ using the Kubo-Greenwood formalism — •Stephan Lowitzer[1], Stanislav Chadov[1], Voicu Popescu[2,1], and Hubert Ebert[1] — [1]Department Chemie/Physikalische Chemie, LMU München, Butenandstraße 5-13, 81377 München — [2]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

The residual resistance (at T = 0K) of the diluted magnetic semiconductor system (DMS) $Ga_{1-x}Mn_xAs$ has been calculated. For these calculations the Kubo-Greenwood formalism has been employed. The electronic structure calculations is based on the Korringa-Kohn-Rostoker (KKR) band structure method in connection with the coherent potential approximation (CPA) alloy theory. The results show in accordance with other authors a fast decrease of the resistivity with increasing Mn-concentration. This behavior is due to an increase of the density of states at the Fermi edge. Additional calculations show, that the occupation of interstitial positions or the occupation of antisites lead to a clear increase of the resistivity due to disorder. These calculations are in good agreement with experimental data for untreated and tempered samples. Further calculations indicate a small influence of the spin-orbit-coupling on the isotropic residual resistance.

MA 4.5 Mon 11:15 H23

Temperature dependent magnetic properties of low-dimensional systems — •Svetlana Polesya[1], Sergey Mankovsky[1], Voicu Popescu[2], and Hubert Ebert[1] — [1]Dept. Chemie und Biochemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany — [2]Max-Planck-Institut für Metallforschung Abt. Schütz, Heisenbergstr. 3, D-70569 Stuttgart, Germany

Temperature dependent magnetic properties of metallic clusters and ultra-thin magnetic films deposited on metallic substrate have been studied on the basis of Heisenberg model using the Monte Carlo simulations as well as Green's function random-phase approximation. The exchange coupling parameters were obtained on the basis of calculations of electronic structure performed within the KKR Green's functions method.

We studied the dependence of the Curie temperature of ultra-thin magnetic films of 3d transition metals on the thickness of these films. The influence of magnetic anisotropy and inter-diffusion at the interface on the temperature dependent magnetic properties of films were studied as well. The effect of covering layers of non-magnetic metals having different thickness on the anisotropy in magnetic films as well as on the Curie temperature have been investigated.

MA 4.6 Mon 11:30 H23

Influence of correlation effects on spin-orbit induced magnetic properties of disordered systems — •Stanislav Chadov[1], Jan Minár[1], Diemo Ködderitzsch[1], Hubert Ebert[1], and Leonid Pourovskii[2] — [1]Universität München, Dept. Chemie und Biochemie, Physikalische Chemie, Butenandtstr. 5-13, 81377 München — [2]Institute for Molecules and Materials, Radboud University of Nijmegen, NL-6525 ED Nijmegen, The Netherlands

We present results for orbital magnetic moments of the ferromagnets Fe, Co and Ni as well as for disorderd Fe_xCo_{1-x} alloys calculated within the relativistic full potential Korringa-Kohn-Rostoker (KKR) method using the Coherent Potential Approximation (CPA). Particular attention is paid to the influence of local correlation effects which have a noticable effect on the spin-orbit induced properties of 3*d* transition metal compounds. Local correlations are taken into account within the framework of the Dynamical Mean Field Theory (DMFT) combined with the KKR in a fully self-consistent scheme. The relativistic version of the DMFT solver used in the present work allows to take into account explicitely the interplay of the spin-orbit coupling and local correlations. Therefore, a more accurate treatment of the orbital magnetic moments is obtained. A corresponding comparison with experimental data is presented.

MA 4.7 Mon 11:45 H23

Magnetic properties of Cr teluride-selenide alloys — •Sergey Mankovsky[1], Svetlana Polesya[1], Hubert Ebert[1], Zhong-Le Huang[2], and Wolfgang Bensch[2] — [1]Dept. Chemie und Biochemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany — [2]Institute for Anorganic Chemistry, Olshausenstr. 40, D-24098, Kiel, Germany

Results of a theoretical study of the magnetic properties of Cr telluride-selenide alloys having trigonal crystal structure are presented in comparison with experimental results. Both ground state and temperature-dependent magnetic properties of $Cr_{1-\delta}Te$ and $Cr_x(Te_\alpha Se_\beta)_2$ (with ratio $\alpha : \beta = 7 : 1,6 : 2,5 : 3$) have been investigated in a wide region of chromium content. For the alloys $Cr_x(Te_\alpha Se_\beta)_2$ a transition to the state with antiferromagnetic order in a fully occupied sub-lattice and with no order in a partially occupied sub-lattice was obtained. For the alloys $Li_xCr_{0.5}Ti_{0.75}Se_2$, a non-monotonic dependence of structural and magnetic properties have been found upon increase of Li concentration x, that is in agreement with experimental results.

The ground state properties have been studied on the basis of electronic structure calculations using the Korringa-Kohn-Rostoker (KKR) band structure method combined with the CPA alloy theory. Using Monte Carlo simulations we obtained the magnetic configuration at $T = 0K$ and studied the magnetic properties at $T > 0K$ as well. The required exchange coupling parameters were obtained from our ab-initio electronic structure calculations.

MA 4.8 Mon 12:00 H23

Magneto-kristalline Anisotropie von FePt in Abhängigkeit von der Unordnung — •Gerhard Kuhn, Michal Kosuth, Diemo Koedderitzsch und Hubert Ebert — Department Chemie und Biochemie / Physikalische Chemie, Universität München, Butenandstr. 5-13, D-81377 München, Germany

Die magnetischen Eigenschaften von FePt in der CuAu-Struktur wurden mittels des KKR (Korringa-Kohn-Rostoker)-Bandstrukturverfahrens untersucht. Die Verwendung der Coherent Potential Approximation erlaubte dabei den Einfluß einer Interdiffusion der beiden Teilgitter zu untersuchen. Die Verwendung der relativistischen Version ermöglichte die Berechnung von Spin-Bahn-induzierten Größen wie orbitales Moment und die magneto-kristalline Anisotropie. Für tetragonales geordnetes FePt wurde, im Einklang mit dem Experiment, die leichte Achse senkrecht zu den Fe- bzw. Pt-Atomlagen gefunden. Eine Interdiffusion zwischen den Fe- und Pt-Atomlagen führt zu einem raschen Abbau der Anisotropie. Im Grenzfall einer tetragonalen Legierung verbleibt eine kleine Anisotropie mit der leichten Richtung längs der c-Achse. Die Annahme einer kubischen Einheitszelle verändert die Ergebnisse nur geringfügig, wobei im Falle der Legierung die drei kubischen Achsen äquivalent sind.

MA 4.9 Mon 12:15 H23

Magnetic behaviors under pressure of some cubic Laves phase compounds — •Wenxu Zhang, Manuel Richter, and Helmut Eschrig — Leibniz Institute for Solid State and Materials Research Dresden,Dresden,Germany

The electronic structures of four *Laves* phase iron compounds(e.g. YFe_2,$ZrFe_2$,$LuFe_2$,and $HfFe_2$) have been calculated by the state-of-the-art LSDA code FPLO. The magnetic moments collapse under hydrostatic pressure. This feature is found to be universal in these materials. Its electronic origin is provided by the sharp peaks in the density of states near the Fermi level. The bonding characteristics are discussed to elucidate the equilibrium lattice constant variation. Possible occurrence of superconductivity under pressure, e.g. close to the quantum critical points, is proposed.

MA 4.10 Mon 12:30 H23

Representation of the adiabatic magnetic energy on the atomic level by the spin-cluster expansion technique — •Reinhard Singer, Frank Dietermann, and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

The adiabatic magnetic energy on an atomic level may be represented in principle exactly within the spin-cluster expansion (SCE) [1] by contributions arising from all possible spin clusters. The basis functions for this representation thereby are constructed from a complete set of one-spin basis functions (like, e.g. spherical harmonics $Y_{lm}(\mathbf{e}_i)$) of the unit vector $\mathbf{e}_i$ describing the orientation of the atomic magnetic moment at site i. The complete set of cluster basis functions is then obtained by reducing each corresponding direct product of one-spin functions according to the symmetry restrictions of the magnetic system under consideration, i.e., time-reversal and rotational invariance in the case of isotropic magnets.[2] The expansion coefficients corresponding to the cluster basis functions can be practically obtained by carefully fitting to reference configurations calculated with the ab-initio electron theory. The so constructed SCE of the magnetic energy comprises ab-initio accuracy and thus lends itself to quickly find the true magnetic ground state in complicated systems, to thermo-statistical methods like Monte-Carlo simulations, or to large scale spin dynamics simulations. First results for the SCE of fcc Fe and fcc Ni are presented.

[1] R. Drautz and M. Fähnle, Phys. Rev. B 69, 104404 (2004).
[2] R. Singer and M. Fähnle, J. Math. Phys. 47, 113503 (2006).

MA 4.11 Mon 12:45 H23

On the theory of x-ray absorption spectroscopy in solids: Mixing of the core states by the aspherical effective potential — •Christos Kostoglou[1], Matej Komelj[2], and Manfred Fähnle[1] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Jožef Stefan Institute, Jamova 39, SI 1000 Ljubljana, Slovenia

For the early transition metals the spin-orbit splitting of the $2p_{1/2}$ and the $2p_{3/2}$ core states is rather small. As a consequence, the $2p_{1/2}$ and $2p_{3/2}$ excitations by x-ray absorption at the L edges exhibit a quantum mechanical mixing which has an influence on the x-ray absorption spectrum. The main source for this mixing is a many-electron effect, i.e., the Coulomb interaction between the core hole (created by the absorption) and the valence electron. We discuss another possible source which so far has never been quantified and which is a one-electron contribution, i.e., the mixing of the two core states by the aspherical part of the static effective potential. We calculate the influence of this mixing on the x-ray magnetic dichroism spectrum of CrO_2 within the framework of the pertubation theory for nearly-degenerate states and within the ab-initio density functional electron theory in the LDA+U version. It turns out that the effect of this type of mixing on the spectrum is rather small.

MA 4.12 Mon 13:00 H23

Orbital magnetism in UN and UT_2Si_2 compounds — •Carsten Neise, Mahdi Sargolzaei, Klaus Koepernik, Ingo Opahle, Manuel Richter, and Helmut Eschrig — IFW Dresden, P.O.B. 270016,D-01171 Dresden Germany

Usually orbital moments are underestimated in spin polarized relativistic density functional calculations. To get rid of this problem, so-called orbital polarisation (OP) corrections were introduced first in [1] and later derived in a slightly different form in [2].
In this work OP corrections have been applied for UN compound and UT_2Si_2 compounds, where T is (Co,Cu,Cr,Fe,Mn,Ni,Os,Pd,Rh,Ru), with a focus on the orbital moment. The results of the individual atomic moments in these compounds will be compared with available experimental data and calculations in literature.
[1] O. Eriksson, M.S.S. Brooks and B. Johansson, Phys. Rev. B **41** (1990), 7311-7314
[2] H. Eschrig, M. Sargolzaei, K. Koepernik and M. Richter, Europhys. Lett. **72** (2005), 611-617

MA 5: Invited Talks Pätzold / Gruner

Time: Monday 14:00–15:00 Location: H10

Invited Talk MA 5.1 Mon 14:00 H10

Novel magnetoresistive effect in organic semiconductors — •Ralph Paetzold, Manfred Ruehrig, and Joachim Wecker — Siemens AG, CT MM1, Guenther-Scharowsky-Strasse 1, 91058 Erlangen, Germany

Besides the more classical organic applications like organic PV and organic LEDs organic semiconductors have also been demonstrated to show a significant magnetoresitive effect. In 2004 the first article on the so called OMR (organic magnetoresistive effect) was published by T. Francis et al [1]. Devices that show significant OMR effect are quite similar to standard OLEDs in terms of materials and device architecture. The effect itself can vary with materials and the device architecture used. In this contribution we will give an overview about the general effect and discuss some possible causes. Experimental results will be introduced in order to evaluate the different mechanisms.

Invited Talk MA 5.2 Mon 14:30 H10

Structural and magnetic properties of transition metal nanoparticles from first principles — •Markus Ernst Gruner, Georg Rollmann, Alfred Hucht, and Peter Entel — Dept. of Physics, University of Duisburg-Essen, Campus 47048 Duisburg

Until recently, the simulation of transition metal particles in the nanometer range was only feasible with semi-empirical approaches and classical molecular dynamics simulations. However, the close interrelation of electronic and structural properties often leaves no alternative to a fully quantum mechanical treatment. The evolution of modern supercomputer technology nowadays allows for the simulation of nanometer-sized objects from first principles in the framework of the density functional theory (DFT). A technologically relevant example is the search for ultra-high density magnetic recording media where the decrease of the magnetic grain size competes with the inset of superparamagnetism. Here, FePt nanoparticles are discussed as a promising solution due to their large magnetocrystalline anisotropy in the ordered $L1_0$ phase. However, in experiment also other, less favorable, structures are observed. Therefore, a systematic *ab initio* investigation of the morphologies of FePt particles concerning their energetics

and magnetism at sizes relevant for future application appears highly desirable. Within this contribution, we report on DFT calculations of Fe and FePt clusters of up to 561 atoms including full geometric optimization. The calculations were carried out using the Vienna Ab initio Simulation Package (VASP) on up to 2048 processors on the IBM BlueGene/L installation at Forschungszentrum Jülich.

MA 6: Magnetic Particles/Clusters II

Time: Monday 15:15–17:00 Location: H10

MA 6.1 Mon 15:15 H10

Strukturelle und magnetische Charakterisierung der FePt Nanopartikel aus der Gasphase — •Olga Dmitrieva, Mehmet Acet, Günter Dumpich, Jochen Kästner, Carolin Antoniak und Michael Farle — Experimentalphysik, AG Farle, Universität Duisburg-Essen, 47048 Duisburg

In diesem Beitrag werden Herstellung und Charakterisierung von vorwiegend L10-geordneten FePt Nanopartikel aus der Gasphase vorgestellt. Mittels gezielter Zugabe von Stickstoff während der Partikelproduktion werden Bedingungen für eine begünstigte Einstellung der geordneten Phase erzeugt. Hochauflösende transmissionsmikroskopische Analysen zeigen, dass ca. 70% aller Nanopartikel eine einkristalline L10-geordnete Struktur besitzen [1]. Um zu prüfen, ob die Nanopartikel in der Gasphase Oxidationsprozessen ausgesetzt sind, wird der Oxidierungszustand der Partikel mittels Röntgensabsorptionsspektroskopie untersucht. Wir können damit nachweisen, dass die Partikel oberflächlich oxidiert sind. Die magnetische Charakterisierung der Nanopartikel erfolgt mittels Röntgenzirkulardichroismus. Da die Oxidationsschicht durch Behandlung in einem Wasserstoffplasma entfernt werden kann, ist es möglich, magnetische Bahn- und Spinmomente an anoxidierten und an oxidfreien Nanopartikeln zu ermitteln. Somit wird der Einfluss der Oxidation auf die magnetischen Eigenschaften festgestellt. Gefördert aus Mitteln der DFG im Rahmen des SFB 445. [1] O. Dmitrieva, M. Acet, G. Dumpich, J. Kästner, C. Antoniak, M. Farle, K. Fauth, J. Phys. D: Appl. Phys. 39, 4741 (2006).

MA 6.2 Mon 15:30 H10

HR-TEM Studies of FePt Nanoparticles by Exit Wave Reconstruction — •Daniela Sudfeld[1], Olga Dmitrieva[1], Nina Friedenberger[1], Günter Dumpich[1], Michael Farle[1], ChengYu Song[2], Christian Kisielowski[2], Markus Gruner[1], and Peter Entel[1] — [1]Department of Physics and the Center for Nanointegration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg — [2]National Center for Electron Microscopy, LBNL, One Cyclotron Road, Berkeley CA 94720, USA

To understand the magnetic properties of FePt nanoparticles [1] it is essential to get insights into the lattice structure of isolated clusters. FePt nanocrystals were investigated carrying out a direct reconstruction of the phase and the amplitude of the scattered electron wave from a focal series of HR-TEM images, resulting in a determination of the layer-resolved structure with sub Ångstrom resolution [2]. As an example, the formation of 5-fold twinned structures of 3 to 7 nm sized monodisperse FePt nanocrystals is discussed for fcc particles from colloidal solution and L10 ordered particles prepared by inert gas condensation [3]. In addition, ab initio density functional theory (DFT) calculations of FePt particles with a diameter larger than 2 nm were performed to obtain structural data which were used to model the microscopy data. This work was supported by the DFG (SFB 445) and the EU MRTN-CT-2004-0055667. References: [1] C. Antoniak et al.; Phys. Rev. Lett. 97, No. 11, 117201 (2006). [2] C. Kisielowski et al.; Ultramicr. 89 243 (2001). [3] O. Dmitrieva et al.; J. Phys. D: Appl. Phys. 39 (2006) 4741.

MA 6.3 Mon 15:45 H10

Structural stability of multiply twinned FePt nanoparticles — •Michael Müller and Karsten Albe — TU Darmstadt, Institut für Materialwissenschaft, FG Materialmodellierung, Petersenstr. 23, D-64287 Darmstadt

The structural stability of FePt nanoparticles in multiply twinned and single crystalline morphologies is investigated by means of molecular statics calculations based on a recently developed analytic bond-order potential. The results obtained from the atomistic calculations are used for validating a continuum model which allows to assess the contributions of elastic strain, surface and and twin boundary energies, separately. The static model calculations predict a strong energetic preference for single crystalline morphologies in the ordered L1_0 and disordered A1 phases, if the particle size exceeds 2.6 nm, while smaller particles tend to form icosahedral structures. Based on these results, experimentally observed shapes of FePt nanoparticles are discussed.

MA 6.4 Mon 16:00 H10

Lagenaufgelöste Kristallstruktur von FePt Nanopartikeln mit sub-Ångstrom Auflösung — •Nina Friedenberger[1], Olga Dmitrieva[1], Daniela Sudfeld[1], Christian Kisielowski[2] und Michael Farle[1] — [1]Universität Duisburg-Essen, Fachbereich Physik und das Center for Nanointegration Duisburg-Essen (CeNIDE), Lotharstr. 1, 47048 Duisburg — [2]National Center for Electron Microscopy, LBNL, One Cyclotron Road, Berkeley CA 94720, USA

Die Kristallstruktur nass-chemisch und durch Kondensation in der Gasphase hergestellter FePt Nanopartikel wurde mittels hochaufgelöster Transmissionselektronenmikroskopie und Exit-Wave-Reconstruction (EWR) untersucht. Anhand der rekonstruierten vollständigen Amplituden- und Phaseninformationen der HRTEM-Aufnahmen können fehlende Atomkolonnen an der Oberfläche identifiziert und die lagenaufgelöste Relaxation an der Partikeloberfläche bestimmt werden. Wir finden sowohl für kolloidale als auch für Gasphasen-Partikel im Mittel eine Aufweitung der Gitterkonstante bis zu 4% im Vergleich zur entsprechenden Gitterkonstante des Volumenmaterials. Diese Resultate bieten eine mögliche Erklärung für stark erhöhte orbitale Momente wie sie vor kurzem mittels Röntgenzirkulardichroismus beobachtet worden sind [1,2]. Unterstützt durch DFG (Sfb 445) und EU MRTN-CT-2004-0055667. [1] O. Dmitrieva, et al., J. Phys. D: Appl. Phys. 39 (2006) 4741 [2] C. Antoniak, et al., Phys Rev. Lett. 97 (2006) 117201

MA 6.5 Mon 16:15 H10

Kinetics of the ordering transition in FePt nanoparticles — •Michael Müller and Karsten Albe — TU Darmstadt, Institut f"ur Materialwissenschaft, FG Materialmodellierung, Petersenstr. 23, D-64287 Darmstadt

Kinetic Monte Carlo simulations based on an Ising-type lattice Hamiltonian are employed to investigate the kinetics of ordering processes in FePt nanoparticles. In non-supported particles, the A1 to L1_0 transition proceeds with a higher rate in layers at the surace than in the volume of the particles, which demonstrates the important influence of surface diffusion. Because of the statistical nucleation of the ordered phase, however, no single domain particles are obtained and an elimination of the antiphase boundaries can not be observed within the time scales accessible by the simulations. Based on these findings, possibilities for increasing the transition rate in supported nanoparticles are investigated. By systematically modifying interface energetics, surface diffusion can be increased and a preferential ordering direction in the particle can be induced.

MA 6.6 Mon 16:30 H10

$L1_0$-ordering of FePt nanoparticles by in-flight optical heating — •Elias Mohn, Darius Pohl, Franziska Schäffel, Ludwig Schultz, and Bernd Rellinghaus — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

FePt nanoparticles with sizes in the range of 4-6 nm are prepared by DC-magnetron sputtering in argon. Upon leaving the nucleation and growth chamber, the particles are ejected into high vacuum via differential pumping. This allows to effectively control both the degree of agglomeration and the primary particle size. Prior to their deposition, the particles are heated in flight by means of a newly constructed paraxial light furnace. Transmission electron microscopy (TEM) investigations reveal that upon increasing the furnace power, particle agglomerates successively coalesce, and fully sintered spherical particles are formed at powers of $P \geq 3$ kW. This proves that effective radiative heating of the particles is accomplished even though the heating times are as short as 1 ms. A comparison of these findings with recent experiments of Stappert et al. [1] allows to estimate a minimum particle

temperature of T $\geq$ 800 ^{o}C at P = 3 kW. Structural characterization by high resolution TEM reveals the onset of the $L1_0$ order in likewise treated FePt nanoparticles. This goes along with an increase of the coercivity which is, however, substantially smaller as compared to that of fully ordered FePt thin films. The obtained results are analyzed with respect to the $L1_0$ ordering kinetics. They confirm our assumption that the ordering is predominantly governed by volume diffusion. [1] S. Stappert et al., J. Cryst. Growth 252 (2003) 440.

MA 6.7 Mon 16:45 H10

Improved kinetics of the phase transformation of FePt nanoparticles from fcc to fct by ion irradiation — •Andreas Klimmer[1], Ulf Wiedwald[1], Birgit Kern[1], Luyang Han[1], Kai Fauth[2], Hans-Gerd Boyen[1], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm, Germany — [2]Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany

$Fe_{50}Pt_{50}$ alloy nanoparticles are promising candidates for ultra high density data storage due to their huge magnetic anisotropy energy in the chemically ordered $L1_0$ phase (fct). Starting from chemically disordered particles in fcc phase, the transformation into the chemically ordered fct phase is obtained by annealing at typically 600° - 800° C. We present experiments on arrays of $Fe_{51}Pt_{49}$ fcc nanoparticles (diameter 7 nm, inter-particle distances 60 nm), which were prepared using a micellar technique. The particles were irradiated with 350 keV He^+ ions up to 10^{16} ions/cm^2 at room temperature. Using XMCD measurements the transformation into the chemically ordered $L1_0$ phase can be extracted from the hysteresis in the magnetisation curves. A comparison of irradiated and non-irradiated samples reveals improved kinetics of the phase transformation of the ion irradiated nanoparticles. Thus coercive fields of 330 Oe at 300 K were obtained after 600° C annealing temperature for the irradiated particles, whereas the unirradiated ones still show superparamagnetic behaviour under identical annealing conditions.

MA 7: Micromagnetism/Computational Magnetics

Time: Monday 17:00–18:30 Location: H10

MA 7.1 Mon 17:00 H10

Application of exchange coupled composite layers for magnetic recording — Helmut Kronmüller and •Dagmar Goll — MPI für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

High-density recording systems require magnetic bits with large magnetocrystalline anisotropy to guarantee thermal stability. However, the large magnetic fields required for magnetization reversal cannot be afforded by conventional write heads. Therefore, composite exchange coupled spring systems of soft and hard magnetic layers are used to reduce the switching field. The reversal of magnetization in this case takes place in two steps: A nucleation process in the soft layer and a depinning process for the displacement of a domain wall (dw) into the hard layer thus inducing full switching of the exchange coupled system. The nucleation and depinning fields are calculated analytically on the basis of the continuum theory of micromagnetism. It is shown that the nucleation fields decrease according to a $1/D^2$ law with increasing thickness D of the soft layer and in general remain smaller than the depinning fields of the dws. For longitudinal recording the depinning field is that of a Bloch wall whereas for perpendicular recording we deal with a Néel wall. The Bloch wall depinning field is found to be of the order of 1/4 of the ideal nucleation field of the hard phase. The Néel wall depinning field depends on the relative values of the spontaneous polarizations of the hard and soft phase and may be larger or smaller than the depinning field of the Bloch wall.

MA 7.2 Mon 17:15 H10

Current-induced high-frequency normal modes in single-crystalline Fe nanodisks — •A. Kakay, R. Hertel, and C. M. Schneider — Institut für Festkörperforschung IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

The magnetization dynamics in a single-crystalline Fe nanodisk (diameter: 150 nm, thickness: 4 nm) driven by a spin-polarized current flowing perpendicular to the plane has been studied by means of micromagnetic simulations. The micromagnetic simulations have been performed with a finite-element algorithm based on the Landau-Lifshitz-Gilbert equation including Slonczewski's torque term. The magnetic excitations are induced by a spin-polarized current. At current densities between 4-6$\times 10^{11}$A/m^2, two pronounced peaks can be observed in the Fourier spectra. A spatial Fourier filtering shows that the lowest frequency peak (12.2 GHz) arises from a magnetic mode localized at opposite sides of the nanodisk. The main peak at 15.7 GHz represents a macrospin oscillation. In addition, well-defined and more complicated normal modes are observed in a frequency range around 22 GHz. Our simulations show that spin-polarized currents can induce stationary, non-uniform high-frequency normal modes, similar with those reported on the magnetization dynamics created by external field pulses. The occurrence of these normal modes emphasizes the need for a full-scale micromagnetic approach. The influence of the Oersted field (created by the current flowing through the sample) on the high-frequency normal modes will also be discussed.

MA 7.3 Mon 17:30 H10

Influence of spin waves on the dynamics of magnetization processes — •Sebastian Macke, Dagmar Goll, and Gisela Schütz — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart, Germany

Spin wave influenced switching of the magnetization of thin Co and permalloy films is studied by micromagnetic simulations. Therefore standing spin waves are superimposed on the magnetization configuration in the ground state. The dependence of magnetization reversal is analyzed for variable frequencies and phases with amplitudes up to 30°. Most spin waves cause an increase of the switching time but not all of them. The variation of switching times depends strongly on the external field. In the field range in which the switching time increases a significant dependence on the spin wave phase is oberserved. Thermally excited spin waves with Bose-Einstein distribution reduce the saturation magnetization by the well-known Bloch $T^{3/2}$ -law. In order to take care of the role of the spectrum of spin waves the effect of a discrete number of spin waves with different frequencies is determined quantitatively.

MA 7.4 Mon 17:45 H10

Switching magnetic vortices on the picosecond timescale — Riccardo Hertel, •Sebastian Gliga, and Claus M. Schneider — Institut für Festkörperforschung IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Magnetic vortices are naturally occurring structures in confined-geometry ferromagnetic materials: regions where the magnetization curls around a perpendicularly magnetized core. Highly stable, the core has until now been assumed to behave like a rigid structure. Only very recently has it been shown that the core could easily be switched by applying an in-plane magnetic pulse [1].

In this study, we present the dynamics of vortex core reversal using three-dimensional micromagnetic simulations based on finite-elements. The simulations show that a single suitable in-plane magnetic pulse of intermediate strength (ca. 70 mT) can be used to reverse the orientation of a vortex core. We found that this process is mediated by the creation and annihilation of a vortex-antivortex pair in the sample. We have systematically studied the influence of the field pulse strength and duration and found that it is possible to trigger the core reversal with ultrafast pulses (as short as 5 ps). The simulations predict that for very strong pulses, the core switches multiple times.

We find that the magnetization dynamics is driven by the exchange field, which allows the magnetization reversal process to unfold on the picosecond time scale, making it faster than any field-driven magnetization reversal process previously known from micromagnetic theory.
[1] B. Van Waeyenberge et al., Nature **444**, 461 (2006)

MA 7.5 Mon 18:00 H10

Magnetization Dynamics during Vortex-Antivortex Annihilation — •R. Hertel and Claus M. Schneider — Institut für Festkörperforschung IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Magnetic vortices and antivortices in thin-film elements can annihilate, resulting in a homogeneous magnetization. Both, the vortex and the antivortex contain a small core magnetized perpendicular to the film plane [1]. The direction of the magnetization of the core is called the polarization. A detailed description of the magnetization dynamics of vortex-antivortex annihilation processes is obtained by micromagnetic finite-element simulations based on the Landau-Lifshitz-Gilbert equation. As an example to study such an annihilation process, we simulated the dynamic domain structure conversion in a 100 × 100 × 10 nm^3 Permalloy element from a cross-tie structure to a single vortex structure. The simulations show that, depending on the relative polarization of the vortex-antivortex pair, the annihilation process is either a continuous transformation of the magnetic structure or it involves the propagation of a micromagnetic singularity (Bloch point) causing a burstlike emission of spin waves (exchange explosion) [2].

[1] Shinjo et al. Science 289, 930 (2000).
[2] R. Hertel and C.M. Schneider, PRL 97, 177202(2006).

MA 7.6 Mon 18:15 H10

Ferromagnetic resonance in ordered magnetic particle systems — •Peter Majchrák[1,3], Zdeněk Frait[2], Ján Dérer[1], Eva Kováčová[1], Vasil Šmatko[1], and Ivo Vávra[1] — [1]Institute of Electrical Engineering SAS, Bratislava, Slovakia — [2]Institute of Physics, AS CR, Na Slovance 2, Prague Czech Republic — [3]on leave at Institute of Physics, AS CR, Na Slovance 2, Prague Czech Republic

Microwave properties of arrays of circular FeSi dots were studied by ferromagnetic resonance (FMR) technique in wide range of frequencies from 17GHz to 70GHz. All of the dots had the radius 2 - 3 μm, thickness 40 nm, and were arranged into square array with 4 μm dot period. In the case of perpendicular magnetization (in field up to 28 kG) multiple resonance peaks were observed below the main FMR peak. Quantitative description of the observed multiresonance FMR spectra is given using the dipolar intradot interactions, and also the inhomogeneity of the intradot static demagnetization field in the nonellipsoidal dot is taken into account. In the next part of the contribution there are presented the results of FMR measurements performed on the superlattice of iron nanoparticle layers.

MA 8: Magnetic Materials II

Time: Monday 15:15–17:15 Location: H22

MA 8.1 Mon 15:15 H22

New half-metallic ground state in non-ideal $Co_{2-x}Mn_{1+x}Si$ — •Björn Hülsen[1], Peter Kratzer[2], and Matthias Scheffler[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, D-14195 Berlin — [2]Fachbereich Pysik, Universität Duisburg-Essen, Lotharstr. 1, D-47048 Duisburg

The half-metallic full Heusler alloy Co_2MnSi is a promising candidate for spintronics applications. Heterostructures like magnetic tunnel junctions where Co_2MnSi is incorporated with metal oxide layers are annealed with temperatures of $400 - 500°C$ during the growth process. To access the finite-temperature properties of Co_2MnSi we apply a combined approach of density functional theory (DFT), cluster expansion (CE), and Monte Carlo (MC) techniques. Since the most abundant defects in Co_2MnSi are Mn and Co antisites which are also the ones that influence the electronic structure most significantly, we regard Co_2MnSi as a pseudo-binary alloy and perform a CE that takes only the interactions between the Co and Mn atoms into account, while the Si atoms are confined to their sublattice. The coefficients of this CE are fitted to the energies of 59 structures that have been determined by DFT calculations using the full-potential linearized augmented plane wave method. Two of the seven predicted ground states show a spin gap, one is the well known $L2_1$ structure while the new half-metallic ground state has a Mn concentration of 50%. The effective Hamiltonian is used as input for a simulated annealing of ideal and non-ideal compositions of $Co_{2-x}Mn_{1+x}Si$ that allow the computation of the equilibrium configurations of these structures.

MA 8.2 Mon 15:30 H22

GdPdSb as a weak ferromagnet and half metal at low temperature — •Frederick Casper, Hem Kandpal, and Claudia Felser — Institut für Analyt. Chemie und Anorg. Chemie, Johannes Gutenberg Universität Mainz, Staudinger Weg 9, D-55099 Mainz, Germany

REPdSb compounds exhibit a variety of interesting properties, such as Kondo effect, half metallic behaviour and heavy fermion behaviour with magnetic instability [1]. GdPdSb crystallizes in the LiGaGe structure (space group P 6_3 m c). The self-consistent band structure calculations using the full potential linear augmented plane wave (FLAPW) method [2] confirmed the antiferromagnetic behaviour of this compound with $T_N = 14K$ [3].

The antiferromagnetic configuration is more stable compared with the ferromagnetic configuration, but the energy difference is very small between antiferromagnetic and ferromagnetic configuration; therefore one could expect (weak) ferromagnetic behaviour at low temperature. SQUID measurements show a rising of the magnetic susceptibility below T_N at 7K. Also a small hysteresis loop is observed. This could be of possible weak ferromagnetic ordering in agreement with the prediction of the calculation. According to band structure calculations, ferromagnetic ordered GdPdSb is half metallic, which is the first half metallic ferromagnet with LiGaGe structure.

This work is supported by DFG via SPP1166

MA 8.3 Mon 15:45 H22

X-ray diffraction and quadratic MOKE-measurements on Co_2MnSi-alloys — •Sebastian Hermsdörfer[1], Oksana Gaier[1], Yuya Sakuraba[2], Jaroslav Hamrle[1], Yasuo Ando[2], Burkard Hillebrands[1], and Terunobu Miyazaki[2] — [1]Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, Erwin-Schrödinger-Str. 56, 67661 Kaiserslautern, Germany — [2]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Aoba-yama 6-6-05, Aramaki, Aoba-ku, Sendai 980-8579, Japan

Heusler alloys are attracting more and more attention due to their theoretical spin polarization of up to 100 % at the Fermi level. The full Heusler alloy Co_2MnSi should have a theoretical spin polarization of 100 % in its $L2_1$-structure whereas the spin polarization should be lower for the B2-structure.

In this talk, the influence of the B2 to $L2_1$ transition on the magnetic properties of the Heusler alloy Co_2MnSi is reported. The transition from one structure to the other is obtained by different post-growth annealing temperatures. The crystal structure itself was determined by X-ray diffraction measurements and shows the transition between the two ordered states. Quadratic MOKE measurements have been carried out for studying the magnetic properties and show a distortion of the cubic crystal structure in the transition phase.

The work was supported by the Research Unit 559 "New materials with high spin polarization" funded by the Deutsche Forschungsgemeinschaft and by the NEDO Grant.

MA 8.4 Mon 16:00 H22

Influence of the B2 to $L2_1$ phase transition on exchange interaction and coercive field in the Co_2MnSi Heusler compound — •Oksana Gaier[1], Jaroslav Hamrle[1], Sebastian Hermsdörfer[1], Burkard Hillebrands[1], Yuya Sakuraba[2], and Yasuo Ando[2] — [1]Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, Erwin-Schrödinger-Straße 56, 67663 Kaiserslautern, Germany — [2]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Aoba-yama 6-6-05, Aramaki, Aoba-ku, Sendai 980-8579, Japan

It has been shown theoretically that the spin polarization of the Heusler compound Co_2MnSi is very sensitive to the atomic disorder in the crystal lattice. We have investigated the influence of the disorder between Mn and Si sites on the magnetic properties of thin epitaxial Co_2MnSi films with crystal structures varying from B2 to $L2_1$ phases. The phase transition between B2 and $L2_1$ was obtained by different annealing temperatures of the sample after its deposition. Brillouin light scattering studies show very small changes of the exchange stiffness constant and the saturation magnetization upon the B2 to $L2_1$ phase transition. On the other hand, magneto-optical magnetometry reveals that the anisotropy energy gradually decreases when the crystal structure changes from B2 to $L2_1$.

The work was supported by the DFG in the Research Unit 559 and

by the NEDO project 2004IT093 of the Japanese government

MA 8.5 Mon 16:15 H22

Electronic structure, magnetism, and disorder in the Heusler compound Co_2TiSn — •Hem Chandra Kandpal[1], Vadim Ksenofontov[1], Marek Wojcik[2], Ram Seshadri[3], and Claudia Felser[1] — [1]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität, Staudinger Weg 9, 55099 Mainz, Germany — [2]Institute of Physics, Polish Academy of Sciences, Al. Lotnikow 32/46, 02-668 Warszawa, Poland — [3]Materials Department and Materials Research Laboratory, University of California, Santa Barbara, CA 93106, USA

Polycrystalline samples of the Heusler compound Co_2TiSn have been prepared and studied using bulk techniques (X-ray diffraction and magnetization) as well as local probes (^{119}Sn Mössbauer spectroscopy and ^{59}Co nuclear magnetic resonance spectroscopy) in order to determine how disorder affects half-metallic behavior and also, to establish the joint use of Mössbauer and NMR spectroscopies as a quantitative probe of local atom ordering in these compounds. Additionally, density functional electronic structure calculations on ordered and partially disordered Co_2TiSn compounds have been carried out at a number of different levels of theory in order to simultaneously understand how the particular choice of DFT scheme as well as disorder affect the computed magnetization. Our studies suggest that a sample which seems well-ordered by X-ray diffraction and magnetization measurements can possess up to 10% of antisite (Co/Ti) disordering. Computations similarly suggest that even 12.5% antisite Co/Ti disorder does not destroy the half-metallic character of this material.

MA 8.6 Mon 16:30 H22

Mössbauer and NMR study of Heusler alloy $Co_2Mn_{1-x}Fe_xSi$ — •Vadim Ksenofontov[1], Hem Chandra Kandpal[1], Marek Wojcik[2], Benjamin Balke[1], and Claudia Felser[1] — [1]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität, Staudinger Weg 9, 55099 Mainz, Germany — [2]Institute of Physics, Polish Academy of Sciences, Al. Lotnikow 32/46, 02-668 Warszawa, Poland

The Heusler alloys $Co_2Mn_{1-x}Fe_xSi$ have recently attracted particular interest due to the unique possibility to tune the spin polarization by varying the Mn/Fe fraction. The calculated band structures show the shift of the Fermi energy from the top of the minority valence band for Co_2MnSi to the bottom of the minority conduction band for Co_2FeSi upon Fe doping. From computational results it has been predicted that a compound with an intermediate Fe concentration of about 50% should be best suited for spintronic applications. These theoretical findings still require experimental proofs. We report on ^{57}Fe Mössbauer spectroscopic, ^{59}Co and ^{55}Mn NMR studies of hyperfine magnetic fields (HFF) in $Co_2Mn_{1-x}Fe_xSi$ ($0 \leq x \leq 1$). The hyperfine magnetic field on Fe atoms is non-monotonic and shows maximum at $x = 0.5$. We argue that the maximum value of the HFF found on Fe and Co atoms at $x = 0.5$ is due to the existence of maximal spin-polarization in $Co_2Mn_{0.5}Fe_{0.5}Si$. Experimentally found HFF values are compared with results following from electronic band structure calculations taking into account electronic correlations (LDA+U).

MA 8.7 Mon 16:45 H22

A spatially resolved investigation of the local, micro-magnetic domain structure of single and polycrystalline Co_2FeSi. — •Andrei Gloskovskii[1], Joachim Barth[1], Benjamin Balke[1], Gerhard Fecher[1], Claudia Felser[1], Florian Kronast[2], Ruslan Ovsyannikov[2], and Gerd Schönhense[3] — [1]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg - Universität Mainz, D-55099 Mainz, Germany — [2]BESSY GmbH, Albert-Einstein-Straße 15, 12489 Berlin, Germany — [3]Institut für Physik, Johannes Gutenberg - Universität Mainz, D-55099 Mainz, Germany

The Heusler compound Co_2FeSi is a promising material for magneto-electronic devices. With a Curie temperature of 1100 K and a saturation magnetisation of 6 Bohr magnetons and a high spin polarisation at the Fermi edge it fulfils the essential requirements for magnetic sensors or spin valve structures. An essential feature for such devices is the micro-magnetic domain structure. XMCD-PEEM has been used for a direct observation of the domain structure of single- and polycrystalline samples. The (110)-oriented surface of the single crystal exhibits a multi-domain pattern characteristic for systems with an easy axis that might point out of the surface. Spin polarised photo emission from a single domain of the single crystal shows a spin polarisation of 16% at the Fermi energy and up to 35% in the *d*-bands, at room temperature.

MA 8.8 Mon 17:00 H22

Sr_2CrOsO_6: Spin polarized metal-insulator transition by $5d$ band filling — Yoshiharu Krockenberger[1,2], Kaylash Mogare[2], Manfred Reehuis[2,3], Martin Tovar[3], Martin Jansen[2], Ganapathy Vaitheeswaran[4], Venkata Kanchana[4], Anna Delin[4], Fabrice Wilhelm[5], Andrei Rogalev[5], Andreas Winkler[1], and •Lambert Alff[1] — [1]Institut für Materialwissenschaft, TU Darmstadt — [2]Max-Planck-Institut für Festkörperforschung, Stuttgart — [3]Hahn-Meitner-Institut, Berlin — [4]Department of Materials Science and Engineering, KTH Stockholm — [5]European Synchrotron Radiation Facility (ESRF), Grenoble

In the search for new spintronic materials with high spin-polarization at room-temperature, we have synthesized an osmium based double perovskite with a Curie-temperature of 725 K. Our combined experimental results confirm the existence of a sizable induced magnetic moment at the Os site, supported by band-structure calculations in agreement with a proposed kinetic energy driven mechanism of ferrimagnetism in these compounds. The intriguing property of Sr_2CrOsO_6 is that it is at the endpoint of a metal-insulator transition due to $5d$ band filling, and at the same time ferrimagnetism and high-spin polarization is preserved.

[1] Y. Krockenberger, K. Mogare, M. Reehuis, M. Tovar, M. Jansen, G. Vaitheeswaran, V. Kanchana, F. Bultmark, A. Delin, F. Wilhelm, A. Rogalev, A. Winkler, and L. Alff. Phys. Rev. B, Rapid Comm. (2007).

MA 9: Anisotropy/Magnetoelasticity

Time: Monday 17:15–18:30 Location: H22

MA 9.1 Mon 17:15 H22

A novel approach to induce biaxial stress on magnetic thin films and its influence on the Magnetic anisotropy — •Jorge Enrique Hamann, Senthilnathan Mohanan, and Ulrich Herr — Institute for Micro and Nanomaterials, University of Ulm, Ulm-89081, Germany

Magnetic thin films and multilayers exhibiting perpendicular anisotropy (PA) are the promising candidates for the perpendicular magnetic recording media and solid state magnetic memory. Stress induced magnetic anisotropy plays a major role for PA in magnetic-noble metal multilayer systems. The main aim of this study is to investigate the influence of biaxial stress on the magnetic anisotropy of thin films with positive and negative magnetostriction constants, namely CoFe alloy and Ni. In this study, we introduce a novel way to induce biaxial in-plane stress on to the thin films. We deposited magnetic thin films on Ta substrate and an isotropic biaxial stress is introduced in the magnetic thin films by loading the Ta substrate with H2. Films with varying biaxial tensile stress are produced by changing the H2 loading time. We measured the influence of biaxial tensile stress with the corresponding change in the out of plane hysteresis loop measurement. We observed a gradual change in the slope of M(H) curve in case of CoFe, and of saturation field in case of Ni, which correlates well with varying stresses induced in the film. We made a quantitative analysis of the data using a micromagnetic model with which we estimated the values for corresponding magnetostriction constant and crystalline anisotropy.

MA 9.2 Mon 17:30 H22

Effects of uniaxial stress on the properties of giant magnetoresistive sensors on polyimide substrates — •Berkem Özkaya, Srinivasa Rao Saranu, Senthilnathan Mohanan, and Ulrich Herr — Institute for Micro and Nanomaterials, University of Ulm, D-89081, Germany.

The change in the sensitivity of giant magnetoresistive (GMR) sensors

on polyimide substrate was demonstrated. Applying uniaxial stress on magnetic layers leads to stress induced anisotropy. Initially, we investigated stress effects on single Co thin film prepared by DC magnetron sputtering, which exhibits macroscopic in-plane easy axis induced by the preparation process. In-situ magnetisation curves in the stressed state were obtained by using MOKE magnetometer. When stress is applied perpendicular to induced in-plane easy axis, coercivity field (Hc) and remanent magnetisation (Mr) are decreasing, and saturation field (Hs) is increasing. For [Cu/Co]15 multilayer exhibiting ˜20% GMR value, it is observed that when the stress is applied parallel to the external magnetic field (Hext), Hs is increasing and the GMR remains constant, resulting in a reduced sensitivity. On the other hand, when the stress is applied perpendicular to Hext, we observed that Hs is decreasing and the GMR remains constant, resulting in a increased sensitivity. For trilayer system of Co/Cu/Ni in which Co is positive and Ni is negative magnetostrictive layer, applying stress leads to reverse rotation of magnetisation in both magnetic layers. When the stress is applied parallel to Hext, the GMR is decreasing, and Hs is increasing, resulting in a reduced sensitivity.

MA 9.3 Mon 17:45 H22

Magnetische Anisotropie von epitaktischen Fe_3Si-Filmen auf MgO(001) — •Florian Römer, Khalil Zakeri, Jürgen Lindner, Michael Farle, Natalia Utochkina und Werner Keune — Fachbereich Physik und Centre for Nanointegration (CeNIDE), Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

Epitaktische Fe_3Si-Filme mit Dicken zwischen 5 und 50 nm wurden mittels Ferromagnetischer Resonanz und Magnetooptischen Kerreffekt bei Raumtemperatur untersucht. Die Beiträge zur magnetischen Anisotropie wurden separiert und quantitativ bestimmt.

Neben einer dickenunabhängigen dominierenden kubischen Anisotropie $K_4 = 27,5 \cdot 10^2$ J/m^3 im Volumen, wurde eine schwache uniaxiale Anisotropie in der Filmebene $K_{2\parallel}$ gefunden, die auf Grenzflächeneffekte zurückzuführen ist. Bei 5 nm Filmdicke ist $K_{2\parallel} \approx K_4/10$. Das effektive Entmagetisierungsfeld M_{eff} wird neben der Magnetisierung, die gegenüber dem Volumenwert von Fe_3Si um etwa 30% reduziert ist, von einem uniaxialen Anisotropiebeitrag senkrecht zur Filmebene beeinflusst. Letzterer kann auf die tetragonale Verzerrung des Filmes aufgrund des epitaktischen Wachstums zurückgeführt werden.

Unterstützt durch DFG, Sfb 491.

MA 9.4 Mon 18:00 H22

Nonlinear magnetoelastic coupling coefficients in strained Fe, Co and Ni monolayers — •Zhen Tian, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik,

Magnetoelastic (ME) coupling in magnetic thin films has an essential influence on the magnetic anisotropy. The experimental results[1] in recent years indicate a second-order ME coupling effect in thin films with large epitaxial strain. It is the goal of this study to extend the experiments to compressive strain. We deposited Fe, Co and Ni films on Ir(100) in the thickness range 0.1 to 10 nm. Film stress and ME stress were measured by the optical beam bending method[1]. The magnetic films show large film stress of the order GPa due to the mismatch between the film and the substrate, and we deduce a large epitaxial strain of the order percent in the films. We investigate the correlation between film stress, strain and the ME coupling. Our results indicate that ME coupling coefficients B_1 of Fe films and B_2 of Co and Ni deviate from the bulk value and depend on the film strain ϵ. The experimental results can be fitted with an effective strain-dependent ME coupling coefficient B_i^{eff} with $B_i^{eff} = B_i + D^{eff}\epsilon$. Our analysis shows that the nonlinear coefficient D^{eff} is much larger than the first order coupling term B_i. For Co we obtain $B_2 = 5.8\frac{MJ}{m^3}$ and $D^{eff} = 275\frac{MJ}{m^3}$, while the bulk value is $7.7\frac{MJ}{m^3}$. Our results are discussed in view of recent theoretical predictions[2].

[1] D. Sander: Rep. Prog. Phys. **62**, 809(1999).
[2] M. Fähnle, M. Komelj: Phys. Rev. B, **65**, 212410 (2002); M. Fähnle, M. Komelj: Phys. Rev. B, **73**, 012404 (2006).

MA 9.5 Mon 18:15 H22

The Magnetoelastic Paradox — •Manuel Zschintzsch[1], Dirk C. Meyer[1], Günter Behr[2], Jan Prokleska[3], Herwig Michor[4], Mathias Doerr[5], Michael Loewenhaupt[5], and Martin Rotter[6] — [1]ISP, TU Dresden, Germany — [2]IFW, Dresden, Germany — [3]Charles University, Prague, Czech Republic — [4]TU-Wien, Austria — [5]IFP TU-Dresden, Germany — [6]IPC, Universität Wien, Austria

The Magnetoelastic Paradox [1] describes the difference between the low temperature magnetoelastic behavior of antiferromagnetic compounds and the theoretical predictions due to the spin interactions. While studying the behavior at an atomic scale it's important to separate the different kinds of interactions, in our case domain effects, single ion contributions and spin interactions.

Accordingly our measurements were performed on antiferromagnetic Gd based compounds: Due to antiferromagnetism domains don't have to be considered. Additionally Gd exhibits no magnetic orbital momentum. Thus, single-ion contributions to the magnetoelastic behaviour don't occur. The alloying partners were chosen in a way that they have no, or only weak magnetic moments. All magnetoelastic effects which can be seen from our X-ray diffraction experiments can be attributed to spin interaction of Gd exclusively. We measured the temperature dependend lattice parameters and peakwidths in the temperature range of 15 to 300K. The experimentally determined absence of symmetry breaking distortions (no changes of peakwidth detected) at the Neel-temperature leads to the existence of the magnetoelastic paradoxon.

[1] M. Rotter et al. *Europhys. Lett.* 75, 160-166 (2006)

MA 10: Spinelectronics/Spininjection in Heterostructures

Time: Monday 15:15–19:00 Location: H23

MA 10.1 Mon 15:15 H23

Remanent spin injection and spin density distribution in a spin FET structure — •Philipp Kotissek[1], Matthieu Bailleul[2], Matthias Sperl[1], Alexander Spitzer[1], Dieter Schuh[1], Werner Wegscheider[1], Christian Back[1], and Günther Bayreuther[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]IPCMS/GEMME, 23 rue du Loess, BP 43, 67034 Strasbourg, France

The spin field-effect transistor first proposed by Datta and Das is considered to be the paradigm of spintronic devices. Spin injection and detection are the main requirements for the implementation of such a device. Electric spin injection has recently been achieved by inserting a Schottky barrier or a tunnel barrier between a ferromagnetic metal source contact and the semiconductor. The detection techniques used up to now require large magnetic fields, or they only measure a transient component of the polarization. Here we introduce a novel optical spin detection method from a cleaved edge of the semiconductor wafer which allows us to visualize directly electrical spin injection into GaAs from a magnetically soft FeCo film at remanence. The spin polarization can be reversed by a small magnetic field. Moreover, we could quantitatively determine the dependence of the spin polarization of the current on the injection energy. The local spin density distribution in the semiconducting channel including depth profiles for different geometries can be directly accessed. This method will be particularly useful for the future development of semiconductor-based spintronic devices.

MA 10.2 Mon 15:30 H23

First-principles calculations of conduction electron's spin relaxation time — •Dmitry Fedorov, Peter Zahn, and Ingrid Mertig — Institut für Physik, Martin-Luther-Universität Halle, D-06099 Halle/Saale, Germany

To inject, transfer and detect spin currents in the framework of spintronics, it is decisive to know how long conduction electrons 'keep' their spin state. As it was proposed by Elliott [1] and Yafet [2] and later confirmed by any experimental investigations, the dominant relaxation mechanism at low temperatures is caused by spin-orbit interaction of the conduction electrons with impurities.

We have performed ab initio calculations of the spin relaxation time of conduction electrons in transition metals containing different types

of impurities. A screened KKR Green's function method based on density functional theory was applied to these studies. The obtained results are in good agreement with conduction electron spin resonance (CESR) experiments.
[1] R.J. Elliott, Phys. Rev. **96**, 266 (1954)
[2] Y. Yafet, in Solid State Physics, Vol. 14, F. Seitz and D. Turnbull, Eds. (Academic Press, New York, 1963)

MA 10.3 Mon 15:45 H23

Exchange Interactions in Dilute Magnetic Semiconductors: Local Environment Effects — •Peter Dederichs[1], Kazunori Sato[2], and Hiroshi Katayama-Yoshida[2] — [1]IFF, Forschungszentrum Jülich, 52425 Jülich — [2]ISIR, Osaka University, Ibaraki, Osaka 567-0047, Japan

The ferromagnetism in dilute magnetic semiconductors like (Ga, Mn) As is due to the exchange interactions Jij between neighboring Mn impurities. The disorder in these systems is usually described by the powerful coherent potential approximation (CPA). Thus, the exchange interactions Jij are also usually calculated by applying Lichtenstein's formula and using the CPA Green function Gij between the sites i and j. Here we investigate the validity of this approach, by embedding a whole cluster of impurities around the atoms i and j into the CPA medium, and by explicitly calculating the resulting exchange interactions as a function of the disordered environment. We find large fluctuations of the Jij values depending on the positions of neighboring third and fourth impurities. Upon ensemble averaging significant deviations from the standard Lichtenstein-CPA formula are obtained, in particular for small distances i-j and small concentrations. However good agreement with the ensemble average is obtained, if we replace the Green functions by the one for the impurity pair (i, j) properly embedded in the CPA medium. We discuss the reason for the failor of the standard approach in the dilute limit.

MA 10.4 Mon 16:00 H23

First-principles studies on co-doping effects in dilute magnetic semiconductors — •Sanjeev Kumar Nayak[1], Markus Ernst Gruner[1], Hisazumi Akai[2], and Peter Entel[1] — [1]Physics Department, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany — [2]Department of Physics, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan

Dilute magnetic semiconductors are a special class of materials that have high spin polarization at the Fermi level, and hence are promising materials for spintronics applications. The occurrence of room temperature ferromagnetism in these materials makes it interesting for practical applications. Recently, giant magnetic moments per dopant atom in experiments for Co doped ZnO [1] and the Gd doped GaN [2] were observed. We present theoretical studies for Co doped ZnO and Gd doped GaN done using the density functional theory together with the PAW method using Vienna ab-initio simulation package. We explore co-doping with other elements like N and Al to study the influence of defects. Furthermore, transport calculations of these systems using the KKR-CPA-LDA aproach are presented.
[1] C. Song et al., Phys. Rev. B, 73, 024405 (2006)
[2] S. Dhar et al., Appl. Phys. Lett. 89, 062503 (2006)

MA 10.5 Mon 16:15 H23

Ultrafast spin and magnetization dynamics in diluted magnetic semiconductors — •Klaus Schmalbuch[1], Johannes Bongers[1], Bernd Beschoten[1], Gernot Güntherodt[1], Nicoleta Kaluza[2], Hilde Hardtdegen[2], Thomas Schäpers[2], Mariana Ungureanu[3], and Heidemarie Schmidt[3] — [1]II. Physikalisches Institut, RWTH Aachen and Virtuelles Institut für Spinelektronik VISel, Templergraben 55, 52056 Aachen — [2]Institut für Bio- und Nanosysteme IBN-1, Forschungszentrum Jülich, 52425 Jülich — [3]Institut für Experimentelle Physik II, Universität Leipzig, Linnéstraße 5, 04103 Leipzig

GaN and ZnO are promising material systems for applications in spin-electronics, since they provide extended electron spin coherence times because of their weak spin-orbit coupling. Furthermore these materials might become room temperature ferromagnets upon magnetic doping. To explore the influence of magnetic dopants on the ultrafast spin and magnetization dynamics in these semiconductors, we performed optical fs-pump-probe measurements on Cr-doped GaN and Gd-doped ZnO samples.

The results for the magnetically doped samples are qualitatively different in both systems: electron spin coherence in GaN is not affected by doping Cr at low concentrations. In ZnO:Gd dephasing times of conduction electrons are reduced compared to undoped ZnO. In addition we observe high frequency coherence at ps time scales which arises from the coherent sp-d exchange interaction between the local Gd moments and the conduction electrons. *Work supported by HGF*

MA 10.6 Mon 16:30 H23

Thermal phase transformation and perpendicular exchange coupling of Co nanocrystals embedded in ZnO — •Shengqiang Zhou, Kay Potzger, Wolfgang Skorupa, Manfred Helm, and Jürgen Fassbender — 1Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany

Recently, due to the potential application in spintronics, ferromagnet-semiconductor hybrid structures have attracted huge attention [1]. Large magnetoresistance was observed in GaAs consisting MaAs nanocrystals and granular ZnO/Co systems [2, 3]. Wide-band-gap semiconductors (e.g. ZnO) doped with transition metals were reported to be diluted magnetic semiconductors with Curie temperatures above room temperature [4]. However, the origin of the observed ferromagnetism is still controversial. In this work, Co nanocrystals (NCs) were formed inside ZnO by ion implantation. The Co NCs are crystallorgraphically oriented inside ZnO. The magnetic properties, e.g. anisotropy and blocking temperature, can be tuned by annealing. In the as-implanted and annealed (823 K) samples, Co NCs have been found and show superparamagnetism. After annealing at 923 K, the sample exhibits a much higher blocking temperature and shows a perpendicular exchange bias effect. The semiconducting ZnO consisting of Co NCs could be a promising hybrid for spin-injection. 1.Ohno, Semicond. Sci. Technol. 17, 275 (2002). 2.Wellmann, et al., App. Phys. Lett. 73, 3291 (1998). 3.Pakhomov, et al., J. App. Phys. 95, 7393 (2004). 4.MacDonald, et al., Nat. Materials 4, 195 (2005).

MA 10.7 Mon 16:45 H23

First-principles prediction of high Curie temperature for ferromagnetic bcc-Co and its relation to Co/MgO/Co magnetic tunnel junctions — •Phivos Mavropoulos, Marjana Ležaić, and Stefan Blügel — IFF, Forschungszentrum Jülich, Jülich, Germany

We determine from first principles the Curie temperature of bulk Co in the ground state hcp phase and the metastable fcc and bcc phases. For fcc-Co we found a Curie temperature of T_C(fcc-Co) = 1280 K, in reasonable agreement with experimental results. For bcc-Co, a Curie temperature of T_C(bcc-Co) = 1400 K is predicted. This suggests that bcc-Co/MgO/bcc-Co tunnel junctions offer high tunneling magnetoresistance ratios even at elevated temperatures, giving them an advantage over Fe/MgO/Fe junctions. T_C(bcc-Co) appears robust under tetragonalization upon epitaxial growth on MgO, in contrast to Fe for which T_C(bcc-Fe) is found to drop by more than 20% (from 970 K to 750 K) upon such a tetragonalization. We find that FeCo alloys have an even higher T_C, as high as 1660 K for ordered FeCo. We discuss the origin of these effects in terms of the electronic structure and densities of states. The Curie temperatures are calculated by mapping *ab initio* results to a Heisenberg model, which is solved by a Monte Carlo method.

MA 10.8 Mon 17:00 H23

Magnetic and transport properties of embedded magnetic cells for a front-end-of-line MRAM design — •Thomas Uhrmann[1], Theodoros Dimopoulos[1], Christoph Stepper[1], Ludwig Bär[2], Uwe Paschen[3], and Hubert Brückl[1] — [1]Austrian Research Centers GmbH - ARC, Nano System Technologies, Donau-City-Str. 1, 1220 Wien, Austria — [2]Siemens AG, CT MM1, Paul-Gossen-Str. 100, 91052 Erlangen, Germany — [3]Fraunhofer Gesellschaft, Finkenstrasse 61, 45057 Duisburg, Germany

A non-conventional, front-end MRAM design will be presented, based on spin-polarized current injection and detection by adjacent magnetic cells through the semiconductor. Magnetic cells of: tunnel barrier (MgO)/ ferromagnet (CoFe or CoFeB)/ capping, are sputtered on the properly doped Si, inside holes formed in SiO_2 dielectric.
Here we will focus on the characterization of the embedded sub-μm Metal/ Insulator/ Semiconductor(MIS)-tunneling diodes dedicated for spin injection and detection. The magnetic properties of the cells were characterized by magneto-optical Kerr effect, combined with micromagnetic simulations. The thermal stability of the multilayer was verified for annealing conditions up to 550°C. Finally, we used temperature dependent current-voltage and capacitance-voltage measurements to study the electrical transport properties of isolated cells and injector-detector pairs. From these measurements we extract informa-

tion regarding the quality of the tunnel barrier/silicon interface, which is crucial in order to attain high current spin polarization in silicon.
We acknowledge support from the EU project EMAC-Strep 017412.

MA 10.9 Mon 17:15 H23

The effect of flash lamp annealing on Fe implanted ZnO single crystals — •Kay Potzger, Wolfgang Anwand, Helfried Reuther, Shengqiang Zhou, Georg Talut, Gerhard Brauer, Wolfgang Skorupa, Manfred Helm, and Jürgen Fassbender — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany

Doping of semiconductors with transition metals for the creation of diluted magnetic semiconductors (DMS) recently attracted great attention. For doping of the wide band gap semiconductor ZnO, high temperature processing often leads to diffusion and the formation of unwanted secondary phases. We investigate a combined approach far from thermal equilibrium, i.e. low temperature ion implantation combined with flash lamp annealing. Therefore, ZnO single crystals have been implanted with 3.6 at. % Fe at a temperature of 200 K and flash lamp annealed at a pulse length of 20 ms. For intermediate light power, the implantation induced surface defects could be annealed without creation of secondary phases within the implanted region. At the same annealing temperatures, however, ion beam induced open volume defects start to increase in size. Recrystallization is initiated for the highest light power applied, i.e. the ion beam induced lattice disorder reflected by the minimum channelling yield of Rutherford backscattering spectroscopy decreasing from 76 % to 46 % and the open volume defects are decreased in size. At the same time, the Fe3+ fraction increases at the cost of the Fe2+ states. Weak ferromagnetic properties are induced, that are mainly associated with nanoparticles.

MA 10.10 Mon 17:30 H23

Hot electron transport in fully epitaxial FeCo/Au/FeCo-spin-valves using (Scattering) Ballistic Electron Magnetic Microscopy — •Emanuel Heindl, Christian Back, and Johann Vancea — Department of Physics, Universität Regensburg, D-93040 Regensburg

The transport of nonequilibrium (hot) electrons in FeCo/Au/FeCo spin-valves epitaxially grown on n-GaAsP has been studied at room temperature by the local technique (scattering) ballistic electron magnetic microscopy BEMM (SBEMM).

A STM-tip injects hot electrons into the spin-valve (BEMM-mode), where they undergo spin-dependent scattering processes. Thus the inelastic decay of the nonequilibrium electrons varies for parallel and antiparallel magnetization configuration of the spin-valve. On our fully epitaxial FeCo/Au/FeCo spin-valves we obtained magnetocurrent effects of up to 600% and relative high transmission values compared to similar studies. Unwanted scattering processes within the spin-valve are reduced to a minimum due to its epitaxial structure.

By reversing the tunnel-voltage hot holes are injected into the spin-valve (scattering BEMM-mode). In this mode a signal can only be created via the excitation of electron hole pairs. This excitation spectroscopy (SBEMM) gives insights into the electron-electron-scattering processes within the spin-valve. On our epitaxial spin-valve we also found a dependence on the magnetization configuration of the spin-valve with magnetocurrents of several hundred percent.

MA 10.11 Mon 17:45 H23

Investigation of different Mn states in $Ga_{1-x}Mn_xAs$ by HX-PES — •Benjamin Schmid[1], Andreas Müller[1], Michael Sing[1], Jan Wenisch[2], Karl Brunner[2], Laurens Molenkamp[2], Wolfgang Drube[3], and Ralph Claessen[1] — [1]Lehrstuhl für Experimentelle Physik IV, Universität Würzburg, Germany — [2]Lehrstuhl für Experimentelle Physik III, Universität Würzburg, Germany — [3]HASYLAB, DESY, Hamburg, Germany

The complex interplay of ferromagnetic coupling and compensating effects in the diluted magnetic semiconductor (DMS) $Ga_{1-x}Mn_xAs$ ($x = 2-8\,\%$) is currently under intense discussion. Both the Curie temperature T_C and the carrier concentration induced by manganese hosted in the lattice at regular sites are reduced by interstiatial Mn. In order to minimize those defects for applications and investigate possible changes in the electronic structure under various chemical and physical surface treatments we performed bulk sensitive hard X-ray photoemission spectroscopy (HX-PES) at $h\nu = 4500\,\mathrm{eV}$. The enlarged inelastic mean free path of the photoelectrons provides an information depth of up to 5 nm. A comparison with the related system manganese arsenid, untreated and oxidized under controlled conditions, allows a direct observation of fingerprints associated with different valencies in the core levels.

MA 10.12 Mon 18:00 H23

Proof of coherent electrical spin injection across a Fe/GaAs interface — •Lars Schreiber[1], Sebastian Schulz[1], Bernd Beschoten[1], Gernot Güntherodt[1], Christoph Adelmann[2], Paul Crowell[2], and Chris Palmstrøm[2] — [1]2. Physikalisches Institut, Aachen University, Germany and Virtual Institute for Spinelectronics — [2]University of Minnesota, Minneapolis, USA

Electrical spin injection from a ferromagnet into a semiconductor was shown for different material systems [1,2] and recently even high injection efficiency for electron spins has been achieved [3]. Despite this progress, an essential ingredient for spintronics is still missing: electrical injection of *coherent* spin packets. In all-optical time-resolved measurements, coherent spins can be readily oriented using 100 fs circularly polarised laser pulses and probed by means of time-resolved Faraday rotation (TRFR) [4]. However, no time-resolved measurement of electrical spin injection has been successfully performed yet.

Therefore, we apply ns-current pulses in order to electrically inject short spin packets from a Fe injector through a reverse biased Schottky barrier into 5 μm thick bulk n-GaAs, which exhibits long spin relaxation time. Probing the injected spins in the GaAs layer with TRFR, we observe spin precession and resonant spin amplification [4] in a transverse magnetic field. This proofs the phase-coherence of the electrical injected spin packet. The result will be compared to all-optical TRFR measurements. Supported by BMBF FKZ 13N8244 and HGF.

[1] Y. Ohno, Nature **402** (1999) [2] H. J. Zhu, PRL **87** (2001)
[3] C. Adelmann, PRB **71** (2005) [4] J. M. Kikkawa, PRL **80** (1998)

MA 10.13 Mon 18:15 H23

Curie temperature vs conductivity relation: (Ga,Mn)As alloy — •Josef Kudrnovsky[1], Georges Bouzerar[2], and Ilja Turek[3] — [1]Institute of Physics AS CR, Prague, Czech Republic — [2]Institut Laue Langevin and Laboratoire Luis Neel, Grenoble, France — [3]Institute of Physics of Materials AS CR, Brno, Czech Republic

We evaluate from first principles the Curie temperature and conductivity of (Ga,Mn)As alloys at various levels of annealing, from as-grown samples to samples with very low compensation.

The Curie temperature was estimated in the framework of the local RPA approach [1] starting from the classical random Heisenberg model constructed from first-principles [2] and assuming that compensating defects are Mn-interstitials [3].

Conductivity is estimated using Kubo-Greenwood formula with the impurity-induced vertex-part [4] and assuming the antiparallel orientation of Mn(Ga) and Mn-interstitial moments. Various stages of annealing are simulated by the effective Mn-concentration and compensation ratio obtained from the experiment [5].

Assuming also a small amount of As-antisites, a good quantitative agreement between theory and experiment [5] was obtained thus giving a strong theoretical support to the carrier-induced model of ferromagnetism in (Ga,Mn)As diluted magnetic semiconductors.

References
[1] Europhysics Letters 69 (2005) 812 [2] Phys. Rev. B69 (2004) 115208 [3] Phys. Rev. B72 (2005) 125207 [4] J.Phys.: Condens. Matter 16 (2004) S5607 [5] Appl. Phys. Letters 81 (2002) 4991

MA 10.14 Mon 18:30 H23

Ferromagnetic interactions in Mn-doped magnetic semiconductors Ga(As,P) and (Al,Ga)As — •František Máca and Josef Kudrnovský — Institute of Physics ASCR, Praha, Czech Republic

The optimization of the host composition is one way for systematical theoretical search for new spintronic materials. In this contribution we study in detail the hole mediated ferromagnetism in Mn-doped Ga(As,P) and (Al,Ga)As. Mn incorporation in ternary hosts is investigated using ab initio electronic structure calculations based on the density functional theory. For a set of ordered ternary alloys we discuss the influence of lattice parameters as well as valence band off-set on the close neighbor exchange interactions. Our results predict an increase of Curie temperature for systems with larger amount of P, i.e. for materials with smaller lattice constant and with valence band edge closer to Mn d-states. For ternary alloys with a higher content of P also a reduced number of compensating impurities was predicted [1].

[1]J. Mašek at all. Phys. Rev. B (2006) in print.

MA 10.15 Mon 18:45 H23

A THEORETICAL STUDY ON HALFMETALLIC ANTIFERROMAGNETIC DILUTED MAGNETIC SEMICONDUCTORS FROM FIRST-PRINCIPLES AND STATISTICAL METHODS — •Lars Bergqvist and Peter Dederichs — Institute für Festkörperforschung, Forschungzentrum Jülich, D-525 25 Jülich, Germany

Based on electronic structure calculations and statistical methods we investigate a new class of materials for spintronic applications: halfmetallic antiferromagnetic diluted magnetic semiconductors (HMAF-DMS). As shown recently by Ogura and Akai these DMS systems contain equal amounts of low-valent and high-valent transition metal impurities, such that their local moments exactly compensate each other. We present ab-initio calculations by the KKR-CPA method and by the PAW-supercell methods, using the LDA and LDA+U methods, and show that quite a few halfmetallic antiferromagnets should exist. Our calculations demonstrate, that the exchange coupling parameters in these systems are dominated by a strong antiferromagnetic interaction between the two impurities. The Neel temperatures are calculated by Monte Carlo simulations and in mean field approximation. It is shown that the latter method strongly overestimates the critical temperatures and that the more realistic values obtained by Monte Carlo are rather low.

MA 11: Magnetic Thin Films I

Time: Tuesday 10:15–13:00 Location: H10

MA 11.1 Tue 10:15 H10

Structural and magnetic properties of epitaxial Pr-Co films with varying rare-earth content — •Ajit Kumar Patra[1,2], Volker Neu[1,2], Sebastian Fähler[1,2], Rainer Groetzschel[3], Subhankar Bedanta[4], Wolfgang Kleemann[4], and Ludwig Schultz[1,2] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, 01171 Dresden, Germany — [2]Institute for Physics of Solids, Department of Physics, Dresden University of Technology, 01062 Dresden, Germany — [3]Institute of Ion Beam Physics and Materials Research, Forschungszentrum Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [4]Angewandte Physik, Universität Duisburg-Essen, D-47048 Duisburg, Germany

Pulsed laser deposited epitaxial Pr_xCo_{100-x} (x = 8.7 to 27.6 at.%) thin films were systematically studied as a function of Pr content. Structural and magnetic measurements reveal different phases for specific composition range and in some cases the phases observed are in contrast to their bulk counterpart. Uniaxial anisotropy at room temperature is observed in all the films enabling excellent hard magnetic properties. For the optimum combination of coercivity and polarization, the measured $(BH)_{max}$ reaches values of 310 kJ/m^3, which exceeds the highest energy product value reported for RE-Co (RE = Rare Earth) systems. Temperature dependent ac susceptibilty measurements reveal that films x = 8.7 to 20.4 undergo a spin reorientation from easy axis to easy cone, but films with x = 22.9 to 27.6 maintain their uniaxial anisotropy throughout the temperature range of investigation.

MA 11.2 Tue 10:30 H10

Epitaxial Nd-Fe-B films grown on Mo buffers — •Ah-Ram Kwon, Sebastian Fähler, Volker Neu, Ruben Hühne, Bernhard Holzapfel, and Ludwig Schultz — IFW Dresden, P.O. Box 270116, D-01171 Dresden

Nd-Fe-B films are attractive for perpendicular magnetic recording due to the typically achieved c-axis texture and therefore high perpendicular anisotropy. Magnetic recording requires smooth film surfaces, in contrast to the rough morphology and discontinuous growth observed for thin films deposited on Ta or W. In order to achieve epitaxial growth with full control of the crystallite orientation, a Mo buffer layer is grown on MgO(100), MgO buffered Si(100) and TiN-IBAD(100) substrates by pulse laser deposition. Prepared directly on MgO(100) substrates, Mo grows epitaxially with a (00l) orientation and Nd-Fe-B films onto this buffer possess the desired (00l) out-of-plane orientation with one in-plane epitaxy relation. These films have smoother and continuous surfaces than earlier prepared films on Ta and the magnetic contrast reveals continuous band domains. At 520 °C, films show the largest magnetic anisotropy. Saturation magnetization reaches 1.5 T, but coercivity is low (Hc < 0.5 T) due to the continuous film microstructure. MgO buffered Si substrates behave differently from MgO substrates. MgO grows fiber textured, and Mo grows with both (110) and (100) orientations.

MA 11.3 Tue 10:45 H10

Micromagnetic analysis of the coercivity of hard magnetic $L1_0$-FePt thin films — •Dagmar Goll, Nam Hoon Goo, and Wilfried Sigle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

FePt thin films in the ordered face-centered tetragonal structure ($L1_0$-phase) have gained significant attention for ultrahigh-density magnetic recording and high-performance permanent magnets due to their outstanding intrinsic magnetic properties and their chemical stability. Starting from Fe-Pt-multilayers of different individual layer thicknesses by postannealing either highly textured or isotropic $L1_0$-FePt monolayers are formed. The formation of the $L1_0$ phase has been studied in situ during annealing by using high-resolution transmission electron microscopy. The determination of the microstructural parameters allows a quantitative correlation between the microstructure and the magnetic properties.

MA 11.4 Tue 11:00 H10

Magnetocrystalline Anisotropy in Permalloy Revisited — Lifeng Yin[1], Dahai Wei[1], Na Lei[1], •Lihui Zhou[1], Chuanshan Tian[1], Guosheng Dong[1], Xiaofeng Jin[1], Liping Guo[2], Quanjie Jia[2], and Ruqian Wu[3] — [1]Surface Physics Laboratory, Fudan University, Shanghai 200433, China — [2]Beijing Synchrotron Radiation Facility, Beijing 100049, China — [3]Department of Physics and Astronomy, University of California at Irvine, Irvine, California 92697, USA

We present our observation on the magnetic properties of Permalloy (Py) with a bcc structure1 to address the long-standing issue that why Py is a soft magnet.

bcc Py, which does not exist in nature, has been achieved on GaAs(001) by molecular beam epitaxy at 200K. It is ferromagnetic with the Tc lower than that of the conventional Py - its fcc counterpart, and with the magnetic moment almost equal to that of fcc Py. Most strikingly, depending not on the atomic structure but only on the stoichiometry of Fe and Ni of the alloy, the cubic magnetocrystalline anisotropy of bcc Py is also vanishing, which directly challenges the standard cancellation model2. The experimental result is further confirmed by first-principles electronic-structure calculations, and attributed to the charge redistribution after alloying.

1.L. F. Yin et al., Phys. Rev. Lett. 97, 067203 (2006). 2.Derek Craik, Magnetism: Principles and Applications (John Wiley and Sons, Chichester, 1995), p. 392.

MA 11.5 Tue 11:15 H10

Pinning and exchange coupling in epitaxial $SmCo_5$ films — Aarti Singh[1], •Volker Neu[1,2], Sebastian Fähler[1,2], Konstantin Nenkov[1], Ludwig Schultz[1,2], and Bernhard Holzapfel[1] — [1]IFW Dresden, P.O. Box: 2270116, 01171 Dresden, Germany — [2]Institute for Physics of Solids, Department of Physics, Dresden University of Technology, 01062 Dresden, Germany

Highly coercive $SmCo_5$ thin films (Hc = 3.6 T) were epitaxially prepared by pulsed laser deposition on Cr buffered MgO(100) substrates with two orthogonal orientations of the easy axis in the film plane [1]. Magnetic hysteresis measurements for fields applied at different in-plane angles show two steps in the demagnetisation branch. These correspond to the switching of areas with different easy axes orientation at different applied fields. Both switching fields H_{sw1} and H_{sw2} follow an inverse $\cos\theta$ behaviour, which points towards a pinning dominated magnetization process but also reveals an independent magnetisation switching for grains with perpendicular orientation. Thus the behaviour suggest, that the film consists of partially decoupled grains. On the other hand, a detailed remanence analysis results in a strong positive δJ, which is indicative of exchange coupling between grains. These two contradictory pictures can be merged by assuming

that grains with parallel c-axis form a strongly coupled network which behaves independent from the orthogonal grain network during the reversal process.

[1] A. Singh, V. Neu, R. Tamm, K. Subba Rao, S. Fähler, W. Skrotzki, L. Schultz and B. Holzapfel, APL 87, 2005, 072505

MA 11.6 Tue 11:30 H10

In-situ strain effect on extrinsic magnetotransport in polycrystalline and ste-edge-junction manganite films — •Ramesh Babu Gangineni, Kathrin Dörr, Konstantin Nenkov, Ingolf Mönch, and Ludwig Schultz — IFW, Dresden, Germany

Grain boundaries and step-edge junctions in ferromagnetic manganites $La_{0.7}A_{0.3}MnO_3$ (A = Sr; Ca) typically act as tunnel junctions for the spin-polarized transport. Variable biaxial strain applied to such a manganite sample may affect the tunnel transport, additionally to the intra-grain effect. Thin polycrystalline films of $La_{0.7}A_{0.3}MnO_3$ (A = Sr; Ca) have been grown by Pulsed Laser Deposition on $YMnO_3$ - buffered piezoelectric PMN-PT(001) substrates. Films containing step- edge junctions were grown on PMN-PT(001) substrates with etched, 600 nm high parallel steps. Magnetization measurements characterize the magnetic behaviour of the film volume. Electrical resistance has been recorded in dependence on in-situ applied reversible biaxial strain at selected temperatures, temperature and magnetic field. Favourably from practical viewpoint, the strain response of polycrystalline films is typically much less temperature-dependent than that of epitaxial films. A step-edge-junction film of $La_{0.7}Sr_{0.3}MnO_3$ shows huge (gauge factor) G values (of up to 400) in a wide temperature range and associated reduction of resistance and magnetoresistance upon piezoelectric in-plane compression of the film. Relations of microstructure, electric transport mechanism and strain effect will be discussed.

MA 11.7 Tue 11:45 H10

Magnetic superstructure in Fe/native Fe-oxide multilayers — •Sebastien Couet, Thomas Diederich, and Ralf Röhlsberger — Hamburger Synchrotron Strahlungslabor (HASYLAB) at Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg

It has been discovered recently that Fe/native Fe-oxide multilayers carry an anomalously high magnetic moment [1], the origin of which is not understood yet. We present here a study on the magnetic structure of such systems. Multilayer samples are prepared by repeated deposition of 2.3 nm of Fe and subsequent exposure to oxygen that forms a native oxide layer of about 1.6 nm. Using the isotope sensitive technique of nuclear resonant scattering of synchrotron radiation we are able to selectively probe the magnetic structure of the metallic Fe of the system. A non-collinear alignment is found between adjacent Fe layers coupled through the oxide spacer with a canting angle close to 90° in low fields. The measured magnetic field dependence shows that the spin system rotates as a rigid unit upon magnetization reversal while the coupling angle slowly decreases in high field. This behavior can be explained by a proximity magnetism model which implies an antiferromagnetically ordered oxide spacer layer [2].

[1] G.S.D. Beach et al., Phys. Rev. Lett. 91, 267201 (2003).
[2] J.C. Slonczewski, J. Magn. Magn. Mater. 150, 13 (1995).

MA 11.8 Tue 12:00 H10

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

Controlling the crystalline strain in ferromagnetic thin films is a promising approach to multifunctional spintronic devices, since crystalline and magnetic degrees of freedom are connected via magnetostrictive effects. We have investigated magnetite (Fe_3O_4) thin films grown on (001)-oriented MgO substrates by pulsed laser deposition. Upon attaching these samples to piezoelectric actuators such that the main actuator elongation is parallel to a magnetite [100] direction, the magnetic anisotropy of the Fe_3O_4 layer can be manipulated. We quantify the effect of the piezo-induced strain on the magnetic anisotropy by monitoring the dependence of the Fe_3O_4 ferromagnetic resonance spectrum on the voltage V applied to the actuator. We find that at room temperature, the in-plane and out-of-plane uniaxial magnetic anisotropy constants $K_u^{[010]}$ and $K_u^{[001]}$ can be tuned by several 10 percent and about one percent, respectively, within the range of voltages applicable to the actuator. We quantitatively compare these findings to the magneto-strictive effects expected in magnetite, using high-resolution x-ray diffraction experiments as a function of V to determine the piezo-induced crystalline strain.

MA 11.9 Tue 12:15 H10

Der Einfluss von Querfeldern auf die Domänenwandbewegung in 200nm GMR-Streifen — •Sascha Glathe und Roland Mattheis — IPHT Jena e.V., A.-Einstein-Str. 9, D-07745 Jena

Die Ummagnetisierung von 200 nm breiten und 15 nm dicken NiFe-Schichten, welche die Sensorschicht eines GMR-Stapels bilden, geschieht durch Nukleation und Bewegung von 180° Domänenwänden und wird mit Hilfe zeitaufgelöster Widerstandsmessung untersucht. Ohne Querfeld sind Felder um 12 kA/m zur Nukleation nötig. Bei dieser Feldstärke bewegt sich die Domänenwand mit einer Geschwindigkeit von 265 m/s durch den 0,5 mm langen NiFe-Draht. Ein gleichzeitig angelegtes Querfeld von 1 bis 20 kA/m führt zu einer linearen Abnahme des zur Nukleation nötigen Längsfeldes auf 4.4 kA/m. Bei steigendem Querfeld nimmt die Geschwindigkeit bis ca. 8 kA/m ebenfalls linear auf Werte um 210 m/s ab. Überaschenderweise steigt sie mit weiter ansteigendem Querfeld auf Werte von 300 m/s (bei 20 kA/m) an. Wir erklären dieses Verhalten mit dem Einfluss von Querfeldern auf die in diesen NiFe-Strukturen auftretenden Instabilitäten der Domänenwandbewegung oberhalb des so genannten kritischen Walkerfeldes.

MA 11.10 Tue 12:30 H10

GMI in galvanisch FeNiMo-beschichteten Cu-Mikrodrähte — Thomas Nentwig, Wai-Yip Man, Christian Schiefer, •Andres Gabriel Munoz und Erhard Kisker — Institut für Angewandte Physik, Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf

Die galvanische Beschichtung von Kupfermikrodrähte mit weichmagnetischen FeNiMo-Legierungen zeigt ein grosses Interesse wegen des wachsenden Bedürfnisses, immer kleinere und empfindlichere magnetische Sensoren herzustellen, die eine direkte Anwendung u.a. in der Aufbau von Navigationssysteme und in der Messung von Hirnwellenaktivitäten finden. Drähte mit Beschichtungen von 1-2 Mikrometers und einer Zusammensetzung von Fe0.22Ni0.69Mo0.09 haben unter dem Einfluss von kleinen externen Magnetfeldern bis 40 Oe und mit Wechselstromfrequenzen f > 1MHz bereits einen GMI-Quotienten von 70 % pro Oe, zusammen mit einem GMI-Maximum von bis zu 1000 % und einem Anisotropiefeld von 6-8 Oe, gezeigt. Der Effekt ist deutlich höher als die von FeNiCo- Legierungen und kann zusätzlich durch die nachträgliche Temperung unter einem Magnetfeld und die daraus folgende Modifizierung der transversalen Anisotropie verbessert werden. Die Anwesenheit von Mo spielt bei diesem Effekt eine wesentliche Rolle, dieser wird vorgestellt. Der Einfluss des Anlegens eines Magnetfeldes während der galvanischen Abscheidung auf die magnetische Anisotropie als auch auf den Verlauf der Mo-Abscheidung wird in Zusammenhang mit der Struktur und Zusammensetzung der abgeschiedenen Schichten diskutiert.

MA 11.11 Tue 12:45 H10

Magnetic ordering in amorphous nanolaminates — Panagiotis Korelis[1], •Andreas Liebig[1], Hans Lidbaum[2], Björgvin Hjörvarsson[1], and Klaus Leifer[2] — [1]Department of Physics, Uppsala University, Box-530, SE-75121 Uppsala, Sweden — [2]Department of Engineering Sciences, Uppsala University, Box-534, SE-75121 Uppsala, Sweden

The magnetic properties of $Fe_{90}Zr_{10}/Al_{70}Zr_{30}$ amorphous nanolaminates were explored using the Magneto Optical Kerr Effect. The structural quality was determined using X-ray reflectivity as well as High Resolution Transmission Electron Microscopy. The samples exhibited well-defined total-, as well as layer- thicknesses. The absence of long range order was established by X-ray diffraction, and the chemical composition by Rutherford Back scattering.

The critical temperature of the nanolaminates is extremely well defined, consistent with chemical and structural homogenity. The moment is confined within the layers and no in-plane anisotropy is observed. The ordering temperature scales with the inverse thickness of the $Fe_{90}Zr_{10}$ layers, when the coupling across the $Al_{70}Zr_{30}$ layers is weak. The critical temperature was determined to be 200 K, in the thick film limit, which is similar to the value obtained for bulk samples with the same composition.

We will discuss the influence of the interlayer coupling on the or-

dering and illustrate the presence of a dimensional crossover when the thickness of the magnetic layers reaches a critical thickness.

MA 12: Spindependent Transport I

Time: Tuesday 10:15–13:00 Location: H22

MA 12.1 Tue 10:15 H22

Spin-valve effect and spin precession in lateral all-metal spin-valve devices — •Jeannette Wulfhorst, Alexander van Staa, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstrasse 11, 20355 Hamburg (Germany)

The efficiency of electronic devices could be improved drastically by the use of spin polarized currents. Important properties like the spin precession and the spin-diffuson length can be analyzed with the help of lateral spin valves. At low temperatures and with an applied external magnetic field we examine spin valves which consist of two ferromagnetic permalloy electrodes and an aluminum strip either with or without integrated aluminum oxide tunnel barrier. A tunnel barrier can enlarge the spin polarization of the injected current [1]. Due to the shape anisotropy the electrodes are quasi-single domain and can be oriented parallel or antiparallel in an external magnetic field. To obtain the coercive fields of the electrodes we have measured the anisotropic magnetoresistance of both. The nonlocal spin-valve effect is determined by using the first electrode to inject a spin polarized current into the aluminum strip and to detect it with the aid of the other electrode [2]. With an out-of-plane external magnetic field spin precession, i.e. the Hanle-effect, is observed and fitted with the model used in Ref. [1]. We estimate a spin diffusion length in aluminum of 329 ± 19 nm.

[1] F.J. Jedema et al., Nature **416**, 713 (2002)
[2] A. van Staa and G. Meier, Physica E **31**, 142 (2006)

MA 12.2 Tue 10:30 H22

Transport properties of magnetic tunnel junctions with the quaternary Heusler alloy $Co_2Mn_{0.5}Fe_{0.5}Si$ — •Daniel Ebke[1], Jan Schmalhorst[1], Andreas Hütten[1], Günter Reiss[1], Benjamin Balke[2], and Claudia Felser[2] — [1]Thin Films and Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Institute for Inorganic and Analytical Chemistry, Johannes Gutenberg University, 55099 Mainz, Germany

Due to the half metallic character predicted by band structure calculations and because of the high Curie temperature the Heusler alloys Co_2MnSi and Co_2FeSi are promissing canditates for spintronic applications. Both alloys, as well as a multilayered Heusler electrode, have been integrated sucessfully into magnetic tunnel junctions (MTJs) in the past. In case of the multilayered electrode TMR ratios of more than 110% can be observed at 20K and about 40% at RT, respectively. Recently, Balke et al have shown band structure calculations for the quaternary Heusler alloy $Co_2Mn_{1-x}Fe_xSi$ and found a shift of the Fermy energy from the top of the valence band to the bottom of the conduction band with a increase of the Fe concentration. To enhance the TMR ratio for Heusler alloys at room temperature as well, we have integrated the Heusler alloy $Co_2Mn_{0.5}Fe_{0.5}Si$ into MTJs as the bottom electrode. We will present the resulting TMR effect amplitudes in dependence of preparation conditions and the thickness of the AlO_x barriere. The temperature dependence of the TMR ratio will be discussed in combination with magnetic and XRD measurements.

MA 12.3 Tue 10:45 H22

Temperature dependence of resistance and TMR in MgO based tunnel junctions — •Volker Drewello, Andy Thomas, and Günter Reiss — Bielefeld University, Universitätsstraße 25, 33615 Bielefeld

In magnetic tunnel junctions the widely used Alumina barriers are more and more replaced with MgO, which shows much higher TMR rates. While Alumina based junctions show quite big temperature dependence of the conductance in parallel magnetic state, it is commonly observed that this tendency is much smaller in MgO junctions.

We have prepared MgO based tunnel junctions with CoFeB electrodes. The junctions show TMR of over 140% at room temperature, which increases by a factor of 1.4 when temperature is decreased to 12 K. The parallel resistance however only changes by 8% so that the chance of the TMR is mainly the change of the anti parallel resistance. This behavior is also observed in MgO junctions with higher TMR and different electrode materials [1, 2].

Different existing models for the TMR temperature dependence of these junctions are discussed. We will see that that these can describe the MgO junctions temperature dependence but the physical meaning of the parameters used remains unclear. Therefore, we will present a modified model with convincing results.

[1] S.S.P. Parkin et. al., Nat. Mat. **3**, 862 (2004)
[2] T. Ishikawa et. al., Appl. Phys. Lett. **89**, 192505 (2006)

MA 12.4 Tue 11:00 H22

Electronic structure of Fe/MgO_x interfaces studied by photoemission — •Martina Müller, Frank Matthes, and Claus Schneider — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52428 Jülich, Germany

Ferromagnet/insulator (FM/I) systems have experienced a long-term interest by providing fundamental insights in the physics of spin-dependent transport. A critical factor concerns the electronic structure of the FM/I boundary which is considered to act decisive on the tunneling spin-polarization. Whereas the interface of nearly stoichiometric Fe/MgO systems is well characterized, the interaction mechanisms with off-stoichiometric MgO_x barriers remain concealed so far.

We present results on modifications of the Fe(001) 3*d* electronic structure at Fe/MgO_x interfaces resulting from variations of the MgO_x stoichiometry. Spin- and angle-resolved photoemission spectroscopy experiments have been performed at low photon energies (< 40eV) at the beamline U250-PGM of the storage ring DELTA (Germany). Fe(001)/GaAs samples have been prepared under UHV conditions covered with ultrathin MgO_x layers. Their degree of oxidation was monitored via Mg 2*p* core-level shifts. We found a noticeable dependence of the magnitude of the interfacial spin-polarization P on the MgO_x degree of oxidation. P is strongly enhanced for oxygen-deficient MgO_x overlayers, whereas it drops down in case of an oxygen excess at the interface. We ascribe these findings to well-defined chemical bonding mechanisms between the Fe 3*d* and O 2*p* electronic states, thereby taking into account the particular occupancy of the MgO_x lattice sites.

MA 12.5 Tue 11:15 H22

Spin Polarization at the Co / MgxO1-x interface: the influence of interface stoichiometry — •Frank Matthes[1], Liu-Niu Tong[2], Martina Müller[1], and Claus M. Schneider[1] — [1]Institute of Solid State Research, Research Centre Jülich, 52425 Jülich, Germany — [2]Institute of Material Science and Engineering, Anhui University of Technology, Ma-An-Shan, 243002, Anhui, China

One decisive factor for the functionality of single crystalline magnetoresistive tunnelling junctions, like Fe/MgO/Fe or Co/MgO/Co, are the spin transport properties through the interface between ferromagnet and isolator. In this study, we extended our earlier studies of Fe/MgO to the Co/MgO system, because i) the affinity to form oxides at the interface should be less compared to Fe/MgO , ii) theoretically, a higher tunnelling magnetoresistive ratio is predicted and iii) we want to compare the results of both systems. We modified the interfacial bonding conditions by precisely controlling the amount of oxygen offered during growth of MgO. Utilizing spin polarized valence band photoemission spectroscopy, we studied the electronic band structure of bct Co and monitor its modification upon the coverage with MgO layers of different stoichiometries. Upon coverage with MgO of correct stoichiometry, we determined an unexpected attenuation of the spectral weight for transitions originating from $\Delta 5$ spin down initial states. The oxygen deficiency in MgO caused a positive increase in the measured spin polarization. Analogue observations existing in the Fe/MgO system lead to the assumption that similar mechanism is responsible for the observed effects in both systems.

MA 12.6 Tue 11:30 H22

FIB-structured nanoconstrictions for the study of domain wall magnetoresistance — •Daniel Stickler[1], Robert Frömter[1], Holger Stillrich[1], Yun Zhou[2], Genhua Pan[2], and

Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg , Germany — [2]CRIST, Faculty of Technology, University of Plymouth, Plymouth, Devon PL4 8AA, UK

Several fundamentally and technologically interesting physical effects emerge when spin polarized currents in a ferromagnet pass through a laterally confined domain wall. We pursue different approaches for the fabrication of suitable structures for domain wall pinning which are based upon direct FIB (Focused Ion Beam) structuring. Our FIB is operating under ultrahigh vacuum condition. While the lateral resolution for imaging is 6 nm, the smallest structures written so far are 20nm. First results on 70 nm wide constrictions in a current in plane (CIP) geometry are presented. The experiments have been performed in a homogenous external field. Specifically shaped magnetic pads are used as a spin reservoir for injection. In 3 nm Ta / 8 nm NiFe / 3 nm Ta multilayers characteristic jumps in the magneto resistance (MR) are found which indicate the controlled injection of a domain wall into the constriction. We have also investigated the magneto resistance in a current perpendicular to plane (CPP) geometry. A cobalt point contact (smaller than 30 nm) has been fabricated by filling a pinhole milled into a silicon-nitride membrane. Financial support by the EU via EU04-586 "BMR" is gratefully acknowledged.

MA 12.7 Tue 11:45 H22

Current induced domain wall motion and domain wall transformations observed with XMCDPEEM — •Lutz Heyne, Dirk Backes, Markus Laufenberg, Mathias Kläui, and Ulrich Rüdiger — Universität Konstanz, 78457 Konstanz

While current-induced domain wall motion (CIDM) has been known theoretically [1] as well as experimentally, only recently controlled current-induced motion of single domain walls has been observed.

In this work we investigate CIDM in zig-zag permalloy wires of different dimensions. To image the magnetization configuration, x-ray magnetic circular dichroism photoemission electron microscopy (XMCDPEEM) is used. By imaging the magnetization contribution we can estimate an average domain wall (DW) velocity and directly observe spin-torque induced transformations of the internal DW structure.

In thick wires we observe a spin-torque induced nucleation and annihilation of magnetic vortices. The velocity is found to be directly correlated to these transformations [2]. Depending on the wire dimensions, several DW configurations are stable. A periodic transformation of the DW under current from vortex to transverse and vice versa is predicted by theory [3]. In a wire where both configurations can coexist we succeeded to image different DW configurations after the current pulses in agreement with theory, we also saw intermediate states, showing the actual transformation from transverse to vortex walls.

[1] C.H. Marrows, Adv. Phys. **54** 585 (2005).
[2] M. Kläui, *et al.*, Appl. Phys. Lett. **88**, 232507 (2006).
[3] A. Thiaville *et al.*, Europhys. Lett. **69**, 990 (2005);

MA 12.8 Tue 12:00 H22

Epitaxial $Co_2Cr_{0.6}Fe_{0.4}Al$ thin films and magnetic tunneling junctions — •Andres Conca, Martin Jourdan, Christian Herbort, and Hermann Adrian — Institut für Physik, Johannes Gutenberg University, Staudinger Weg 7, 55128 Mainz, Germany

The full-Heusler compound $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA) is expected to be a half metal, i.e. to show a 100% spin polarization at the Fermi energy. This property, together with the relatively high Curie temperature (800K) and the soft magnetic behaviour make CCFA a promising candidate for implementation in spinelectronic devices.

Magnetic tunneling junctions were deposited using epitaxial CCFA thin films as ground electrode with AlOx as barrier and Co as counter electrode. The use of an Fe buffer layer on MgO(100) induces the growth of highly ordered CCFA films with smooth surface even at low deposition temperatures, as proved by XRD, TEM and in-situ STM investigations. The CCFA films were additionally annealed at different temperatures up to 600°C. The dependence of the TMR ratio on the annealing temperature was studied. A maximum TMR ratio of 40.5% was measured from which a spin polarization of 54% is deduced by the Jullière model. Possible correlations between the TMR ratio and the surface properties, as observed with STM and RHEED, are discussed.

Alternatively, epitaxial CCFA films were also grown directly on $MgAl_2O_4(100)$ and $Al_2O_3(110)$. A comparison with the results on MgO substrates is shown.

MA 12.9 Tue 12:15 H22

Inverted spin polarization of Heusler alloys — •Andy Thomas[1], Dirk Meyners[1], Daniel Ebke[1], Ning-Ning Liu[1], Jan Schmalhorst[1], Guenter Reiss[1], and Andreas Huetten[1,2] — [1]Bielefeld University, Thin films and nanostructures, Germany — [2]Research Center Karlsruhe, Institute for Nano-technology, Germany

We prepared magnetic tunnel junctions with different Heusler compound electrodes and investigated the transport properties of these devices. The most striking feature of these structures is the inversion of the tunnel magnetoresistance (TMR) effect at certain bias voltages.

We use this feature to present a magnetic logic concept that overcomes the limitations of field programmable logic arrays while having a 50% smaller unit cell then conventional TMR designs. To reach that the negative TMR effect is used as an additional degree of freedom. This might be possible in other spintronic devices.

Band structure calculations give the theoretic explanation of the negative TMR.

MA 12.10 Tue 12:30 H22

On the asymmetry of the inelastic tunneling spectra on magnetic materials — •Albert F. Takács[1], Timofey Balashov[1,2], Wulf Wulfhekel[1,2], Jürgen Kirschner[2], Markus Däne[3], Arthur Ernst[2], and Patrick Bruno[2] — [1]Physikalisches Institut, Universität Kalrsuhe (TH), Wolfgang-Gaede Str. 1, 76131 Karlsruhe — [2]MPI für Mikrostrukturphysik, Weinberg 2, 06108 Halle — [3]Martin-Luther-Universität Halle-Wittenberg, Fachbereich Physik, 06099 Halle

Inelastic tunneling spectroscopy (ITS) is a valuable tool to study excitations in metallic systems. We have applied ITS to investigate low lying magnetic excitations. For tunneling between a non-magnetic tip and a ferromagnet, the excitations were found to be asymmetric with respect to the Fermi energy.

For Fe(001) magnon creation was found predominantly for tunneling into the ferromagnet, while for opposite bias the excitation is much weaker. For fcc Co(001) strong magnon excitations were found for both positive and negative bias. Using *ab-initio* calculations of the spin-polarised DOS of the ferromagnets we show that this asymmetry is related to the spin-polarisation of the ferromagnet. This effect has strong implications for the efficiency of the spin transfer effect used in switching of MRAM cells.

MA 12.11 Tue 12:45 H22

Magneto-transport hysteresis loop of a single nanostructure — •Guillemin Rodary, Sebastian Wedekind, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120, Halle (Saale), Germany

We have studied morphological, electronic and magnetic properties of a single cobalt nano-island by means of spin-dependent scanning tunneling microscopy (SP-STM) at 7K and under a high magnetic field (7T). Two monolayer high triangular Co islands are grown on Cu(111) surface at room temperature and are then imaged by STM at low temperature. Scanning tunneling spectroscopy reveals spin polarized states of the nano-islands [1]. In contrast to previous studies using the field variation of images contrast to obtain a magnetic hysteresis loop [2], we directly record the apparent topology change with magnetic field variation at a single point. This method allows to understand the magnetic properties of a single nano-object, as the coercitive field or the switching behavior. The magneto-transport hysteresis curve obtained is explained from a tunnel magnetoresitance standpoint. We discuss the precise method to obtain such measurement with a STM in comparison to solid state spin electronic experiments, specially artifacts that have been isolated.

[1] L. Diekhöner, M. A. Schneider, A. N. Baranov, V. S. Stepanyuk, P. Bruno and K. Kern, Phys. Rev. Lett. 90, 236801 (2003).

[2] O. Pietzsch, A. Kubetzka, M. Bode and R. Wiesendanger, Science 292, 2053 (2001).

MA 13: Spinstructures and magnetic Phase Transitions

Time: Tuesday 10:15–13:15 Location: H5

MA 13.1 Tue 10:15 H5

First-principles description of phase transitions in transition-metal compounds. — •Leonid Sandratskii — Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

We calculate interatomic exchange parameters in hexagonal MnAs and orthorhombic MnAs. The magnetic transition temperatures are estimated within the mean-field and random-phase approximations. The results of the calculations are used to interpret the unusual sequence of the phase transitions in the system. The limitations of the Heisenberg-Hamiltonian description of the hexagonal MnAs are revealed and interpreted. The importance of the adequate choice of the magnetic degrees of freedom is demonstrated. We obtain strong difference in the properties of hexagonal MnAs and half-metallic Heusler compound NiMnSb.

MA 13.2 Tue 10:30 H5

Nuclear spin ferromagnetic phase transition in an interacting 2D electron gas — •Pascal Simon[1,2] and Daniel Loss[1] — [1]Department of Physics and Astronomie, University of Basel (Switzerland) — [2]LPMMC, university Joseph Fourier & CNRS, Grenoble (France)

Electrons in a two-dimensional semiconducting heterostructure interact with nuclear spins via the hyperfine interaction. Using a a Kondo lattice formulation of the electron-nuclear spin interaction, we show that the nuclear spin system within an interacting two-dimensional electron gas undergoes a ferromagnetic phase transition at finite temperatures. We find that electron-electron interactions and non-Fermi liquid behavior substantially enhance the nuclear spin Curie temperature into the mK range with decreasing electron density.

MA 13.3 Tue 10:45 H5

Magnetic Ordering in Strongly-Correlated Systems from ab initio — •Markus Däne[1], Ian Hughes[2], Arthur Ernst[3], Wolfram Hergert[1], Julie Staunton[2], Axel Svane[4], Julian Poulter[5], Martin Lüders[6], Zdzislawa Szotek[6], and Walter Temmerman[6] — [1]Naturwissenschaftliche Fakultät II, Institut für Physik, Martin Luther Universität Halle-Wittenberg, Friedemann-Bach-Platz 6, 06108 Halle, Germany — [2]Department of Physics, University of Warwick, U.K. — [3]Max Planck Institute of Microstructure Physics, 06120 Halle, Germany — [4]Institute of Physics and Astronomy, University of Aarhus, Denmark — [5]Mahidol University, Bangkok, Thailand — [6]Daresbury Laboratory, Daresbury, Warrington WA4 4AD, U.K.

We use a first-principles theory of finite temperature metallic magnetism to investigate the onset of magnetic order in strongly-correlated systems. Thermally induced spin fluctuations are treated within a mean-field disordered local moment (DLM) picture. The scheme is implemented using the Korringa-Kohn-Rostoker (KKR) method, with a self-interaction corrected local spin-density approximation. This is applied to Ce, Gd and transition metal oxides.

MA 13.4 Tue 11:00 H5

Theory of the helical spin crystal. A candidate for the partially ordered state of MnSi — •Benedikt Binz[1,2] and Ashvin Vishwanath[2] — [1]Institut fuer theoretische Physik, Universitaet zu Koeln — [2]Departement of Physics, University of California, Berkeley

Recent experiments in the "partial order" regime at high pressure in MnSi quite intriguingly suggest diffuse spin correlations and slow dynamics in a pure crystalline metal. As a starting point for a theoretical description of this phase, we are investigating the nature of its dominant spin correlations. Particularly, the observed location of maximal neutron scattering intensity around <110> is difficult to explain in terms of fluctuating helical spin-density waves alone. We therefore investigate helical spin crystals. These are magnetic structures obtained by superimposing distinct spin spirals, via a process reminiscent of crystallization. Based on a phenomenological Landau description, we identify which spin crystal structures may be energetically stabilized and study their properties. One of these states, a bcc spin crystal, is compatible with existing data on MnSi from neutron scattering and magnetic field studies. It also shows new and interesting phenomena, such as symmetry stabilized topological textures, missing higher order Bragg reflections and an octupolar order parameter. Possible routes towards "partial order", which requires the destruction of long-range order by some mechanism, will be briefly discussed.

MA 13.5 Tue 11:15 H5

Discovery of a Cycloidal Spin Spiral in a Two-Dimensional Antiferromagnet — •Matthias Bode[1], Marcus Heide[2], Kirsten von Bergmann[1], Paolo Ferriani[1], Stefan Heinze[1], Gustav Bihlmayer[2], Andre Kubetzka[1], Oswald Pietzsch[1], Stefan Blügel[2], and Roland Wiesendanger[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

Spin structures observed in nanomagnets are commonly explained on the basis of the Heisenberg exchange interaction and the magnetic anisotropy. In a two-dimensional antiferromagnetic metal film with the thickness of a single-atomic Mn layer on W(110) we observe a spin spiral in real space by means of spin-polarized scanning tunneling microscopy at 13 K. First-principles calculations identify the spiral as cycloidal spin order with specific chirality and prove that it is caused by the Dzyaloshinskii-Moriya (DM) interaction arising from the lack of structural inversion symmetry inherent to all surfaces and interfaces. We establish the significance of the DM interaction for magnets in reduced dimensions, whose strength is sufficient to destabilize the so far anticipated collinear magnetic structures. The chirality in nanomagnets can contribute to interesting phenomena in spintronics.

MA 13.6 Tue 11:30 H5

Deconfined spinons and first-order transition in easy-plane quantum antiferromagnets — •Flavio Nogueira[1], Steiner Kragset[2], and Asle Sudbo[3] — [1]Institut für Theoretische Physik, Freie Universität Berlin — [2]Department of Physics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway — [3]Department of Physics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway

We report recent Monte Carlo and renormalization group results for quantum antiferromagnets in the deep easy-plane limit [1]. By performing large scale Monte Carlo simulations, we are able to show that the spinons are deconfined at the phase transition point. This is in agreement with the recently proposed scenario in which a destructive interference mechanism between instantons and the Berry phase deconfine the spinons at the phase transition. However, we show that the phase transition is first-order, in contrast with the second-order phase transition predicted by the deconfined quantum criticality scenario. Our numerical results are confirmed by a renormalization group analysis of the system at the critical point.

[1] S. Kragset, E. Smørgrav, J. Hove, F. S. Nogueira, and A. Sudbø, Phys. Rev. Lett. **97**, 247201 (2006)

MA 13.7 Tue 11:45 H5

Low temperature formalism for glassy order — •Manuel Joachim Schmidt and Reinhold Oppermann — Institut für Theoretische Physik und Astrophysik, Am Hubland, 97074 Würzburg

While the low temperature limit usually simplifies the description of physical systems in a very obvious way, this limit can remain complicated in case of disordered systems like spin- or structural glasses. The reason for this is the appearance of replica-symmetry-breaking (RSB), which complicates the analysis even of the simplest models. The mean-field theory of systems which exhibit RSB needs an infinite number of order parameters which are conveniently described as an order function. For temperatures well below the spin-glass transition temperature, only numerical solutions are available. The approach to T=0, however, is plagued by singularities within the traditional formalism. The proper T=0 limit of the order function and its implications is the objective of our work.

We have developed a novel formalism, free of singularities, which allows for the treatment of RSB in spin glasses and other random systems at low temperatures and directly at T=0. Physical observables like the ground state energy or susceptibilities have been obtained with unprecedented accuracy.

MA 13.8 Tue 12:00 H5

Uniform and Staggered Magnetizations Induced by Dzyaloshinskii-Moriya Interactions in Isolated and Coupled Spin 1/2 Dimers in a Magnetic Field — S. Miyahara[1], J.-B.

Fouet[2], •S. Manmana[3,4,5], R. Noack[5], H. Mayaffre[6], I. Sheikin[7], C. Berthier[6,7], and F. Mila[3] — [1]Dep. of Physics, Aoyama Gakuin University, Sagamihara, Kanagawa 229-8558, Japan — [2]IRRMA, PPH-Ecublens, CH-1015 Lausanne, Switzerland — [3]Inst. of Theor. Phys., EPFL, CH-1015 Lausanne, Switzerland — [4]ITP III, Univ. Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart, Germany — [5]Fachb. Physik, Philipps-Univ., D-35032 Marburg, Germany — [6]Lab. de Spectr. Phys., Univ. J. Fourier & UMR5588 CNRS, BP 87, 38402, Saint Martin d'Hères, France — [7]GHMFL., CNRS, BP 166, F-38042 Grenoble Cedex 09, France

We investigate the interplay of Dzyaloshinskii-Moriya (DM) interactions and an external field in spin 1/2 dimers. For isolated dimers and at low field, we find in the limit where the D vector of the DM interaction is parallel to the external field a uniform magnetization *perpendicular* to the field. For larger fields, we find the staggered magnetization of an isolated dimer to have a maximum close to one-half the polarization. We investigate the effect of inter-dimer coupling in the context of ladders with Density Matrix Renormalization Group (DMRG) calculations and show that, as long as the parameters allow the staggered magnetization to be finite, the simple picture for isolated dimers is valid for weakly coupled dimers with minor modifications. The results are compared with torque measurements on $Cu_2(C_5H_{12}N_2)_2Cl_4$.

MA 13.9 Tue 12:15 H5

New features in the phase diagram of $TbMnO_3$ — •D. Meier[1,2], N. Aliouane[3], D. Argyriou[3], J. Mydosh[1], and T. Lorenz[1] — [1]II. Physikalisches Institut, University of Cologne, 50937 Cologne, Germany — [2]HISKP, University of Bonn, 53115 Bonn, Germany — [3]Hahn-Meitner-Institut, 14109 Berlin, Germany

We report new features in the phase diagram of the magnetoelectric (ME) multiferroic $TbMnO_3$, derived by thermal expansion and magnetostriction measurements. Below $T_N = 41$ K the Mn spins develop an incommensurate sinusoidal antiferromagnetic ICAFM alignment. Below $T_{FE} = 28$ K, the ICAFM order changes into a helix and a spontaneous electric polarization $P||c$ appears. Sufficiently high magnetic fields $H||a$ or $H||b$ induce a polarization flop ($P||c \rightarrow P||a$), accompanied by a commensurate antiferromagnetic (CAFM) order of the Mn spins. Strongly anisotropic thermal expansion was measured along the crystal axes a, b and c (Pbnm). We observe pronounced anomalies when the various phase boundaries are crossed as a function of T or H, reflecting large uniaxial pressure dependencies of the transition temperatures or fields. Thus, our data allow a detailed investigation of the (H,T) phase diagram. Opposite to previous publications, we find that even in high fields there are no direct transitions from the sinusoidal ICAFM- to the CAFM-phase. For $H||a$, the hysteretic phase boundary between the phases with $P||c$ and $P||a$ was detected in detail for the first time. Furthermore, complex phase boundaries reflecting changes in the Tb ordering for $H||i$ ($i = a, b, c$) were determined.

This work was supported by the DFG through SFB 608.

MA 13.10 Tue 12:30 H5

Magnetic phase diagram of Tb_2PdSi_3 studied by neutron diffraction — •Matthias Frontzek[1], Andreas Kreyssig[1], Mathias Doerr[1], Astrid Schneidewind[1,2], Jens-Uwe Hoffmann[3], and Michael Loewenhaupt[1] — [1]TU Dresden, Institut für Festköperphysik, D-01062 Dresden — [2]Forschungsneutronenquelle Heinz-Maier-Leibnitz, Lichtenbergerstr. 1, D-85747 Garching — [3]Hahn-Meitner-Institut, Glienickerstr. 100, D-14109 Berlin

Tb_2PdSi_3 crystallises in an AlB_2 derived hexagonal structure (space group $P6/mmm$) yielding a latent geometric frustration for the magnetic Tb^{3+} ions. The anisotropy of the crystal electric field leads to a magnetic easy basal plane with six possible moment directions. The RKKY interaction gives rise to an antiferromagnetic transition at $T_N = 23$ K. To clarify the microscopic nature of the rich magnetic phase diagram we performed neutron scattering experiments in external magnetic fields up to $\mu_0 H = 6.5$ T along the (100) direction.

In zero field we observe an antiferromagnetic long-range ordered (LR) structure with a magnetic unit cell doubled in the basal plane with respect to the chemical unit cell and a (0 0 1/16) propagation along the hexagonal axis. Below 8 K an additional antiferromagnetic short range ordered (SR) structure with a wave vector (0.16 0.16 0.06) appears. The LR propagation changes through two intermediate phases to (0 0 1/4) in the field range 0.1 - 3.0 T. The SR structure seems decoupled from the LR structure and becomes itself long-range ordered around 1.5 T with a propagation (0.13 0.13 0.1) which is further modified to (1/6 1/6 1/4) at fields above 3 T.

MA 13.11 Tue 12:45 H5

Neutron Scattering on the Spin-Orbit Liquid State of $FeSc_2S_4$ — •Michael Mücksch[1,2], Alexander Krimmel[1], Vladimir Tsurkan[1,3], Denis Sheptyakov[4], Michael Marek Koza[2], Amir Murani[2], Hannu Mutka[2], Siegfried Horn[1], and Alois Loidl[1] — [1]Institute of Physics, University of Augsburg, D-86159 Augsburg, Germany — [2]Institute Laue Langevin, F-38042 Grenoble, France — [3]Institute of Applied Physics, Academy of Sciences of Moldova, MD-2028 Chisinau, R. Moldova — [4]Laboratory for Neutron Scattering, ETH Zürich & PSI, CH-5232 Villigen PSI, Switzerland

The developement of the spin-orbital liquid ground state in the normal cubic spinel compound $FeSc_2S_4$[1] based on the electronic degenerate magnetic Fe^{2+} ($3d^6$) ions is studied by extensive neutron scattering studies. The dynamic structure factor $S(Q,\omega)$ as obtained by neutron time-of-flight measurements exhibits at 300 K a paramagnetic quasielastic contribution, which evolves below about 120 K into a broad excitation band centered around 2 meV with a softening at particular Q - positions. This indicates a dynamic Jahn-Teller effect including spin-orbit coupling and magnetic exchange [2]. Implications on the neutron derived phonon spectra will be discussed. The magnetic excitation spectra, and in particular the gap value, are not affected by either cooling down to 200 mK or applying an external field of 2.5 T. The resolution limited elastic scattering shows a remaining paramagnetic contribution, but no changes on cooling down to 200mK, thus excluding spin glass freezing. This demonstrates the dynamic character of the ground state in $FeSc_2S_4$.[1] V. Fritsch et al., Phys. Rev. Lett. **92** (2004) 116401.[2] A. Krimmel et al., Phys. Rev. Lett. **94** (2005)237402.

MA 13.12 Tue 13:00 H5

Magnetostriction in high pulsed magnetic fields — •Wolfram Lorenz[1], Nadejda Kozlova[2], Jos Perenboom[3], Mathias Doerr[1], and Michael Loewenhaupt[1] — [1]TU Dresden, D-01062 Dresden — [2]IFW Dresden, Helmholtzstraße 20, D-01069 Dresden — [3]Radboud University Nijmegen, 6525 ED Nijmegen

Measurements of the magnetostriction complement very well the set of experimental methods in high pulsed magnetic fields. It allows not only to examine the interaction of magnetic moments with each other but also with the lattice system. Nowadays pulsed magnets with up to 100 T are under development, for which magnetostriction is a promising experimental method.

To measure magnetostriction up to the highest available fields a special capacitive dilatometer has been developed. It yields a high resolution of magnetostrictive effects ($\sim 10^{-5}$ in $\Delta l/l$) in magnetic fields up to 50 T and at temperatures down to 2 K. Its special design reduces the influence of eddy currents and mechanical vibrations.

First experiments with this setup have been made on the rare earth compounds GdSi and $SmCu_2$ that show transitions at 20 T and 30 T, respectively. Our data are in excellent agreement with measurements done in static fields (Bitter-magnet). We could verify the spin-flop character of the transition of GdSi. For $SmCu_2$ the magnetic phase diagram has been constructed, which shows clear indication for a temperature dependent compensation of its spin and orbital momentum.

In this talk the measuring setup and first experimental results will be presented.

MA 14: Invited Talks (joint seesion with O) Bruno / Göring

Time: Tuesday 14:00–15:00 Location: H10

Invited Talk MA 14.1 Tue 14:00 H10

Controlling magnetism and self-organization of adatoms on surfaces by using quantum interferences — •Patrick Bruno, Valeri Stepanyuk, Nikolay Negulyaev, and Larissa Niebergall — Max Planck Institute of Microstructure Physics, Halle, Germany

Due to the presence of a surface state, a quasi-free two-dimensional electron gas (2DEG) floats on the (111) surface of noble metals. This 2DEG mediates long-range oscillatory interactions among adatoms, and therefore controls to a large extent the formation of magnetic nanostructures on such surfaces. The competition between this long-range inter-adatom interaction and the adatom-surface interaction gives rise to a wide variety of structures, depending on the nature of adatoms, on their density, on temperature, on the presence of atomic steps, etc. These processes have been studied theoretically by using a combination of first-principles and kinetic Monte-Carlo methods. We have also investigated the spin-polarization and the exchange interaction among adatoms mediated by the 2DEG, as well as how they can be influenced by using quantum confinement and quantum interferences.

V. S. Stepanyuk et al., Phys. Rev. Lett. 94, 187201 (2005)
N.N. Negulyaev et al., Phys. Rev. B 74, 035421 (2006)
L. Niebergall et al., Phys. Rev. Lett. 96, 127204 (2006)
V.S. Stepanyuk et al., Phys. rev.. Lett. 97, 186403 (2006)
P. Wahl et al., Phys. Rev. Lett (in press, 2007)

Invited Talk MA 14.2 Tue 14:30 H10

XMCD in TM Oxides: Are there hidden orbital moments in magnetite? — •Eberhard Goering — Max-Planck-Institiut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart

X-ray magnetic circular dichroism has become a powerful tool, used by scientists to gain a deep microscopic understanding of magnetism in an element specific and very sensitive manner. Sum-rules, based on integral spectral intensities, provide average spin- and orbital- magnetic moments in a quantitative way. It has been shown, that the shape of the spectra could be used to go beyond sum rules, providing a more detailed understanding of the magnetic polarization of different parts of the unoccupied band structure. The theoretical fundament for this approach has been recently theoretically confirmed. To exemplify the potential of this ansatz, absorption spectroscopy results of Magnetite will be presented, showing hidden orbital magnetism at the Fe site. This is very important, because orbital ordering and orbital magnetism is believed to play a key role in the understanding of the Verwey transition. On the other the hand, this transition plays also a fundamental and important role in solid state physics, which has been discussed frequently in the literature in the past decades.

MA 15: Poster:ThinFilms(1-33),Transp.(34-49),ExchBias(50-56), Spindynamics(57-70),Micro-nanostr.Mat.(71-82), Particles/Clust.(83-88), Mag.Imag./Surface(89-96), Spinelectronics(97-109), Theory/Micromag.(110-116), Spinstruct/Phasetr.(117-128),Magn.Mat.(129-139), Aniso.+Measuring(140-145), MolMag.(146-152), MSMA(153-156)

Time: Tuesday 15:00–19:00 Location: Poster A

MA 15.1 Tue 15:00 Poster A

Dynamic strain in epitaxial ferroic oxide films — •Orkidia Bilani, Martina Dekker, Christian Thiele, Kathrin Dörr, Konstantin Nenkov, and Ludwig Schultz — IFW Dresden, Postfach 270116, 01171 Dresden, Germany

Epitaxial strain is known or theoretically predicted to essentially influence the electronic properties of transition metal perovskite oxides like (Ba,Sr)TiO_3. One approach for reversible biaxial strain variation in epitaxial films fitting to a pseudocubic lattice parameter of about 4.0 Angstrom is the utilization of a ferro- and piezoelectric PMN-PT(001) substrate. (PMN-PT stands for 0.72$PbMg_{1/3}Nb_{2/3}O_3$-0.28$PbTiO_3$.) The huge, homogeneous and nearly linear piezoelectric strain of PMN-PT(001) allows one to biaxially compress as-grown films by about 0.2 % by applying an electric voltage.

In this contribution, the structural properties of PMN-PT(001) substrates and of epitaxial perovskite films of $SrTiO_3$ and ferromagnetic manganites $R_{1-x}A_xMnO_3$ (R = rare earth metal or La, A = doping metal) grown on them are analysed. Atomic force microscopy and methods of four-circle x-ray diffraction have been employed for the measurements. Electric and magnetic properties like the ferroic ordering temperature as a direct function of the biaxial strain varied in-situ have been recorded and are discussed.

MA 15.2 Tue 15:00 Poster A

Growth and properties of epitaxial Sr_2CrReO_6 thin films — •F. Czeschka, S. Geprägs, S.T.B. Goennenwein, M. Opel, and R. Gross — Walther-Meißner-Institut, Bayerische Akademie derWissenschaften, Walther-Meißner-Str. 8, 85748 Garching

In the last couple of years a tremendous interest in new materials with high spin polarisation for spintronic devices has been emerged. One group of these materials are the ferromagnetic double perovskites $Sr_2BB'O_6$ (with B a magnetic transition metal ion, and B' a non-magnetic ion). Among them, Sr_2CrReO_6 has the highest transition temperature ($T_C = 635\,\mathrm{K}$) observed so far and band structure calculations predict a high spin polarisation of $P \approx 86\%$. We have prepared Sr_2CrReO_6 thin films by laser molecular beam epitaxy on (001) $SrTiO_3$ substrates. The films were grown in different atmospheres (Ar, O_2), at various pressures ($6 \times 10^{-4}\mathrm{mbar} \leq p_{O_2} \leq 5 \times 10^{-2}\mathrm{mbar}$) and in a wide range of substrate temperatures ($450°\mathrm{C} \leq T_S \leq 900°\mathrm{C}$). The films are c-axis oriented and coherently strained. We found, that thin films grown at $T_S = 700°\mathrm{C}$ in an oxygen atmosphere with $p_{O_2} = 6.6 \times 10^{-4}\mathrm{mbar}$ show optimal magnetic and crystallographic properties, as evident from the full width at half maximum of the rocking curves. Moreover, our films show a high degree of B site order. The hysteresis loops at 25K reveal a high saturation magnetization of $0.8\mu_B$ per formula unit and a high coercive field of 1.2T. We discuss these observations and compare them to results from magnetotransport measurements.

This work is supported by the DFG via SPP1157.

MA 15.3 Tue 15:00 Poster A

Multiferroic Materials Based on Artificial Thin Film Heterostructures — •S. Geprägs, M. Opel, S.T.B. Goennenwein, and R. Gross — Walther-Meißner-Institut, Bayerische Akademie derWissenschaften, Walther-Meißner-Str. 8, 85748 Garching

Recent advances in the understanding of the coexistence of different ferroic ordering phenomena (such as ferroelectricity and ferromagnetism) triggered a tremendous research activity on so-called multiferroic materials. Unfortunately, only very few multiferroics exist. A promising way to improve the situation is the use of layered thin film heterostructures. The double perovskite Bi_2CrFeO_6 (BCFO), for example, could be built up from $BiFeO_3$ (BFO) and $BiCrO_3$ (BCO). To realize such superlattices, one must be able to grow unit cell thin BCO and BFO layers in a two-dimensional growth mode. Here, we report the growth of c-axis oriented epitaxial BFO and BCO films by laser molecular beam epitaxy on (001) $SrTiO_3$ substrates. A two-dimensional

growth mode could be achieved using an imposed layer-by-layer interval deposition technique. All BCO and BFO thin films show high crystalline quality with a mosaic spread below 0.04°. Furthermore, reciprocal space maps indicate no monoclinic or rhombohedral distortion up to a film thickness of 35nm. Magnetic measurements demonstrate a weak ferromagnetic phase in both material systems due to spin canting of the antiferromagnetic sublattices. However, we find no evidence of enhanced ferromagnetic properties stemming from epitaxial strain.
This work is supported by the DFG via SPP1157.

MA 15.4 Tue 15:00 Poster A

Scanning tunneling spectroscopy on $La_{0.75}Ca_{0.25}MnO_3$ thin films in external magnetic fields — •Sigrun A. Köster, Thomas Mildner, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Perovskite manganites show the most intriguing and still far from understanding colossal magnetoresistance effect (CMR). 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 and lead to a percolative phase transition, the CMR. This coexistence is expected to depend on different material parameters, since the properties of manganites are very sensitive to lattice strain (e.g. Jahn-Teller strain) and disorder. We are able to very precisely tune the microstructure of our samples by the metallorganic aerosol deposition (MAD) technique. In our work we can show by scanning tunneling spectroscopy, that low resistivity and high resistivity regions exist in the samples, depending on the microstructure of the films, temperature and magnetic fields. Our study is aimed at achieving a more detailed picture of these electronic phases. Particularly we concentrated on STS measurements in magnetic fields at the transition temperature. This project was partially supported by the DFG in the course of SFB 602 Project A2.

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

MA 15.5 Tue 15:00 Poster A

Synthesis, Structure, and Magnetism of the Electron-Doped Cobaltates $La_{1-x}Ce_xCoO_3$ — •Christian Pinta[1,2], Dirk Fuchs[1], Peter Adelmann[1], Thorsten Schwarz[1,2], Peter Schweiss[1], Stefan Mangold[3], and Stefan Schuppler[1] — [1]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, 76021 Karlsruhe, Germany — [2]Universität Karlsruhe, Fakultät für Physik, 76128 Karlsruhe, Germany — [3]Forschungszentrum Karlsruhe, Institut für Synchrotronstrahlung, 76021 Karlsruhe, Germany

Electron doping of lanthanum cobaltate, $LaCoO_3$, with doping levels exceeding minute values had been impossible until recently, when we succeeded in synthesizing epitaxial thin films of the system $La_{1-x}Ce_xCoO_3$ ($0.1 \leq x \leq 0.4$) using pulsed laser deposition. In these thin films, ferromagnetic order is observed within the entire doping range, with the maximum of the Curie temperature, T_C, occurring at $x \approx 0.3$. This results in a magnetic phase diagram similar to that of hole-doped lanthanum cobaltates. The measured spin values suggest an intermediate-spin state of the Co ions which has been also found in the hole-doped system. However, in contrast to the hole-doped material where T_C is well above 200 K, we observe a strong suppression of the maximum T_C to about 22 K. In order to study possible effects of distortions or disorder on T_C, the local spatial and electronic structure of the films was investigated in more detail by x-ray absorption spectroscopy (NEXAFS and EXAFS), illustrating that the material is indeed electron-doped, and showing an increased structural distortion of $La_{1-x}Ce_xCoO_3$ compared to the undoped cobaltates.

MA 15.6 Tue 15:00 Poster A

Growth of $La_{1-x}Ca_xMnO_3$ and $BaTiO_3$ thin films and multilayers using PLD with in-situ RHEED — •Heiko Fasold, Alexander Hirsch, Ralf Koppert, Frank Ludwig, and Meinhard Schilling — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig,Hans-Sommer-Straße 66, D-38106 Braunschweig, Germany

Multiferroics, materials with ferroelectric and ferromagnetic properties, are interesting for both basic research and applications. One way to design multiferroic materials for new sensor applications is to grow superlattices with alternating ferromagnetic and ferroelectric layers.

Using Pulsed Laser Deposition (PLD) $La_{1-x}Ca_xMnO_3$ (LCMO) and $BaTiO_3$ (BTO) thin films and multilayers were grown. The growth of the films is monitored by in-situ reflection high energy electron diffraction (RHEED). The characterization is supplemented by X-ray diffraction (XRD) and atomic force microscopy (AFM).

The LCMO films were grown with different calcium concentrations. Optimal growth conditions lead to high quality oriented crystalline magnetic films with a rms roughness less than 1nm for layer thicknesses up to 500 nm. Both LCMO and BTO were deposited on single terminated atomically flat $SrTiO_3$ (100) and $NdGaO_3$ (110) substrates. The influence of substrate and its surface quality on the growth conditions and properties of the thin films is analyzed. Superlattices with alternating LCMO and BTO layers were grown. RHEED intensity oscillations are used to determine and control the thickness of the multilayers.

MA 15.7 Tue 15:00 Poster A

Physical properties and microstructure of $La_{0,67}Ce_{0,33}MnO_3$ thin films — •Christian Stingl, Vasily Moshnyaga, Yuansu Luo, Bernd Damaschke, and Konrad Samwer — I. Physikalisches Institut der Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen

In the perowskite manganites $A_{1-x}B_xMnO_3$, the replacement of a trivalent A-ion by a divalent B-ion, which is the case in the majority of the compounds, is usually referred to as *hole-doping*. Cerium has been suggested as a tetravalent substituent to achieve *electron-doping* in PLD thin films of $La_{0,67}Ce_{0,33}MnO_3$ (LCeMO) [1]. However, LCeMO seems to be structurally unstable and the single-phase nature of the PLD films has been questioned [2].

We have therefore tried two other deposition techniques and prepared thin $La_{0,67}Ce_{0,33}MnO_3$ films by magnetron sputtering and MAD (metal-organic aerosol deposition) and investigated their microstructure with TEM. In both cases, a chemical phase separation is observed: The sputtered samples are insulating over a wide temperature range but show an interesting form of self-organized growth, with $\approx$ 10 nm thick cylindrical columns of a Ce-rich phase embedded in a manganite matrix. The MAD samples exhibit ferromagnetic metallic behavior for $T < T_{MI} \approx 260$ K due to self-doping by La vacancies.

[1] C. Mitra et al., J. Appl. Phys. **89** (2000), 524.
[2] T. Yanagida et al., Phys. Rev. B **70** (2004), 184437.

MA 15.8 Tue 15:00 Poster A

Magnetism and Magnetic Microstructure in Heusler Alloy Based Thin Film Systems — •Alexander Kaiser, Diana Rata, Stefan Cramm, and Claus M. Schneider — Institut für Festkörperforschung IFF-IEE, Forschungszentrum Jülich, Germany

Due to high spin polarization at the Fermi level and structural compatibility to compound semiconductors half-metallic Heusler alloys are promising materials for spintronic devices such as magnetic tunnel junctions and spin injection elements. For this study single films and magnetic tunnel junctions of the Heusler alloys Co_2MnSi and Co_2FeSi were sputter-deposited. The films have been magnetically characterized by SQUID and the micromagnetic structure has been studied by photoelectron emission microscopy. By microstructuring the films the influence of a magnetic stray field could be investigated. Ferromagnetic coupling of the $Co_2MnSi/MgO/Co_2FeSi$ trilayers was shown by exploiting the elemental selectivity of the X-PEEM technique.

MA 15.9 Tue 15:00 Poster A

Growth and characterization of Ni_2MnIn Heusler films — •Jan Michael Scholtyssek, Lars Bocklage, Rainer Anton, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

Heusler alloys are interesting materials for spintronic devices. We grow thin Ni_2MnIn films by coevaporation of Ni and the alloy MnIn on a variety of substrates including amorphous carbon films and Si_3N_4 membranes for TEM studies as well as on Si and InAs for investigations of the electronic interface structure. The latter is especially interesting because of the predicted halfmetallicity of Ni_2MnIn in the $L2_1$ phase at the interface to InAs [1]. The almost perfect lattice match between InAs and Ni_2MnIn supports highly oriented growth, as we have proven by electron diffraction under grazing incidence [2]. We present morphologic and structural investigations performed during a post growth annealing process in which the sample grown at a substrate temperature of 100 °C is heated up to 400 °C. The formation of the $L2_1$ crystal structure presumably in coexsistence with the B2 phase is observed. Point contact Andreev-reflection spectroscopy on Ni_2MnIn thin films grown on Si and on (110)-surfaces of InAs, perpared by in-situ cleaving of the substrate, yields spin polarizations of up to 34% [3].

[1] K.A. Kilian and R.H. Victora, J. Appl. Phys. **87**, 7064 (2000).
[2] J.M. Scholtyssek et. al., J. Magn. Magn. Mat. accepted (2006).
[3] L. Bocklage et. al., J. Appl. Phys. accepted (2006).

MA 15.10 Tue 15:00 Poster A

Towards a full Heusler alloy showing room temperature half-metallicity at the surface — •Mirko Cinchetti[1], Jan-Peter Wüstenberg[1], Andrés Conca[2], Martin Jourdan[2], and Martin Aeschlimann[1] — [1]University of Kaiserslautern, Institute of Physics, Erwin-Schrödingerstr. 46, 67663 Kaiserslautern, Germany — [2]University of Mainz, Institute of Physics, Staudinger Weg 7, 55128 Mainz, Germany

The spin polarization at the surface region of a 100 nm $Co_2Cr_{0.6}Fe_{0.4}Al$ film grown epitaxially on MgO(100) with a 10 nm Fe buffer layer has been investigated by means of spin resolved photoemission. We show that a careful *in situ* preparation of the sample surface leads to reproducible values for the room temperature spin polarization up to 45% at the Fermi level. To our knowledge, this is the highest value measured so far at the surface region of a full Heusler alloy at room temperature.

MA 15.11 Tue 15:00 Poster A

Magneto-optical Kerr Effect Spectroscopy of Magnetic Nanoclusters in Organic Thin Films — •Wen Li[1], Roxana Pacurariu[2], Dietrich Zahn[1], and Georgeta Salvan[1] — [1]Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]Babes-Bolyai University, RO-400085 Cluj-Napoca, Romania

The magnetic properties exhibited by magnetic nanoparticles are of great importance in view of their applications such as e.g. biosensors or high-density recording media. The surrounding medium can have a significant influence on the magnetic properties. One of the methods used to fabricate thin films of magnetic nanoparticles in organic molecular matrices with a good control on the particle size is the co-evaporation of the metal and the organic molecules in vacuum. In this work Ni nanoparticles with an average size of about 5 nm are produced in matrices of fullerene and rubrene. The molecule of fullerene consists of C atoms and has an icosahedral symmetry, while the rubrene molecule contains also H atoms and has a lower symmetry. The magnetic properties of the hybrid films are studied by magneto-optical Kerr-effect (MOKE) spectroscopy in a spectral range from near infrared (1.5 eV) to near ultraviolet (5.5 eV).

Magneto-optical Kerr effect resides in the change in the polarisation state of the light upon reflection on a magnetized sample and is often exploited to record magnetic hysteresis loops of thin metallic films. In addition, MOKE spectroscopy is capable of providing an insight in the electronic properties of the nanoparticles and thus in the structure and size of the metallic clusters.

MA 15.12 Tue 15:00 Poster A

Magnetoelectric effects in Manganite-Titanate Composite Films — •Kai Gehrke, Vasily Moshnyaga, and Konrad Samwer — I.Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Multiferroic materials with coexistence of ferromagnetism and ferroelectricity are in the focus of modern fundamental and applied research. The coupling of order parameters is believed to be very strong in nanocomposite films, containing epitaxial co-grown and elastically coupled Manganite and Titanate phases. The strain induced by the piezo effect of the Titanate phase should alter the magnetization of the CMR-Manganite phase and vice versa. Thin Manganite-Titanate films were grown on MgO and STO substrates by Metalorganic Aerosol Deposition (MAD) technique. Manganites like La-Mn-O, La-Ca-Mn-O and La-Sr-Mn-O where combined with ferroelectric Barium Titanate. XRD, AFM and TEM (EELS) where used to study the microstructure of the samples. M(H) and M(T) measurements show the magnetic properties of the manganite phase. Magnetoelectric effects were studied in terms of magnetocapacitance and magnetoloss measurements. The observed magnetocapacitance up to 1600% for H=70 kOe is discussed within CMR, Interface Magnetoresistance and Maxwell-Wagner model (see APL 88, 102902 (2006)). SFB 602 TP A2 is acknowledged.

MA 15.13 Tue 15:00 Poster A

X-ray magnetic circulardichroism in cobalt-doped ZnO — •Karl-Wilhelm Nielsen[1], Sebastian Bauer[1], Konrad Senn[1], Sebastian T. B. Goennenwein[1], Matthias Opel[1], Júlio Cezar[2], Dieter Schmeisser[3], and Rudolf Gross[1] — [1]Walther-Meissner-Institut, Bayerische Akademieder Wissenschaften, Garching, Germany — [2]EuropeanSynchrotron Radiation Facility, Grenoble Cedex, France — [3]Brandenburgische Technische Universität,Cottbus, Germany

Cobalt-doped ZnO is a diluted magnetic semiconductor with a reported Curie-temperature well above 300 K. Nevertheless, the origin of the ferromagnetic exchange still is under debate. To clearify this issue we have investigated cobalt-doped ZnO thin films with x-ray magnetic circular dichroism (XMCD). The (0001)-oriented $Zn_{0.95}Co_{0.05}O$ thin films were grown on (0001) ZnO, (0001) Al_2O_3, and (0001) $ScAlMgO_4$ substrates by pulsed laser deposition. The magnetic properties were measured by SQUID magnetometry and XMCD. Room temperature magnetization measurements by SQUID magnetometry and XMCD in the fluorescence yield mode reveal ferromagnetic behavior with similar shape of the magnetization curves, however, with different absolute values. XMCD magnetization in total electron yield, which is surface sensitive, show only small magnetic moments, most likely due to a magnetically dead surface layer.

This work is supported by the DFG via SPP1157.

MA 15.14 Tue 15:00 Poster A

No Co ferromagnetism in Co doped ZnO — •Thomas Tietze[1], Sebastian Brück[1], Eberhard Goering[1], Gisela Schütz[1], Milan Gacic[2], Gerhard Jakob[2], Christian Herbort[2], and Hermann Adrian[2] — [1]Max-Plank-Institute for Metal Research, Heisenbergstrasse 3, 70569 Stuttgart, Germany — [2]Institute of Physics, University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany

Diluted magnetic semiconductors, doped with a few percent (<10%) of magnetic ions such as Co or Mn, have attracted recently enormous interest, due to the room temperature ferromagnetism observed in such systems. The original intention for doping is that localized magnetic moments couple with each other ferromagnetically via the semi conducting host material. We have investigated 5% Co doped ZnO prepared by pulsed laser deposition (PLD). X-ray magnetic circular dichroism provides element specific magnetic moments of Co, Zn an O. We have performed field and temperature dependent XMCD-measurements at the Co and Zn L2,3 edges and the O K edge. As expected, Zn does not contribute to the ferromagnetism, but Co exhibits only paramagnetic behavior at all temperatures and fields. But surprisingly we found magnetic polarization, related to a small orbital moment; at the O site, suspected to be responsible for room temperature ferromagnetism of ZnO.

MA 15.15 Tue 15:00 Poster A

Defect-induced Ferromagnetism in Co-doped ZnO Thin Films — •Gillian Mayer[1], Erwin Biegger[1], Mikhail Fonin[1], Nils Janssen[1], Markus Beyer[1], Rudolf Bratschitsch[1], Yury Dedkov[2], and Ulrich Rüdiger[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz — [2]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden

Ferromagnetic diluted magnetic oxides (DMOs) have been the subject of intense research due to their possible application in spintronic devices. Much attention has been paid to transition metals doped wide band-gap semiconductors such as ZnO.

In this study, Co-doped ZnO films have been prepared in order to investigate the structural, magnetic, optical, and electronic properties of the DMO. Control over the oxygen vacancy concentration in the ZnO host lattice was achieved by using different preparation conditions. Magnetization measurements indicate weak ferromagnetism at low temperature only for the samples prepared at oxygen poor conditions. X-ray absorption spectroscopy (XAS) and optical transmittance measurements have been performed to identify the oxidation state as well as site symmetry of Co in the ZnO host lattice. Comparison of O *K* XAS spectra show oxygen vacancies related features in case of ferromagnetic $Zn_{1-x}Co_xO$ samples. Our findings indicate that ferromagnetism of the Co-doped ZnO is strongly correlated to the presence of oxygen vacancies in the ZnO host lattice supporting the spin-split impurity band model [1].

[1] J.M.D. Coey *et al.*, Nat. Mater. **4**, 173 (2005)

MA 15.16 Tue 15:00 Poster A

Thermal spin-wave excitations in GaMnAs — Matthias Sperl, •Ursula Wurstbauer, Werner Wegscheider, Christian Back, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

In conventional ferromagnets thermally excited spin waves determine the temperature dependence of magnetization well below the Curie temperature. The question, whether the distinct exchange interac-

tion between Mn local moments mediated by holes in GaMnAs leads to a different $M_S - T$ relation compared to conventional ferromagnets with direct exchange interaction among 3d electrons, was investigated in this work. GaMnAs samples with thicknesses of 5-200 nm and (2-6%) Mn where grown on GaAs(100) and annealed under different conditions. M(T) was measured with a SQUID (superconduction quantum interference device) magnetometer at temperatures between 2 K and 30 K with regard to thermal spin excitations. It was found that for all samples $M_S(T)$ is in good agreement with Bloch's law, $M_S(T) = M(0) \cdot (1 - BT^{3/2})$. Interestingly, the spin wave parameter, B, we found is about two orders of magnitude higher than for Fe or FeCo films. This large difference cannot be understood by a reduced exchange interaction by a reduced Curie temperature alone. However, recent calculations [1,2] indicate that disorder and competing interactions in GaMnAs result in a strong thermal decay of the magnetization and can explain the order of magnitude of B found in the present experiment. [1] A. Singh et. al., cond-mat/0607633 [2] A. Singh et. al., cond-mat/0608474

MA 15.17 Tue 15:00 Poster A

Magnetotransport and magnetic anisotropy in (Ga,Mn)As thin films — •Matthias Althammer, Andreas Brandlmaier, Sebastian W. Schink, Matthias Opel, Rudolf Gross, and Sebastian T. B. Goennenwein — Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

Magnetic anisotropy governs the magnetization orientation in ferromagnetic thin films, and therefore is relevant both for basic research as well as for applications. Using magnetotransport measurements, we investigate the magnetic anisotropy of the prototype ferromagnetic semiconductor (Ga,Mn)As. We patterned a 20 nm thick, (001)-oriented $Ga_{0.96}Mn_{0.04}As$ film into Hall-bar mesa structures with optical lithography and etching. The anisotropic magnetoresistance (AMR) is then measured with the external magnetic field applied in the film plane. We observe clear steps at magnetic fields $|H_1|$ and $|H_2|$ in both the longitudinal (sheet) and the transverse (planar Hall) magnetoresistance. This shows that the AMR is determined by one single, macroscopic magnetic domain, which abruptly switches from one easy axis to another. The fields H_1 and H_2 characteristically depend on the orientation of the externally applied magnetic field with respect to the current direction. We show that this dependence allows to quantitatively determine the orientation of the easy in-plane magnetic axes as well as the ratio of the magnetic anisotropy contributions. We furthermore discuss the influence of temperature, crystalline strain and specimen shape on the in-plane magnetic anisotropy.

MA 15.18 Tue 15:00 Poster A

Imaging magnetic structures in $Ga_{1-x}Mn_xAs$ films by low temperature laser scanning microscopy — •Stefan Guenon[1], Michael Wagenknecht[1], Sebastian Goennenwein[2], Rudolf Gross[2], Dieter Koelle[1], and Reinhold Kleiner[1] — [1]Physikalisches Institut-Experimentalphysik II, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner Straße 8, D-85748 Garching, Germany

Diluted magnetic semiconductor alloys, such as epitaxial $Ga_{1-x}Mn_xAs$ films, have attracted considerable interest. They are potentially useful for spintronics applications in which information processing and storage is achieved by utilizing the electron spin. We used low temperature laser scanning microscopy on a hall bar like structure made of a 20 nm thick $Ga_{0.96}Mn_{0.04}As$ film grown on a (100)-oriented GaAs substrate by low-temperature molecular beam epitaxy. An unusual strong thermoelectric signal was observed as a response to the pulsed laser beam on the structure. The signal can be modeled by an electrical dipole induced in the area of the laser spot. In a temperature range well below the Curie temperature $T_C \approx 70K$ where the in-plane magnetic anisotropy of the ferromagnetic film is biaxial we were able to image structures that are similar to already observed ferromagnetic domains in $Ga_{1-x}Mn_xAs$ films by Kerr microscopy.

MA 15.19 Tue 15:00 Poster A

Magneto-optical Kerr effect of EuO Thin Films — •S. Altendorf, R. Sutarto, T. Haupricht, and L. H. Tjeng — II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany

EuO is a ferromagnetic semiconductor with a Curie temperature (T_C) of 69 K [1]. Large magneto-optical effects such as a specific Faraday rotation of 5×10^5 degrees per cm [2] were reported making this compound an interesting starting material for research and applications in the field of magneto-optics.

We report on our measurements of the magneto-optical Kerr effect (MOKE) of EuO thin films. EuO thin films were grown on a 50 nm Cr layer on Al_2O_3 substrates by means of molecular beam epitaxy using a distillation technique which allows a precise control of the stoichiometry. The dependence of the Kerr rotation on the film thickness and temperature is investigated.

[1] A. Mauger and C. Godart, Phys. Rep. **141**, 51 (1986)
[2] K. Ahn and J. Suits, IEEE Trans. Mag. **3**, 453 (1967)

MA 15.20 Tue 15:00 Poster A

Preparation, Capping and Characterization of Gd doped EuO Thin Films — •T. Haupricht[1], R. Sutarto[1], H. Ott[1], N. Hollmann[1], H. Hartmann[1], T. Lorenz[1], Z. Hu[1], C. F. Chang[1], H. H. Hsieh[2], H. J. Lin[3], C. T. Chen[3], P. Nagel[4], S. Schuppler[4], and L. H. Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany — [2]Chung Cheng Institute of Technology, National Defense University, Taoyuan 335, Taiwan — [3]NSRRC, 101 Hsin-Ann Road, Hsinchu 30076, Taiwan — [4]ANKA, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

EuO belongs to the rare class of ferromagnetic semiconductors. By electron doping the Curie temperature (T_C) of 69 K for stoichiometric bulk EuO can be enhanced up to 160 K [1].

We report on the growth and characterization of Gd doped EuO thin films. We prepared samples by means of MBE under distillation conditions, which allows a very precise control of the oxygen stoichiometry. Using LEED and RHEED we show that the EuO films can be grown epitaxially and that the [100] directions of the films and MgO substrates are aligned. In order to perform *ex-situ* measurements we covered the samples with Au and Al capping layers. Using Vibrating Sample Magnetometry we investigated the dependence of T_C on Gd doping and O deficiency. We have observed record high T_C's of 170 K for a Gd concentration of about 4% [2].

[1] A. Mauger and C. Godart, Phys. Rep. **141**, 51 (1986)
[2] H. Ott et al., Phys. Rev. B **73**, 094407 (2006)

MA 15.21 Tue 15:00 Poster A

Spinresolved Photoemission Spectroscopy of Amorphous CoFeB — •Martin Sperlich[1], Coen Smits[1], Reza Gadhimi[4], Frank Matthes[2], Theodoros Dimopoulos[3], Joachim Wecker[3], Claus M. Schneider[2], and Gernot Güntherodt[1] — [1]II. Physik. Inst., RWTH Aachen — [2]Inst. für Festkörperforschung, FZ Jülich — [3]Siemens AG, Corporate Technology — [4]Gemeinschaftsinstitut für Elektronenmikroskopie, RWTH Aachen

Tunnel magnetoresistance (TMR) junctions of the system CoFeB/MgO/CoFeB based on amorphous CoFeB show the highest TMR values of all FM/MgO/FM junctions (FM = ferromagnet) of over 350% at room temperature [1]. This is very surprising since the highest TMR values have been theoretically predicted for epitaxial junctions. Due to annealing the TMR values increase which is attributed to a surface crystallisation of the amorphous CoFeB at the interface with MgO. By means of UV Spin-polarised Photoemission Spectroscopy (SP-PES) we have investigated the spin polarisation of amorphous CoFeB films. On a relative scale compared to tunneling the spin polarisation obtained from SP-PES gives an indication of the influence of annealing processes on the TMR values. Upon annealing at 275 °C the spin polarization of CoFeB increases by a factor of two. This is explained by the onset of surface crystallisation of CoFeB and a reduction of oxygen at its surface. We paid special attention to the metal/oxide interfaces by using Mg/MgO overlayers on CoFeB. The oxidation states of Mg were controlled by the position of the Mg 2p core levels. - [1] Y.M. Lee et al., Appl. Phys. Lett. 89, 042506 (2006)

MA 15.22 Tue 15:00 Poster A

Magnetic anisotropy in $Fe_{1-x}Co_x$ films on Pd(001), Pd/Cu(001) and Pd/GaAs(001) — •Xiuli Fu, Feng Luo, Jochen Barthel, Marek Przybylski, and Jurgen Kirschner — Max-Planck-Institut fur Mikrostrukturphysik, Halle, Germany

Tetragonally distorted $Fe_{1-x}Co_x$ alloy films were grown on Pd(001) at room temperature (RT) by molecular beam epitaxy using thermal evaporation from two effusion cells. First-principles calculations for such films predict a high uniaxial magnetic anisotropy energy for specific values of the lattice distortion and the alloy composition x. Magneto-optical Kerr effect measurements have shown that the mag-

netic anisotropy depends strongly on temperature. For example, the out-of-plane easy axis of magnetization is observed for $Fe_{0.5}Co_{0.5}$ films up to the thickness of 14 ML at 60 K, whereas at RT the films are magnetized in-plane. A thermal expansion and related changes of the tetragonal distortion are supposed to be responsible for this effect. The explanation is verified by a comparison to the $Fe_{1-x}Co_x$ alloy films grown on a Pd buffer layer on Cu(001) and GaAs(001). Such systems are characterized by different thermal expansion coefficients. Additionally, the tetragonal distortion can be controlled by the thickness of the Pd buffer layer. It decreases for the growth on Cu(001) and increases for the growth on GaAs(001) with decreasing Pd thickness.

MA 15.23 Tue 15:00 Poster A

Magnetic anisotropy in ultrathin Pd,Au/Fe bilayers on GaAs(001) — Oleksander Mosendz[1], Jan Zukrowski[2], Bartek Kardasz[1], Bret Heinrich[1], •Marek Przybylski[3], and Jurgen Kirschner[3] — [1]Simon Fraser University, Vancouver, Canada — [2]AGH University of Science and Technology, Krakow, Poland — [3]Max-Planck-Institut fur Mikrostrukturphysik, Halle, Germany

The role of the deposition technique on the magnetic anisotropies in Fe/GaAs(001) based structures was investigated by ferromagnetic resonance (FMR) and conversion electron Mössbauer spectroscopy (CEMS). The Fe layers were prepared by thermal deposition (TD) or by pulsed laser deposition (PLD) techniques. For CEMS experiments, the ^{57}Fe probe layer was placed either in the Fe/GaAs(001) interface, in the interface with the Au or Pd coating layers, or at various depth of the films. To assure film continuity and a Curie temperature well above room temperature (RT), the total film thickness was kept around 10 ML of Fe. CEMS spectra, measured ex situ at RT, show that TD samples have a better interface lattice structure than those deposited by means of PLD. Further, diffusion of As into the film volume is detected from the spectra. Interestingly, even the upper interface is affected by the deposition technique due to As floating on top of the Fe film. It is shown that perpendicular anisotropy is mostly increased at the Fe/Au(001) interface, and becomes maximum for the PLD-grown Fe films. PLD also increases the magnetic damping which is caused by two magnon scattering.

MA 15.24 Tue 15:00 Poster A

X-ray magnetic linear dichroism in reflection and absorption spectra measured in the vicinity of the $L_{2,3}$ edges of ultrathin cobalt films on W(110) — •Nagamony Ponpandian, Armin Kleibert, Stefan Gutzeit, Stefan Polei, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, Universitätsplatz 3, D-18051 Rostock

X-ray magnetic linear dichroism (XMLD) is a valuable tool to measure the magnetocrystalline anisotropy energy (MAE) of thin films and multilayers in an element specific and even in laterally resolved manner. Normally, the XMLD in absorption is a quite weak effect in the important case of the 3*d* transition metals. However, recent experiments revealed a strong enhancement in XMLD-type effects when detecting the specular reflectivity instead of the absorption. In order to investigate the origin of this enhancement we studied the XMLD both in absorption and reflection in epitaxially grown Co films on W(110). These samples possess atomically flat interfaces and thus are well suited for reflectivity experiments. Moreover, they exhibit a thickness dependent MAE. In this contribution we will compare the experimentally observed effects in reflection with respective calculations based on a 4×4-matrix formalism. Furthermore, we will address the anisotropy in the shape of the XMLD spectra and its theoretically predicted relation to the thickness dependent MAE of the Co films.

MA 15.25 Tue 15:00 Poster A

Thin magnetic Co-based films with perpendicular anisotropy — •Jens Brandenburg[1,2], Volker Neu[1], Ruben Hühne[1], and Ludwig Schultz[1] — [1]Leibniz Institut für Festkörper- und Werkstoffforschung Dresden, Institut für Metallphysik — [2]Max Planck Institut für Chemische Physik fester Stoffe

Epitaxial Cobalt films with high c-axis texture have been prepared by PLD either directly onto Al_2O_3(0001) single crystal substrates or with an intermediate Ruthenium buffer layer. The influence of the substrate temperature on texture and crystal growth was investigated by XRD. The crystal structure and epitaxial growth relation was studied by XRD, pole figure measurements and 'reciprocal space mapping'. Detailed VSM analysis shows that the perpendicular anisotropy of highly textured Co films reaches the value reported for the magnetocrystalline anisotropy of Co bulk material. The preparation of very thin Co films ($20\,\text{nm} < t < 100\,\text{nm}$) gives the possibility to examine the stripe domain phase over a larger thickness range as was reported so far. The thickness dependence of the domain width of this periodic domain pattern was studied by magnetic force microscopy (MFM) and compared with different models of domain theory. Especially the discrepancies at smallest film thicknesses show that the system is in an intermediate state of in-plane and out-of-plane domains, which is not described by existing stripe domain models. The experiments are extended to materials with higher magnetocrystalline anisotropy. First results on $Co_{80}Pt_{20}$- and $SmCo_5$-films show evidence for epitaxial growth of these compounds on Al_2O_3(0001) single crystal substrates.

MA 15.26 Tue 15:00 Poster A

10keV He ion bombardment of $Ni_{80}Fe_{20}$/Au/Co/Au multilayers with alternating in-plane and out-of-plane magnetization — •Tanja Weis[1], Dieter Engel[1], Arno Ehresmann[1], Maria Tekielak[2], Andrzej Maziewski[2], Bogdan Szymanski[3], Janusz Dubowik[3], and Feliks Stobiecki[3] — [1]Institute of Physics and CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Institute of Molecular Physics, Polish Academy of Sciences, ul. Smoluchowskiego 17, 60-179 Poznan, Poland — [3]Institute of Experimental Physics, University of Bialystok, Lipowa 41, 15-424 Poland

Ion bombardment with light ions enables the alteration of the magnetic properties in magnetic thin film systems [1]. This technique was used to modify magnetic anisotropies in $Ni_{80}Fe_{20}$/Au/Co/Au multilayers. The as-prepared multilayers show prior to bombardment alternating in-plane (NiFe) and out-of-plane (Co) magnetization. We will present Kerr Microscopy images of 10keV He ion bombarded samples with either Au- or Co-wedges to show the dependence of the modifications of magnetic properties like anisotropy and interlayer coupling on the Au- and Co- thickness (t_{Au} and t_{Co}) and on the ion dose. Due to an increase of interface roughness the surface induced perpendicular anisotropy is reduced for $0.95\text{nm} \leq t_{Co} \leq 1.05\text{nm}$. On the other hand the ion bombardment heavily mixes ultrathin Co layers ($0.35\text{nm} \leq t_{Co} \leq$ nm) resulting in their superparamagnetic behavior.

[1] A. Ehresmann et al., Phys. Stat. Sol (b), 243, 29-36 (2006)
[2] F. Stobiecki et al., J. Magn. Magn. Mater., in press

MA 15.27 Tue 15:00 Poster A

Analysis of the structure and stoichiometry in iron/native iron oxide multilayers — •Thomas Diederich, Sebastien Couet, and Ralf Röhlsberger — Hamburger Synchrotron Strahlungslabor (HASYLAB) at Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg

Recently we have found that multilayers consisting of iron and native iron oxide layers exhibit a magnetic superstructure [1]. It is clear that the mechanism leading to the observed coupling strongly depends on the multilayer structure and the properties of the native iron oxide. In order to characterize the multilayers in more detail we have used different X-ray techniques at the DORIS storage ring (DESY, Hamburg) such as X-ray absorption spectroscopy (XAS) and X-ray reflectometry (XRR). By using reference samples for XAS measurements at the Fe K-edge we have been able to extract the absorption profile resulting from the oxide in the multilayer. From this we conclude that the native oxide is a mixture of FeO and Fe_3O_4 with a ratio of about 1:1. The XRR experiments have been used to characterize the structure of the multilayer. Superstructure Bragg peaks in the reflectivity data arise due to the chemical periodicity. From a simulation of the data we found average thicknesses of 1.7 nm and 1.6 nm for the Fe and the Fe-oxide layers, respectively. The interface roughness is about 0.4 nm for the bottom layers and increases to roughly 0.7 nm for the upper layers.

[1] Th. Diederich, S. Couet, and R. Röhlsberger, submitted

MA 15.28 Tue 15:00 Poster A

Ultrathin magnetic films on rhodium substrates — •Ali Al-Zubi, Gustav Bihlmayer, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich

Using density functional theory calculations we investigate relaxations, magnetic order, and the magnetic anisotropy energy (MAE) of Fe, Co, and Ni monolayers on Rh(001) and Rh(111) substrates. We employ the full-potential linearized augmented planewave method in thin film geometry. The Co and Ni films were found to order ferromagnetically, while for Fe a tendency towards antiferromagnetism is observed. We compare to the Fe/Ir(111) system, where more complicated spin-structures were observed in theory and experiment [1]. Especially for Co films we find very large induced moments in Rh, therefore we study

the substrates influence on the MAE and compare also to the case of Co/Ir(111).
[1] K. von Bergmann et al. Phys. Rev. Lett. **96**, 167203 (2006)

MA 15.29 Tue 15:00 Poster A

Micromagnetic analysis of magnetization reversal in nanolayers with competing anisotropies and applications to layers of dilute magnetic semiconductor materials — Andrei A. Leonov[1], Igor E. Dragunov[1,2], Ulrich K. Rössler[2], and •Alexei N. Bogdanov[1,2] — [1]Donetsk Institute for Physics and Technology — [2]IFW Dresden

The interplay between intrinsic and surface/interface-induced magnetic anisotropies causes remarkable reorientation effects and strongly influences magnetization processes in nanomagnetic systems. We apply a phenomenological theory [1,2] to describe the field-driven reorientation in nanomagnets with cubic and uniaxial anisotropies. The equilibrium magnetization states are calculated as functions of the applied magnetic field for systems with misalignment between uniaxial and cubic easy axes. The magnetic phase diagrams classified through their topological features allow a detailed analysis of the magnetization processes in these system. Equilibrium parameters of multidomain structures have been derived as functions of applied field, the ratio between cubic and uniaxial anisotropy, and the field misalignment. The theory is applied to analyze switching processes and transformations of domain patterns for experimental observations on layers of dilute magnetic semiconductors as (Ga,Mn)As from the literature.

[1] U.K. Rößler, S.V. Bukhtiyarova, I.V. Zhikharev, A.N. Bogdanov, J. Magn. Magn. Mater. **290-291**, 772 (2005). [2] I.E. Dragunov, S.V. Bukhtiyarova, I.V. Zhikharev, A.N. Bogdanov, U.K. Rößler, Phys. Solid State **48** 1591 (2006).

MA 15.30 Tue 15:00 Poster A

Theory of stripe domains in ferromagnetic multilayers with perpendicular anisotropy — Igor E. Dragunov[1,2], Nicolai S. Kiselev[1], Ulrich K. Rössler[2], and •Alexei N. Bogdanov[1,2] — [1]Donetsk Institute for Physics and Technology — [2]IFW Dresden

Exchange coupled multilayer systems with perpendicular anisotropy, as [CoPt]/Ru, [CoPt]/NiO, Co/Ir, Fe/Au, display magnetic stripe phases as regular equilibrium multidomain states [1]. In contrast to other bulk and nanomagnetic systems, the formation of these multidomain structures is due to the interplay between interlayer exchange and dipolar couplings [2]. We have derived effective micromagnetic equations to calculate the existence regions and geometrical parameters of equilibrium stripe domains and their evolution in a bias field. In multilayers with ferromagnetic exchange coupling the equilibrium parameters can vary in a broad range depending on relative values of the magnetic layer and spacer thicknesses. In superlattices with antiferromagnetic exchange coupling three different ground states can be realized in the system depending on the materials parameters, namely the homogeneous antiferromagnetic state, and multidomain antiferromagnetic and ferromagnetic modes. These results on ground states are represented by magnetic phase diagrams in terms of the materials parameters describing strengths of interlayer exchange coupling, thickness of the ferromagnetic single layer, and number of layers.

[1] O. Hellwig et al., Nature Mater. 2 (2003) 112. [2] U. K. Rößler, A. N. Bogdanov, J. Magn. Magn. Mater. 269 (2004) L287; A. N. Bogdanov, U. K. Rößler, cond-mat/0606671.

MA 15.31 Tue 15:00 Poster A

Green Function theory vs. Quantum Monte Carlo Calculation for thin magnetic films — •Sören Henning[1], Fritz Körmann[1], Stefan Schwieger[2], Jochen Kienert[1], and Wolfgang Nolting[1] — [1]Lehrstuhl Festkörpertheorie, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstrasse 15, 12489 Berlin, Germany — [2]Technische Universität Ilmenau, Theoretische Physik I, Postfach 100565, 98684 Ilmenau, Germany

Up to now comparison between numerically exact Quantum Monte Carlo (QMC) calculations and Green function (GF) theory of thin magnetic films including second order anisotropies are only available for easy axis systems, i.e. for systems that favour a magnetization perpendicular to the film plane. Unfortunately there are no QMC data available for easy plane systems for which the anisotropy favours the magnetization parallel to the film plane. In this work we will discuss these systems. We present temperature and field dependent transitions and obtain good agreement between QMC results and Green function theory. Besides that we found an interesting magnetic disorder-order transition for increasing temperature.

MA 15.32 Tue 15:00 Poster A

Tunable strain in MgO single crystals — •Mathias Weiler, Andreas Brandlmaier, Stephan Geprägs, Matthias Opel, Sebastian T. B. Goennenwein, and Rudolf Gross — Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

Crystalline strain affects many properties of solid state materials, e.g. the electronic band structure or the magnetic anisotropy of ferromagnets. The application of controllable strain thus is interesting for the realization of multifunctional materials. We discuss how the expansion of a piezoelectric actuator alters the strain in a MgO crystal at room temperature. Using two-component epoxy, we glued a $2 \times 2 \times 0.1\,\mathrm{mm}^3$ piece of a (001)-oriented MgO single crystal onto a piezoelectric actuator. The main elongation axis of the actuator is aligned in the platelet plane, along a MgO [100] direction. We measure the modification of the MgO crystalline structure as a function of the voltage V_{piezo} applied to the actuator, using high-resolution x-ray diffraction. From 2Θ-ω scans, we find that the MgO lattice constant c along [001] (perpendicular to the platelet plane) can be linearly and reversibly tuned by up to $\Delta c/c = 3 \times 10^{-5}$ upon applying $-30\,\mathrm{V} \leq V_{\mathrm{piezo}} \leq +90\,\mathrm{V}$. According to elasticity theory, this implies that only about 10% of the actuator stroke is transferred into the MgO crystal. We discuss this observation, and compare our results to the effect of V_{piezo} on the magnetic anisotropy of Fe_3O_4 thin films grown onto MgO and then attached to a piezoelectric actuator.

MA 15.33 Tue 15:00 Poster A

Electric-Field Induced Modification of Magnetism in Thin Film Ferromagnets — Martin Weisheit[1,2], •Sebastian Fähler[1,2], Alain Marty[3], Yves Souche[1], Christiane Poinsignon[4], and Dominique Givord[1] — [1]Laboratoire Louis Néel, CNRS, Grenoble, France — [2]IFW Dresden, Germany — [3]DRFMC / SP2M / NM, CEA Grenoble, France — [4]LEPMI / ENSEEG, Saint Martin d'Hères, France

A large electric field at the surface of a ferromagnetic metal is expected to appreciably change the electron density. In particular, the intrinsic magnetic properties, which commonly are regarded as fixed material constants, will be affected. This requires, however, that the surface has a strong influence on the material*s properties, as is the case in ultrathin films. We show that the magnetocrystalline anisotropy of ordered FePt and FePd intermetallic compounds can be reversibly modified by an applied electric field when immersed in an electrolyte. A voltage change of -0.6 V on 2 nm thick films altered the coercivity by -4.5% and +1% in FePt and FePd, respectively. The modification of the magnetic parameters was attributed to a change in the number of unpaired d-electrons in response to the applied electric field. Our device structure is general and should be applicable for characterisation of other thin film magnetic systems.

Science, forthcoming 19.1.2007

MA 15.34 Tue 15:00 Poster A

Magnetoresistive effects in ultrathin permalloy films — •Stephen Krzyk, Mathias Kläui, and Ulrich Rüdiger — Fachbereich Physik, Universität Konstanz, 78457 Konstanz

Inspired by the successful industrial application of the giant magnetoresistance effect (GMR), magnetoresistance properties of nanoscale structures are the subject of intense research. Recent experiments [1] have shown that decreasing the cross section of a nanocontact leads to a significantly increased magnitude of the anisotropic magnetoresistance.

A possible approach to small contact sizes are ultrathin films near the percolation threshold. We investigate magnetotransport through permalloy ($Ni_{80}Fe_{20}$) films grown in between the gaps of Au leads. Permalloy films in the monolayer range were deposited via molecular beam epitaxy in ultra high vacuum conditions. A magnetic field of up to 100 mT was applied in the sample plane, and the conductance of the contact region was measured during depostion as a function of the field angle.

[1] K. I. Bolotin et al., Phys. Rev. Lett. **97**, 127202 (2006)

MA 15.35 Tue 15:00 Poster A

Current-induced magnetic vortex dynamics: micromagnetic simulations and time-resolved x-ray microscopy — •A. Drews[1], M. Bolte[1], B. Krüger[2], G. Meier[1], U. Merkt[1], B. Van Waeyenberge[3], A. Puzic[4], K. W. Chou[4], and H. Stoll[4] — [1]Institut für Angewandte Physik, 20355 Hamburg. — [2]I. Institut für Theo-

retische Physik, 20355 Hamburg — [3]Department of Subatomic and Radiation Physics, Ghent University, 9000 Gent, Belgium — [4]Max-Planck-Institut für Metallforschung, 70569 Stuttgart

We investigated the current-driven vortex and antivortex dynamics in permalloy rectangles by time-resolved x-ray microscopy and micromagnetic simulations. Experimentally, the vortex rotation was excited by electric ac currents passing directly through the samples. The dynamics was observed by time-resolved x-ray microscopy at beamline 11.0.2. at the Advanced Light Source in Berkeley. From the direction of gyration of the vortices, we determine the polarization of the vortices and the phase of the rotation. We show that in the present experiments only the spin torque and not the Oersted field causes the vortex rotation. We also observe the current-induced rotation of an antivortex at higher frequencies. Micromagnetic simulations were performed for the samples' geometries with OOMMF, extended by the spin-torque term of Zhang and Li. From the simulations we deduce the eigenfrequencies of the vortex motion. We find that two vortices and one antivortex are excited to rotation in a 2x3 μm^2 permalloy rectangle, in agreement with the experiments. Simulations with higher current densities yield a flipping of the polarization of both vortices and antivortex.

MA 15.36 Tue 15:00 Poster A

Impedance of ferromagnetic microrings up to 120 MHz — •Thomas Kamionka, Toru Matsuyama, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg (Germany)

The interaction between a spin-polarized current and the magnetization in a ferromagnetic micro- or nanostructure is of great interest. It will offer new opportunities to design magnetic memory and logic devices. We will analyze the resonant interaction between a spin-polarized current and a magnetic domain wall using a ferromagnetic microring. Using the shape anisotropy of the ring a domain wall can be prepared. This is proven by magnetic-force microscopy and by measuring the anisotropic magnetoresistance. In a magnetic field in the plane of the microring an alternating current forces a transverse domain wall to oscillate like a particle with finite mass [1]. At resonance the oscillation should effect a detectable increase of the ring impedance. At a critical external magnetic field the domain wall becomes unstable and the magnetization of the ring switches to the global vortex state. Concomitantly we detected a sharp increase of the anisotropic magnetoresistance. We varied the amplitude and the frequency of the current and found indications of current-assisted magnetization switching.

[1] E. Saitoh et al., Nature **432**, 203 (2004).

MA 15.37 Tue 15:00 Poster A

Magnetoresistive effects in single LSMO:MgO grain-boundaries — •Markus Esseling, Vasily Moshnyaga, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen

The LSMO:MgO nanocomposite system shows a low-field magnetoresistance up to 30% at low temperatures which is due to the spin polarized tunneling of the conducting electrons across the insulating MgO, which separates individual LSMO grains [1]. Up to now it is still unclear whether the interesting properties of the nanocomposites are a result of the averaging process over all involved grain-boundaries (GB) or are intrinsic to every GB. Therefore we prepared single LSMO:MgO grain-boundaries using $SrTiO_3$- and MgO-bicrystal substrates. Junctions of different width (50μm - 300nm) were defined by e-beam lithography and focussed ion beam etching across the GB. A strong influence of the junction width is observed on both the resistance and the magnetoresistance, indicating an inhomogeneous GB. Moreover we show that smallest structures across the GB offers a possibility to study current-induced switching effects in lateral systems, which can be compared to heterostructures.

[1] M. Esseling et al., Appl. Phys. Lett. 87 (2005) 082509

Supported by SFB 602, TP A2 and DFG Sa337/9-1

MA 15.38 Tue 15:00 Poster A

Temperature dependence of current induced domain wall motion in NiFe — •Markus Laufenberg, Wolfgang Bührer, Pascal Dagras, Pierre-Eric Melchy, Mathias Kläui, Lutz Heyne, Dirk Backes, Daniel Bedau, and Ulrich Rüdiger — Universität Konstanz, 78457 Konstanz

Recently reversal by current-induced domain wall motion (CIDM) has become the focus of intense research [1], but quantitative agreement between experiment and theory is often poor. Since so far theory does not consider temperature whereas experiments are often carried out at room temperature, that might be one reason for the observed discrepancies.

In this work we present an experimental study of domain wall motion induced by current pulses as well as by conventional magnetic fields at temperatures between 2 and 300 K in $Ni_{80}Fe_{20}$ rings. The rings are contacted by gold pads to allow for current injection and magnetoresistance measurements. Via the AMR-effect a change in the magnetic configuration can be detected.

Whereas field-induced domain wall motion is a thermally activated process it turns out that CIDM at higher temperatures is less effective than at lower temperatures [2]. The effect of Joule heating due to the current pulses is measured and taken into account to obtain critical fields and current densities at constant sample temperatures. This allows for a comparison of our results with theory.

[1] M. Kläui, *et.al.*, Phys. Rev. Lett. **94**, 106601 (2005).
[2] M. Laufenberg, *et.al.*, Phys. Rev. Lett. **97**, 046602 (2006).

MA 15.39 Tue 15:00 Poster A

AlZr tunnel barriers in magnetic tunnel junctions — •Andrea Niemeyer[1], Andy Thomas[1], Hubert Brückl[2], and Günter Reiss[1] — [1]Bielefeld University, Thin Films & Nanostructures, Bielefeld, Germany — [2]ARCS research GmbH, Nano System Technologies, Vienna, Austria

Magnetic tunnel junctions are due to various possible applications interesting for research and development. Different electrode and barrier materials were used for preparation. During the last ten years the most commonly used barrier material was aluminum oxide. AlZr compositions form a very homogenous and amorphous barrier which is important for a good quality tunneling barrier. This might as well lead to higher tunneling magneto resistance. CoFeB as an electrode material provides high tunneling magneto resistance, about 70% at room temperature with commonly used aluminum oxide. The combination of CoFeB and a Zr alloyed barrier promises even higher TMR amplitudes. The magnetoresistance was measured in dependence on the barrier thickness for several AlZr alloy compositions.

MA 15.40 Tue 15:00 Poster A

Spin transfer torque in granular films AgCo and spin-valve structure Co/Cu/CoNiFeSiB — •Yuansu Luo[1], Markus Esseling[1], Markus Münzenberg[2], and Konrad Samwer[1] — [1]I. Phys. Institut — [2]IV. Phys. Insitut, Universität Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

We explore spin transfer torque (STT) effect in granular films $Ag_{70}Co_{30}$ and spin-valve structure $Co/Cu/(CoNiFe)_{74}(SiB)_{26}$ by means of point contact technique. Several special properties, such as single-domain properties of Co nanoparticles, a large GMR effect (55% measured at 4.2K) in AgCo, a small coercivity ($H_c \approx 1$ Oe) and a low magnetization ($M_s \approx 0.7$ kG) of the amorphous free layer $(CoNiFe)_{74}(SiB)_{26}$, are convenient for STT observations. A novel STT effect is observed in the granular film, as the current rises above a threshold value I_c. It is accompanied with an abrupt decrease in resistance (R), presumably due to further alignment of small size Co granules. The behavior is polar and I_c disproportional to the magnetic field. For the spin-valve structure a normal current-induced magnetization switching was measured under a standard condition, i.e. an electron flux from the fixed Co-layer to the amorphous free layer $(CoNiFe)_{74}(SiB)_{26}$ stabilizes the parallel alignment (low R), while an opposite current results in the antialignment of two magnetic layers (high R). *Supported by DFG-project, SA 337/9-1*

MA 15.41 Tue 15:00 Poster A

Analysis of the oscillatory tunnel magnetoresistance caused by antiferromagnetic Mn Layers — •Peter Bose[1], Jürgen Henk[2], and Ingrid Mertig[1] — [1]Martin-Luther-Universität Halle-Wittenberg, FB Physik, FG Theoretische Physik, D-06099 Halle (Saale), Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle (Saale), Germany

It is well-established that interfaces determine essentially the transport properties of spintronic systems [1]. However, the essence of this phenomenon is not clarified until now and is still a subject of lively debates. By considering the effect of well-defined magnetic interfaces, the present theoretical investigation provides additional arguments to this discussion.

The ballistic magnetoresistance of tunnel junctions that comprise Mn films is found to exhibit oscillations with increasing Mn-film thick-

ness, as is investigated by means of first-principles electronic-structure and transport calculations. The period of two monolayers is directly related to the layer-wise antiferromagnetic structure of the Mn films, in particular to the alternating magnetization at the interfaces [2]. These findings substantiate unequivocally the effect of the electronic and magnetic structure of interfaces on the conductance of tunnel junctions.

[1] C. Heiliger, P. Zahn, B. Yu. Yavorsky and Ingrid Mertig, Phys. Rev. B **72**, 180406 (2005)

[2] U. Schlickum, W. Wulfhekel, J. Henk, P. Bruno, and J. Kirschner, Phys. Rev. B **74**, 054409 (2006)

MA 15.42 Tue 15:00 Poster A

Structural properties and transport behaviour of polycrystalline $Co_2Cr_{0.6}Fe_{0.4}Al$ films as electrode materials in MTJs — •Rainer Kaltofen[1], Hartmut Vinzelberg[1], Dieter Elefant[1], Ingolf Mönch[1], Joachim Schumann[1], and Rainer Grötzschel[2] — [1]IFW Dresden, P.O.Box 27 01 16, D 01171 Dresden — [2]Institute of Ion Beam Physics and Materials Research, FZ Dresden-Rossendorf, P.O. Box 51 01 19, D 01314 Dresden, Germany

Owing to the high spin polarization predicted for ferromagnetic half-metallic Heusler alloys many experimental attempts are known to verify this feature on real systems. The present work studies polycrystalline $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA) films prepared by dc magnetron sputtering. The film composition checked by RBS and PIXE is in good correspondence with the target composition. X-ray studies showed a disordered B2 structure characterized by Co-Al antisite defects. Saturation magnetization measurements by SQUID magnetometry at T=4K showed the number of Bohr magnetons per formula unit to vary between N_B/FU=2...3 in dependence on the deposition substrate temperature and annealing treatments. A strong influence of these treatments on the magnetization temperature dependence is observed. The TMR results exhibit a marginal influence of preparation conditions (T_S,p_{Ar},T_{ann}), however the best values did not exceed $\sim$ 30% at 4.2 K indicating that half-metallic behaviour of the CCFA films is not observed. The main reason of the failure of high spin polarization predicted for CCFA seems to be the imperfect crystalline structure suppressing the formation of a half-metallic band structure.

MA 15.43 Tue 15:00 Poster A

Concept of a Metal Single-Electron Transistor as Spin-Valve Structure — •Markus Kasper, Saskia Fischer, and Ulrich Kunze — Werkstoffe und Nanoelektronik,Ruhr-Universität Bochum, D-44780 Bochum

The generation, manipulation and investigation of spin-polarized currents still need to be improved to make new spintronic components reality. In this contribution we present a concept for a metal single-electron transistor that exploits the combination of Coulomb Blockade and spin-dependent tunneling processes between ferromagnetic leads and a metallic quantum dot [1]. Spin-polarized electrons tunneling through the quantum dot will lead to a non-equilibrium spin accumulation, i.e. a finite polarization of the quantum dot spin. The state of the quantum dot spin is reflected in the transport characteristics of the device. This structure is probably feasible to provide new insights into the mechanisms of spin controlled electron transfer and might actually show new effects resulting from the interaction of both phenomena. We present preliminary results for a metal single-electron transistor with an aluminium quantum dot and tunneling barriers formed by plasma oxidation.

[1] J. König and J. Martinek, PRL 90, 166602 (2003)

MA 15.44 Tue 15:00 Poster A

Magnetotransport Properties of Cobalt-doped ZnO — •Konrad Senn, Karl-Wilhelm Nielsen, Sebastian T. B. Goennenwein, Matthias Opel, and Rudolf Gross — Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching

Cobalt-doped ZnO, which is predicted to be a diluted magnetic semiconductor (DMS) with a Curie-temperature well above room temperature, is a promising candidate for application in spintronics. We have grown (0001)-oriented $Zn_{0.95}Co_{0.05}O$-films on (0001) Al_2O_3 and (0001) $ScAlMgO_4$ substrates by pulsed laser deposition. The growth was monitored by high pressure RHEED. The structural quality of the films was characterized by x-ray diffraction and the magnetic properties have been analyzed by SQUID magnetometry, it revealed room temperature ferromagnetism with magnetic moments up to 0.7 μ_B/Co. To study the relation between magnetism and electrical transport, we measured their magnetotransport properties in applied magnetic fields up to 14 T in the temperature range between 3 K and 300 K. We observed an anomalous Hall effect in samples grown on both Al_2O_3 and $ScAlMgO_4$. We discuss our results in terms of an intrinsic ferromagnetic exchange coupling and the possible presence of cobalt precipitates.

This work is supported by the DFG via SPP 1157.

MA 15.45 Tue 15:00 Poster A

Transport properties of magnetic Co doped ZnO thin films — •Milan Gacic, Gerhard Jakob, and Hermann Adrian — Institut für Physik, Universität Mainz, Staudinger Weg 7, 55128 Mainz

Diluted magnetic semiconductors (DMS) have recently attracted much interest because of their potential application in spintronics. Thereby ferromagnetism above room temperature is essential for practical applications, as found in Co doped ZnO. We have investigated magnetic and transport properties of 5% Co doped and undoped ZnO thin films deposited on r-plane Al2O3 substrates by pulsed laser deposition. The Co doped films showed paramagnetic and ferromagnetic behaviour as well as a high magnetoresistance and a small anomalous Hall effect. In a range of 0 to 5 Tesla at low temperatures we observed a double sign change of the magnetoresistance. For undoped ZnO films, prepared by the same conditions, only a negative MR was observed, but suprisingly also a very small anomalous Hall effect. We explain our results by applying a semiempirical fit consisting of a positive and a negative contribution to the magnetoresistance.

MA 15.46 Tue 15:00 Poster A

Structural and electrical characterization of magnetic tunnel junctions with ultrathin MgO-barriers — •Gerrit Eilers, Tore Niermann, Michael Seibt, and Markus Münzenberg — IV. Phys. Inst., Universität Göttingen

Ultrathin barriers are necessary to provide sufficient high tunnel current densities, which are required for spin current induced switching experiments. For future MRAMs with high read and write performance a high room-temperature tunnelling magnetoresistance (TMR) is also necessary. The thinner the barrier, the more important become the interfaces between the ferromagnetic electrodes and the insulating barrier.

We have prepared magnetic tunnel junctions (MTJs) with trilayers of CoFeB/MgO/CoFeB by means of e-beam evaporation of stoichiometric MgO and magnetron sputtering CoFeB. After characterizing the transport properties (I/V characteristics, TMR) the structural analysis was made by cross-sectional TEM. Aim is to correlate structurel defects and quality of the interfaces with the transport properties.

In future experiments we are planning to integrate the MTJs into a strip line with a photoconductive switch in order to study the dynamics of spin current induced switching effect.

Research was funded by DFG, SFB 602

MA 15.47 Tue 15:00 Poster A

Low-temperature tunneling magneto-resistance on LSMO-based junctions with organic barrier — •Hartmut Vinzelberg, Dieter Elefant, Joachim Schumann, Kathrin Dörr, Ramesh Gangineni, and Bernd Büchner — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

In analogy to the initiative work [1] on giant magneto-resistance in organic spin-valves LSMO-based junctions with an Alq_3-spacer were investigated with the aim to understand the transport behaviour in these new magnetic switching elements. The field and temperature dependence of the magneto-resistance of the prepared elements confirm the experimental observations in [1]. The described spin-valve effects at 4.2 K have been observed in a broad resistance interval from kΩ to MΩ-range without systematic area dependence. In some samples the magneto-resistance changes sign as a function of the bias voltage.

The observed similarity in the bias voltages dependences in comparison with (i) conventional MTJs with Al_2O_3 or MgO barriers and (ii) ferromagnetic contacted carbon nanotubes as well as the insulating nature of Alq_3 characterized by trapped-charge-limited conductivity [2] suggest to describe the found effects within a classical tunnelling concept. The proposed model implies the realization of the spin-dependent transport via local tunnelling paths embedded in the LSMO/Alq_3/Co sandwich structure.

[1] Z.H. Xiong et al., Nature 427, 821(2004)

[2] P.E. Burrows et al., J. Appl. Phys. 79, 7991(1996)

MA 15.48 Tue 15:00 Poster A

Investigation of Spin Polarization by Point Contact Spec-

troscopy — •Christoph Jurecka, Martin Jourdan, and Hermann Adrian — Institut für Physik, Johannes Gutenberg Universität Mainz, 55099 Mainz

Materials with high spin polarization play a key role in modern magnetoelectronic devices. However, the experimental investigation of the spin polarization is in general a complex task. One possible method is Point Contact Spectroscopy (PCS) employing a superconducting tip [Sou98]. Intending to study the possibilities and limitations of PCS we realised a setup for PCS allowing variable tip pressure and tested our setup on conventional magnetic and non-magnetic materials. For non magnetic materials (e.g. Copper) we where able to identify Andreev Reflection by clear fits employing Mazin*s theory [Maz2001] and excluding any spin-polarization. Spectra of magnetic materials (Ni, Fe) showed a qualitatively different behaviour. However, only an upper limit for the spin polarization could be defined, which corresponds approximately to literature values measured by tunnel spectroscopy. Measurements on the Heusler compound Co2Cr0,6Fe0,4Al, for which a high spin polarization is predicted by band structure calculations, showed an upper limit for the spin polarisation of 40-50%. This is less than indicated by results of tunnel spectroscopy. The main reason for this apparently reduced spin polarization measured by ex-situ PCS could be surface oxidation effects. [Sou98] R. J. Soulen et al., Science 282, 85 (1998); [Maz2001] I. I. Mazin et al., Phys. Rev. B 68, 104430 (2003)

MA 15.49 Tue 15:00 Poster A

Comparison between MgO and AlO_x barriers in $Co_2Cr_{0.6}Fe_{0.4}$Al-Tunnel Junctions — •Christian Herbort, Andres Conca, Martin Jourdan, and Hermann Adrian — Institut für Physik, Johannes Gutenberg Universität, Staudinger Weg 7, 55128 Mainz, Germany

In magnetic tunnel junctions with conventional ferromagnetic electrodes MgO proved to be a superior barrier material concerning the achievable tunnel magnetoresistance effect (TMR). Alternatively, large TMR effects could be obtained by employing novel materials with high spin polarisation. On example for such a material is the Heusler compound $Co_2Cr_{0.6}Fe_{0.4}Al$ (CCFA). We compare the TMR effect of CCFA based tunnel junctions with amorphous AlOx and epitaxial MgO barriers. Whereas we have already optimized junctions with AlO_x barriers and obtained TMR effects which can be associated to a spin polarization of the CCFA > 50 %, the process of MgO deposition requires further improvement. The interface at the barriers is characterized by in situ RHEED and LEED as well as by STM investigations. It is shown that epitaxial MgO can be grown by rf-magnetron sputtering on epitaxial (100) oriented CCFA thin films. The barrier morphology of AlO_x and MgO is compared by transmission electron microscopy (TEM) and related to the TMR effect. The dependence of the TMR effect on the major preparation parameters is shown.

MA 15.50 Tue 15:00 Poster A

A study on the influence of nano-oxide layer on magnetotransport properties of NiMn based giant magnetoresistive spin valve sensors — Anoop Gupta[1], •Senthilnathan Mohanan[1], Ulrich Herr[1], Zaoli Zhang[2], and Ute Kaiser[2] — [1]Institute for Micro and Nanomaterials, University of Ulm, Ulm-89081, Germany — [2]Electron Microscopy Group of Material Science, University of Ulm, Ulm-89069, Germany

NiMn with L1o structure is one of the good antiferromagnetic materials that can be used for exchange bias in giant magnetoresistive spin valve (GMR-SV) sensors. However, as-deposited NiMn exists in FCC phase which exhibits paramagnetic behaviour. So it has to be annealed at around 300°C in order to achieve FCC to FCT structural phase transformation. Annealing leads to interdiffusion, but this can be controlled by using a nano-oxide layer (NOL). The main aim of this study is to investigate the influence of NOL on the magnetotransport and the structural properties of NiMn/Co/Cu/Co GMR-SV sensors. An increase in the GMR has been observed with the inclusion of NOL in the pinned layer, which is due to the reduced diffusion of Ni and Mn on to the GMR active region. However, we observed a decrease in exchange bias field of the pinned Co layer. A detailed investigation of the influence of the position of NOL in the pinned layer on exchange bias and magnetotransport properties has been done. The optimum position for the NOL is found to be in the middle of the pinned Co layer. The structural phase transformation of NiMn upon annealing has been studied using x-ray diffractometer and HR-TEM.

MA 15.51 Tue 15:00 Poster A

Influence of ion bombardment induced patterning of exchange bias in pinned artificial ferrimagnets on the interlayer exchange coupling — Volker Höink[1], •Jan Schmalhorst[1], Günter Reiss[1], Tanja Weis[2], Dieter Engel[2], and Arno Ehresmann[2] — [1]Thin Films and Nanostructures, Department of Physics, University of Bielefeld, P.O. Box 100131, D-33501 Bielefeld, Germany — [2]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Kassel University, Heinrich-Plett-Str.40, D-34132 Kassel, Germany

Artificial ferrimagnets (AFi) have many applications as, e.g., pinned reference electrodes in magnetic tunnel junctions. It is known that the application of ion bombardment induced magnetic patterning with He ions on a single layer reference electrode of magnetic tunnel junctions is possible. For some applications a combination of ion bombardment induced magnetic patterning and artificial ferrimagnets as a reference electrode is desirable. The effect of ion bombardment induced magnetic patterning on pinned artificial ferrimagnets with a Ru interlayer which is frequently used in magnetic tunnel junctions as well as pinned AFis with a Cu interlayer has been tested. Special attention has been given to the question whether the antiferromagnetic interlayer exchange coupling can withstand the ion dose necessary to turn the exchange bias.

MA 15.52 Tue 15:00 Poster A

Blocking temperature distribution of magnetically diluted exchange biased systems — •Marian Fecioru-Morariu, Mohammad Reza Ghadimi, Bernd Beschoten, and Gernot Güntherodt — Physikalisches Institut (IIA), RWTH Aachen, 52056 Aachen, Germany

We have systematically investigated the blocking temperature distribution (BTD) of two different exchange bias systems: the epitaxial system $Co(111)/Co_{1-y}O(111)$ with the insulating high-anisotropy antiferromagnet (AFM) CoO and the polycrystalline system $CoFe/(IrMn)_{1-x}Cu_x$ with the metallic intermediate-anisotropy AFM IrMn. The effects of Co deficiencies in $Co_{1-y}O$ and of nonmagnetic Cu defects in $(IrMn)_{1-x}Cu_x$ on the exchange bias field (H_{EB}) and BTD are analyzed by reversing the AFM domains at successively higher temperatures in the reverse cooling fields. For both systems, the nonmagnetic defects give rise to an enhancement of H_{EB}. Additionally, a broadening of the BTD is observed for the system $Co_{1-y}O$. For the AFM IrMn, with increasing Cu dilution, the AFM grain size decreases and therefore the BTD shifts to lower temperatures. The BTD is correlated with the domain and grain size distribution within the AFM. Further influences of dilution, temperature, time and reversal fields on H_{EB} and BTD will be discussed. We acknowledge the financial support from NEXBIAS Research Training Network (Contract No. HPRN-CT-2002-00296) financed by the EU.

MA 15.53 Tue 15:00 Poster A

Antiferromagnetic thickness dependence of exchange bias — •Shrawan Mishra, Florin Radu, Bernd Heitkamp, Jaime Sanchez-Barriga, Hermann Dürr, and Wolfgang Eberhardt — BESSY GmbH, Albert-Einstein Strasse 15, D-12489,

We have studied systematically the dependence of exchange bias and coercive fields as function of antiferromagnetic (AF) layer thickness. A series of $Si(100)/SiO_2/Cu(5\ nm)/Ni_{81}Fe_{19}(20\ nm)/Ir_{20}Mn_{80}(x)/Cu(2.5\ nm)$ bilayers were grown at MAGSSY magnetron sputtering system of BESSY. For each AF thickness the coercive and exchange bias fields were extracted from the azimuthal dependent hysteresis loops measured by Magneto Optical Kerr Effect(MOKE). It is observed that at the critical thickness for the AF layer, the EB bias field exhibits a sudden jump increasing monotonically as a function of the AF thickness towards a saturation value. The coercivity in this region is equal to the coercive field of the ferromagnetic layer measured separately. On the other hand, below the critical AF thickness the exchange bias vanishes with effective enhanced coercivity. The coercive field is maximum close to the critical AF thickness and decreases with decreasing the AF layer thickness. Therefore, at room temperature the phase diagram for exchange bias and coercivity can be described using a Meiklejohn and Bean mechanism for exchange bias. This is further demonstrated by comparing numerical simulations with experimental data.

MA 15.54 Tue 15:00 Poster A

Magnetization reversal processes in patterned exchange biased NiO/Ni and Fe/CoO layers — •Pablo Asshoff[1],

Florin Radu[2], Katharina Theis-Bröhl[1], and Hartmut Zabel[1] — [1]Department of Physics, Ruhr-University Bochum, D-44780 Bochum, Germany — [2]BESSY GmbH, Albert-Einstein-Str. 15, D-12489 Berlin, Germany

We have investigated the magnetization reversal of arrays of exchange biased NiO/Ni and Fe/CoO squares with SQUID magnetometry. The edges of the squares were 0.5, 1.5 and 3.0 μm long. When the sizes of the structures are reduced, for the Fe/CoO structures both the exchange bias field and the slope of the hysteresis loops decrease continuously.

The NiO/Ni structures exhibit hysteresis loops typical of a vortex state. In a micromagnetic simulation of the system this special shape of the hysteresis loop was reproduced and a vortex state was observed. The exchange bias field behaves very unusual: for the arrays with NiO/Ni structures of 1.5 μm edge length the sign of the exchange bias field changes, as compared to the same continuous NiO/Ni layer. We attribute this to the interplay between shape and unidirectional anisotropy. In the exchange biased microstructures the unidirectional anisotropy causes a deformation of the whole hysteresis and not merely a uniform shift.

Support by SFB 491 is acknowledged.

MA 15.55 Tue 15:00 Poster A

Resonant magnetic x-ray reflectivity on Co/Cu/Co — •Valeriano Ferreras Paz, Sebastian Brück, Eberhard Goering, and Gisela Schütz — Max Planck Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

The interaction between ferromagnetic layers across a nonmagnetic or isolating spacer layer has reached great technological importance during the last years, i.e. GMR sensors. A Co/Cu/Co has been grown epitaxially on a Cu (100) single crystal substrate by molecular beam epitaxy. The quality of the film is controlled by LEED and TEM. On this system resonant magnetic x-ray reflectivity measurements were performed at BESSY II, which allows the determination of the magnetic depth profile in an element selective way. This has been done on the Co and Cu L_3 edge in order to learn more about the origin of the oscillatory exchange coupling in such systems.

References:

J. Geissler et al. Phys. Rev. B 65, 020405 (2001)
P. Bruno J. Phys.: Condens. Matter 11 9403-9419 (1999)
M. G. Samant et al. Phys. Rev. Lett. 72, 1112 - 1115 (1994)

MA 15.56 Tue 15:00 Poster A

Exchange bias in Fe/Cr bilayers — •Syed Rizwan Ali, Marian Fecioru-Morariu, Bilal Janjua, Coen Smits, and Gernot Güntherodt — Physikalisches Institut (IIA), RWTH Aachen, 52056 Aachen, Germany

Exchange coupling in Fe/Cr bilayers have been studied in either molecular beam epitaxy (MBE) grown or sputtered samples. Our sputtered samples show exchange bias which changes its sign as a function of temperature. This temperature was found to increase with the thickness of the Cr layer. The positive part of the exchange bias shows a maximum and decreases with temperature up to the blocking temperature of the Cr thin film. The coercivity was also found to vary in close correlation with the exchange bias. In order to exclude the possibility of antiferromagnetic oxide formation at the interface, samples were also grown in ultra high vacuum using MBE. We have found a similar qualitative behaviour of exchange bias and coercivity in the MBE grown samples as compared to the sputtered ones. However, the sign change effect was more pronounced in MBE grown samples.

MA 15.57 Tue 15:00 Poster A

Current-driven domain walls in nanowires — •Benjamin Krüger[1], Daniela Pfannkuche[1], Markus Bolte[2], Guido Meier[2], and Ulrich Merkt[2] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstrasse 9, 20355 Hamburg — [2]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Current-induced motion of a domain wall in a semicircle nanowire with an applied Zeeman field is investigated. Starting from the micromagnetic equation of motion extended by the adiabatic as well as the non-adiabatic current-induced spin torque introduced by Zhang and Li [1], we derive an analytical solution characterizing the domain-wall motion as a harmonic oscillation. This solution relates the micromagnetic simulation parameters with the dynamical characteristics of a harmonic oscillator. The results are compared to numerical calculations. For these calculations we extended the Object Oriented Micromagnetic Framework (OOMMF) [2] with the current-induced spin torques. The numerical calculations confirm our analytical solution. Our calculations disclose a strong dependence of the motion and the structural changes of the wall on the Gilbert damping and the non-adiabatic spin torque. For wires with strong curvature the dipole moment of the wall as well as its geometry influence the eigenmodes of the oscillator. Based on these results we suggest experiments for the determination of material parameters which otherwise are difficult to access.

[1] S. Zhang and Z. Li, PRL **93**, 127204 (2004).
[2] M. J. Donahue and D. G. Porter, http://math.nist.gov/oommf

MA 15.58 Tue 15:00 Poster A

Domain wall motion in perpendicularly magnetized $(Co/Pt)_n$-multilayer-wires — •Christoph Hassel[1], Jan Rhensius[2], Theo Kleinefeld[2], Jürgen Lindner[1], and Günter Dumpich[1] — [1]Fachbereich Physik, AG Farle, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg — [2]Fachbereich Physik, Angewandte Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg

We prepare $(Co/Pt)_n$-multilayer wires by means of a two step electron beam lithography process. The magnetization reversal process of $(Co/Pt)_n$-multilayer-wires with perpendicular magnetic anisotropy is investigated with an optical Kerr Microscope. Different structures are used so that we can nucleate domain walls in the wire using the application of external magnetic fields. The wires are contacted with nonmagnetic gold wires, which allows us to inject currents into the wire. To move the domain walls we use pulsed currents with current densities of up to 10^8 A/cm^2. Sample heating is controlled my measuring the resistance during the application of the pulses. We carried out experiments as well with additional application of small magnetic fields as without external magnetic field. Results are discussed in terms of the spin-transfer-torque effect.

This work is financially supported within SFB 491.

MA 15.59 Tue 15:00 Poster A

Stray Fields and Anisotropic Magnetoresistance of Domain Walls in Permalloy Nanowires — •Peter Lendecke, Hannah Ziehlke, René Eiselt, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

Magnetic domain walls in nanowires have attracted a lot of interest because of their application in logic [1] and memory devices [2]. We present Hall micromagnetometry and anisotropic magnetoresistance (AMR) measurements of domain walls in wires of 100 – 500 nm width and 30 nm thickness. In our experiments domain walls are induced into the wires at well defined positions either at a lithographically defined notch or in the curved region of a wire. In both geometries a suitable sequence of applied magnetic fields serves to generate the domain walls. AMR measurements are performed in order to verify the presence and movement of the wall in an external magnetic field. The AMR contribution of the wall is small, of the order of 0.1 %. For the realization of the proposed "racetrack" memory, a quantitative determination of stray-field strenghts for different domain-wall types is crucial. The high sensitivity and non-invasive nature of Hall micromagnetometry allow for the determination of the stray field as well as the nucleation and the depinning field of the walls [3].

[1] D. A. Allwood et al., Science **309**, 1688 (2005)
[2] S. S. P. Parkin, U. S. Patent No. US 6834005 (2004)
[3] G. Meier et al., J. Appl. Phys. **92**, 7296 (2002)

MA 15.60 Tue 15:00 Poster A

Single shot measurement of current- and field-induced domain wall motion in a Permalloy nanowire — •Philipp Möhrke[1], Thomas Moore[1], Mathias Kläui[1], Dirk Backes[2], Laura Heyderman[2], and Ulrich Rüdiger[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]Paul Scherrer Institut, 5232 Villingen PSI, Switzerland

In order to obtain full information about the stochastic nature of current-induced domain wall (DW) motion [1] in ferromagnetic nanowires, single shot measurements are necessary. We use a focused magneto-optic Kerr effect (MOKE) technique to capture single DW movements in a 500 nm-wide, ∼30 nm-thick $Ni_{80}Fe_{20}$ wire. A DW is prepared at a specified position, as in [2]. By applying fields $H < H_p$ (depinning field) along the wire direction and concurrently injecting a

50 μs current pulse of $\sim$2 x 10^{12} A/m^2 to depin the domain wall, we probe the interplay between field- and current-induced domain wall motion, as well as inducing wall motion by current pulses alone (H = 0). Subsequently the wall passes through the focused MOKE laser spot ($\sim$1 μm diameter), which covers a straight section of the wire a few micrometres from the wall's initial position. The wall motion is detected with sub-nanosecond time resolution, and the experiment is repeated to gather statistics on the wall motion. Depending on the field and current densities applied, wall velocities of 10-100 m/s are observed.

[1] M. Kläui et al., Appl. Phys. Lett. 88 (2006) 232507
[2] M. Kläui et al., Phys. Rev. Lett. 95 (2005) 026601

MA 15.61 Tue 15:00 Poster A

Spin waves in semi-circular Permalloy ring segments in the presence of domain walls — •Christian Sandweg, Helmut Schultheiss, Sebastian Hermsdörfer, Peter Andreas Beck, Britta Leven, and Burkard Hillebrands — Fachbereich Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, Germany

Semi-circular $Ni_{81}Fe_{19}$ ring segments are interesting systems to investigate spin wave properties in confined dimensions. The ring segments have a radius of 10 μm, a width of 500 nm and a thickness of 10 nm. A 200 nm wide protrusion has been added in the pole of the ring segment in order to create a nucleation site for a domain wall if an external field in radial direction is applied. Thereby it is possible to study spin wave spectra in the structure both in the presence and the absence of a domain wall just by applying an external magnetic field in radial or tangential direction, respectively. The ring segments have been prepared employing a combination of electron beam lithography using a lift-off process and molecular beam epitaxy. The spin waves have been detected with a spatial resolution of 300 nm by means of micro-focus Brillouin light scattering spectroscopy. The experiments reveal the typical spin wave quantization effects as expected in confined structures. However, in the presence of a domain wall the quantized wave profile is distorted in its vicinity as a result of the variation of the internal magnetic field. The authors acknowledge support of the Nano+Bio Center of the TU Kaiserslautern during sample preparation and financial support by the DFG within the SPP1133 and the NEDO project No 2004IT093 funded by the Japanese government.

MA 15.62 Tue 15:00 Poster A

Nonlinear spin dynamics and microwave assisted switching in nanostructured rings — •Jan Podbielski[1], Kristina Reckwell[1], and Dirk Grundler[2] — [1]Institut für Angewandte Physik und Zentrum für Mikrostukturforschung, Universität Hamburg, Jungiusstr. 11, D-20355 Hamburg — [2]Physik Department E10, Fakultät für Physik, Technische Universität München, James-Franck-Str. 1, D-85748 Garching

We report a method to induce large angle spin precession in nanostructured ferromagnets. For this we have fabricated coplanar wave guides (CPWs) with a width of only 3 μm. We have patterned mesoscopic Permalloy rings with an outer diameter of 2 μm directly on top of such CPWs. Using a broadband network analyzer we generate a microwave magnetic field to induce large angle spin precession phenomena. We observe shifts of the ring's spin wave eigenfrequencies as a function of microwave magnetic field amplitude. In particular we find both shifts to higher and to lower frequency. The behavior depends on the ring segment where the spin wave eigenmode is localized. Increasing the microwave power further leads to irreversible jumps in the spin wave spectrum. We attribute this to microwave assisted switching. The dynamically induced switching reveals a resonant behavior, i.e. the efficiency for switching depends on not only the amplitude but also the frequency of the irradiated microwave. We will discuss possible microscopic mechanisms for these intriguing observations. The work is supported by the DFG via SFB668 and via the excellence cluster "Nanosystems Initiative Munich (NIM)".

MA 15.63 Tue 15:00 Poster A

Spin-wave quantization in nanoscaled magnetic rings — •Sebastian Schäfer[1], Helmut Schultheiss[1], Patrizio Candeloro[1], Hans T. Nembach[2], Peter Andreas Beck[1], Britta Leven[1], Andrei N. Slavin[3], and Burkard Hillebrands[1] — [1]FB Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern — [2]NIST, Boulder, Colorado, USA — [3]Oakland University, Rochester, Michigan, USA

Spin dynamics in small confined structures is interesting with respect to fundamental understanding as well as in view of applications in, e.g. magnetic memory or logic devices. The eigenmode spectra of small magnetic elements were discussed extensevily in the past. Yet the question of (de-)coherence of spin waves was not adressed so far, even though this is an essential requirement for an eigenmode system. Spin wave spectra in mesoscopic magnetic ring structures made of Permalloy with a thickness of 15 nm, diameters ranging from 1 to 3 μm and radii from 100 to 300 nm respectively, are investigated by means of micro focus Brillouin light scattering spectroscopy. The two predominant remanent magnetic configurations of the ring structures, the so called onion and the vortex state, and their switching behavior were studied extensively. Model calculations and dynamic micromagnetic simulations using the OOMMF code reveal excellent agreement with our experimental results. This work is supported by the DPG within the SPP1133 and the Japanese government within the NEDO project 2004IT093.

MA 15.64 Tue 15:00 Poster A

Wellenlänge von Konzertina-Mustern in Permalloy-Schichten — •Holm Wieczoreck[1], Rudolf Schäfer[1], Jeffrey McCord[1], Ludwig Schultz[1], Jutta Steiner[2], Ruben Cantero-Alvarez[2], Antonio Capella[2] und Felix Otto[2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, Helmholtzstraße 20, 01069 Dresden — [2]Universität Bonn, Wegelerstraße 10, 53115 Bonn

Ein äußeres magnetisches Feld sättigt rechteckige weichmagnetische Schichten. Wird das Feld reduziert, zerfällt unterhalb einer bestimmten Feldstärke die einheitliche Magnetisierung in ein Konzertinamuster[1]. In [2] wird für anisotropiefreie Schichten mit Hilfe eines mathematischen Modells die Abhängigkeit der Konzertinawellenlänge von der Breite und Dicke lateral strukturierter Schichtelemente gezeigt. Wir untersuchen die Abhängigkeiten der Wellenlänge von Konzertina-Mustern jeweils in Permalloy-Schichten (10 - 300 nm) mit einer Streifenbreite von 10 bis 200 μm. Die Anisotropie der Probenserien beträgt ca. 5 Oe bzw. 2 Oe. Unsere Untersuchungen erfolgen mit Hilfe der Kerrmikroskopie und FFT. Dabei interessiert die Periodizität entlang der Längsrichtung der Proben. Das äußere Magnetfeld zeigt in Richtung der leichten bzw. schweren Achse. Wir beschreiben die Wellenlängenabhängigkeit von Schichtdicke und Streifenbreite und vergleichen mit [2]. Außerdem gewinnen wir statistische Angaben zu den interessierenden Abhängigkeiten. [1] A. Hubert, R. Schäfer, Magnetic domains, Springer, 1998 [2] A. DeSimone, R. V. Kohn, S. Müller and F. Otto. Recent analytical developments in micromagnetics. in: Science of Hysteresis, Elsevier, G. Bertotti and I Magyergyoz, Eds., 2005.

MA 15.65 Tue 15:00 Poster A

Magnetization dynamics of iron thin film triggered by photoconductive switches — •Zhao Wang[1], Anne Parge[1], Malte Scherff[1], Markus Münzenberg[1], and Mihail Ion Lepsa[2] — [1]IV. physikalische Institut Universität Göttingen — [2]Forschungszentrum Jülich(IBN-1)

The photoconductive switches are based on a coplanar waveguide with a metal-semiconductor-metal contact pad using low temperature grown GaAs (LT-GaAs). The carriers in the semiconductor are excited by a Ti:Sapphire Laser with the pulse length 80fs. Because of the short relaxation time of the LT-GaAs, the generated current pulse corresponding magnetic field pulse is in ps range. the pulse length can be defined by the autocorrelation measurenments. the amplitude of the created current pulse can be up to some Ampere corresponding to a magnetic field over 150mT.

The field pulse is used to trigger the magnetization dynamics in an iron thin film on top of the coplanar waveguide, structured wth the help of e-Beam lithography. The dynamic measurements are compared to micromagnetic simulations.

Research supported by DFG SPP 1133.

MA 15.66 Tue 15:00 Poster A

Charge and magnetization dynamics in correlated solids observed with THz time-domain spectroscopy — •Tobias Kampfrath, Jan Nötzold, Luca Perfetti, Christian Frischkorn, and Martin Wolf — Fachbereich Physik der Freien Universität Berlin, Arnimallee 14, D-14195 Berlin

THz pulses covering the spectral range from 8 to 30 THz have been employed to measure the dielectric function of carbon nanotube and graphite films which were excited with a 10-fs, 780-nm laser pulse. In contrast to graphite, the nanotube sample does not show a free-carrier response which clearly demonstrates that strongly bound excitons are the main product of photoexcitation in semiconducting nanotubes.

In case of ferromagnetic Fe, Co, and Ni films, we have detected the THz waveform that is emitted upon excitation of these samples with an intense 20-fs, 800-nm laser pulse. We discuss the origin of the emitted radiation and its relationship to the ultrafast magnetization dynamics of the sample.

MA 15.67 Tue 15:00 Poster A

Magnetization dynamics in interlayer exchange coupled NiFe/Ru/NiFe thin films at high excitation amplitudes — •Tobias Martin, Mohamed Belmeguenai, Markus Maier, Georg Woltersdorf, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

The technological applications of interlayer exchange coupling are manifold, e.g. to bias GMR and TMR elements in read heads of hard disk drives. Furthermore it is used to produce synthetic antiferromagnets acting as soft layers in toggle MRAM cells. In order to further increase the data rates in such applications, it is of importance to understand the dynamic magnetization motion.

Here, coupled NiFe/Ru/NiFe film systems with varying Ru thickness are examined with static and dynamic techniques. The static characterization and determination of coupling constants is done by means of magneto optic Kerr effect and vibrating sample magnetometer. The precessional motion is investigated with a pulsed inductive microwave magnetometer (PIMM) and with vector network analyser FMR (VNA-FMR). The PIMM allows for excitation pulse fields of up to 150 Oe. Both dynamic techniques show optic and acoustic modes, although the VNA-FMR method was able to excite both modes simultaneously over a larger bias field range. At high excitation amplitudes additional pulse field dependent modes were observed. A large part of the modes can be explained by simulations using the simple macrospin model, which also helped to identify optical and acoustical mode.

MA 15.68 Tue 15:00 Poster A

Electronic control of magnetization in magnetic diluted quantum dots — Tobias Voigt, •Peter Moraczewski, and Daniela Pfannkuche — I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg

Recent investigations have suggested precise control of ferromagnetism in diluted magnetic (II,Mn)VI semiconductor quantum dots by variation of electron numbers [1]. The spins of the itinerant electrons couple the spins of the localized manganese ions leading to dilute ferromagnetism. We study effects of electron-electron interaction on the magnetization of the localized Mn impurities in these systems. Due to e. g. Hunds rule coupling we expect deviations from the electron number dependence of the magnetization observed in [1].

Manganese atoms in GaAs act as acceptors. In contrast to electron systems a striking difference in the behaviour of the hole states is expected because of the degeneracy in the valence bands of GaAs. We examine the impact of the localized Mn impurities on the hole states in the quantum dot.

[1] J. Fernández-Rossier and L. Brey, PRL 93, 117201 (2004)

MA 15.69 Tue 15:00 Poster A

Kerr microscopical investigations of domain wall dynamics in ultrathin trilayers of Pt/Co/Pt — •Jan Rhensius[1], Theo Kleinefeld[1], Wolfgang Kleemann[1], Jacques Ferré[2], Jean-Pierre Jamet[2], and Harry Bernas[3] — [1]Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany — [2]LPS, Université Paris-Sud, 91405 Orsay, France — [3]CSNSM, Université Paris-Sud, 91405 Orsay, France

The dynamics of ferromagnetic domain walls in ultrathin trilayers Pt/Co(0.5 nm)/Pt with perpendicular anisotropy is investigated by polar Kerr microscopy. The coercive field has been reduced to a few mT by irradiation with a dose of $1.5\text{x}10^{16}\text{cm}^{-2}$ He^+ ions at 30 keV energy [1]. Magnetization reversal processes are recorded with a temporal resolution of about 0.8 s. Field-induced domain growth and domain wall velocities are analyzed by treating the differences of subsequent images. Apart from the dependence of the velocity on a perpendicularly applied static magnetic field, the change of wall conformations and their average velocities are also determined in sinusoidally modulated external fields. The results are related to linear magnetic *ac* susceptibility spectra being excited under similar conditions [2]. They help understanding the role of the different dynamic domain wall modes - creep, slide and switching - observed in disordered ferroic materials [3].

[1] C. Chappert, H. Bernas, J. Ferré et al., Science **280**, 1919 (1998). [2] O. Petracic, A. Glatz, W. Kleemann, Phys. Rev. B **70**, 214432 (2004). [3] W. Kleemann, Ann. Rev. Mat. Res. **37** (2007) in press.

MA 15.70 Tue 15:00 Poster A

Ultrafast Demagnetization Probed by Femtosecond X-Ray Pulses — •Marko Wietstruk, Torsten Kachel, Niko Pontios, Christian Stamm, Hermann A. Dürr, and Wolfgang Eberhardt — BESSY m.b.H., Albert-Einstein-Straße 15, 12489 Berlin, Germany

The energy of an intense fs laser pulse exciting a ferromagnetic sample is absorbed by the electronic system. The subsequent transfer of energy to the lattice and spin systems leads to a demagnetization of the sample within a few 100 fs. However, the total angular momentum previously carried by the ordered spins has to be conserved and consequently transferred to the other reservoirs on the same time scale.

Using X-ray magnetic circular dichroism (XMCD), we observe the evolution of the magnetization as a function of time delay between the laser pump and the x-ray probe pulse. The contribution of the spin and orbital moments can be obtained by XMCD sum rules. Our goal is to get new insight into the energy and angular momentum transfer mechanisms during the ultrafast demagnetization of ferromagnetic thin films.

The experiments were done at the femtosecond slicing source at BESSY have a temporal resolution better than 150fs. It provides circularly polarized synchrotron radiation at energies in the range of absorption edges of 3d transition metals and rare earths (L and M edges, respectively), covering important ferromagnetic elements like Fe, Ni and Gd.

MA 15.71 Tue 15:00 Poster A

Spin structure investigations of domain walls in nanoscale constrictions — •Dirk Backes[1,2], Laura Heyderman[1], Christian David[1], Mathias Kläui[2], Friederike Junginger[2,4], Henri Ehrke[2,4], Ulrich Rüdiger[2], Caros Vaz[3], Tony Bland[3], Cheng-Shi Chen[4], Takeshi Kasama[4], and Rafal Dunin-Borkowski[4] — [1]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, Switzerland — [2]FB Physik, Universität Konstanz — [3]Cavendish Laboratory, University of Cambridge, UK — [4]Department of Materials Science and Metallurgy, University of Cambridge, UK

Domain walls of ferromagnetic curved-line elements exhibit two spin-configurations - the vortex and the transverse wall type. If a notch is included forming a constriction, transverse walls get pinned inside of the constrictions and vortex walls in the vicinity of the notch [1]. We report on the fabrication of such elements on membranes with constrictions as small as approx. 30 nm [2]. Electron holography is the ideal technique to study the spin-structure near and in these constrictions because it is able to visualize the magnetic induction with a resolution below 5 nm. Concentrating on transverse walls we systematically determine the shape which could be either symmetrical or asymmetrical depending on the geometry. We characterize the transverse wall by its opening angle and compare the experimental data with simulations.

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

MA 15.72 Tue 15:00 Poster A

Room temperature magnetic order in proton irradiated graphite: latest results — •Kristian Schindler[1], Jose Barzola-Quiquia[1], Martin Rothermel[2], Annette Setzer[1], Pablo Esquinazi[1], and Tilman Butz[2] — [1]Division of Superconductivity and Magnetism, Institute for Experimental Physics II, University of Leipzig, Linnéstr. 5, 04103 Leipzig, Germany — [2]Division of Nuclear Solid State Physics, Institute for Experimental Physics II, University of Leipzig, Linnéstrasse 5, 04103 Leipzig, Germany

We discuss recent results concerning the magnetic properties of proton irradiated micro-spots produced on highly oriented pyrolytic graphite (HOPG) samples. A proton microbeam of 2.25MeV energy was used to create micrometer spots on HOPG. We have used specially made sample holders that allow us to irradiate the samples and to measure them in the SQUID without any change in their positions. The SQUID resolution and reproducibility enable the measurement of relative changes in the magnetic moment of the sample of the order of 2×10^{-7} emu. We discuss the influence of parameters like proton current and irradiation under low temperature conditions on the measured magnetic order. We compare and combine the results obtained by SQUID and scanning probe microscopy measurements. The electrostatic and thus material changes at the irradiated area are discussed. We compare our results with recently obtained results of X-rays magnetic circular dichroism (XMCD) measurements (at the carbon K-edge) on irradiated spots in carbon films that support the ferromagnetic order observed in SQUID

measurements.

MA 15.73 Tue 15:00 Poster A

Geometrically Confined Domain Walls — •Daniel Bedau[1], Mathias Kläui[1], Ulrich Rüdiger[1], Dirk Backes[2], and Laura Heyderman[2] — [1]Universität Konstanz — [2]PSI Villigen

Magnetic domain walls (DWs) that are geometrically confined exhibit unique quasi-particle features. Depending on the geometry two basic spin configurations for head-to-head domain walls exists, which are called vortex walls and transverse walls. We present phase diagrams for the domain wall types [1] and demonstrate thermally activated transformations between the wall types, from which we estimate the energy barrier separating the two types [2].

Using magnetic rings in an external rotating field the domain wall can be positioned at any position along the ring, and the position of the domain wall can be accurately determined using magnetoresistance measurements. Applying this method we determine the wall propagation fields and the details of pinning at geometrical variations. [3-5]

Using electron holography we map the stray field of transverse and vortex walls and find that transverse walls can strongly interact for sufficiently small spacings leading to a shift in the phase boundary [6]. Quantitative measurements allow us to determine the statistical distribution of energy barriers for the vortex core nucleation [6].

[1] M. Kläui et al., Appl. Phys. Lett. **85**, 5637 (2004) [2] M. Laufenberg et al., Appl. Phys. Lett. **88**, 052507 (2006) [3] M. Kläui et al., Phys. Rev. Lett. **90**, 97202 (2003) [4] M. Kläui et al., Appl. Phys. Lett. **87**, 102509 (2005) [5] D. Bedau et al., J. Appl. Phys., (in press 2007) [6] M. Laufenberg et al., Appl. Phys. Lett. **88**, 212510 (2006)

MA 15.74 Tue 15:00 Poster A

Preparation and characterization of periodic two-dimensional two-phase magnets — •Sven Schnittger[1], Sebastian Dreyer[1], Christian Jooss[1], and Sibylle Sievers[2] — [1]Institut für Materialphysik, Universität Göttingen — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

Two-phase magnets play an important role in the production of permanent magnet applications; especially the interplay of the different magnetostatic interactions is of great interest.

In this contribution, a model system for the study of a two-dimensional two-phase ferromagnet is presented. The sample consists of arrays of hard magnetic squares ($L1_0$-CoPt) embedded in a soft magnetic film (Permalloy, $Fe_{19}Ni_{81}$). Arrays with different distances of the square elements are prepared.

The fabrication process is done as follows: a magnetron-sputtered CoPt film on a (100)-MgO substrate is structured by electron beam lithography. Electron-resist and exposure parameters of the RAITH electron lithography system have been optimized with respect to straight edges and the realization of well-defined interfaces. The negative structure is etched into the film by reactive ion etching using an aluminum mask. The Permalloy film is deposited by ion beam sputtering.

The magnetic characterization is accomplished by a magneto-optical indicator film technique using the Faraday Effect and by magnetic force microscopy.

MA 15.75 Tue 15:00 Poster A

Magnetization processes in highly coercive, epitaxial $SmCo_5$ elements — •Volker Neu, Ulrike Wolff, Aarti Singh, Felix Fleischhauer, Sebastian Fähler, and Ludwig Schultz — IFW Dresden, P.O. Box: 270116, 01171 Dresden, Germany

Highly coercive, epitaxial $SmCo_5$ films with unique in-plane alignment of the easy magnetization axis were prepared by pulsed laser deposition on Cr buffered MgO(110) single crystal substrates ($\mu_0 H_c$ = 2 to 3 T). Despite the good orientation of neighboring grains, these films possess a very small scaled domain structure in the as prepared state. Magnetic force microscopy (MFM) studies have been performed in the remanent state on structured 10μm x 10μm elements after applying increasingly higher magnetic fields. The magnetization process proceeds slowly and without the formation of larger domains until fields exceed 1 T. Changes are most pronounced between 1.2 T and 1.6 T, i.e. about 0.6 H_c. Close to saturation, the element is almost fully magnetized, as seen from contrast free inner areas and charge build-up at the element edges, but for small isolated areas. We interpret this behavior as a pinning dominated magnetization process with a large pinning density. The defect distance is estimated from the size of the smallest observable isolated magnetic domains and is of the order of 50 nm for a film thickness of likewise value. This observation offers an explanation for the high coercivities of these well textured films and is of importance for the possible use in magnetic recording applications. There, a new concept of percolated media is based on granular, exchange coupled materials with high pinning density.

MA 15.76 Tue 15:00 Poster A

Patterned Fe/Cr/Co spin valve structures — •Frank Brüssing, Gregor Nowak, Hartmut Zabel, and Katharina Theis-Bröhl — Department of Physics, Ruhr-University Bochum, D-44780 Bochum

Weakly antiferromanetically coupled Fe/Cr/Co films were grown via molecular beam epitaxy on MgO (001). We designed the samples such that both magnetic layers (Fe and Co) have similar magnetization by adjusting their thicknesses. The structural quality of these multilayers was studied by X-ray reflectometry. The magnetic properties were measured by MOKE and SQUID.

The films were patterned into stripes using e-beam lithography with a negative photo resist. Subsequently the structure was etched via ion beam. Vektor-MOKE was performed as a function of the azimuthal angle. For the easy axis (stripes || external field) an extend plateau region is observed, which decreases by rotating the sample to the hard axis. These results were compared with Fe and Co stripes.

This project was supported by the DFG via SFB491.

MA 15.77 Tue 15:00 Poster A

Nanoscale surface ripples on ferromagnetic films with correlated magnetic — Kun Zhang[1], Frank Rotter[1], Michael Uhrmacher[1], Carsten Ronning[1], Hans Christian Hofsäss[1], Johann Krauser[2], and •Klaus Jesiek[1] — [1]II.Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Fachbereich Automatisierung und Informatik, Hochschule Harz, Friedrichstrasse 57-59, 38855 Werningerode, Germany

The correlation between nanoscale surface ripple patterns and the magnetic texture of polycrystalline iron and nickel thin films was investigated. The ripple patterns were created by ion beam sputter erosion of films evaporated on Si substrates with 5 keV Xe ions under grazing incidence and fluences between $10^{15}$and $10^{17} cm^{-2}$. The as-deposited films with an rms roughness of about 1 nm are magnetically isotropic. MOKE measurements reveal a pronounced uniaxial magnetic anisotropy of the only 1-2 nm thin irradiated surface region of the films with an orientation parallel to the ripple orientation and also to the ion beam direction. Sputter erosion reduced the coercive field of the films for all erosion conditions investigated. Sputter erosion at an incidence angle of 80° with respect to the surface normal produces rather smooth films and for ion-fluences exceeding $10^{16} cm^{-2}$ formation of ripples parallel to the ion beam direction with wavelength between 30 nm and 80 nm is observed. Almost complete sputter erosion of Fe films resulted in the formation of Fe nanorods oriented parallel to the ion beam direction with 100% uniaxial magnetic texture.

MA 15.78 Tue 15:00 Poster A

Structural and magnetic characterization of FePt films deposited onto SiO_2 spherical particle arrays — •Christoph Brombacher[1], Denys Makarov[1], Mireille Maret[2], Fabiola Liscio[2], Guenter Schatz[1], and Manfred Albrecht[1] — [1]University of Konstanz, Department of Physics, D-78457 Konstanz, Germany — [2]Laboratoire de Thermodynamique et Physico-Chimie Métallurgiques, ENSEEG, Saint Martin d'Heres, France

The growth of FePt films at 450°C on a Pt/Cr buffer layer deposited onto SiO_2 spherical particle arrays and for comparison on flat thermally oxidized Si(001) substrates has been studied. The structural properties of the FePt films, such as the orientation and size of the crystalline grains and the degree of $L1_0$-type chemical ordering, were investigated by in-situ RHEED and ex-situ XRD. Magnetic characterization was performed by MFM, polar MOKE and SQUID. Increasing the Cr buffer underlayer thickness favors the formation of the FePt chemically ordered $L1_0$ phase. An out-of-plane coercivity of the FePt alloy about 4 kOe was thus obtained for a Cr thickness of 50 nm. While the continuous films on oxidized Si(001) substrates show magnetic domain patterns with domain sizes in the range of 50-100 nm, multi-domain states are observed for the FePt alloy grown on the particle arrays. The influence of the Cr underlayer thickness and Pt buffer layer on the magnetic properties of FePt are discussed for various particle arrays and compared to micromagnetic simulations, providing a description of magnetization reversal. Project is funded by the DFG through the Emmy Noether program at the University of Konstanz.

MA 15.79 Tue 15:00 Poster A

Structural, magnetic and magneto-optical properties of novel nanocrystalline face centered cubic Co1-xCrx/Pt multilayers with perpendicular anisotropy — •Evangelos Papaioannou[1], Christoph Rüdt[1], Paul Fumagalli[1], Panagiotis Poulopoulos[2], Makis Angelakeris[3], and Nikolaos Flevaris[3] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14,D-14195 Berlin-Dahlem, Germany — [2]Materials Science Department, University of Patras, 26504 Patras, Greece — [3]Department of Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Co1-xCrx alloyed layers are combined with extremely thin Pt layers in order to produce novel face centered cubic multilayered films to be considered as a potential perpendicular magnetic recording medium. The films were grown on Si, glass and polyimide substrates by e-beam evaporation at a temperature slightly higher than the room temperature. The multilayered structure of the films was checked by x-ray diffraction experiments. Plane view transmission electron microscopy images have revealed the formation of very small grains in the range of 7-9 nm. Hysteresis loops as a function of temperature were recorded by means of the magneto-optical Kerr effect. It was found perpendicular magnetic anisotropy, which increases as temperature decreases. Values like squareness = 1 and coercivity = 1.45 kOe, at 10 K were obtained. Furthermore, the complete magneto-optical spectra of the films are recorded, showing a strong magneto-optical enhancement in the ultraviolet region at around 4.5 eV.

MA 15.80 Tue 15:00 Poster A

Thermal Switching Behavior of Superparamagnetic Nanoislands: SP-STM on Fe/W(110) — •Gabriela Herzog[1], Stefan Krause[1], Luis Berbil-Bautista[1,2], Elena Vedmedenko[1], Matthias Bode[1], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Department of Physics, University of California at Berkeley, USA

Recently it has been shown that spin-polarized tunneling microscopy (SP-STM) can be applied to investigate the dynamic thermal magnetization switching processes of individual superparamagnetic nanoislands in real time [1]. While the experiments of Ref. [1] were performed only for a very limited temperature range, we have now used a home-built variable-temperature STM for detailed temperature-dependent investigations to examine the so-called Néel-Brown law, which predicts an Arrhenius-like behavior of coherently switching nanomagnets.

Our sample consists of in-plane magnetized uniaxial Fe monolayer islands on W(110). For islands with an area of approximately 20 nm^2 we find a blocking temperature of about 45 K. The high stability of our experimental setup allows the observation of the same islands over a temperature range between 40 K and 50 K, causing a variation of the switching rate by three orders of magnitude. The experimental data as well as Monte-Carlo simulations reveal that within this temperature range a crossover from coherent rotation to the nucleation of domain walls occurs.

[1] M. Bode *et al.*, Phys. Rev. Lett. **92**, 067201 (2004).

MA 15.81 Tue 15:00 Poster A

Manipulating the dipolar magnetic interactions in FePt square arrays: The role of edge roughness — •Jonas Norpoth[1], Sebastian Dreyer[1], Christian Jooss[1], and Sibylle Sievers[2] — [1]Institut für Materialphysik, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]Physikalisch-Technische Bundesanstalt,Bundesallee 100, 38116 Braunschweig

The high magnetocrystalline anisotropy energy in hard magnetic materials may sustain magnetization distributions in the remanent state which exhibit a high number of magnetic surface charges and thus significant magnetic stray fields . Here, we focus onto the stray field distribution in the exterior and the demagnetization field distribution in the interior of hard magnetic FePt elements without and with artificial saw tooth edge roughness. The square elements are patterned by a focused ion beam. Magnetic stray field distributions are quantitatively measured by magnetic force microscopy (MFM) and a magneto-optic indicator film technique (MOIF). The demagnetization field distribution is calculated by magnetostatic methods. Our experiments and calculations reveal that external stray fields and internal demagnetization fields are considerably modified by the artificial edge roughness. Although the remagnetization process is dominated by nucleation of reverse domains at microstructural inhomogeneities, the inhomogeneous demagnetization field at rough sample edges significantly affects the remagnetization behaviour via the domain wall propagation.

MA 15.82 Tue 15:00 Poster A

Magnetic multilayer films on template-assisted particle arrays — •Judith Moser, Vojko Kunej, Denis Makarov, Günther Schatz, Elke Scheer, and Manfred Albrecht — University of Konstanz, Department of Physics, D-78457 Konstanz, Germany

We present a technique of template-assisted self-assembly of polystyrene particles forming one-dimensional arrangements induced by linear groove structures which were fabricated by e-beam lithography and reactive ion etching. After the particle assembly magnetic Co/Pt multilayer films with perpendicular magnetic anisotropy are grown onto the particle chain. The so-formed magnetic caps are single-domain and magnetically exchange decoupled [1] but provide a metal contact between the particles. The magnetic domain configuration along the particle chain is investigated by magnetic force microscopy and compared to micromagnetic simulations. First results on magneto-resistance along the chain structure and on comparable two-dimensional particle arrays are presented and discussed.

This project is funded by the DFG through the Emmy Noether program at the University of Konstanz.

[1] M. Albrecht, G. Hu, I. L. Guhr, T. C. Ulbrich, J. Boneberg, P. Leiderer, and G. Schatz, Nature Materials 4, 203 (2005).

MA 15.83 Tue 15:00 Poster A

Magnetism in confined geometry: Magnetic critical scattering of MnO nanoparticles — •Mikhail Feygenson[1], Werner Schweika[1], Serguei Vakhrushev[2], Alexander Ioffe[1], and Thomas Brückel[1] — [1]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich — [2]A. F. Ioffe Physico-Technical Institute, 194021, St. Petersburg, Russia

We studied the magnetic order and phase transition of MnO embedded in a porous glass by polarized neutron scattering using the DNS-instrument at the research center in Jülich. The nanopores filled with MnO are wormlike structures with a typical diameter of 70 Å. From the temperature dependence of the magnetic $(\frac{1}{2}\ \frac{1}{2}\ \frac{1}{2})$ Bragg intensity we obtained that for the MnO nanoparticles the phase transition is continuous with a Néel temperature $T_N = 122K$. This is in contrast to bulk MnO, which exhibits a first order phase transition at $118K$. Furthermore, we observed that a part of the MnO nanoparticle material remains disordered even at $2K$, which indicates frustration at the interface MnO to glass. We interpret the higher T_N to be due to strain on MnO embedded in nanopores. The change in T_N can be related to an effective pressure of $23GPa$ according to the (p,T)-phasediagram of bulk MnO [1]. The continuous character of the transition and the unusual temperature dependence with a reduced order parameter can be described and modeled by surface induced disorder [2,3].

[1] C.S.Yoo et. al., PRL 94 115502 (2005) [2] R.Lipowsky, Ferroelectrics 73(1987) [3] W.Schweika et. al., PRB 53, 8937 (1996)

MA 15.84 Tue 15:00 Poster A

Structural properties of magnetic $Fe_{50}Co_{50}$ alloy Clusters — •Furkan Bulut[1], R. Kerstin Gebhardt[1], Daniela Sudfeld[2], Joachim Bansmann[3], Armin Kleibert[4], and Mathias Getzlaff[1] — [1]Institut für Angewandte Physik, Universität Düsseldorf — [2]Fachbereich Physik, Universität Duisburg-Essen — [3]Insitut für Oberflächenchemie und Katalyse, Universität Ulm — [4]Institut für Physik, Universität Rostock

$Fe_{50}Co_{50}$ alloy clusters were produced by a continuously working arc cluster ion source (ACIS) and subsequently mass-filtered by means of an electrostatic quadrupol. Their diameter is in the range between 6 and 12nm. We discuss the structural properties of such alloy clusters by means of high resolution transmission electron microscopy (HR-TEM). The alloy clusters were deposited on a W(110) surface under UHV condition. The structural properties of supported clusters were determined by in-situ scanning tunneling microscopy (STM) and compared to that of free clusters. Element specific magnetic studies performed by means of X-ray magnetic circular dichroism (XMCD) have shown that magnetic moments of $Fe_{50}Co_{50}$ alloy clusters are in good agreement with the theoretically expected values in the bulk. Our former investigations have shown that magnetic behaviour of clusters in this size regime becomes size and shape dependent, which makes structure analysis indispensable [1,2].

[1] J. Bansmann and A. Kleibert, Appl. Phys. A 80 (2005) 957
[2] M. Getzlaff et al., Appl. Phys. A 82 (2006) 95

MA 15.85 Tue 15:00 Poster A

Synthesis of magnetic nanoparticles with pronounced shape anisotropy and characterisation via small angle x-ray scattering — •Frank Döbrich, Andreas Michels, and Rainer Birringer

— Universität des Saarlandes, Technische Physik, Geb. D22, 66041 Saarbrücken, Germany

Ferrofluids (FF) are stable colloidal suspensions of magnetic particles in a nonmagnetic carrier fluid. This fact renders a FF sensitive to an external magnetic field, which leads to a coupling of magnetic and rheological properties. A prominent example is the magnetoviscous effect, i.e. the increase of the FF's viscosity due to an externally applied magnetic field. It is expected that a dispersion of highly anisometric particles such as rods or chains reveals a large enhancement (compared to spherical particles) of the magnetoviscous effect. This contribution reports on the synthesis of a highly anisometric FF containing stable chains of iron nanoparticles and on the microstructural characterization by means of transmission electron microscopy (TEM) and small-angle X-ray scattering (SAXS). The SAXS measurements develop a pronounced anisotropy of the scattering pattern as a function of increasing external magnetic field. Evaluation of the radially averaged SAXS curves in terms of basic scattering functions is discussed.

MA 15.86 Tue 15:00 Poster A

Magnetzation of Ni_xPt_{1-x}-Nanoparticles — •Ole Albrecht[1], Detlef Görlitz[1], Kirsten Ahrenstorf[2], and Horst Weller[2] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg — [2]Institut für Physikalische Chemie, Universität Hamburg

We present SQUID-measurements of chemically disordered Ni_xPt_{1-x}-nanoparticles having a spherical shape (d_{mean} = 4.7 nm), embedded in an organic matrix[1]. These particles are the missing link in the series of 3d-transition-metal/platinum alloys. Zero-field-cooled magnetization reveals superparamagnetic behavior with a characteristic blocking-temperature T_b=7.9 K. Below this temperature the particles show hysteretic behavior with coercive field of H_C(T=5 K)=320 Oe and remanent magnetization of M_{rem}(T=5 K)=0.293 emu/g. Above T_b the magnetization can be described by the isotropic Langevin superparamagnetic model (ISPM) with a Curie-temperature of T_C=108 K and particle moment of μ_p(T=0)=104 μ_B. The ISPM-behavior contrasts to the anisotropic superparamagnetism (ASPM) previously found in FePt- and CoPt-nanoparticles[2].

[1] K. Ahrenstorf et al., small-journal, DOI:10.1002/smll.200600486
[2] F. Wiekhorst et al., Phys. Rev. B 67, 224416(2003)

MA 15.87 Tue 15:00 Poster A

Synthesis of homo- and heterometallic two-layer nanoparticles as labels for magnetic biochips — •Nadezhda Kataeva[1,2], Sergey Pavlovich Gubin[2], Joerg Schotter[1], and Hubert Brückl[1] — [1]Austrian Research Centers GmbH - ARC, Nano-System-Technologies, Tech Gate Vienna, Donau-City-Strasse 1, 1220 Vienna, Austria — [2]N.S. Kurnakov Institute of General and Inorganic Chemistry RAS, Leninskii pr. 31, Moscow, 119991 Russia

We will present our results on the development of ferromagnetic nanoparticles with properties optimized for the application as labels for magnetic biochips. This application requires functionalized magnetic nanoparticles that are stabilized in aqueous solutions and posses high magnetic moments. Thus, we synthesize magnetic nanoparticles from materials with high saturation magnetization (e.g. CoFe alloys) and plan to increase the diameter of the particles from our initial value of about 10 nm up to about 50 nm, which poses a good compromise between high magnetic moment of the nanoparticles and good binding properties to surface-immobilized molecules. We obtain magnetic nanoparticles of complex composition with different functional groups by the reduction of water-soluble salts of cobalt or iron by NaBH4. Ethylenediamine, different amino acids, surfactants, polyacrylic acid, polyvinyl alcohol, polydimethylsiloxane and other lyophylic coatings are employed as functional shells of the nanoparticles. For the synthesis of steady suspensions in organic solvents, the reaction was carried out in a two-phase system of hexane/water and with surfactants.

MA 15.88 Tue 15:00 Poster A

Temperaturabhängige Magnetrelaxometrie an magnetischen Nanopartikeln im Temperaturbereich von 4 K bis 325 K — •Markus Büttner[1], Frank Schmidl[1], Thomas Müller[1], Stefan Prass[1], Michael Mans[1], Christoph Becker[1], Dimitri Berkov[2] und Paul Seidel[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Germany — [2]Innovent e.V., Jena, Germany

Um magnetische Nanopartikel im Hinblick auf ihre Anwendung charakterisieren zu können, ist es von grundlegender Bedeutung, Aussagen über die Verteilung der Energiebarrieren zu gewinnen, die wesentliche Aussagen über das magnetische Verhalten der Partikel liefern. Im weiteren Verlauf sind Angaben zum mittleren Durchmesser der Partikel bei entsprechenden Maxima der Energiebarrierenverteilung unter Verwendung weiterer magnetischer Messverfahren zur experimentellen Bestimmung der Aniosotropiekonstante möglich. Bei Vorliegen geeigneter Proben lassen sich außerdem magnetische Wechselwirkungen der Partikel in Abhängigkeit von deren mittlerem Abstand untersuchen.

Das magnetische Signal der Nèel-Relaxation der zu untersuchenden Probe wird mit einem axialen SQUID-Gradiometer zweiter Ordnung (Arbeitstemperatur 4,2 K) detektiert. Das ermöglicht die Charakterisierung der Proben in magnetisch und elektrisch unabgeschirmter Laborumgebung. Die Probentemperatur kann dabei durch einen entsprechenden Antikryostaten im Bereich von 4,2 K bis 325 K variiert werden. Aus der gemessenen Temperaturabhängigkeit des Relaxationssignals erhält man die Energiebarrierenverteilung der untersuchten Proben. Förderung durch das EU- Projekt Biodiagnostics Nr. 017002.

MA 15.89 Tue 15:00 Poster A

Quantitative Magnetic Imaging using Combined Magnetooptics and Magnetic Force Microscopy — •Sibylle Sievers[1], Sebastian Dreyer[2], Joachim Lüdke[1], Martin Albrecht[1], Uwe Siegner[1], and Christian Jooss[2] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — [2]Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

We present our results on the stray field calibration of a magnetic force microscope (MFM) based on a combination of MFM with magnetooptics using indicator films (MOIF). The MFM stray field measurements are not quantitative unless the measured signal is calibrated. The mosts general calibration ansatz based on a transfer function is pursued by Hug and coworkers [1]. Our groups are working on a transfer function based calibration ansatz using reference samples with well defined stray field distribution. As reference samples patterned hard magnetic FePt films which exhibit out-of-plane easy magnetization axes were produced. MOIF in combination with inverse and forward magnetostatic calculation techniques and micromagnetic simulations allows for a complete characterization of the magnetization and the stray field of the reference samples. This is the prerequisite for a calibration of the MFM signal. The results on the combined MFM and MOIF characterization of reference samples will be presented.

[1] P.J.A. van Schendel, H.J. Hug, B. Stiefel, S. Martin, and H.J. Güntherodt, J. Appl. Phys. 88 (2000) 435.

MA 15.90 Tue 15:00 Poster A

Magnetic domain structures in [Co/Pt]/Ru multilayers studied by MFM in magnetic field — •Cristina Bran[1,2], Ulrike Wolff[1], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany — [2]IMPRS "Dynamical Processes in Atoms, Molecules and Solids", Nöthnitzer Str. 38, Dresden, Germany

The detailed study of the magnetization process is important for the understanding of the coupling mechanism of the recently developed AF-coupled [Co/Pt]/Ru multilayers [1]. The field-dependent domain structure of a $[(Co(4Å)/Pt(7Å))_8/Ru(9Å)]_{18}$ multilayers was investigated by magnetic force microscopy (MFM). Measurements were performed using a DI Dimension 3100, upgraded for measurements with an external magnetic field applied perpendicular to the sample. In the zero field state, band domains with average domain width of 300 nm are observed. Upon increasing the external magnetic field, the domains first modify gradually, without changing the general configuration, until they transform into a bubble domain structures at 0.4 T, which is about 80% of the saturation field of the sample. An analysis of individual field dependent line scans represents the first attempt towards finding a quantitative correlation between domain structure and net magnetization. [1]O. Hellwig et al, Nature Materials, vol. 2, pp. 112-116, 2003

MA 15.91 Tue 15:00 Poster A

Spin-polarized scanning tunneling microscopy applied to nanoscale Fe islands — •Dinesh Subramaniam, Marco Pratzer, and Markus Morgenstern — II. Institute of Physics B, RWTH Aachen, 52056 Aachen

The magnetic properties of single-crystal nanoscale Fe islands on W(110) have been studied by spin-polarized scanning tunnelling microscopy. All measurements have been done at room temperature by a modified commercial Omicron "AFM/STM" using a 5 monolayer iron covered tungsten tip with an in-plane magnetic sensitivity. Prepara-

tion has been done by molecular beam epitaxy in UHV. We investigated islands with lateral dimensions of 200 by 400 nm^2 and different heights from 3 to 8 nm. The observed domain structures are in line with previous results [1] and with theoretical analysis. Variation of the thickness leads to different magnetic domain structures of the islands, which are dominated by the surface anisotropy with an easy axis along the [1$\bar{1}$0] direction [1,2]. For islands with a thickness of 3.5 nm, the uniaxial surface anisotropy of Fe/W(110) leads to a single domain state. For thicker islands the magnetostatic energy becomes dominant due to the reduced anisotropy energy. This results in a multi domain configuration.

[1] M. Bode, A. Wachowiak, J. Wiebe, A. Kubetzka, M. Morgenstern, R. Wiesendanger, Appl. Phys. Lett. 84 (2004) 948.
[2] A.Wachowiak, J. Wiebe, M. Bode, O. Pietzsch, M. Morgenstern, R. Wiesendanger, Science 298 (2002) 577.

MA 15.92 Tue 15:00 Poster A

Spin-resolved PEEM study of a single crystal Heusler alloy — •Ruslan Ovsyannikov[1], Florian Kronast[1], Andrei Gloskovskii[2], Gerhard H. Fecher[2], Claudia Felser[2], Hermann A. Dürr[1], and Wolfgang Eberhardt[1] — [1]BESSY GmbH, Albert-Einstein-Straße 15, 12489 Berlin, Germany — [2]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg - Universität Mainz, D-55099 Mainz, Germany

Heusler compounds are of the general formula X_2YZ. X and Y are usually transition metals and Z is either a non-magnetic metal or a non-metal. The crystal structure of a Heusler is marked by four interpreting fcc-lattices. Certain Heusler like Co_2FeSi have been theoretically predicted to be half-metallic ferromagnets. The high spin polarization at the Fermi level in combination with a high Curie temperature makes those materials promising candidates for applications in spintronics. Because of the difficult surface preparation and a complex domain pattern in remanence a direct experimental prove of half-metallicity e.g. by spin-resolved photoemission is still missing. A new spin-resolved photoemission electron microscope (S-PEEM) at BESSY helps to overcome at least one of this problem since it combines spatial resolution with spin analysis. The S-PEEM at the UE49 microfocus beamline is based on a commercial Elmitec PEEM with integrated energy analyzer, additionally equipped with two Mott polarimeter for spin analysis. Thus it allows to record spin resolved photoemission spectra from selected area e.g. a single magnetic domain. In this poster we present spin-resolved photoemission measurements from selected magnetic domains of a Co_2FeSi single crystal.

MA 15.93 Tue 15:00 Poster A

Heterogeneous mixed valence of a Sm/Gd(0001) monolayer revealed by scanning tunneling spectroscopy — •Daniel Wegner and Günter Kaindl — Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin

Many photoelectron spectroscopy studies show that low coverages of the lanthanide metal Samarium on various substrates are mostly mixed-valent. Due to the spatial averaging of this technique, the nature of the mixed valence – whether it is homogeneous or heterogeneous – could not be shown directly. Moreover, a lot of effort is necessary to rule out artifacts, e.g. structural disorder and nonuniform layer or island growth. We show that STS of a well-ordered monolayer of Sm on a Gd(0001) substrate proves a heterogeneous mixed valence, while islands of a second layer are divalent. The determination by STS is possible, because the Sm monolayer exhibits a localized surface state that indicates the valence state indirectly through a splitting. The results can be understood by comparison with STS on Sm(0001) and on Eu/Gd(0001).

MA 15.94 Tue 15:00 Poster A

Circular magnetic dichroism in x-ray absorption of $Co_2Cr_{0.6}Fe_{0.4}Al$ and Co_2FeSi(110) alloy films — •Michael Kallmayer[1], Horst Schneider[1], Andres Conca[1], Gerhard Jakob[1], Martin Jourdan[1], Hans-Joachim Elmers[1], Benjamin Balke[2], Andrei Gloskovskii[2], and Stefan Cramm[3] — [1]Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz, Germany — [2]Institut für Anorganische und Analytische Chemie Johannes Gutenberg-Universität, D-55099 Mainz, Germany — [3]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Theory predicts complete spin polarization for $Co_2Cr_{0.6}Fe_{0.4}Al$ and Co_2FeSi. We investigated epitaxial films of these materials using x-ray circular dichroism (XMCD). Properties of the interfaces and the core of the films could be determined separately using total electron yield and transmission signals. We find a strong correlation of structural properties and the Cr moment for $Co_2Cr_{0.6}Fe_{0.4}Al$. Moreover the Co absorption spectra reveal an extra peak at 4 eV above the L_3 edge increasing with increasing local order, in agreement with theory. For Co_2FeSi films we could determine a decreased magnetization at both interfaces corresponding to an effective number of dead layers of 0.15 nm at the top interface an 0.55 nm at the bottom interface.

MA 15.95 Tue 15:00 Poster A

Structural, electronic and magnetic properties of ultrathin epitaxial AuFe/Mo(110) films — •Andrei Kukunin[1], Jacek Prokop[1,2], and Hans Joachim Elmers[1] — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudingerweg 7, D-55099 Mainz — [2]Max-Planck Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle (Saale)

Structural, electronic and magnetic properties of epitaxial Fe monolayers (ML) grown on a single crystalline Mo(110) surface coated by a monolayer coverage of Au were studied by low temperature (5K) spin polarized scanning tunneling microscopy (SP-STM) and spectroscopy (SP-STS). We observed a magnetic contrast on the Fe nanowires through a Au monolayer. The Au coverage provokes a loss of magnetic contrast for Au coverages exceeding 0.1 ML, suggesting an instantaneous spin reorientation transition of the Fe ML from an out-of-plane easy axis for up to 0.1 ML Au to an in-plane easy axis for higher Au coverages. The magnetic contrast of the Au coated Fe ML is similar to the contrast observed for the uncovered Fe/Mo(110) ML. Annealing of an ultrathin Au/Fe/Mo(110) film completely destroys the Fe nanowire structure resulting in circular shaped islands of double layer (DL) height surrounded by a homogeneous monolayer coverage. The DL islands reveal a perpendicular magnetization, while the surrounding ML areas appear non-magnetic. Spectroscopic data suggests that the DL islands consist of an Fe layer at the Mo(110) substrate and a Au coating layer.

MA 15.96 Tue 15:00 Poster A

Thickness dependent spin wave properties in ultrathin Fe films — •Yu Zhang, Wen Xin Tang, Ioan Tudosa, Jacek Prokop, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

The spin wave excitations were investigated by spin polarized electron energy loss spectroscopy (SPEELS) in ultrathin epitaxial Fe/ W(110) films. In this report, the spin wave spectra vs. the thickness of Fe films on W (110) with different wave vectors are presented. The iron films, from 2 to 12 monolayers (ML) thick, are deposited using molecular beam epitaxy in ultra high vacuum at room temperature. The spin wave peaks appear clearly in the spectra of 2 ML Fe films, however for thicker films ($\geq$4 ML), the spin-wave excitations show broad peaks in the spectra, and it is difficult to extract the dispersion relation. The reason for obscuring the spin-wave dispersion for the thicker films will be discussed according to the increase of film thicknesses. The obtained results are also compared and discussed with calculations known from the literature.

MA 15.97 Tue 15:00 Poster A

Transport properties of magnetic tunnel junctions with Co2MnSi electrode: influence of temperature-dependent interface magnetization and electronic band structure — •Jan Schmalhorst[1], Andy Thomas[1], Oliver Schebaum[1], Daniel Ebke[1], Marc Sacher[1], Andreas Hütten[1], Andrej Turchanin[2], Armin Gölzhäuser[2], Elke Arenholz[3], and Günter Reiss[1] — [1]Thin Films and Nano Structures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [3]Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

The investigation of the temperature-dependent magnetic and chemical properties of the Co2MnSi / Al-O interface in Co2MnSi / Al-O / Co-Fe MTJs showed, that with increasing degree of disorder, interfacial magnetic moments are reduced and their temperature dependences are more pronounced. Magnon excitation is stronger at the Co2MnSi / Al-O interface compared with Co-Fe-B based tunnel junctions and bulk Co2MnSi. We suggest, that mainly this contributes to the larger bias voltage and temperature dependence of the TMR in the Co2MnSi based junctions by means of enhanced magnon-assisted tunneling. Furthermore, several fingerprints of the ideal Co2MnSi bandstructure of atomically ordered Co2MnSi films are revealed by the XAS-, XMCD- and XPS-investigations in accordance with SPR-KKR calculations. Fi-

nally, we suggest that the observed inversion of the TMR effect occuring when electrons are tunneling from the Co-Fe into the atomically ordered Co2MnSi electrode is the most striking bandstructure effect.

MA 15.98 Tue 15:00 Poster A

Chemical and magnetic interface properties of tunnel junctions with Co2MnSi / Co2FeSi multilayer electrode — •Daniel Ebke[1], Jan Schmalhorst[1], Marc Sacher[1], Ning-Ning Liu[1], Andy Thomas[1], Andreas Hütten[1], Elke Arenholz[2], and Günter Reiss[1] — [1]Thin Films and Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Transport as well as chemical and magnetic interface properties of two kinds of magnetic tunnel junctions (MTJs) with Co2FeSi electrode, Al-O barrier and Co-Fe counter electrode are investigated. For junctions with Co2FeSi single layer electrode a tunnel magnetoresistance of up to 52% is found for an optimal Al thickness of 1.5nm, whereas the room temperature bulk magnetization of the Co2FeSi film reaches only 75% of the expected value. By using a [Co2MnSi / Co2FeSi] multilayer electrode the magnetoresistance can be increased to 114% and the full bulk magnetization is reached. For Al thickness smaller than 1nm the TMR of both kinds of MTJs decreases rapidly to zero. On the other hand for 2 to 3nm thick Al the TMR decreases only slowly. The Al thickness dependence of the TMR is directly correlated to the element-specific magnetic moments of Fe and Co at the Co2FeSi / Al-O interface for all Al thickness. Especially, for optimal Al thickness and annealing, the interfacial Fe moment of the single layer electrode is about 20% smaller than for the multilayer electrode indicating smaller atomic disorder at the barrier interface for the latter MTJ.

MA 15.99 Tue 15:00 Poster A

Absence of ferromagnetism in V-implanted ZnO single crystals — •Shengqiang Zhou, Kay Potzger, Helfried Reuther, Karsten Kuepper, Wolfgang Skorupa, Manfred Helm, and Juergen Fassbender — Institute for Ion Beam Physics and Materials Research, Forschungszentrum Rossendorf, POB 510119, 01314 Dresden, Germany

Diluted magnetic semiconductors (DMS) have recently attracted huge research attention because of their potential application for spintronics devices [1]. ZnO doped with V was found to be ferromagnetic at room temperature [2]. However, the origin of the observed ferromagnetism in transition metal doped ZnO is still controversial, e.g. ferromagnetic clusters [3], or extrinsic reasons [4]. In this paper the structural and magnetic properties of V doped ZnO are presented. V ions were introduced into hydrothermal ZnO single crystals by ion implantation with fluences of 1.2*10ˆ16 to 6*10ˆ16 cmˆ-2. Post-implantation annealing was performed in high vacuum from 823 K to 1023 K. The ZnO host material still partly remains in a crystalline state after irradiation, and is partly recovered by annealing. The V ions show a thermal mobility as revealed by depth profile Auger electron spectroscopy. Synchrotron radiation x-ray diffraction revealed no secondary phase formation which indicates the substitution of V onto Zn site. However in all samples no pronounced ferromagnetism was observed down to 5 K by a superconducting quantum interference device magnetometer.

1.T. Dietl, et al., Science 287, 1019 (2000). 2.N. H. Hong, et al., J. Phys.: Condens. Matter 17, 199 (2005). 3.J. H. Park, et al., APL 84, 1338 (2004). 4.D. W. Abraham, et al., APL 87, 252502 (2005).

MA 15.100 Tue 15:00 Poster A

Magnetic and structural properties of Co-implanted ZnO films — •Numan Akdogan[1], Alexei Nefedov[1], Werner Becker[2], Rustam Khaibullin[3], Lenar Tagirov[3,4], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik IV, Ruhr-Universität Bochum — [2]Institut für Physik mit Ionenstrahlen, Ruhr-Universität Bochum — [3]Kazan Physical-Technical Institute of RAS — [4]Kazan State University

The ZnO-based dilute magnetic semiconductors (DMSs), which can be formed by doping 3d transition metals in ZnO, offers an interesting combination of electrical, optical, and magnetic properties. Moreover, according to suggestion of Dietl [1], the ZnO-based DMSs can order ferromagnetically at room temperature. In this contribution we report on structural and magnetic properties of Co-doped ZnO. ZnO films were grown on sapphire via rf-sputtering and doped with Co-ions via ion implantation with energy of 40 keV and implantation dose in the range of 0.25-1.50*1017 ions/cm2. The structural characterization was carried out using synchrotron radiation at the HASYLAB and the DELTA. The magnetic properties were investigated using x-ray resonant magnetic scattering at BESSY. Magnetic dichroism was observed at the Co L2,3 edges, as well as at the O K edge at room temperature for the highest dose doped sample, indicative of a spin polarization of oxygen atoms in the host matrix. - Partial support by SFB 491, by RFBR (grant 04-02-97505), and by TUBITAK (project 104T176) is acknowledged. N. Akdogan acknowledges a fellowship through IMPRS-SurMat. 1. T. Dietl et al., Science 287, 1019 (2000).

MA 15.101 Tue 15:00 Poster A

Growth and properties of Fe_3O_4(111) thin films on ZnO* — •Andrea Boger[1], Jürgen Simon[2], Andreas Brandlmaier[1], Matthias Opel[1], Sebastian T. B. Goennenwein[1], Werner Mader[2], and Rudolf Gross[1] — [1]Walther-Meissner-Institut der BayerischenAkademie der Wissenschaften, 85748 Garching — [2]Institut für Anorganische Chemie der Universität Bonn, 53117 Bonn

Fe_3O_4, a ferrimagnet with a Curie temperature of about 860 K, is an attractive candidate for direct spin injection into a semiconductor. Compared to metallic 3-d ferromagnets, its electrical conductivity is lower, which reduces conductivity mismatch issues [1]. Furthermore, a high spin polarization of $P = -(80\pm5)$ % and $P = -(55\pm10)$% has been measured for (111) and (001) oriented Fe_3O_4 surfaces, respectively [2]. Therefore (111)-oriented films are desirable for spin injection.

We have grown 30 nm thick Fe_3O_4 films on ZnO(0001) substrates by pulsed laser deposition. X-ray diffractometry shows, that the films are relaxed and grow (111)-oriented ($Fe_3O_4(1\bar{1}0) \parallel ZnO(2\bar{1}\bar{1}0)$) with high crystalline quality, as demonstrated by a FWHM of the rocking curves of the Fe_3O_4(222) reflection of only 0.02°. High-resolution TEM proves homogeneous growth and good interface quality. SQUID magnetometry reveals ferromagnetic behavior with a saturation magnetization of $3.2\,\mu_B$/f.u. at 300 K, about 80 % of the theoretical value. Epitaxial Fe_3O_4 electrodes thus appear promising for spin injection into ZnO.

[1] G. Schmidt et al., Phys. Rev. B **62**, R4790 (2000)
[2] M. Fonin et al., Phys. Rev. B **72**, 104436 (2005)
* This work is supported by the DFG via SPP 1157.

MA 15.102 Tue 15:00 Poster A

Magnetic and electronic properties of half-metallic ferromagnetic Mn-stabilised zirconia — •Igor Maznichenko[1], Arthur Ernst[2], Lars Bergqvist[3], Sergey Ostanin[2,4], Leonid Sandratskii[2], Patrick Bruno[2], Markus Däne[1], Ian Hughes[4], Julie Staunton[4], Wolfram Hergert[1], Ingrid Mertig[1], and Josef Kudrnovsky[2,5] — [1]Martin-Luther-Univ Halle-Wittenberg, Inst Phys, 06099 Halle, Germany — [2]Max-Planck-Inst Mikrostrukturphys, Weinberg 2, 06120 Halle, Germany — [3]Dept Phys, Uppsala Univ, Box 530, 751 21 Uppsala, Sweden — [4]Dept Phys, Univ Warwick, Coventry CV4 7AL, UK — [5]Inst Phys, Acad Sci of the Czech Republic, Na Slovance 2, 18221 Prague 8, Czech Rep.

The investigations of the manganese stabilised cubic zirconia (Mn-SZ) show that this dilute magnetic semiconductors possess unique magnetic properties. Based on *ab-initio* electronic structure calculations which include the effects of thermally excited magnetic fluctuations, the autors predict Mn-SZ to be ferromagnetic for a wide range of Mn concentration up to high T_C. It was found that this material, which is well known both as a diamond imitation and as a catalyst, is half-metallic with majority and minority spin states of the Mn impurities lying in the wide band gap of zirconia. The high T_C ferromagnetism is robust against oxygen vacancies and against the distribution of Mn impurities on the Zr fcc sublattice. This work responds to the question concerning the key electronic and structure factors behind an optimal doping. The autors propose this stable half-metallic ferromagnet to be a promising candidate for future spintronics applications.

MA 15.103 Tue 15:00 Poster A

Exchange constants in Mn doped Ge and GaAs: a first principles study of the environment effects — •Marjana Ležaić[1], Silvia Picozzi[2], Phivos Mavropoulos[1], Yuriy Mokrousov[3], and Stefan Blügel[1] — [1]IFF, Forschungszentrum Jülich, Jülich, Germany — [2]CNR-INFM CASTI Regional Lab., L'Aquila, Italy — [3]Institute for Applied Physics, University of Hamburg, Hamburg, Germany

*A*b-initio calculations have been performed for [001]-ordered Mn/Ge and Mn/GaAs "digital alloys", focusing on the effects of the band-gap width and the semiconducting host on the exchange constants of the Mn atoms. Our results for Mn/Ge, obtained using a frozen-magnon scheme [1], show that a larger band-gap tends to give a stronger nearest-neighbor ferromagnetic coupling and an overall enhanced in-plane ferromagnetic coupling even for longer-ranged coupling constants. Mn/GaAs shows a smaller nearest-neighbor ferro-

magnetic coupling than Mn/Ge, but exchange constants for higher Mn-Mn distance show an overall increased ferromagnetic behavior in Mn/GaAs [2]. The environmental dependence of the exchange constants in Mn-doped Ge was also investigated. We find that while the exchange constants in [001] and [111] direction remain small and practically unaffected by the different arrangements of the Mn atoms in Ge matrix, the coupling along [110] direction shows a strong environmental and concentration dependence. We discuss the exchange mechanisms and their consequences to the Curie temperature of the alloys.

[1] As implemented in the `FLEUR` code, `http://www.flapw.de`
[2] S.Picozzi, M.Ležaić, S.Blügel, Phys.Stat.Sol.(a) **203**, 2738 (2006)

MA 15.104 Tue 15:00 Poster A

Spin-Pump-Effekt in Co/Cu/Py Pillars untersucht mit ferromagnetischer Resonanz — •Oliver Posth, Jürgen Lindner und Günter Dumpich — Fachbereich Physik, AG Farle, Universität Duisburg-Essen, Campus Duisburg

In verschiedenen Arbeiten wurde gezeigt, dass ein spin-polarisierter Strom im Ferromagneten ein Drehmoment auf die Magnetisierung ausübt [1,2]. Dieser Strom kann z.B. dazu verwendet werden die Magnetisierung einer ferromagnetischen Schicht in einer Ferromagnet/Nichtmagnet/Ferromagnet (FM/NM/FM) spin-valve Struktur zu schalten [3]. Wir haben den Einfluss eines spin-polarisierten Stromes auf das Dämpfungsverhalten der ferromagnetischen Schichten in Pillar-Strukturen mit Hilfe der ferromagnetischen Resonanz (FMR) untersucht. Die Strukturen werden mit hochauflösender Elektronenstrahllithographie (HR-EBL) und Elektronenstrahlverdampfung in einem drei-Schritt-Prozess hergestellt und kontaktiert. Die Lagenstruktur und die Grenzflächen zwischen den Metallen, welche entscheidenden Einfluss auf den Transfer des spin-polarisierten Stromes haben, werden mit einem Tunnelmikroskop (TEM) anhand von Querschnittspräparaten und mit der FMR untersucht. Zusätzlich wird das Schaltverhalten der ferromagnetischen Lagen der Pillars mit Hilfe von Magnetowiderstandsmessungen (MR) studiert.

Diese Arbeit wird im Rahmen des SFB 491 gefördert.

[1] J. C. Slonczewski, J. Magn. Magn. Mater. **159**, 1 (1996)
[2] L. Berger, Phys. Rev. B **54**, 9353 (1996)
[3] J. A. Katine *et al.* Phys. Rev. Lett. **84**, 3149 (2000)

MA 15.105 Tue 15:00 Poster A

Bulk sensitive HX-PES study of chemically etched $Ga_{1-x}Mn_xAs$ — •Andreas Müller[1], Benjamin Schmid[1], Michael Sing[1], Jan Wenisch[2], Karl Brunner[2], Laurens Molenkamp[2], Wolfgang Drube[3], and Ralph Claessen[1] — [1]Experimentelle Physik IV, Universität Würzburg — [2]Experimentelle Physik III, Universität Würzburg — [3]HASYLAB DESY, Hamburg

Diluted magnetic semiconductors (DMS) have gained particular interest in the last years due to their potential in spintronic applications. One promising candidate for future devices is $Ga_{1-x}Mn_xAs$ ($0.04 < x < 0.07$) with Curie temperatures up to 170 K. However, the origin of the ferromagnetic properties is still far from clear.

We investigated the electronic structure of $Ga_{1-x}Mn_xAs$ using hard x-ray photoelectron spectroscopy (HX-PES). For analysing the intrinsic physical properties it is on the one hand essential to remove any surface oxides and adsorbates, since PES is a comparable surface sensitive technique. On the other hand, bulk information can be increased significantly by performing PES in the hard x-ray regime.

Wet chemical etching was used to clean the surface. This technique widely used in the semiconductor industry yields surfaces with controllable roughness and preserved stoichiometry. The samples were etched either in HCl or H_2SO_4 followed by rinsing with deionized water. Information on the depth profile of the composition was gained by measurements under different emission angles at a photon energy of 4.5 keV. Results on all relevant core levels and the valence band depending on the chemical treatment are presented.

MA 15.106 Tue 15:00 Poster A

Transport properties of ion-implanted ferromagnetic SnO_2:Co from van-der-Pauw measurements — •Ali Awada[1], Dirk Menzel[1], Joachim Schoenes[1], Frank Ludwig[2], and Meinhard Schilling[2] — [1]Institut für Physik der Kondensierten Materie, TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig, Germany — [2]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Str. 66, 38106 Braunschweig, Germany

In the field of diluted magnetic semiconductors, transition metal doped oxides have attracted much interest because of a Curie temperture which, in contrast to GaAs:TM, is beyond 300 K. In this work, magnetron-sputtered SnO_2 thin films on fused silica substrates were doped with Co using the ion implantation technique. Thereby, the risk of Co clustering in the host material is minimized. The implanted films order ferromagnetically at room-temperature exhibiting a saturation moment of 1.2 μ_B per Co at 300 K. Since it is still under discussion whether the magnetic exchange is mediated via free electrons or by a polaron-assisted mechanism, the conductivity of the pure and implanted SnO_2 films is determined by transport measurements in van-der-Pauw geometry. Results from Hall-effect investigations yield the polarity and the concentration of the carriers. The transport data are discussed in the view of the magnetic properties.

MA 15.107 Tue 15:00 Poster A

Chemical and magnetic interface properties of Co-Fe-B / MgO / Co-Fe-B tunnel junctions — •Jan Schmalhorst[1], Xinli Kou[1,2], Andy Thomas[1], Elke Arenholz[3], and Günter Reiss[1] — [1]Thin Films and Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Lanzhou University, 222 South Tianshui Road, Lanzhou 7300000, China — [3]Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

The chemical and magnetic properties at the lower Co-Fe-B / MgO interface of Co-Fe-B /MgO / Co-Fe-B magnetic tunnel junctions is investigated by X-ray absorption spectroscopy and X-ray magnetic circular dichroism. The influence of the annealing temperature and of a thin (0.5nm or 0.75nm) metallic Mg interlayer between the lower electrode and the RF-sputter deposited MgO barrier is studied. The room temperature tunnel magnetoresistance increases strongly with annealing temperature for both Mg interlayer thicknesses. Starting at 20% after annealing at 200°C it reaches a maximum value of 112% after annealing at 350°C. The annealing temperature dependent influence of the thermally induced reduction of interfacial Fe-O, the simultaneous increase of the Fe magnetic moment and the boron concentration in the electrode and in the Mg-O barrier on the TMR amplitude will be discussed.

MA 15.108 Tue 15:00 Poster A

High TMR ratio in Fe/MgO/Fe junctions with even one atomic Fe layer — Christian Heiliger, Martin Gradhand, •Peter Zahn, and Ingrid Mertig — Institut für Physik, Martin-Luther-Universität Halle/Wittenberg, D-06099 Halle, Germany

Recent experiments based on epitaxially grown Fe/MgO/Fe samples shed light on the microscopic origin of tunneling magnetoresistance (TMR). The obtained TMR ratios exceeded the predictions by Julliere's model by far. A screened Korringa-Kohn-Rostoker (KKR) method based on density-functional theory was applied to calculate the electronic and magnetic structure of the junctions self-consistently. The conductance was calculated in the limit of coherent transport using the Landauer formula by means of Green's functions.

Positive and negative TMR ratios are obtained as a function of interface structure and even a sign reversal of TMR as a function of bias was found [1]. It will be demonstrated how the structure of the electrodes, and especially the finite thickness of the Fe layers influence the TMR ratio and the corresponding bias voltage dependencies. It will be shown that the leads have just to provide states of Δ_1 symmetry which tunnel most efficiently across the barrier and the spin-filter effect is generated by even one monolayer of Fe [2].

[1] C. Heiliger et al., Phys. Rev. B **72**, 180604(R) (2005), C. Heiliger et al., Phys. Rev. B **73**, 214441 (2006).
[2] C. Heiliger et al., in preparation (2006).

MA 15.109 Tue 15:00 Poster A

Magnetic tunnel transistor with epitaxial FeCo/Au/FeCo base — •Alexander Spitzer, Julien Vigroux, and Günther Bayreuther — Universität Regensburg, Institut für Experimentelle und Angewandte Physik, Regensburg

The magnetic tunnel transistor (MTT) is a promising candidate for a highly sensitive magnetic sensor. In the present MTT structure hot electrons are injected into a spin valve base from a metallic emitter across a tunnel barrier. They cause a ballistic current, I_C, across the Schottky barrier with the GaAs substrate as the collector. By epitaxial growth of the spin valve the transfer ratio of collector current I_C to emitter current I_E is expected to increase because of less structural defects [1]. We present MTTs with a fully epitaxial $Fe_{34}Co_{66}/Au/Fe_{34}Co_{66}$ spin valve base grown on a n-GaAs(001) substrate, capped with an Al_2O_3 tunnel barrier and a Ta emitter. The

samples are characterized by STM, XPS, TEM and temperature dependent MOKE. For electron energies above 0.8 eV a clear magnetic field-dependent ballistic current is measured in the collector. The temperature dependence of the magneto-current ratio (MCR), i.e. normalized difference of I_C between parallel and antiparallel alignment of both FeCo layers, is discussed.

[1] T. Hagler, C. Bilzer, M. Dumm, W. Kipferl, G. Bayreuther, J. Appl. Phys. 97, 10D505 (2005)

MA 15.110 Tue 15:00 Poster A

Ferromagnetic multiband Kondo lattice model — •Anand Sharma and Wolfgang Nolting — Institut fuer Physik, Humboldt Universitaet zu Berlin, Lehrstuhl Festkoerpertheorie, Newtonstr.15, D-12489, Berlin.

The spin exchange interaction between the itinerant electrons and localized moments on a periodic lattice, studied within the so-called Kondo lattice model (KLM), is considered for multiband situation where the hopping integral is a matrix in general. The modified RKKY theory (PRB **65**, 144419 (2002)), wherein one can map such a model onto an effective Heisenberg-like system, is extended to a two band situation with a finite bandwidth and hybridization on a simple cubic lattice. As an input for the evaluation of the effective exchange integrals, one requires the multiband electronic self energy which is taken from an earlier proposed ansatz (PSSB **243**, 641 (2006)). Using the above procedure, we determine the magnetic properties of the system like Curie temperature (within Random Phase Approximation) while calculating the chemical potential and magnetization within a self consistent cycle for various values of system parameters. The results are discussed in detail and the model is also considered for the study of the electronic and magnetic properties of real materials like GdN.

MA 15.111 Tue 15:00 Poster A

Disordered Correlated Kondo-lattice model — •Vadym Bryksa and Wolfgang Nolting — Institut für Physik, Humboldt-Universität zu Berlin, Theoretische Festkörperphysik, Newtonstraße 15, D-12489 Berlin

We propose a self-consistent approximate solution of the disordered Kondo-lattice model (KLM) to get the interconnected electronic and magnetic properties of 'local-moment' systems like diluted ferromagnetic semiconductors. Aiming at compounds $(A_{1-x}M_x)$, where magnetic (M) and non-magnetic (A) atoms are distributed randomly over a crystal lattice, we present a theory which treats the subsystems of itinerant charge carriers and localized magnetic moments in a homologous manner. The coupling between the localized moments, being mediated by itinerant electrons (holes), is treated by a modified RKKY-theory which maps the KLM onto an effective Heisenberg model. The exchange integrals turn out to be functionals of the electronic selfenergy guaranteeing selfconsistency of our theory. The disordered electronic and moment systems are both treated by CPA-type methods. We discuss in detail the dependencies of key-terms such as the long range and oscillating effectice exchange integrals, 'the local-moment' magnetization, the electron spin polarization, the Curie temperature as well as the electronic and magnonic quasiparticle densities of states on the concentration x of magnetic ions, the carrier concentration n, the exchange coupling J, and the temperature. The disorder causes anomalies in the spin spectrum especially in the low-dilution regime, which are not observed in the mean field approximation.

MA 15.112 Tue 15:00 Poster A

Magnetocrystalline anisotropy of 5d-transition-metal chains — •Alexander Thiess, Yuriy Mokrousov, and Stefan Heinze — Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

The magnetic properties of monoatomic linear chains consisting of 5d transition-metal atoms are investigated using *ab initio* density functional theory [1]. Ferromagnetic as well as antiferromagnetic configurations are considered in order to find the ground state of the system. Due to the large atomic number and reduced dimensionality the spin-orbit coupling is extremely important and influences the electronic and magnetic properties of these systems significantly. We study the correlation of the spin- and orbital moments with the magnetocrystalline anisotropy energy (MAE), the total energy difference between the configurations with magnetization parallel and perpendicular to the chain axis. Giant values of the MAE up to 40 meV per atom are reached already for the equilibrium interatomic distance, even larger than for 4d-chains [2]. Stretching the chain leads to even higher values of the MAE (up to 120 meV per atom). The nontrivial behavior of the anisotropy energy, and the spin- and orbital moments with respect to the interatomic distance is discussed in detail in terms of the band filling [3].

[1] Y. Mokrousov et al., Phys. Rev. B **72**, 045402 (2005)
[2] Y. Mokrousov et al., Phys. Rev. Lett. **96**, 147201 (2006)
[3] G. van der Laan, J. Phys.: Condens. Matter **10**, 3239-3253 (1998)

MA 15.113 Tue 15:00 Poster A

Spin-wave excitations from time-dependent density-functional theory — Manfred Niesert, •Arno Schindlmayr, Christoph Friedrich, and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

Spin waves constitute an important class of low-energy excitations in magnetic solids with a characteristic material-specific dispersion and a direct relation to magnetization dynamics. Until now most theoretical studies are based on the Heisenberg model of localized spins or on the frozen-magnon method, but neither is applicable to investigate the dynamics of spin waves in metallic systems with itinerant electrons. As a possible solution, time-dependent density-functional theory gives access to the full frequency-dependent transverse spin susceptibility, from which the lifetimes of spin-wave excitations as well as related spectral information can be extracted. We develop a practical scheme to calculate spin-wave spectra from first principles within this framework and illustrate its performance by applications to prototype ferromagnetic transition metals. Our implementation uses the full-potential linearized augmented-plane-wave method, and dynamic exchange-correlation effects are in the first instance described by the adiabatic local-density approximation. This work is funded by the Deutsche Forschungsgemeinschaft through the Priority Programme 1145.

MA 15.114 Tue 15:00 Poster A

Numerical investigation of geometrically confined domain walls and spin torque using the Heisenberg model — •C. Schieback[1], U. Nowak[2], M. Kläui[1], D. Backes[1,3], L. J. Heydermann[3], F. Junginger[1], R. E. Dunin-Borkowski[4], U. Rüdiger[2], and P. Nielaba[1] — [1]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]Department of Physics, University of York, York YO10 5DD, UK — [3]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, CH-5232 Villingen PSI, Switzerland — [4]Department of Material Science and Metallurgy, University of Cambridge, Cambridge CB2 3QZ, UK

We study systematically the influence of lateral dimensions on the spin structure of domain walls. Computer simulations on a classical spin model are performed for ferromagnetic permalloy nano-structures with lateral constrictions. Thermal activations of the system are taken into account by the numerical solution of the Landau-Lifshitz-Gilbert equation with Langevin dynamics. The domain wall width is found to be strongly correlated with the constriction width. The smaller the constriction width the smaller the domain wall width.

Furthermore we calculate the response of a domain wall to a current due to a spin transfer torque resulting in current-induced domain wall motion. We compute the behavior of domain walls in a one dimensional chain when currents are injected using adiabatic and non-adiabatic spin torque terms. Our results are compared to analytical calculations and are found to agree very well for small current density predictions. The work was supported by the Landesstiftung Baden-Württemberg.

MA 15.115 Tue 15:00 Poster A

Evolution of magnetization from the vortex state in soft magnetic square platelets — Manfred Wolf, •Ulrich K. Rössler, and Rudolf Schäfer — IFW Dresden

The zero-field ground state of magnetically soft films (with lateral dimensions above the single-domain limit) is governed by the demagnetization energy, which causes flux-closure. The quasistatic magnetization process in an external field is obtained by minimizing the micromagnetic free energy. Much like domains, the magnetization patterns in these structures are determined by the sample geometry and the applied field H. These patterns can display regions with homogeneous magnetization separated by walls and can be understood with a scaling analysis of the different energy contributions in the micromagnetic energy, which is valid for films of vanishing thickness $t \to 0$.

Here we investigate the magnetization process and the evolution of the vortex pattern in square Permalloy platelets with edge lengths $l = 1$ μm and finite $t = 8$, 12, 16 and 20 nm and for a field applied along the square's diagonal by numerical computation using a standard micromagnetism code. The results can be semi-quantitatively

understood by a modified phase theory approximation that describes the magnetization process in terms of the position of the vortex as single parameter. This approach gives a good explanation, as a function of the film thickness, of (i) the critical field, at which the vortex is expelled, (ii) the initial slope of the magnetization-vs-field curve $m(H)$, (iii) the dependence of the field energy on m, and (iv) the dependence of the demagnetization energy.

MA 15.116 Tue 15:00 Poster A

Current-induced magnetic vortex core reversal in a permalloy nanodisk — •Yaowen Liu, R. Hertel, and Claus M. Schneider — Institut für Festkörperforschung IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Magnetic vortex structures in ferromagnetic thin-film elements contain a nanometric core magnetized perpendicular to the film plane [1]. It has recently been demonstrated that a vortex core can be switched by short, resonant magnetic field pulses applied in the film plane [2]. In this work, we use micromagnetic finite-element simulations to demonstrate that vortex cores can also be switched by in-plane sub-ns electric current pulses. The vortex core of a permalloy nanodisk of 200 nm size and 20 nm thickness can be switched, e.g., by a 200 ps polarized current pulse with a peak value of $5{\times}10^8$ A/cm^2. In the simulations, both the spin transfer torque (adiabatic) term and the force (non-adiabatic) term due to the current have been considered. The simulations show that the core switching process is mediated by a rapid vortex-antivortex pair creation and annihilation mechanism [3]. For stronger current pulses, multiple core reversals are observed. By changing the strength of the current pulse, the number of the reversal times can be controlled.

[1] Shinjo et al. Science 289, 930 (2000).
[2] B. Van Waeyenberge et al., Nature 444, 461 (2006).
[3] R. Hertel and C.M. Schneider, PRL 97, 177202 (2006).

MA 15.117 Tue 15:00 Poster A

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

Transition-metal nanowires are very attractive systems to study the interplay of low dimensionality and magnetism. The results of recent experiments indicate the existence of noncollinear order in ferromagnetic nanowires [1,2]. However, for systems with a large number of magnetic degrees of freedom a direct unambiguous measurement of the magnetic configuration is quite impossible without preliminary theoretical considerations. In this respect the predictive role of first-principles calculations is of great importance. We have developed a new version of the screened Korringa-Kohn-Rostoker (KKR) method that can suitably be applied to noncollinear magnetic systems. In terms of this method we calculate both the diagonal and the off-diagonal elements of the spin density matrix from which we obtain information for both the magnitudes and the directions of the local moments. We performed *ab initio* calculations for magnetic nanowires suspended between two semi-infinite leads. These three parts of the system were treated on the same footing without adjustable parameters. We point out the possibility of the formation of noncollinear magnetic states in Ni, Co and Fe nanowires. In addition, the influence of the magnetic anisotropy on the magnetic order will be discussed.

[1] V. Rodrigues et al., Phys.Rev.Lett. **91**, 096801 (2003)
[2] M.R. Sullivan et al., Phys.Rev.B **71**, 024412 (2005)

MA 15.118 Tue 15:00 Poster A

Thermal Expansion and Thermal Transport in $NdMnO_3$ and $TbMnO_3$ — •Kai Berggold[1], Thomas Lorenz[1], Jörg Baier[1], John Mydosh[1], Dennis Meier[2], Joachim Hemberger[3], and Dimitri Argyriou[4] — [1]II. Physikalisches Institut, University of Cologne, Germany — [2]Helmholtz - Inst. f. Strahlen und Kernphysik, University of Bonn, Germany — [3]Inst. f. Physik, University of Augsburg, Germany — [4]Hahn-Meitner-Institut, 14109 Berlin, Germany

We present measurements of the thermal expansion α and the thermal conductivity κ of $NdMnO_3$ and $TbMnO_3$. $NdMnO_3$ is an A type antiferromagnet with $T_N = 88\,\mathrm{K}$, whereas $TbMnO_3$ is known for its multiferroic properties, leading to complex magnetic and electric ordering phenomena at low temperatures. In $NdMnO_3$, the Néel transition causes large anomalies in α as well as in κ. At low temperatures the crystal-field splitting of the Nd^{3+} ground state causes a Schottky-type contribution to the thermal expansion. The thermal conductivity at low temperatures is strongly suppressed by this splitting, as a consequence of resonant phonon-scattering processes. In $TbMnO_3$, we show that the main factor determining κ is also given by resonant scattering between different crystal-field split states of the $4f$ multiplet of the Tb^{3+} ions. In contrast to $NdMnO_3$, the suppression acts in a much wider temperature range. The various transitions at low temperatures observed by anomalies of the thermal expansion have no significant influence on the thermal conductivity.

Supported by the DFG through SFB 608

MA 15.119 Tue 15:00 Poster A

Magnetic field dependent structure of $TbFe_3(BO_3)_4$ resolved by x-ray diffraction — •Martin Philipp[1], Olga Kataeva[1,2], Christian Hess[1], Rüdiger Klingeler[1], Natalia Tristan[1], Bernd Büchner[1], Martin von Zimmermann[3], Alexander Vasiliev[4], and Elena Popova[4] — [1]Leibniz-Institute for Solid State and Materials Research, IFW-Dresden, 01171 Dresden, Germany — [2]A.E.Arbuzov Institute, Russian Academy of Sciences, Arbuzov Str. 8, 420088 Kazan, Russia — [3]HASYLAB@DESY, Notkestr. 85, 22603 Hamburg, Germany — [4]Physics Faculty, Moscow State University, 119992 Moscow, Russia

Recently, rare earth iron borates $RFe_3(BO_3)_4$ (R: Rare Earth) attracted attention as candidates for possible multiferroic behavior. $TbFe_3(BO_3)_4$ exhibits antiferromagnetic order below ~ 39 K. In this ordered phase a spin flop-like transition occurs when a magnetic field is applied parallel to the crystallographic c-axis. This involves the reorientation of the antiferromagnetic ordered Fe and the polarized Tb magnetic moments. We have studied this magnetic transition by means of hard x-ray diffraction ($h\nu \approx 100$ keV). In the high field phase we observed superlattice reflections which indicate a doubling of the unit cell along the c-axis. We compare the field and temperature dependence of these superlattice reflections with results from thermodynamics.

MA 15.120 Tue 15:00 Poster A

Spin-flop transition in uniaxial antiferromagnets — •Alexei N. Bogdanov[1,2], Alexander V. Zhuravlev[2], and Ulrich K. Rössler[1] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology

A comprehensive phenomenological theory of the spin-flop reorientation in easy-axis antiferromagnets has been developed [1]. The characteristic hierarchy of exchange and relativistic interactions in this class of antiferromagnets causes a strongly pronounced *two-scale* character of their magnetic properties. In contrast to the major part of the magnetic phase diagram, near the spin-flop field magnetic properties are determined by weak higher-order intrinsic interactions. In this region the system can be described by an effective model akin to uniaxial ferromagnets. The analysis of magnetic-field-driven reorientation and the concomitant multidomain states provides a consistent picture of the magnetization processes near the spin-flop field. We elucidate such remarkable spin-flop phenomena as reentrance of phases in the coexistence region, enhanced magnetic susceptibility, and complex magnetization processes. The validity of the theoretical results has been demonstrated by experimental investigations of the spin-flop transition in the orthorhombic layered antiferromagnet $(C_2H_5NH_3)_2CuCl_4$ [1,2]. The theory developed in this work can be adopted for investigations on synthetic antiferromagnets and exchange-biased systems [3].

[1] A. N. Bogdanov, A. V. Zhuravlev, U.K. Rößler, cond-mat/0609648. [2] A. N. Bogdanov, A. V. Zhuravlev, I.V. Zhikharev, U.K. Rößler, J. Magn. Magn. Mater. **290-291**, 768 (2005). [3]. A. N. Bogdanov, U. K. Rößler, Appl. Phys. Lett. **89** (2006) 163109.

MA 15.121 Tue 15:00 Poster A

Crystal structure and magnetic fluctuations in $La_{1-x}A_xCoO_3$ (A = Ca, Sr, Ba) — •Thomas Finger[1], Marco Reuther[1], Daniel Senff[1], Matthias Cwik[1], Thomas Lorenz[1], Klaudia Hradil[2], Anatoliy Senychyn[3], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Physikalische Chemie, Georg-August Universität Göttingen — [3]FB Material- und Geowissenschaften, Technische Universität Darmstadt

The phase diagram of perovskite cobaltites is closely related to those of the CMR-manganites as they both show ferromagnetism and metallic behaviour at intermediate doping. We have studied the crystal structure of the series with Ca and Ba doping by combining different neutron and x-ray diffraction techniques and will discuss the corresponding phase diagrams. Furthermore magnetic excitations were studied by inelastic neutron scattering on a thermal triple-axis spectrometer for $La_{0.75}Sr_{0.25}CoO_3$ which exhibits ferromagnetic order below $T_C = 220$ K.The magnon excitations could be followed up to energies of 13 THz yielding an isotropic dispersion. We find a spin-wave stiffness

constant of $D = 400 \pm 35\text{meV}\cdot\text{Å}^2$.

MA 15.122 Tue 15:00 Poster A

Static Characterization of the Antiferromagnetic-To-Ferromagnetic Phase Transition of FeRh Thin Films — •Paul Ramm[1], Ilie Radu[1], Alexander Weber[1], Christian Back[1], Christian Stamm[2], Torsten Kachel[2], Niko Pontius[2], Hermann Dürr[2], Jörg Raabe[3], Christoph Quitmann[3], Luiic Joly[3], and Jan-Ulrich Thiele[4] — [1]Institut für Angewandte und Experimentelle Physik, Universität Regensburg, Germany — [2]BESSY GmbH, Berlin, Germany — [3]Paul Scherrer Institut, Villingen PSI, Switzerland — [4]Hitachi Global Storage Technologies, San Jose Research Center, USA

The antiferromagnetic-to-ferromagnetic phase transition present on the FeRh thin film alloy is studied by employing static magneto-optic Kerr effect (MOKE), X-ray magnetic circular dichroism (XMCD) and X-ray photoemission electron microscopy (XPEEM) techniques, which give information on the average magnetization, the element-specific magnetic moments as well as the domain structure, respectively.

The element-specific hysteresis provided by the XMCD measurements near the transition temperature reveal the growth of the Fe magnetic moment and development of the small but crucial induced Rh magnetic moment in the ferromagnetic phase.

Using temperature dependent XPEEM in the vicinity of the phase transition we observe the formation and the partial reproducibility of the magnetic domain structure. The temperature hysteresis of the magnetic contrast deduced from the XPEEM data is in good agreement with the temperature dependent MOKE measurements.

MA 15.123 Tue 15:00 Poster A

Structural properties of PrB_6 — •Matthias Bleckmann[1,2], Desmond McMorrow[2], Helen Walker[2], Danny Mannix[3], Je-Geun Park[4], Seongsu Lee[4], and Keith McEwen[2] — [1]Institut für Physik der Kondensierten Materie, TU Braunschweig, Braunschweig, Germany — [2]Department of Physics and Astronomy, University College London, London, UK — [3]XMaS UK-CRG, European Synchrotron Radiation Facility, Grenoble, France — [4]SungKyumKwan University, Suwon, Korea

Multiferroic materials represent a topic of current interest in solid state physics. In order to understand the multitude of phenomena occurring in these materials the issue of quadrupolar ordering has attracted a lot of interest. Here, a model system to study and understand quadrupolar ordering phenomena is required. PrB_6, with its simple crystal structure and well known magnetic structure, is a suitable material to act as such a model system. In this contribution, we present a detailed study of the low-temperature structural properties of PrB_6. By means of high-resolution x-ray diffraction we find the first direct experimental proof of a structural lattice distortion in PrB_6, and which seems to be driven by its magnetic phase transition.

MA 15.124 Tue 15:00 Poster A

Frustrated Ising- and Heisenberg-type Spin Systems on a Hexagonal Lattice — Carsten Olbrich[1,2], •Tim Kunze[1], Sibylle Gemming[1,3], Klaus Morawetz[1,4], and Michael Schreiber[1] — [1]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [2]School of Engineering and Science, Jacobs University Bremen, 28725 Bremen, Germany — [3]Forschungszentrum Dresden-Rossendorf, PF 51 01 19, 01314 Dresden, Germany — [4]Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany

The low-temperature behaviour of Ising- and Heisenberg-type spin systems on a periodically repeated hexagonal lattice is investigated by Metropolis-Monte-Carlo simulations. The correlation between various realisations of the local coupling and the order-disorder phase transitions is studied as a function of the external magnetic field. Entropy effects are estimated by thermodynamic integration. Due to frustration effects complex spin patterns are obtained and analysed in specific parameter regimes.

MA 15.125 Tue 15:00 Poster A

Magnetic phases in Y_xCa_1-xMnO_3 — •Uwe Amann[1,2,3], Clemens Ritter[2], Dietmar Hohlwein[1,3], Andreas Pfrommer[1], and Jörg Ihringer[1] — [1]Institut für Angewandte Physik, Universität Tübingen, 72076 Tübingen, Germany — [2]Institut Laue-Langevine, 38100 Grenoble, France — [3]SF2/Magnetism, Hahn-Meitner Institut, 14109 Berlin, Germany

We report on studies on the CMR-compounds Y_xCa_1-xR_yMn_1-yO_3 which exhibit changing magnetic properties depending on concentration x and temperature. From the G-type AF CaMnO3, a new magnetic (C-type AF) phase occurs when exchanging Calcium by Yttrium in the region of x>=0.1. Phase transition temperature, phase fraction and strength of the magnetic moment of these phases depends strongly on the dopant R and amount y. Temperature dependent data collected with neutron and x-ray (powder) diffractometers has been analyzed simultaneously to determine the fractions of the different possible and realized magnetic and nuclear phases (nuclear structures P2_1/m, Pnma, magnetic structure type G,C,F,A).

For the substitution of Manganese by Gallium pronounced shifts in phase transition temperature are recorded, while the substitution by Iron leads to much weaker magnetic intensities with less effects on the nuclear structure.

MA 15.126 Tue 15:00 Poster A

***Ab Initio* Calculations of Exchange Interactions in Transition Metal Oxides** — •Guntram Fischer[1], Arthur Ernst[2], Markus Däne[1], Wolfram Hergert[1], Martin Lüders[3], Zdzislawa Szotek[3], and Walter Temmerman[3] — [1]Naturwissenschaftliche Fakultät II, Institut für Physik, Martin-Luther-Universität Halle-Wittenberg — [2]Max Planck Intitut für Mikrostrukturphysik, Halle — [3]Daresbury Laboratory, Daresbury, Warrington WA4 4AD

For the development of new materials in semi-conductor technology and spintronics it is essential to understand the magnetic effects and interactions in these systems. One method to describe the magnetic effects is to map the interactions onto an effective Heisenberg-Hamiltonian. To do so one needs to obtain the Heisenberg exchange parameters, which carry the relevant physical information about other quantities such as critical temperatures, magnetic susceptibilities, specific heat and others.

We present the results obtained by applying *ab initio*-methods to calculate the exchange parameters of transition metal oxides (TMO). With these results the Néel temperatures of the TMO are calculated via Mean Field Approximation, Random Phase Approximation and classical Monte Carlo simulations. The different results are compared with each other and possible future applications of the methods are shown.

MA 15.127 Tue 15:00 Poster A

Colossal magnetostriction and spin-driven phonon splitting in bond-frustrated Cr-spinels — •Joachim Hemberger, Torsten Rudolf, Christian Kant, Hans-Albrecht Krug von Nidda, Andrei Pimenov, Vladimir Tsurkan, and Alois Loidl — Center for Electronic Correlation and Magnetism, University of Augsburg, D-86135 Augsburg, Germany

The Cr-based cubic spinel compounds $ZnCr_2X_4$ (X=S,Se) exhibit complex magnetic ground states which are determined by the competing ferromagnetic (FM) and antiferromagnetic (AFM) exchange interactions yielding strong bond frustration: While in ZnCr2Se4 a spiral AFM structure is established below $T_N = 21$ K, in $ZnCr_2S_4$ the AFM spiral sets in below $T_{N1} = 15$ K and is changed into a collinear magnetic phase below $T_{N2} = 8$ K. Even though ESR measurements reveal a negligible spin-orbit coupling excluding orbitally induced Jahn-Teller distortions, the observed magnetic transitions are accompanied by significant magnetoelastic anomalies: In both compounds a splitting of individual phonon modes, pronounced thermal expansion anomalies, and large magnetostriction are denoting the spin-driven origin of a structural instability which can be fully suppressed in external magnetic fields. These effects are investigated by means of magnetization, specific heat, thermal expansion, dielectric and IR spectroscopy in external magnetic fields and the results are interpreted in terms of exchange-striction along the competing magnetic bonds.

[1] J. Hemberger et al., Phys. Rev. Lett. **97**, 087204 (2006) [2] J. Hemberger et al., cond-mat/0607811

MA 15.128 Tue 15:00 Poster A

The multiferroic phases of (Eu:Y)MnO_3 — •Florian Schrettle[1], Joachim Hemberger[1], Andrei Pimenov[1], Peter Lunkenheimer[1], Vseva Ivanov[2], Alexander Mukhin[2], Anatoli Balbashov[3], and Alois Loidl[1] — [1]Experimentalphysik V, Center for Electronic Correlations and Magnetism, Institut für Physik, Universität Augsburg, D-86135 Augsburg, Germany — [2]General Physics Institute of the Russian Academy of Sciences, 38 Vavilov Street, 119991 Moscow, Russia — [3]Moscow Power Engineering Institute, 14 Krasnokasarmennaja Street, 111250 Moscow, Russia

In recent years multiferroic magnetoelectrics attracted an increasing

scientific and technological interest. In this rare class of compounds ferroelectricity (or at least a weak ferroelectric component) and (ferro-)magnetism coexist and both order-parameters are strongly coupled. Prominent examples for such type of materials are the heavy rare earth manganites like $TbMnO_3$, where the partial frustration in the spin-sector leads to spiral magnetic structures inducing finite ferroelectric polarization. The system (Eu:Y)MnO_3 offers the possibility to continuously control the orthorhombic distortion of the orbitally ordered perovskite structure and thus to tune the corresponding multiferroic phases without the additional influence of a magnetic rare earth moment. In the concentration range near x=0.2 for these class of materials the unique case of spontaneously coexisting ferroelectric and ferromagnetic components is realized.

[1] J. Hemberger et al., Phys. Rev. B, in press, cond-mat/0603258

MA 15.129 Tue 15:00 Poster A

Electronic and magnetic structure of cuprous oxide (Cu_2O) doped with Mn, Fe, Co, and Ni: A DFT study — Martin Sieberer, Josef Redinger, and •Peter Mohn — Center for Computational Materials Science, Technical University of Vienna, Austria

We investigate the effect of transition metal (TM) substitution in cuprous oxide Cu_2O on the basis of ab-initio calculations employing density functional theory (GGA+U). By using the supercell approach we study the effect of substituting Cu by Mn, Fe, Co, and Ni, assuming both, low TM concentrations (3.2 %) in a cubic geometry and higher TM concentrations (9.1 %) in a trigonal set-up. For the elements Mn and Co magnetic exchange constants up to the fifth nearest neighbor are calculated, assuming both cases, perfect Mn/Co:Cu_2O as well as defects in the host like single copper and oxygen vacancies. Our results clearly show the importance of defects in these materials and thus offer an explanation for various, seemingly opposed experimental results.

MA 15.130 Tue 15:00 Poster A

Electronic structure and magnetic properties of the $Th_xY_{1-x}Co_4B$ intermetallic compounds — •Diana Benea[1], Viorel Pop[1], and Olivier Isnard[2] — [1]Babes Bolyai University, Faculty of Physics, Cluj-Napoca, Romania — [2]Laboratoire de Cristallographie du CNRS, Joseph Fourier University, 38042 Grenoble, France

Detailed theoretical and experimental investigations on the electronic and magnetic properties of the $Th_xY_{1-x}Co_4B$ compounds have been performed. All investigations of the electronic, magnetic and structural properties have been done using the fully relativistic spin polarized Korringa-Kohn-Rostoker (SPR-KKR) band structure method in ferromagnetic state. The disorder in the system has been accounted for by means of the Coherent Potential Approximation (CPA). The $ThCo_4B$ compound orders ferromagnetically at 303 K, whilst the isotypic YCo_4B compound has a higher Curie temperature (380 K). The SPR-KKR calculated total magnetic moment decrease with Th concentration from 2.49 μ_B/f.u. for YCo_4B to 1.64 μ_B/f.u. for $ThCo_4B$. The magnetization measurements show a similar decrease of the magnetic moment with Th content from 2.90 μ_B/f.u. for YCo_4B to 1.49 μ_B/f.u. for $ThCo_4B$. The values of the Co magnetic moments depend strongly on the local environment. The preferential occupation of the Th/Y atoms evidenced by X-ray and neutron scattering experiments is investigated by theoretical calculations. In addition, the influence of the preferential occupation on the magnetic properties of the system is discussed.

MA 15.131 Tue 15:00 Poster A

Investigation of high-k materials $RScO_3$ (R=Sm,Gd,Dy) by XPS and band structure calculations — •M. Raekers[1], S. Bartkowski[1], K. Kuepper[2], S. Zhou[2], K. Potzger[2], A. Postnikov[3], R. Uecker[4], and M. Neumann[1] — [1]Universität Osnabrück, Fachbereich Physik, Osnabrück, Germany — [2]FZ Dresden-Rossendorf, Dresden, Germany — [3]Université Paul Verlaine, Metz, France — [4]IKZ, Berlin, Germany

There has been considerable interest in high-k-dielectrics rare earth oxides as replacement for SiO_2 in advanced field-effect transistors (FETs). Promising candidates are the perovskites $SmScO_3$, $GdScO_3$ and $DyScO_3$. A tendency towards antiferromagnetic ordering at low temperatures is observed for the high magnetic moments at rare earth atoms. We analyse the electronic structure of the single crystalline samlpes by means of X-ray photoelectron spectroscopy and first-principles theory. The electronic structure calculations are performed with the augmented plane waves method (WIEN2k code) of the density functional theory, taking into account the spin-orbit interaction and orbital-dependent potential (LDA+U). The calculated positions of the main features in the valence band agree with the XPS data, the underlying chemical bonding can be analysed in detail. Small differences in the electronic structure, resulting in different stability of ferro- and antiferromagnetic configurations, are discussed.

MA 15.132 Tue 15:00 Poster A

Heat conduction in spin-gap antiferromagnets — Igor Smiljanić[1], •Ante Bilušić[1,2], Ana Smontara[1], Helmuth Berger[3], and László Forró[3] — [1]Institute of Physics, Zagreb, Croatia — [2]Faculty of Science, Univ. of Split, Croatia — [3]Ecole Polytechnique Fédérale de Lausanne, Switzerland

Spin-gap antiferomagnets (SG AFMs) have a discrete spin-energy spectrum due to the existence of short-range spin correlations only. The thermal conductivity of SG AFMs is a tool that probes their spin excitations and spins-phonons interaction. A variety of phenomena are observed: for example, in various strontium-cuprates thermal conductivity strongly enhances due to the opening of the heat channel carried by either magnons or spinons. In spin-Peierls compounds the thermal conductivity exhibits rather unusual double peak features at low temperatures, explained as a fingerprint of the spin-phonon resonance scattering. The thermal conductivity of strongly frustrated systems also shows the existence of spin-phonon resonance at low temperatures. We present the study of the thermal transport of several SG AFMs: (i) of copper-tellurides, quasi-0D geomatrically frustrated compounds with S=1/2, (b) of a "zig-zag"frustrated spin ladder system $LiCu_2O_2$ (S=1/2), and (c) quasi-2D S=1 system nickel-telluride. We find that the thermal conductivity of these systems exhibit features typical for spin-phonon resonance coupling, gradually decreasing as the dimensionality of the systems increase. This work was done within the SNF SCOPES project No. IB7320-111044.

MA 15.133 Tue 15:00 Poster A

Calculation of interface properties for Heusler compounds — •Andrey Beznogov and Peter Entel — Theoretische Tieftemperaturphysik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

Heusler compounds, such as Co_2MnGe, are one of the most attractive half-metallic systems. Their bulk and surface properties are well understood. However, their implementation in devices based on giant and tunnel magnetoresistance effects means introduction of interfaces with other materials, which usually has a strong impact on their electronic and magnetic properties. The most important problem here is preservation of half-metallicity, which has a direct influence on unique transport properties of such systems, and is typically severely reduced by such structural changes.

Using *ab initio* density functional methods, we calculate the magnetic properties and the dependence of the half-metallicity from the interface structure for a layered system with Heusler contacts. Our main interest is the full Heusler compound Co_2MnGe in combination with MgO. Choosing the (001) orientation for MgO, several configurations with different termination and site disorder have been investigated by using the Vienna Ab-initio Simulation Package (VASP), employing the projector augmented wave method (PAW) and the generalized gradient approximation (GGA) for the exchange correlation potential.

This work is supported by the *Deutsche Forschungsgemeinschaft* through SFB 491.

MA 15.134 Tue 15:00 Poster A

Thermodynamic properties of intermetallic ternary rare-earth compounds — •J. Rohrkamp[1], O. Heyer[1], H. Hartmann[1], T. Lorenz[1], J. Mydosh[1], R. Pöttgen[2], and T. Fickenscher[2] — [1]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany — [2]Institut für Anorganische und Analytische Chemie, Universität Münster, 48149 Münster, Germany

Ternary rare-earth intermetallics of the composition $RETMg$ with RE = La, Eu, Gd, Yb and T = Ag, Au and GdAuIn show a rich variety of magnetic phases. Depending on the composition these compounds are paramagnetic (RE = La, Yb) or they order either ferro- or antiferromagnetically with transition temperatures ranging from about 13 to 81 K. We measured the susceptibility χ, the resistivity ρ, the specific heat C_p and the thermal expansion coefficient α and found well pronounced anomalies in each quantity at T_N or T_C. From the measurements of χ and C_p we calculate the magnetocaloric effect, which is sizeable for both the ferro- and the antiferromagnetic compounds. Furthermore we determine the hydrostatic pressure dependencies of the various transition temperatures from the specific heat and thermal expansion data using Ehrenfest's relation. We find rather large pres-

sure dependencies of the transition temperatures. This indicates that the magnetic ordering is driven by the RKKY interaction between the 4f moments of the rare-earth ions via the conduction electrons.
This work was supported by the DPG through SPP 1166.

MA 15.135 Tue 15:00 Poster A

Crystal structure and physical properties of $Eu_4Pd_{29}B_8$ and $YbNi_7B_3$ borides — Igor Veremchuk, •Roman Gumeniuk, Andreas Leithe-Jasper, Walter Schnelle, Yuri Prots, and Yuri Grin — Max-Planck-Institut für Chemische Physik

Crystal structures of the ternary borides $Eu_4Pd_{29}B_8$ ($I41/amd$ (no. 141), $a = 8.5686(4)$ Å, $c = 16.596(1)$ Å, $Z = 2$,) and $YbNi_7B_3$ (structure type $ErNi_7B_3$ [1], s.g. $I41/amd$ (no. 141), $a = 7.6419(4)$ Å, $c = 15.568(1)$ Å, $Z = 8$) were refined by means of X-ray single-crystal method. A X-ray absorption spectroscopic study at the Yb-L_{III} and Eu-L_{III} edges as well as measurements of magnetic susceptibility show Eu atoms to be in mixed (+2–+3) valence state while a stable +3 valence state is observed for the Yb-containing boride. Magnetic susceptibility data of the $Eu_4Pd_{29}B_8$ compound indicate a thermally induced valence change from nonmagnetic $4f^7$ to magnetic $4f^6$ state.

[1] Kuz'ma Yu. B., Babizhetskyj V., Veremchuk I. and Chaban N. J. Solid State Chemistry, **177** 425-430 (2004).

MA 15.136 Tue 15:00 Poster A

Investigation of the valence states of $Fe_{1-x}Cu_xCr_2S_4$ by X-ray absorption spectroscopy — •C. Taubitz[1], M. Raekers[1], V. Tsurkan[2], and M. Neumann[1] — [1]Universität Osnabrück, Fachbereich Physik, Barbarastraße 7, D-49069 Osnabrück, Germany — [2]Institute of Applied Physics, Academy of Sciences of Moldova, Kishinev MD 2028, Republic of Moldova

Spinel compounds of $Fe_{1-x}Cu_xCr_2S_4$ have attracted much attention since the discovery of a very large negative magnetoresistance (MR) effect. A long-standing issue in the attempt to understand the magnetic and electric properties of these compounds has been the Fe valency. We have investigated the valency of Fe by XAS and XPS. In the region 0<x<0.5 the Lotgering model predicts Fe to be in a mixed valence state between Fe^{2+} and Fe^{3+}. For x=0.5 all Fe-ions are assumed to be trivalent. While Mössbauer measurements confirm this model our investigations with XAS and XPS show Fe in a divalent state. We suppose that this is due to charge transfer effects between Fe and the S ligand, that originate from the excitation of electrons during the measurement. XPS and XAS measurements of the region 0.5<x<1 show a mixed Fe valence state. We discuss the valence states in comparison with the models of Lotgering and Goodenough.

MA 15.137 Tue 15:00 Poster A

Dielectric and thermodynamic properties of — •Norman Leps[1], Janet Leschner[1], Andrei Sotnikov[1], Dmitri Souptel[1], Sang-Wook Cheong[2], Rüdiger Klingeler[1], Christian Hess[1], Natalia Tristan[1], and Bernd Büchner[1] — [1]Leibniz-Institute for Solid State and Materials — [2]Department of Physics & Astronomy Rutgers

In so-called multiferroics the magnetic and the ferroelectric order parameter might be controlled by the application of the respective complementary field provided that significant magneto-electric coupling exists. Recently, the materials RMn_2O_5 and $RMnO_3$ (R: small rare earth) have attached attention in this regard. Here we present experimental results for thermodynamic and dielectric properties of several compounds of this family with Eu, Bi and Y on the R sites. We compare our results with data for other multiferroic systems and discuss possibilities for specificly altering the materials properties by doping.

MA 15.138 Tue 15:00 Poster A

Magnetic properties of the tetragonal $Mn_{3-x}Ga$ ($0 \leq x \leq 1$) system — •Jürgen Winterlik, Benjamin Balke, Gerhard H. Fecher, and Claudia Felser — Johannes Gutenberg-Universität Mainz

Recently the cubic DO_3 phase of the compound Mn_3Ga was predicted to be a half-metallic completely compensated ferrimagnet. A tetragonal distortion of the cubic lattice to the DO_{22} structure leads to a change in magnetic properties of the compound.

A series of samples of tetragonal $Mn_{3-x}Ga$ was prepared in the range of ($0 \leq x \leq 1$) by arcmelting under argon atmosphere and annealing the resulting samples in evacuated quartz tubes at 350°C for one week. XRD measurements prove that the DO_{22} structure could be realised in the whole concentration range.

Magnetic measurements were carried out by SQUID magnetometry. All samples show hardmagnetic behaviour. The Curie temperature of the materials cannot be specified due to a phase transition to the hexagonal DO_{19} phase at about 700-800K. The results are evaluated and discussed regarding the Mn-concentration.

MA 15.139 Tue 15:00 Poster A

Single crystal growth and physical properties of $ErPd_2Si_2$ intermetallic compound — •Chongde Cao[1], Günter Behr[1], Wolfgang Löser[1], Irina Mazilu[1], E.V. Sampathkumaran[2], and Bernd Büchner[1] — [1]Leibniz Institute for Solid State and Materials Research Dresden, 01171 Dresden, Germany — [2]Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai - 400005, India

The various classes of multicomponent intermetallic rare earth-transition metal-compounds offer a great potential of outstanding properties. A bulk single crystal (d=6mm, l=50mm) of $ErPd_2Si_2$ compound has been successfully grown at a velocity of 10 mm/h by using floating zone method with optical heating. X-ray Laue backscattering analysis indicates the crystal growth direction is close to [110] orientation with an inclination angle of 14.9° against the rod axis. Morphological observation and concentration measurement show element segregation occurs along the rod axis and the radius directions. The magnetic susceptibility of $ErPd_2Si_2$ single crystal reveals an antiferromagnetic ordering at about 4 K. The crystal structures, electrical resistivity, magnetic susceptibility, heat-capacity and magnetoresistance of different orientations are investigated in comparison with polycrystals. References:

W. Bazela, J. Leciejewicz, A. Szytula, et al., J. Mag. Mag. Mater., 1991, 96, 114.

K. Tomala, J.P. Sanchez, B. Malaman, et al., J. Mag. Mag. Mater., 1994, 131, 345.

MA 15.140 Tue 15:00 Poster A

Temperature driven spin reorientation transition in thin films — •Fritz Körmann[1], Stefan Schwieger[2], Jochen Kienert[1], and Wolfgang Nolting[1] — [1]Lehrstuhl Festkörpertheorie, Institut für Physik, Humboldt Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany — [2]Technische Universität Ilmenau, Theoretische Physik I, Postfach 10 05 65, 98684 Ilmenau, Germany

The temperature dependent orientation of the magnetization vectors in thin ferromagnetic films is directly connected to the giant magneto resistance. Starting from an extended Heisenberg model we calculate the equilibrium angles of the magnetization and the magnetization norm of thin magnetic films quantenmechanically and self consistently. The model includes interlayer exchange (IEC) coupling, single ion anisotropies and dipolar coupling. We present a new type of temperature driven spin reorientation transition (SRT) in thin films. It can occur when the lattice and the shape anisotropy favor different easy directions of the magnetization. Due to different temperature dependencies of the two contributions the effective anisotropy may change its sign and thus the direction of the magnetization as a function of temperature may change. Contrary to the well-known reorientation transition caused by competing surface and bulk anisotropy contributions the presented SRT is also found in film systems with a uniform lattice anisotropy. We show the temperature and external field dependent reorientation of the magnetization vectors of IEC coupled films. The theory is also able to describe experimental ferromagnetic resonance results as accurately as the (classical) Landau Lifshitz equation.

MA 15.141 Tue 15:00 Poster A

Magnetic anisotropy of $Fe_{1-x}Co_x(110)$ on GaAs(110) — •Björn Muermann, Matthias Sperl, Alexander Spitzer, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, Germany

In this contribution we investigate the magnetic anisotropy of epitaxial $Fe_{1-x}Co_x(110)$ films (x = 0...0,64) grown by molecular beam epitaxy (MBE) on GaAs(110). The samples were grown on clean wafer as well as on surfaces prepared by cleaving in ultra high vacuum and studied by means of alternating gradient magnetometry (AGM) and ferromagnetic resonance (FMR) spectroscopy. The angular dependent energy density observed can be explained by two main contributions to the magnetic anisotropy: an effective magnetocrystalline anisotropy $K^{eff}_{cryst}(t)$ caused by the symmetry of the $Fe_{1-x}Co_x(110)$ lattice, and an effective uniaxial anisotropy, $K^{eff}_U(t)$. The strength of these anisotropies is thickness dependent due to a volume and a surface contribution, $K^{eff}_i(t) = K^{Vol}_i + K^{Surf}_i/t$. Néel's pair energy model is used to derive the relation between the surface and volume term

of the crystalline anisotropy. The strain induced uniaxial anisotropy is altered by different compositions of iron and cobalt. The effects of interface roughness and structural defects to the anisotropy are discussed.

MA 15.142 Tue 15:00 Poster A

Magnetfeldsteuerbarer magnetischer Widerstand — •Robert Jäger und Marc Jäger — Resogap, 75053 Gondelsheim

Der Ferromagnetismus und damit der magnetische Widerstand eines Ferromagneten hängen von der Temperatur aber auch von einem steuernden externen Magnetfeld ab. Neben der materialspezifischen kritischen Temperatur T_C (Curie Temperatur) existiert auch eine materialspezifische kritische äußere Feldstärke B_k, ab welcher der Ferromagnetismus vollständig zerstört wird. Mit steigendem äußerem Magnetfeld B_a erfolgt kontinuierlich eine Reduzierung der stoffabhängigen Permeabilität. Dieses Magnetfeld muss groß genug sein, um eine sichtbare Wirkung zu erzielen. Das Magnetfeld der Erregung reicht hierfür normalerweise nicht aus. Wegen der Robustheit eines Magnetfeldes, dem preiswerten Material, dem kleinen Raumbedarf, dem geringen Gewicht und der masselosen Steuerung eines magnetischen Widerstandes werden durch den Effekt viele technische Anforderungen erfüllt. Technische Anwendungen sind immer dann möglich, wenn ein ausreichend starkes Magnetfeld eingesetzt werden kann. Alle Größen, die ein Magnetfeld ändern können, wie z.B. Umdrehungen, Drehmoment, Winkel, Neigungen, Beschleunigungen, Abstände, Dehnungen sowie Materialeigenschaften (über Dämpfungen der Magnetfelder) lassen sich mit diesem Effekt robust in Größen wie Spannungen, Zeiten oder Frequenzen umsetzen. Der Aufbau des Experimentes zur Messung der Magnetisierung in Abhängigkeit von einem äußeren Magnetfeld und das Ergebnis werden beschrieben.

MA 15.143 Tue 15:00 Poster A

Using a highly sensitive TMR sensor array for the detection of moving biomolecules — •Camelia Albon, Sascha Walkenhorst, Simone Herth, Michael Schilling, and Günter Reiss — Thin Films and Nanostructures, Department of Physics, Bielefeld University, Bielefeld, Germany

The use of magnetoresistive biosensors for the detection of biomolecules attached to magnetic nanoparticles is already a well-known technique. For the detection of magnetic nanoparticles attached only by one biomolecule the improvement of the magnetoresistive sensors sensitivity is mandatory. In this way the application of new detection schemes in order to measure the biochemical processes that take place at single biomolecular level can be done more accurately. TMR sensors with MgO as barrier material represent promising candidates to achieve highly improved sensitivity. In order to acquire a spatial resolution for the detection of magnetic nanoparticles a highly integrated sensor array is created. In our approach a sensor array is patterned by e-beam lithography with 20 elliptical sensors having the dimensions of 100×400 nm on an area of $18.2\mu m^2$. This TMR array will be used for detection of single molecule processes with the help of magnetic nanoparticles.

MA 15.144 Tue 15:00 Poster A

Das Swiss-cross-Helmholtz-Design für großvolumige Permanent-Magnet-Anordnungen: vielfältige Zugangsmöglichkeiten und gute Homogenität — •Holger Stork[1], Manuel Ross[1], Achim Gädke[1] und Nikolaus Nestle[1,2] — [1]TU Darmstadt, Institut für Festkörperphysik — [2]BASF AG Ludwigshafen

Hochkoerzitive Permanentmagneten aus FeNdB-Materialien sind heute in einer Reihe von Standardgeometrien zu günstigen Preisen verfügbar. Wegen technischer Probleme bei der Aufmagnetisierung und Sicherheitsauflagen für den Transport ist die Größe dieser Magneten auf ca. 10 x 10 cm begrenzt. Außerdem sind FeNdB-Materialien relativ temperaturempfindlich. Für Messungen bei tiefen oder hohen Temperaturen können aus solchen Magneten aufgebaute Magnetsysteme nur dann eingesetzt werden, wenn die Probenumgebung mit guter Isolierung in den Magneten eingebaut werden kann. Im Beitrag wird ein Konzept für ein großvolumiges Magnetsystem vorgestellt, das für Magnetfelder im Bereich von ca. 0.2 T diesen Anforderungen genügt und außerdem zahlreiche Zugangsmöglichkeiten parallel und senkrecht zur Magnetfeldrichtung ermöglicht. Erfahrungen beim Aufbau eines solchen Magnetsystems werden ebenso präsentiert wie weitere Optimierungen und mögliche Anwendungsgebiete in Halbleiterphysik und TD-NMR.

MA 15.145 Tue 15:00 Poster A

Detection of superparamagnetic nanoparticles with AlOx magnetic tunnel junctions and development of hysteresis free MgO via shape anisotropy — •Sascha Walkenhorst, Michael Schilling, Simone Herth, Andreas Hütten, and Günter Reiss — Bielefeld University, Department of physics, Thin Films & Nanostructures, P.O. Box 100 131, 33501 Bielefeld, Germany

Signal enhancement was so far necessary for detection of single magnetic markers using magnetoresistive sensors. Detection without signal enhancement on basis of a magnetic tunnel junction (MTJ) would be an important feature for miniaturization and for applications as biosensors. Attempts based on conventional MTJs with AlOx and out-of-plane saturation of superparamagnetic beads were done. TMR measurements with and without beads on top of a sensor, alternatively saturated or not were compared. With Helmholtz-coils a shifted and narrow hysteresis is possible, whereas permanent magnets seem to be not applicable due to a very inhomogeneous field in this setup.

Elements are expected to have a hysteresis-free switching due to a perpendicular pinning. For MgO based sensors perpendicular pinning has been established via shape anisotropy. Arrays containing thousands of (sub-)micron elements were structured by electron beam lithography and ion beam etching. Measurements using the magneto optical Kerr-effect show a hysteresis free signal for low magnetic fields.

MA 15.146 Tue 15:00 Poster A

Spin-wave theory for magnetic molecules — •Roman Schnalle[1] and Jürgen Schnack[2] — [1]Universität Osnabrück, Fachbereich Physik, D-49069 Osnabrück — [2]Universität Bielefeld, Fakultät für Physik, PF 100131, D-33501 Bielefeld

Unfortunately exact diagonalization of the Heisenberg Hamiltonian of some molecular systems like the famous $\{Mo_{72}Fe_{30}\}$ is limited by the huge size of the related Hilbert space that quickly grows with system size. Following Takahashi [1] finite-size spin-wave theory seems to be appropriate to access low-temperature properties of huge magnetic molecules. By comparing results calculated by spin-wave theory with results obtained from exact diagonalization it is investigated whether spin-wave theory is able to give reliable information about magnetic and thermodynamic properties of molecular systems. Within this theory rotational invariance of the participating spins is restored by the introduction of a set of Lagrange-multipliers. Then the modified Hamiltonian is diagonalized numerically. The energy spectra and the low-temperature thermodynamics are calculated and compared with results from exact diagonalization for quasi-onedimensional Neél-like systems, namely spin rings, and a frustrated system, where twelve spins occupy the vertices of a cuboctahedron.

[1] M. Takahashi, Phys. Rev. B 40, 2494 (1989)

MA 15.147 Tue 15:00 Poster A

Magnetic properties of homo- $[Ni(II)_4]$ and heterotetranuclear $[Fe(III)_2Cu(II)_2]$ high-spin molecular complexes — •Christian Golze[1], Rüdiger Klingeler[1,2], Bernd Büchner[1], Vladislav Kataev[1], Michel Goiran[2], Jean M. Broto[2], Harison Rakoto[2], Berthold Kersting[3], and Phalguni Chaudhuri[4] — [1]IFW Dresden, Germany — [2]LNCMP Toulouse, France — [3]Institute for Anorganic Chemistry, University of Leipzig, Germany — [4]MPI for Bioinorganic Chemistry Mülheim, Germany

HF ESR and magnetization data of new multicenter complexes are presented. In compound **(1)** two Ni ions are coupled to a dimer via a diaminthio-bridge, and a pair of dimers is coupled in a single molecule via a $\mu_{1,3}$ azide bridge. Thus a single molecule spin cluster of a quadrangular shape comprising four Ni(II) (each $S = 1$) is formed. The magnetically active fragments Fe_2Cu_2 of **(2)** form the so-called *butterfly*-motive. The intramolecular exchange paths between Fe(III) and Cu(II) are provided by OH-, ON-, and O-bridges and yield competing FM and AFM exchange interactions. Both complexes exhibit magnetic ground states which have been characterized by magnetization measurements in fields $< 52\,\mathrm{T}$. ESR has been measured on the polycrystalline samples of **(1)** and **(2)** to determine the zero field splittings of the spin-levels and the g-factors. While the crystallites of **(1)** could be oriented in high fields yielding the possibility to compare experimental quasi single-crystal and powder-averaged ESR data with the theoretical model, the appearence of the low temperature spectra of **(2)** is of unexpected symmetric step-like shape.

MA 15.148 Tue 15:00 Poster A

Inelastic neutron scattering studies of two Mn(III)-

based Single Molecule Magnets — •Oliver Pieper[1,2], Joris van Slageren[3], Tatiana Guidi[1], Bella Lake[1,2], Hannu Mutka[4], Margarita Russina[1], Alexander Schnegg[1], Alexandra Buchsteiner[1], Constantinos J. Milios[5], Euan K. Brechin[5], and Anna Julia[6] — [1]Hahn-Meitner Institut, Glienicker Straße 100, 14109 Berlin — [2]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstraße 36, 10623 Berlin — [3]Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — [4]Institut Laue-Langevin, 6, rue Jules Horowitz, BP 156 - 38042 Grenoble Cedex 9 - France — [5]School of Chemistry, The University of Edinburgh, West Mains Road, UK — [6]UBX Laboratory, Universitat de Barcelona, Spain

Recently, two new SMMs has been synthesised, with similar magnetic structures consisting of six Mn(III)-ions. While one of them contains two antiferromagnetically coupled triangles leading to a S=4 ground state and giving rise to frustration effects, the other consists of six ferromagnetically coupled ions leading to a S=12 ground state and a high anisotropy barrier.

Here we present recently performed inelastic neutron scattering measurements that allowed us to observe magnetic excitations within the anisotropy split ground state multiplet. In addition a number of excitations to lower lying multiplets with different total S have been found. We will discuss the energy level diagram and its relevance to quantum tunnelling in these molecules.

MA 15.149 Tue 15:00 Poster A

Magnetism of the single molecule magnet system $[(Mn^{II}L_2)_3Mn^{II}](BF_4)_2$ — •Manuel Prinz[1], Sebastian Voget[1], Niklas Damnik[1], Michael Raekers[1], Karsten Kuepper[2], Phalguni Chaudhuri[3], Simon George[4], Marin Coldea[5], and Manfred Neumann[1] — [1]Universität Osnabrück, Fachbereich Physik, Barbarastr. 7, D-49069 Osnabrück — [2]Forschungszentrum Rossendorf, Nanofunktionsschichten, Postfach 510119, D-01314 Dresden — [3]MPI für Bioanorganische Chemie, PO Box 101365, D-45413 Mülheim an der Ruhr — [4]Lawrence Berkeley National Laboratory, Advanced Biological and Environmental X-ray Facility, Berkeley, CA 94720, USA — [5]Faculty of Physics, Babeş-Bolyai University, RO-400084, Cluj-Napoca

The single molecule magnet system $[(Mn^{II}L_2)_3Mn^{II}](BF_4)_2$ containing four Mn^{2+} ions has been studied using X-ray photoelectron spectroscopy (XPS), X-ray absorption spectroscopy, and X-ray magnetic circular dichroism (XMCD). The XPS Mn 2p and Mn 3s spectra confirm the manganese 2+ valency. From XMCD measurements at a temperature of $T = 2$ K and a magnetic field of $B = 5$ T we obtained a high magnetic moment of 12 μ_B/f.u. This spin moment agrees in an excellent way with magnetic measurements which show a magnetization saturation of 10 μ_B/f.u. at 7 T and 2 K. From XMCD a quenching of the Mn orbital moments was observed ($m_{\mathrm{orb}} = 0.4$ μ_B/f.u.).

MA 15.150 Tue 15:00 Poster A

Molecular magnetism of metallo-supramolecular hierarchically ordered materials consisting of mixtures from different transition metal ions — •M. Lommel[1], U. Pietsch[1], G. Schwarz[2], D. G. Kurth[2], Y. Bodenthin[3], W. Haase[4], and Z. Tomkowicz[5] — [1]Institute of Physics, University of Siegen, Walter-Flex-Str 3, 57078 Siegen, Germany — [2]Max Planck Institute of Colloids and Interfaces, 14424 Potsdam, Germany — [3]Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland — [4]Institute of Physical Chemistry, Petersenstrasse 20, 64287 Darmstadt — [5]Institute of Physics, Jagellonian University, Reymonta 4, 30-059 Kraków, Poland

We use metallo-supramolecular mesophases consisting of periodic arrangements of transition metal ions tightly coupled through ditopic bis-terpyridine-ligands and embedded in an amphiphilic mesophase called polyelectrolyt-amphiphile-complex. The materials made by self-assembly of transition metal ions, ligands and amphiphilic molecules. We used temperature induced structural changes of an amphiphilic phase to deliberately manipulate the magnetic properties of tightly coupled metal ion coordination centers. Consequently, the energetic separation of the metal centered orbitals (crystal field) can change giving rise to a spin crossover. In our systems the spin-crossover is driven by the induced structural change of surrounding nitrogen-atoms around the ions. We have investigated different types of metallo-supramolecular complexes with mixtures of transition metal ions. We found that several parameters being characteristic for the spincrossover are changing non-linear as a function of the concentration of metal ions.

MA 15.151 Tue 15:00 Poster A

Magnetic and electronic properties of the transition metal containing polyoxotungstate — •Niklas Damnik[1], Manuel Prinz[1], Albert Takács[4], Jürgen Schnack[1], Ulrich Kortz[2], Istvan Balasz[3], Emil Burzo[3], and Manfred Neumann[1] — [1]Department of Physics, University of Osnabrück, Barbarastraße 7, D-49069 Osnabrück — [2]International University Bremen, P.O. Box 750561, D-28725 Bremen — [3]Faculty of Physics, Babes-Bolyai University, RO-400084, Cluj-Napoca — [4]Physikalisches Institut, Universität Karlsruhe, Wolfgang-Gaede-Straße 1, D-76131 Karlsruhe

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. Together with X-ray photoelectron spectroscopic (XPS) studies on dimeric Ni-substituted β-Keggin polyoxotungstates $K_{12}[\{\beta\text{-}GeNi_2W_{10}O_{36}(OH)_2(H_2O)\}_2]\cdot 20\ H_2O$ and $K_{12}[\{\beta\text{-}SiNi_2W_{10}O_{36}(OH)_2(H_2O)\}_2]\cdot 20\ H_2O$ magnetic and XPS measurements on the transition metal substituted, dimeric polyoxotungstate $[Fe_4(H_2O)_{10}(\beta\text{-}SbW_9O_{33})_2]^{6-}$ are reported. Magnetic measurements of the salt $Cs_6[Fe_4(H_2O)_{10}(\beta\text{-}SbW_9O_{33})_2]$, containing Fe^{3+} ions, show a magnetization of approximately 10 μ_B/f.u. at T = 4.2 K and B = 9 T without saturation and were analysed by using an isotropic Heisenberg Hamiltonian. The ground state of the frustrated molecule has a total spin of S = 2. The XPS Fe 2p spectra suggest a 2+ formal valence state indicating that charge-transfer effects are involved.

MA 15.152 Tue 15:00 Poster A

EPR and magnetic susceptibility investigations on Cu(II)-bis(oxamato) complexes — •Björn Bräuer[1], Tobias Rüffer[1], Dietrich Zahn[1], Georgeta Salvan[1], Dante Gatteschi[2], Andrea Caneschi[2], Maria Fittipaldi[2], and Federico Totti[2] — [1]Chemnitz University of Technology, Faculty of Natural Sciences, Reichenhainer Straße 70, 09126 Chemnitz, Germany — [2]University of Florence, Department of Chemistry, Via della Lastruccia 3, 50019 Florence, Italy

Cu(II)-bis(oxamato) complexes are prominent representatives for basic research studies of magnetic exchange phenomena with square planar coordination geometry [1]. In order to study the influence of the deviations from square planar coordination geometry on the spin density determined by electron paramagnetic resonance (EPR), we have synthesized a ligand with a N2O2 donor set providing distortion from a square planar geometry due to steric reasons. The magnetic coupling constant J of tri-nuclear Cu(II)-bis(oxamato) complexes was determined from magnetic susceptibility measurements using superconducting quantum interference device (SQUID) magnetometer. The superexchange interactions between the Cu(II) ions were found to be antiferromagnetic and to vary significantly with the coordination geometry. The trends were reinforced by density functional theory (DFT) studies. [1] O. Kahn, Molecular Magnetism, VCH Weinheim, 1993.

MA 15.153 Tue 15:00 Poster A

Characterization of Magnetic Structure in NiMnGa Alloys by Means of Lorentz Electron Microscopy and Electron Holography — •Karin Vogel[1], Dorin Geiger[1], Hannes Lichte[1], Werner Skrotzki[1], Robert Chulist[1], Uwe Gaitzsch[2], Martin Pötschke[2], Stefan Roth[2], and Andrea Böhm[3] — [1]Institute for Structure Physics, TU Dresden, 01062 Dresden — [2]IFW Dresden, P.O. Box 270116, 01171 Dresden — [3]Fraunhofer IWU, 01187 Dresden

The magnetic field induced strain (MFIS) in NiMnGa alloys is based on easy motion of twin boundaries. Therefore, it is necessary to understand the influence of microstructural parameters on twin boundary motion. We investigate microstructure and magnetic structure of martensitic NiMnGa alloys by conventional transmission electron microscopy (TEM) and Lorentz TEM, as well as electron holography (EH). TEM offers characterization of nano-features like twin boundaries, grain boundaries, precipitates, etc.; Lorentz TEM allows analysing the coarse magnetic structure, e.g. magnetic domain boundaries; EH is used to determine the fine-scale distribution of magnetization, e.g. inside the domains. We use a Philips CM200 TEM equipped with a Lorentz lens and an electron biprism. The conventional in-focus TEM images show the twin-band structure of the martensitic material. From the Lorentz images, the correlation of magnetic domains with the twin band structure both in domain size and orientation follows. In the EH phase images, lines of equal phase display the 3D magnetization distribution projected into the recording plane. Financial support from DFG-SPP 1239 is gratefully acknowledged.

MA 15.154 Tue 15:00 Poster A

Phenomenological models for magnetic shape memory materials — •Ulrich K. Rössler[1], Nicloai S. Kiselev[2], Igor E.

Dragunov[1,2], and Alexei N. Bogdanov[1,2] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology

A phenomenological theory for magnetic shape-memory effects [1] for twinned ferromagnetic martensites with tetragonal lattice structure is described and extended. The theory couples micromagnetic continuum theory for magnetization distribution and linear elasticity in the twin variants. Magnetization processes under external stress and magnetic fields can be analysed based on phase diagrams from the phase-theory approximation that is applicable for volume systems. Generalizations allow (i) to introduce 180-degree magnetic domain structures within the twin variants and (ii) rotation of magnetic moments within magnetic domains in case of relatively weak magnetic anisotropies. Hysteretic processes can be described by an effective relaxation equation, which accounts for a thermally activated twin boundary motion. Geometrical domain models with 90-degree magnetization stripe structure allow to derive characteristic lengths of thermodynamically stable coupled multidomain structures applicable to twinned platelets or thin films with two homogeneously magnetized variants. The application of the theory for (textured) polycrystalline materials through an effective (mean-field) coupling in an assembly of variously oriented single-crystals is demonstrated.

[1] U. K. Rößler, A. N. Bogdanov, A. DeSimone, S. Müller, U. K. Rößler, J. Magn. Magn. Mater. (2002).

MA 15.155 Tue 15:00 Poster A

MBE-thin film growth of NiMn-based magnetic shape memory alloys — •Ralf Hassdorf[1,3], Jürgen Feydt[2], and Michael Moske[1] — [1]Thin adaptive films, Research center caesar, 53175 Bonn — [2]Electron microscopy, Research center caesar — [3]Institute of Condensed Matter Physics, TU Braunschweig, 38106 Braunschweig

In a previous study, we reported on (111) highly oriented Ni-Mn-Al grown films, deposited on amorphous thermal SiO_2. TEM images revealed the occurrence of modulated martensitic structures, more precisely a striped morphology of 2M and 14M within the single grains [1]. By varying the film composition the austenite/martensite transition boundary was experimentally obtained, in accordance with e/a-dependency predictions. In a theoretical approach, using *ab initio* calculations, we confirmed that in the system Ni-Mn-Al the cubic $L2_1$ Heusler structure is unstable against shear displacement along the [110] direction which promotes lattice modulation [2].

Here, we report on single-crystal films grown on several different single crystalline substrates with different orientations, *i.e.*, on MgO (001), α-Al_2O_3 (0001) and (11-20) as well as on GaAs (001). For the latter, specifically, Ga is incorporated into the film structure almost homogeneously arising from a solid state reaction at the film-substrate interface. This opens up the possibility for exploring compositions with an isoelectronic substitution, here, Al *vs* Ga. The compositional and microstructural aspects will be discussed.

[1] R. Hassdorf *et al.*, Mater. Res. Soc. Symp. Proc. 785, 57 (2004).

[2] T. Büsgen *et al.*, Phys. Rev. B 70, 014111 (2004).

MA 15.156 Tue 15:00 Poster A

Towards phase-field modelling of magnetically induced microstructure evolution Towards phase-field modelling of *magnetically induced microstructure evolution — •Britta Nestler — Institute for Computational Engineering, Karlsruhe University of Applied Sciences, Karlsruhe, Germany

The magnetomechanical responses of magnetic shape memory (MSM) alloys to external magnetic fields are correlated with the coupled magneto-elastic domain structure evolutions in these materials. Hence, the kinetic pathways of the domain evolutions play a key role in determining the materials properties. Mesoscopic simulations based on phase-field modelling can provide valuable information to understand the dynamic processes and main quantities affecting the MSM effect. A phase-field model for polycrystals is presented and simulation results of three dimensional grain structures are shown. To consider effects of an external magnetic field the model formulation has to be modified by including elastic, magnetic and elastomagnetic free energy contributions and different martensitic crystal structures.

MA 16: Invited Talks Ebels / Manosa

Time: Wednesday 14:00–15:00 Location: H10

Invited Talk MA 16.1 Wed 14:00 H10

Out of plane steady-state precession for the 'perpendicular polarizer-planar free layer' spin torque oscillator — •Ursula Ebels[1], Dimitri Houssameddine[1], Bertrand Delaet[2], Bernard Rodmacq[1], Ioana Firastrau[2,3], Fabienne Ponthenier[2], Magali Brunet[2], Christophe Thirion[1], Jean-Philipe Michel[1], Liliana Prejbeanu-Buda[1], Marie-Claire Cyrille[2], and Bernard Dieny[2] — [1]SPINTEC URA 2512, C.E.A/DRFMC - C.N.R.S, CEA-Grenoble, 17 rue des Martyrs, 38054 Grenoble, France — [2]LIMN/DIHS/LETI CEA-Grenoble, 17 rue des Martyrs, 38054 Grenoble, France — [3]TRANSILVANIA University of Brasov, 29 Bulevardul Eroilor, R-500036 Brasov, Romania

The possibility to excite large angle steady-state precessions of the free layer magnetisation in spin valves or magnetic tunnel junctions, using a spin polarised DC current, has recently attracted much attention. These steady state precessions, in combination with the magnetoresistance of such devices, open new applications of spin electronics materials such as wide band tuneable radio frequency (RF) oscillators. While previous spin transfer oscillators (STO) were based on in-plane magnetized structures, here we present the realization of an STO that contains a perpendicular polarizer combined with an in-plane magnetized free layer. The static and dynamic transport experiments validate the theoretical predictions for this configuration which will be of interest for the design of STOs having improved output signals and being operated in zero fields and at currents close to the threshold current Ic.

Invited Talk MA 16.2 Wed 14:30 H10

Multifunctional Ni-Mn-based shape memory alloys — •Lluis Manosa[1], Xavier Moya[1], Antoni Planes[1], Seda Aksoy[2], Thorsten Krenke[2], Mehmet Acet[2], and Eberhard Wassermann[2] — [1]Departament d'Estructura i Constituents de la Materia, Facultat de Fisica, Universitat de Barcelona — [2]Experimentalphysk, Duisburg-Essen University

A relevant functional property is the capability of changing shape by application of a magnetic field. This is the magnetic shape memory property which has been reported for several magnetic alloys undergoing martenstic transiti-ons. Such a property relies on a high magnetic anisotropy of the martensitic phase along with a high mobility of mar-tensitic interfaces which results in a re-orientation of martensitic domains under the application of a magnetic field. The most promising magnetic shape memory compounds belong to the Ni-Mn-X family whereby the Ni-Mn-Ga is the prototypical magnetic shape memory alloy. In the recent years, studies for X=Sn,In and Sb have revealed the exis-tence of new properties: magnetic superelasticity, giant magnetocaloric effect (conventional and inverse) and giant magnetoresistance, all of them related to the modification in the coupling between structure and magnetism linked to the martensitic phase change. Typically several of these effects are encountered in a single alloy so that these materials can be considered as being multifunctional. In my talk I will review some of the most elevant features of the coupling between magnetism and structure in the Ni-Mn-X alloy family, and the functional properties derived from such a coupling will be discussed.

MA 17: Magnetic Shape Memory Alloys

Time: Wednesday 15:15–19:15 Location: H10

MA 17.1 Wed 15:15 H10

First-principles study of the magnetoelastic behavior of magnetic shape memory alloys — •Peter Entel, Markus Gruner, Alfred Hucht, and Georg Rollmann — Physics Department, University of Duisburg-Essen, 47048 Duisburg

We investigate the magnetoelastic properties of magnetic shape memory alloys (MSMA) by large-scale *ab initio* calculations, which have been performed on massively parallel platforms like the Blue Gene/L at NIC (FZ Jülich). In particular, we focus on the change of elastic properties with composition and, in addition, under the action of uniaxial strain or external magnetic fields close to the magnetic, structural or combined magnetostructural phase transitons in the systems Ni-Mn-Z (Z = Ga, In, Sn). We highlight the atomistic details and origin of the austenitic to martensitic transformation in the MSMA, the latter of which is connected to the anomalous forces acting on the Ni atoms in Ni-Mn-Z. Note that the X atoms in X_2(Y = Mn)Z are usually responsible for the formation of the cubic $L2_1$ Heusler structure and its stability. However, in case of X = Ni, the high-temperature cubic structure is *band-Jahn-Teller instable* with respect to tetragonal distortions leading to a modulation of valence electron charges and a more favorable crystal field environment for the Ni atoms. We show how the interplay of Fermi surface nesting (and its change when the structure undegoes a tetragonal distortion) and the impact of anomalous force constants allows to understand most of the physical properties of the MSMA.

MA 17.2 Wed 15:30 H10

Ab initio determination of symmetry reduced structures by a soft-phonon analysis in Ni_2MnGa — •Tilmann Hickel, Blazej Grabowski, Matthé Uijttewaal, and Jörg Neugebauer — Max-Planck-Institut für Eisenforschung GmbH, Postfach 140444, 40074 Düsseldorf, Germany

The ferromagnetic shape memory compound Ni_2MnGa undergoes a martensitic phase transition from a high to a low symmetry structure at 200 K. In the low symmetry phase several shuffling structures have been observed experimentally, but their appearance and importance for the shape memory effect are not yet completely understood. In order to identify the stable structures and the phase transition paths, we have calculated free energy surfaces as function of key reaction coordinates (lattice constants, c/a-ratio) in DFT. Due to the large phase space of possible atomic positions and their small formation energies of only a few meV per unit cell, the determination of the shuffling structures is a major challenge in these studies. To overcome this issue, we have developed a scheme which is based on the computation of the phonon spectra using the quasiharmonic approximation. Starting with the symmetric structure, the TA_2 phonon dispersion shows a softening along the [110] direction. From the eigenvectors of the unstable phonon modes and by setting up the corresponding modulated harmonics in supercell calculations, we were able to systematically and efficiently identify stable shuffling structures. Using these structures, the effect of symmetry breaking on magnetic properties has been computed and the results have been compared with recent experiments.

MA 17.3 Wed 15:45 H10

Lattice dynamics in austenitic and martensitic phase of Ni_2MnGa from inelastic neutron scattering — •Tarik Mehaddene[1], Jürgen Neuhaus[2], Winfried Petry[2,1], Klaudia Hradil[3,2], and Peter Link[2] — [1]Physik-Department E13, Technische Universität München, 85748 Garching — [2]Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II), 85748 Garching — [3]Institut für Physikalische Chemie, Universität Göttingen, 37077 Göttingen

We report on the investigation of the normal modes of vibration in the martensitic and austenitic phase of Ni_2MnGa by inelastic neutron scattering. Phonon dispersions of both acoustic and optical phonons in a $Ni_{49}Mn_{31}Ga_{20}$ single crystal have been measured on the three-axis spectrometer PUMA (Forschungsneutronenquelle Heinz Maier-Leibnitz, Garching). The sample undergoes a martensitic transformation at M_s=350 K and orders ferromagnetically below T_c=385 K. We focus on the optical phonons and their temperature dependence, which, to our knowldge, has not been reported yet despite of the intensive previous works on Ni_2MnGa. Acoustic phonons of an orthorhombic 7-layered martensitic variant of the same sample have been measured on both thermal (PUMA) and cold (PANDA) three-axis spectrometers. The measurements revealed low-lying $TA_2[\xi\xi 0]$ phonon frequencies with a Brillouin zone boundary frequency of 2.5 THz.

MA 17.4 Wed 16:00 H10

Investigation of structure and microstructure transformations of Ni-Mn-Ga single crystal exhibiting magnetic shape memory effect by neutron diffraction — •Heczko Oleg[1,3] and Prokes Karel[2] — [1]IFW Dresden,Helmholtzstrasse 20, 01069 Dresden, Germany — [2]Berlin Neutron Scattering Center, Hahn-Meitner-Institut Berlin, Glienicker Straße 100, D-14109 Berlin (Wannsee), Germany — [3]Laboratory of Materials Science, Helsinki University of Technology, Vuorimiehentie 2A, P.O. Box 6200, FI-02015 TKK, Espoo, Finland

Neutron diffraction of single crystal of alloy $Ni_{49.7}Mn_{29.3}Ga_{21}$ exhibiting 6% MSM effect was carried out in HMI, Berlin. The single crystal was mounted into cryostat with one of 100 directions along the magnetic field and perpendicular to diffraction plane. The set of nuclear Bragg reflections was recorded by 2D position sensitive detector after zero-field cooling and cooling in 5T magnetic field at different temperatures above and below martensitic transformation temperatures. The martensitic variants distribution and quality and inhomogeneity of the single crystal were studied using ω scan. Using measurement in reciprocal space we recorded a set of reflections that appear due to structural modulation (5M) of the martensite, however, the set seems to be incomplete with missing or very weak reflections of second order compared with X-ray diffraction. No sharp magnetic reflection of suggested antiferromagnetic ordering of excess Mn was observed.

MA 17.5 Wed 16:15 H10

Characterization of Ni2MnGa Single Crystal for Sensor Applications — •Christoph Bechtold[1], Andreas Gerber[1], and Eckhard Quandt[1,2] — [1]Stiftung caesar, AG Smart Materials, Ludwig-Erhard-Allee 2, 53175 Bonn — [2]CAU Kiel, Technische Fakultät, Inst. f. Materialwissenschaft, Anorg. Funktionsmaterialien, Kaiserstr. 2, 24143 Kiel

In the past 10 years MSM materials received attention as actuator materials on account of their large magnetically induced strains. Sensor applications were almost not pursued. However, those are very attractive and are the focus of this work. The corresponding sensor approaches are the use of MSM/polymer composites as mechanical sensors or as magnetic field sensors by employing piezoelectric polymers.

In this presentation the properties of Ni2MnGa single crystals were characterized with respect to features important for these sensor applications. Especially strain versus pre-stress and change of permeability as a function of strain were measured and will be discussed in view of the envisaged applications.

MA 17.6 Wed 16:30 H10

Structural and mechanical properties of NiMnGa shape memory ferromagnets — •Uwe Gaitzsch[1], Stefan Roth[1], Andrea Böhm[2], Bernd Rellinghaus[1], and Ludwig Schultz[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Fraunhofer IWU, Nöthnitzer Str. 44, D-01187 Dresden, Germany

Magnetic shape memory alloys are of significant research interest owing to their capability to deform quasi-plastically by some percent via twin boundary motion under the influence of a magnetic field. These materials are supposed to react faster than conventional shape memory materials because neither heating nor cooling are involved. We present the structural and mechanical properties of polycrystalline, textured $Ni_{50}Mn_{30}Ga_{20}$ and $Ni_{50}Mn_{29}Ga_{21}$. Upon cooling, these alloys undergo austenite-martensite transitions at 100^{o}C and 55^{o}C, respectively. The evolving martensitic structure is either orthorhombic or tetragonal and depends on the thermomechanical history of the samples and their composition. Since only two of the three possible martensitic structures are capable of providing the mandatory highly moblile twin boundaries, it is essential to understand and control the phase formation process by appropriate thermal and mechanical treatment. Once the sample is given a suitable structure, samples for magnetomechanical testing are hot mold cast for directional solidification and investigated in magnetic fields of up to 0.8 T in compression tests.

MA 17.7 Wed 16:45 H10

Untersuchungen zur Ermüdung von Ni_2MnGa unter zyklischer Belastung — •Katrien Huysmans, Matz Haaks, Torsten Staab und Karl Maier — Helmholtz Institut für Strahlen- und Kernphysik, Universität Bonn, Nußallee 14-16, D-53115 Bonn

Die magnetische Formgedächtnislegierung Ni_2MnGa ist ein neuartiger Werkstoff, dem z.B. in der Automobilindustrie und Medizintechnik hohes Potential zugesprochen wird. Eine bisherige Studie zeigt, dass bei bis zu 10^6 Magnetisierungszyklen ohne Last keine Materialermüdung nachweisbar ist. Im Rahmen einer Diplomarbeit wurde das Verhalten des einkristallinen Materials unter Last untersucht. Dabei zeigte sich lastabhängig bereits nach geringer Zyklenzahl eine signifikante Verschlechterung der Aktuatoreigenschaften. Untersuchungen mit Positronen (PAS) an technischen Legierungen (Fe, Al, Ti,...) zeigten eine deutliche Abhängigkeit der Zerstrahlungsparameter vom Ermüdungszustand. Bei der untersuchten MSMA-Probe wurden während der Ermüdung ortsaufgelöste Untersuchungen mit der Bonner Positronenmikrosonde (BPM) durchgeführt. Zur Aufklärung der bei der Ermüdung enstehenden Fehlstellentypen werden sowohl Untersuchungen mit Positronen (Lebensdauer, Hochimpulsanalyse) als auch Elektronenstrukturrechnungen durchgeführt.

MA 17.8 Wed 17:00 H10

Directional solidification of $Ni_{48}Mn_{30}Ga_{22}$ magnetic shape memory alloys — •Martin Pötschke, Uwe Gaitzsch, Stefan Roth, Bernd Rellinghaus, and Ludwig Schultz — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

NiMnGa ferromagnetic shape memory (FSM) alloys have gained large research interest because of their possible application as actuator materials. The FSM effect is caused by the movement of twin boundaries by virtue of an external magnetic field. So far, this effect has only been observed in single crystals. The preparation of single crystals, however, is a long time and cost intensive process and both compositional changes along the crystal and segregation may occur. This is why for technical applications, there is a great interest in polycrystalline FSM materials. In order to extend the FSM effect to polycrystals, directional solidification was applied to prepare coarse grained, textured samples. Stationary casting in a pre-heated ceramic mold mounted on a copper plate was employed to generate a heat flow from the top of the cylindrical samples to the bottom and thereby a directional solidification in the opposite direction. The martensite start temperatures were checked by DSC, and the preferred growth direction and resulting textures were determined by EBSD. Further annealing, which is necessary for chemical homogeneity, results in grain coarsening and stress relaxation and affects the texture. The results of the investigation of the texture development during annealing will be presented.

MA 17.9 Wed 17:15 H10

Stress-Induced Twin Boundary Motion in NiMnGa-Polymer-Composites — •Nils Scheerbaum[1], Dietrich Hinz[1], Jian Liu[1], Oliver Gutfleisch[1], Werner Skrotzki[2], and Ludwig Schultz[1] — [1]IFW Dresden, Institut für Metallische Werkstoffe, P.O. Box 270116, D-01171 Dresden, Germany — [2]Technische Universität Dresden, Institut für Strukturphysik, D-01062 Dresden, Germany

Composites were prepared by embedding magnetic shape memory (MSM) particles in a polyester matrix. Single-crystalline MSM particles were obtained by mortar grinding of melt-extracted and subsequently annealed Ni50.9Mn27.1Ga22.0 (at.%) fibres. The crystal structure of the martensite is tetragonal (5M) and of uniaxial magnetocrystalline anisotropy with c being the short and easy magnetisation axis. Previous magnetic characterisation of these composites showed indirect evidence for stress-induced twin boundary motion in the MSM particles, as the compressed composite becomes easier to magnetise in the direction of compression [1]. Therefore, the texture of the embedded Ni-Mn-Ga particles is investigated before and after compression by means of synchrotron radiation. In the initial state, the MSM particles have a random texture, i.e. there is no preferred orientation of the c-axis. After a 30% compression of the composite, the MSM particles have a [004]-fibre texture in direction of compression [2]. This confirms stress-induced twin boundary motion.

[1] N. Scheerbaum, D. Hinz, O. Gutfleisch, K.-H. Müller, L. Schultz, Acta Mater., accepted. [2] N. Scheerbaum, D. Hinz, O. Gutfleisch, W. Skrotzki, L. Schultz, J. Appl. Phys., accepted.

MA 17.10 Wed 17:30 H10

EPITAXIAL FILMS OF THE MAGNETIC SHAPE MEMORY MATERIAL Ni_2MnGa — •Tobias Eichhorn, Gerhard Jakob, Michael Kallmayer, and Hans Joachim Elmers — Institute of Physics, Johannes Gutenberg University, 55099 Mainz

By dc-sputtering from a stoichiometric target onto sapphire and MgO substrates we prepared epitaxial films of Ni_2MnGa. Using temperature dependend X-ray diffraction, resistivity and magnetization measurements we find the austenite to martensite transition in these films. The characteristic temperatures are shifted with respect to the bulk values. The presence of two different phases at high and low temperature also shows up in a different behavior of the magnetic hysteresis curves measured in the austenitic state and the martensitic state of the sample, respectively.

The element specific magnetic moments for thin film samples have been determined by magnetic circular x-ray dichroism (XMCD) measurements. From these measurements we determine orbital and spin momentum in austenite and martensite phase.

Changing target and film stoichiometry the martensitic transition temperature can be tuned to be above room temperature.

MA 17.11 Wed 17:45 H10

Epitaxial growth of martensitic Ni-Mn-Ga films prepared by sputter deposition — •Michael Thomas, Jörg Buschbeck, Oleg Heczko, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

Bulk Ni-Mn-Ga material exhibits a large magnetic-field-induced strain up to 6% in the 5M phase and 10% in the 7M phase. While the phenomenology and requirements in bulk single crystals are understood quite well, only little work has been done on thin films until now. Ni-Mn-Ga films were deposited on MgO, Al_2O_3, $SrTiO_3$, $NaCl$ and Si single crystals with different orientations under variation of the deposition temperature by DC sputtering. The estimated film thickness was about 650 nm. The samples were analyzed with XRD using 2θ and pole figure measurements. At certain deposition conditions an epitaxial growth occured. A martensitic phase was observed on MgO, $SrTiO_3$ and $NaCl$ substrates at room temperature. The influence of substrate symmetry and misfit between the substrate and the Ni-Mn-Ga films on the existence of martensitic phase and martensitic variant orientation is discussed. This work is supported by the SPP 1239, project C3 (http://www.magneticshape.de).

MA 17.12 Wed 18:00 H10

In-situ magnetic domain observation during twin boundary movement in bulk Ni-Mn-Ga — •Ryan Yiu Wai Lai, Jeffrey McCord, Nils Scheerbaum, Oliver Gutfleisch, Rudolf Schäfer, and Ludwig Schultz — Leibniz Institute for Solid State and Materials Research IFW Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany

A study of twin boundary movement in a Ni-Mn-Ga single crystal in connection with in-situ magnetic domain observation is presented. Polarization microscopy in connection with a magneto-optical indicator film (MOIF) technique was used to record the magnetic domain pattern's reorganization during the process. A magnetic field up to 330 mT in amplitude was applied to a single variant sample with the structural c-axis being also the magnetically easy axis, aligned perpendicular to the field direction. Structural reorientation by twin boundary movement was induced by the magnetic field. Images at different field strength display no domain wall movement, even during twin boundary movement. This result is different from the previously proposed model, which assumes domain wall movement under an external field [1]. Funding through the DFG priority program SPP1239 is gratefully acknowledged. [1] H.E. Karaca et al. Acta Materialia 54 (2006) 233-245

MA 17.13 Wed 18:15 H10

Controlling the martensitic transformation temperature at constant valence electron concentration in Heusler based Ni-Mn-In alloys — •Seda Aksoy[1], Mehmet Acet[1], Thorsten Krenke[1], Eberhard Wassermann[1], Xavier Moya[2], Lluis Manosa[2], and Antoni Planes[2] — [1]Experimentalphysik (AG-Farle), Universitaet Duisburg-Essen, 47048 Duisburg — [2]Departament d'Estructura i Constituents de la Materia, Facultat de Fisica, Universitat de Barcelona, Diagonal 647, E-08028 Barcelona

Although the martensitic transformation temperature Ms increases linearly with increasing valence electron concentration e/a in Ni-Mn-X Heusler alloys (X: group III or IV element), the slope varies depending on the X-species, i.e., Ms vs. e/a is not universal. This aspect can be favorably exploited to control Ms by holding e/a constant and

replacing X by an isoelectronic X*, where X and X* are elements within the same group. Using this property we have substituted In in Ni50Mn34In16 (Ms˜200 K) with Ga to bring Ms close to room temperature. Here, we show how magnetic field induced phase transition properties and associated magnetocaloric effects in Ni50Mn34In16 are modified in Ni50Mn34(In,Ga)16.

MA 17.14 Wed 18:30 H10

Martensitic transformation and magnetic properties of Ni-Fe-Ga-Co magnetic shape memory alloys — •Jian Liu, Nils Scheerbaum, Dietrich Hinz, and Oliver Gutfleisch — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

To overcome the disadvantage of brittleness in Ni-Mn-Ga alloys, Ni-Fe-Ga-Co alloys with a Ga content of 27 at.% were reported as a new magnetic shape memory (MSM) system due to its good ductility, high mobility of twin boundaries and high martensitic transformation temperature Tm as well as magnetic transition temperature Tc [1]. In this work, the effects of substitution of Co for Ni on the martensitic and magnetic properties in Ni-Ga-Fe alloys with a wider composition range were studied. The influence of composition on the crystal structure of martensite phase was also presented. A series of polycrystalline alloys, Ni54-xFe20Ga26Cox, Ni54-xFe19Ga27Cox and Ni54-xFe18Ga28Cox (x = 0, 2, 4, 6) was produced using arc-melting. As-cast samples were homogenized at 1453 K to obtain a single-phase structure followed by annealing at 673 K to achieve a high degree of atomic order. Tm was measured by differential scanning calorimetry (DSC). Tc and magnetisation were determined by vibrating sample magnetometer (VSM). The structure was investigated by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The results show that Tm and Tc can be tailored by adjusting the composition of the Ni-Fe-Ga-Co alloys.

[1] Morito, K. Oikawa, A. Fujita, K. Fukamichi, R. Kainuma, K. Ishida, T. Takagi, J. Mag. Mag. Mater. 290-291 (2005) 850.

MA 17.15 Wed 18:45 H10

Structural, magnetic and phase transformation properties of Fe-Pd thin film composition spreads — Hayo Brunken[1,2], Sven Hamann[1,2], Sigurd Thienhaus[1,2], Alan Savan[1], Michael Ehmann[1], and •Alfred Ludwig[1,2] — [1]caesar, Ludwig-Erhard-Allee 2, 53175 Bonn — [2]Institut für Werkstoffe, Ruhr-Universität Bochum, 44780 Bochum

Fe-Pd thin film composition spreads have been fabricated by sequential and co-sputtering of elemental targets, both on oxidized Si wafers and on micro-hotplate arrays. The micro-hotplates - microstructured Si3N4 membranes with Pt heaters and measurement electrodes - are used as a materials processing and characterization platform: films can be heated and cooled very quickly with rates of several 1000 K/s which allows for a wide variation of process parameters for the achievement of necessary phases. During the heat treatment, the resistance of the thin film on the micro-hotplate can be monitored, and phase transformations thus can be identified in situ. The films have also been characterized by EDX, XRD, macroscopic resistance versus temperature measurements, and temperature dependent VSM measurements. First results show a phase transformation close to a composition of Fe70Pd30 in an temperature interval from 40°C to 70°C.

MA 17.16 Wed 19:00 H10

Epitaxial Growth, Structure and Magnetic Properties of Fe-Pd films — •Jörg Buschbeck, Inge Lindemann, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, Institute for Metallic Materials, P.O. Box: 270116, 01171 Dresden, Germany

Magnetic shape memory materials like Ni-Mn-Ga and Fe-Pd reach high strains in moderate applied magnetic fields below 1 T due to a selective growth of martensite variants. The maximum strain of Fe70Pd30 is about 3%. Films of this material are interesting candidates for micro-actuators and sensors, because of the materials high ductility and the ability to compensate internal stresses during the straining process. Fe(70+x)Pd(30-x) films are deposited by Pulsed Laser Deposition in UHV of p=10ˆ(-9) mbar at room temperature. It is observed, that the films grow (100) epitaxially on MgO (100) substrates. XRD measurements indicate martensitic phase formation in the films. In the as-depositied state the metastable phases change from fct to bct and bcc when reducing the Pd content. Temperature dependent magnetic measurements indicate a transition occurring in the fct phase. It is suggested that in the films stress induced martensite formation occurs. Furthermore annealing experiments are carried out. After annealing, the films are relaxed and instead of the fct phase the fcc phase is observed in X-ray measurements on Pd-rich films (X<0).

MA 18: Spindependent Transport II

Time: Wednesday 15:15–18:30 Location: H22

MA 18.1 Wed 15:15 H22

Tunneling magnetoresistance effect with amorphous electrodes — •Martin Gradhand, Christian Heiliger, Peter Zahn, and Ingrid Mertig — Martin Luther University, Institut f. Physik, D06099 Halle, Germany

Structural disorder is often used to explain the discrepancies between experimental [1,2] and theoretical [3,4] results for the tunneling magnetoresistance (TMR). To prove the influence of structural disorder on the TMR ratio experimentally well characterized Fe/MgO/Fe tunnel junctions were investigated theoretically. The screened KKR method based on density functional theory was applied to compute the electronic and magnetic structure self-consistently. The Baranger-Stone scheme based on Green functions was used to calculate the conductance of the planar tunnel junction in the coherent limit of transport. First of all it was shown that amorphous Fe electrodes of finite thickness next to MgO barrier cause a break down of the TMR ratio. Recrystallisation of at least, one monolayer of Fe next to the MgO barrier leads to a recovery of the effect and two crystalline Fe layers cause the same TMR ratio as semi-infinite Fe leads. Structural disorder in the electrodes behind the two crystalline layers does not influence the TMR ratio at all. All results are supported by a detailed theoretical analysis of the transport properties of amorphous and crystalline iron.

[1] S. Ikeda et al., Jpn. J. Appl. Phys. **44**, L1442 (2005)
[2] S. Yuasa et al., Appl. Phys. Lett. **89**, 042 505 (2006)
[3] J. Mathon and A. Umerski, Phys. Rev. B **63**, 220 403 (2001)
[4] W. Butler et al, Phys. Rev. B **63**, 054 416 (2001)

MA 18.2 Wed 15:30 H22

Calculations of electronic tunneling through perovskite barriers — •Daniel Wortmann and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, Germany

Two different effects discussed recently draw a lot of attention to spin polarized tunneling: the experimental verification of the theoretically predicted large tunneling magneto-resistance effect in MgO based junctions and the suggestion to use more complex ferroelectric barrier materials in tunneljunctions. Using our all-electron, full-potential transport code based on the embedding Green function method we investigate electronic tunneling in multilayer systems containing transition metal oxides in the perovskite structure. In particular, we focus on the effect of details of the atomic structure, the lattice distortion and the orbital character at the Fermi-level on tunneling in $SrRuO_3/SrTiO_3/SrRuO_3$ tunneljunctions and the resulting spin-polarization of the current. We discuss the transferability of the symmetry selection effects in MgO barriers and the possible extension to ferroelectric junctions.

MA 18.3 Wed 15:45 H22

Interface structure and transport properties of Fe_3Si/GaAs: An *ab initio* study — •Heike C. Herper and Peter Entel — Theoretische Physik, Universität Duisburg-Essen, Campus Duisburg, Lotharstr. 1, 47048 Duisburg

Ferromagnets (FM) on half metals have attracted interest as electronic contacts for spin-injection, because of their high Curie temperature and the possible existence of a Schottky barrier, which acts as natural tunnel barrier in reverse-biasing. However, the quality of the interface is essential for successful spin-injection. Recently successful spin-injection has been reported for Fe_3Si/GaAs(001), while attempts with pure Fe/GaAs failed due to alloy formation at the interface. Here we investigate the influence of Si on the interface structure, in partic-

ular whether alloy formation with GaAs is suppressed. In addition, we study the transport properties of these systems depending on the interface structure.

The electronic and magnetic properties of Fe_3Si/GaAs(001) have been investigated within density functional methods employing the Vienna Ab-initio Simulation Package (VASP) by using the Projector Augmented Wave (PAW) method. The exchange correlation functional is described within the GGA+U method to improve the description of localized d-states and correct the calculated band gap of GaAs. The transport properties of Fe_3Si/GaAs are obtained from the Kubo-Greenwood equation in combination with a Green's function method.

This work is supported by the *Deutsche Forschungsgemeinschaft* (SFB 491).

MA 18.4 Wed 16:00 H22

Ab initio calculations of tunnelling anisotropic magneto-resistance (TAMR) in Fe/GaAs/Au trilayer — Voicu Popescu[1] and •Hubert Ebert[2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Department Chemie/Physikalische Chemie, Universität München, 81377 München

We report results of calculations on the transport properties of Fe/GaAs/Au and magnetic tunnelling junctions (MTJs) that have been obtained using the tight-binding Korringa-Kohn-Rostoker Green function method in a spin-polarised fully relativistic formulation (TB-SPR-KKR).

It has been shown experimentally that the resistance of a MTJ shows a rather strong variation when its magnetisation changes the orientation, either in plane but varying the azimuthal angle, or when it is flipped from in-plane to out-of-plane.

Analogous theoretical investigations on this phenomenon, nowadays commonly termed as Tunnelling Anisotropic Magneto-resistance (TAMR) are presented for MTJs based on metallic (ferromagnetic or non-magnetic) leads. Our results show that a similar dependence is obtained also for such systems and it can be related to the spin-orbit coupling induced magnetic anisotropy at the metal/semiconductor interface. This, in turn, is shown to vary for different terminations (As or Ga) of the semiconductor. A very good qualitative agreement and a reasonable quantitative agreement is found by comparing our results with recent experimental data obtained for a Fe/GaAs/Au junction.

MA 18.5 Wed 16:15 H22

Spin-orbit induced anisotropies in the tunneling magnetoresistance of magnetic tunnel junctions. — •Alex Matos Abiague and Jaroslav Fabian — Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

We investigate the spin-orbit coupling effects on the tunneling magnetoresistance of magnetic tunnel junctions. We propose a theoretical model in which the experimentally observed tunneling anisotropic magnetoresistance (TAMR) effect originates from the interplay between the Dresselhaus and Bychkov-Rashba spin-orbit couplings. Changes in the applied bias produce variations of the Bychkov-Rashba spin-orbit coupling strength that can result in a flipping of the axis of the two-fold symmetry of the TAMR. The theoretical calculations are in good agreement with recent experimental results.

MA 18.6 Wed 16:30 H22

current-induced dynamics in spin-valves due to non-standard angular torque dependence — •Martin Gmitra[1] and Jozef Barnas[2] — [1]University of Regensburg, Regensburg, Germany — [2]Adam Mickiewicz University, Poznan, Poland

The spin transfer phenomena in spin-valves are the subject of extensive experimental and theoretical works due to novel design and promising application of new spintronic devices. A standard spin-valve structure contains fixed and sensing magnetic layer separated by nonmagnetic or insulating layer. The current induced motion of the sensing magnetic layer is related to the angular dependence of the spin torque that gives rise to current driven switching between low and high resistive states of the valve above a certain critical value. Additionally, by application of external magnetic field the microwave steady oscillations of magnetoresistance can be induced.

In the talk, the theoretical study of asymmeric spin valve based on the macroscopic model in diffusive transport regime will be presented. Within the approach, the non-standard angular torque dependence is obtained which leads to destabilization of both the low and high resistive states. Moreover, the steady state oscillations are predicted in zero magnetic field within macrospin model. The results open an interesting way for spin transfer oscillators that do not need an applied field.

MA 18.7 Wed 16:45 H22

Point-contact Andreev spectroscopy on Ni_2MnIn and $Ni_{80}Fe_{20}$ — •Lars Bocklage, Jan M. Scholtyssek, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

We measure the spin polarization of permalloy and the Heusler alloy Ni_2MnIn using point-contact Andreev reflection spectroscopy [1]. Permalloy and Ni_2MnIn are interesting materials for spintronic devices. Permalloy yields a highly spin-polarized current within a few nanometers. For the $L2_1$ structure of Ni_2MnIn full spin polarization is predicted at the interface to InAs [2]. Permalloy films are deposited on Si and on Si covered with a thin highly conductive Au layer. The latter almost eliminates the series resistance of the ferromagnetic film and thus facilitates the interpretation of the differential conductance curves. For permalloy we determine a spin polarization of 35%. Ni_2MnIn is evaporated on Si and on in situ cleaved (110) surfaces of InAs. The spin polarization of Ni_2MnIn crucially depends on its crystal structure. For our present Heusler films we determine a spin polarization of about 30%. The low value is presumably caused by the presence of the undesired B2 structure.

[1] L. Bocklage et al., J. Appl. Phys., accepted (2007);
J. M. Scholtyssek et al., J. Magn. Magn. Mat., accepted (2006).
[2] K. A. Kilian and R. H. Victora, IEEE Trans. Mag. 37, 1976 (2001).

MA 18.8 Wed 17:00 H22

Temperature dependent two-phase behaviour of magnetisation and spin polarisation in NiPt — •Markus Schäfers, Andy Thomas, and Günter Reiss — Bielefeld University, Universitätsstraße 25, D-33615 Bielefeld, Germany

We investigated the temperature dependent behaviour of magnetisation and spin polarisation in NiCu and NiPt alloys. The advantage of these alloys is the reduced Curie temperature compared with pure Nickel. The whole range of magnetisation is accessible in experiment for these alloys.

Magnetic tunnel junctions with these alloys as free electrode were prepared by dc-magnetron sputtering in an UHV system with a base pressure of $1 \cdot 10^{-7}\,mbar$ and argon ion beam etching. TMR ratio was measured temperature dependent with a dc 2-point method. Spin polarisation was calculated by Julliere's formula. Magnetisation was measured with a SQUID for different temperatures.

The NiPt alloy showed a maximum for in-plane magnetisation and spin polarisation at about 190 K. There are indications for a perpendicular magnetic anisotropy at low temperatures in the NiPt alloy.

MA 18.9 Wed 17:15 H22

Transportuntersuchungen an nanoskaligen hybriden Ferromagnet/Nichtmagnet-Metallstrukturen — •Markus Wahle[1], Björn Wilke[1], Saskia Fischer[1], Ulrich Kunze[1], Ellen Schuster[2], Werner Keune[2], Dirk Sprungmann[3] und Kurt Westerholt[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Angewandte Physik, Universität Duisburg-Essen, D-47048 Duisburg — [3]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

In dieser Arbeit sollen ballistische Transportphänomene in Kombination mit spinabhängigem Transport untersucht werden. Hierzu werden dünne Schichten (< 50 nm) von sowohl ferromagnetischen Metallen (FM) als auch nicht-magnetischen Metallen (NM) mittels Elektronenstrahllithographie und anschließendem Trockenätzprozeß nanostrukturiert. Um die für den ballistischen Transport notwendigen mittleren freien Weglängen von der Größe der Strukturabmessungen zu erreichen, werden epitaktisch gewachsene Metallfilme hoher Reinheit verwendet. Die Qualität von Eisen-, Nickel- und Kupferfilmen wird durch das Restwiderstandsverhältnis ($rrr = R_{300K}/R_{4.2K}$) charakterisiert. Die Geometrie der Zuleitungen bei Drähten und Kreuzstrukturen erweist sich als wichtiger Parameter für den resultierenden anisotropen Magnetowiderstand.

MA 18.10 Wed 17:30 H22

Beeinflussung des CMR Effektes von dünnen epitaktisch gewachsenen PCMO Schichten auf vicinalen STO Substraten — •Peter Moschkau, Julia Fladerer, Jörg Hoffmann und Christian Jooss — Materialphysik Universität Göttingen, Göttingen, Germany

Um den Mechanismus des Metal-Isolator-Übergangs im Magnetfeld, die elektrische Phasenseparation und die dabei relewanten Längenskalen in dünnen PCMO Filmen zu untersuchen, wurde mittels vicinaler STO Substrate eine periodische Defektstruktur eingebracht. Die mit gepulster Laserdeposition hergestellten Filme wurden mit Röntgenspektroskopie, AFM, sowie TEM charakterisiert. Bei Erhöhung des Verkippwinkels (3 ... 10Grad) kommt es zu einem Übergang vom Inselzum Stepflow-Wachstum. Es wird eine elektrische und strukturelle Phasenseparation zwischen einer Polaronen-, Orbital- und Ladungsgeordneten Phase und ungeordneten Phase beobachtet. Bei dieser gehen Nukleation und Wachstum der geordneten Phase an Defekten einher. Elektrische Transporteigenschaften in externen magnetischen Feldern zeigen für Filme auf verkippten Substraten eine in-plane Anisotropie im Verlauf und erreichten Endwiderstand. Es soll der Zusammenhang zwischen Struktur und den elektrischen Eigenschaften als Funktion des Verkippwinkels diskutiert werden.

MA 18.11 Wed 17:45 H22

Interplay of multiferroic behaviour, electronic phase separation and colossal resistance effects in $Pr_{1-x}Ca_xMnO_3$ — •C. Jooss[1], S. Schramm[1], P. Moschkau[1], J. Hoffmann[1], L. Wu[2], T. Beetz[2], R. Klie[2], M. Beleggia[2], and Y. Zhu[2] — [1]Institut für Materialphysik, Univ. Göttingen, Friedrich Hund Platz 1, 37077 Göttingen — [2]Brookhaven National Laboratory, Upton NY 11973, USA

$Pr_{1-x}Ca_xMnO_3$ in the doping range between 0.3 ¡ x ¡ 0.5 represent an extremely interesting manganite system for the study of the interplay of different kinds of ordering (charge, orbital, lattice and spin) and the related drastic changes of the transport properties. TEM reveals the presence of electronic and structural phase separation in the chemically homogeneous material between a Zener polaron orbital and charge ordered and disordered phase in a broad temperature and doping regime. The Zener polaron (ZP) type ordering is additionally confirmed by atomic resolution EELS measurements. The ratio of the ZP ordered and disordered phases strongly depend on temperature. The ZP-ordered phase is multiferroic, showing anitferromagnetic order and weak ferroelectric polarisation due to a non-centrosymmetric distortion of the MnO6 octahedra involved in the ZP. In-situ TEM imaging with applied electric currents, we show that local ZP- and charge-ordered domains can be set into motion, be dissolved and reformed by an electric current. This represents a common mechanism for the resistance change at low and room temperatures. In addition, the CMR effect will be analyzed in the background of the determined ordered structure.

MA 18.12 Wed 18:00 H22

Magnetotransport in thin LSMO:CeO_2 nanocomposite films — •Markus Esseling[1], Hamish Gordon[2], Christian Stingl[1], Kai Gehrke[1], Vasily Moshnyaga[1], and Konrad Samwer[1] — [1]I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Cavendish Laboratory, J.J. Thomson Avenue, Cambridge CB3 0HE, UK

Due to the chemical phase separation of the highly spin-polarized manganite LSMO and the insulating CeO_2 it is possible to prepare nanocomposite films. Using the columnar growth mode of the LSMO on Al_2O_3-substrates the microstructure of the films results in LSMO-grains which are separated by the CeO_2-phase. Therefore the system builds a lateral TMR-structure.

$(LSMO)_{1-x}:(CeO2)_x$ nanocomposite films with a thickness ≈70nm were prepared by MAD-technique with $0 \leq x \leq 0{,}5$. The temperature of the metal-insulator transition decreases systematically with increasing CeO_2-content, whereas the influence on the Curie-temperature is not so strong. The system shows a low-field magnetoresistance (LFMR) up to 60% for the x = 0.2 sample, which is near the percolation threshold. To study the effect of the number of involved grains some samples were microstructured into current stripes of well-defined width. A strong influence on the temperature dependence of the resistance is observed, whereas the LFMR is nearly unchanged. The effect of the quality of the interfaces $LSMO/CeO_2$ will be discussed.

Supported by SFB 602, TP A2 and DFG Sa337/9-1

MA 18.13 Wed 18:15 H22

Magnetothermal transport in the spin-1/2 chains of copper pyrazine dinitrate — •Alexandr V. Sologubenko[1], Kai Berggold[1], Thomas Lorenz[1], Achim Rosch[2], Efrat Shimshoni[3], Matt D. Phillips[4], and Mark M. Turnbull[4] — [1]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany — [2]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany — [3]Department of Mathematics–Physics, University of Haifa at Oranim, Tivon 36006, Israel — [4]Carlson School of Chemistry and Department of Physics, Clark University, Worcester, MA 01610

We present experiments on the thermal transport in the spin-1/2 chain compound copper pyrazine dinitrate $Cu(C_4H_4N_2)(NO_3)_2$. The heat conductivity shows a surprisingly strong dependence on the applied magnetic field B, characterized at low temperatures by two main features. The first one appearing at low B is a characteristic dip located at $\mu_B B \sim k_B T$, that may arise from Umklapp scattering. The second one is a plateau in the quantum critical regime, $\mu_B|B - B_c| < k_B T$, where B_c is the saturation field at $T = 0$. The latter feature clearly points towards a momentum and field independent mean free path of the spin excitations, contrary to theoretical expectations.

Supported by the Deutsche Forschungsgemeinschaft through SFB 608.

MA 19: Spin-Dynamics/Switching I

Time: Wednesday 15:15–19:00 Location: H23

MA 19.1 Wed 15:15 H23

Observation of partial decoherence of quantized spin waves in nanoscaled magnetic ring structures — •Helmut Schultheiss[1], Patrizio Candeloro[1], Sebastian Schäfer[1], Hans Nembach[2], Britta Leven[1], Andrei Slavin[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, Germany — [2]NIST, Boulder, Colorado, USA — [3]Oakland University, Rochester, Michigan, USA

Nanoscale magnetic ring structures have recently attracted large attention due to their richness in magnetization structures. Not many investigations have been devoted to the spin waves in such elements and a full picture of the spin dynamics has not been emerged so far. Here we report on micro-focus Brillouin light scattering spectroscopy studies of the quantization mechanisms and in particular of the coherence of spin waves in 15 nm thick NiFe rings with varying diameters (from 1 to 3 μm). The magnetic excitations for both the vortex and the onion state were investigated. For the onion state several interesting effects were identified. First, in the pole regions spin wave wells are created due to the inhomogeneous internal field. Second, in the regions in between, modes with constant frequencies are observed only for the smallest structures, which are quantized in radial and azimuthal directions due to spatial coherence and confinement in the ring structure. For larger rings a continuous frequency variation with position is observed and is well reproduced by spin-wave calculations and micromagnetic simulations. This work is supported by the DPG within the SPP1133 and the Japanese government within the NEDO project 2004IT093.

MA 19.2 Wed 15:30 H23

Spin waves in semi-circular $Ni_{81}Fe_{19}$ ring segments in the presence of domain walls — •Britta Leven, Christian Sandweg, Helmut Schultheiss, Sebastian Hermsdörfer, and Burkard Hillebrands — FB Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

We present a study of spin wave properties in semi-circular $Ni_{81}Fe_{19}$ ring segments in the presence of domain walls. The spin wave spectra are detected with a lateral resolution of 300 nm employing micro-focus Brillouin light scattering spectroscopy. The elements are prepared using a combination of electron beam lithography and molecular beam epitaxy. The ring segments have a radius of 10 μm, a width of 500 nm and a thickness of 10 nm. In order to localize a domain wall a 200 nm wide protrusion has been added at the pole region of the ring structure, which acts as nucleation site if an external magnetic field is applied in radial direction. It is thus possible to study spin wave spectra in the

element either in the presence or in the absence of a domain wall by applying an external magnetic field in radial or tangential direction, respectively. In the absence of a domain wall we observe typical spin wave quantization effects due to the confinement of the ring segment in radial direction. In contrast, in the presence of a domain wall the quantized wave profile is distorted in the vicinity of the domain wall due to the variation of the internal magnetic field. Technical support of P.A. Beck, of the Nano+Bio Center, TU Kaiserslautern and financial support by the DFG within the SPP1133 and the NEDO project No 2004IT093 funded by the Japanese government is acknowledged.

MA 19.3 Wed 15:45 H23

Detecting Vortex Chirality by Ferromagnetic Eigenmodes in Mesoscopic Rings — •Fabian Giesen[1,2,3], Jan Podbielski[1], Bernhard Botters[1,4], and Dirk Grundler[1,4] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg — [2]Department of Physics, University of Alberta, Edmonton, Alberta, T6G 2J7 Canada — [3]Max-Born-Institut für ür Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Straße 2 A , 12489 Berlin — [4]Lehrstuhl für Experimentalphysik E10, TU München, James-Franck-Straße 1, 85747 Garching

Using broadband ferromagnetic resonance and specially engineered asymmetries in permalloy rings we are able to detect the statistics of chirality of the vortex state in an array of rings. We make use of localized modes in the rings which serve as a probe for the local magnetization direction. We find that the asymmetry suppresses the usual domain wall propagation reversal process, which in the case of concentric rings, leads to a distribution of vortex chirality directions. Instead the reversal takes place through a buckling of the magnetization in the wide ring arm. This arm always switches first and leads to a control of the vortex chirality with a fidelity of better than 97%. The chirality $\xi = \pm 1$ can be selected by the inital external field direction.

The research was funded by BMBF Spintronic 12N8283, iCore and CIAR.

MA 19.4 Wed 16:00 H23

Eigenmode-Localization Transition in Mesoscopic Ferromagnetic Rings — •Fabian Giesen[1,2,3], Jan Podbielski[1], and Dirk Grundler[4] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg — [2]Department of Physics, University of Alberta, Edmonton, Alberta, T6G 2J7 Canada — [3]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Straße 2 A , 12489 Berlin — [4]Lehrstuhl für Experimentalphysik E10, TU München, James-Franck-Straße 1, 85747 Garching

We have investigated the dynamic eigenmode spectrum of ferromagnetic micron-sized rings in the quasi-saturated ('onion') state. Inductive broadband detection of spin dynamcis (vector network analyzer ferromagnetic resonance) was used to detect the spin dynamics spectrum. The ring width was varied systematically and the spectra revealed a gradual localization of eigenmodes in the regions where the internal field is at maximum and at minimum. Using micromagnetic simulations and a semi-analytical WKB approach the increasing internal field inhomogeneity can be shown to be the reason for the mode localization process. The research was funded by BMBF Spintronic 12N8283, iCore and CIAR.

MA 19.5 Wed 16:15 H23

Direct observation of the out-of-plane vortex core magnetization — K.W. Chou[1], A. Puzic[1], •H. Stoll[1], D. Dolgos[1], M. Curcic[1], B. Van Waeyenberge[2], A. Vansteenkiste[2], T. Tyliszczak[3], G. Woltersdorf[4], C.H. Back[4], and G. Schütz[1] — [1]MPI für Metallforschung, Stuttgart — [2]Dep. of Subatomic and Radiation Physics, Ghent University — [3]Advanced Light Source, Berkeley, CA — [4]Inst. für Exp. und Angew. Physik, Univ. Regensburg

The vortex core, which plays a key role in magnetic vortex dynamics, was investigated by time-resolved scanning transmission X-ray microscopy. Reversal of the vortex core by excitation with short bursts of an in-plane alternating field was discovered recently [1]. This allows dynamic switching of the vortex core polarization with a one-period magnetic field burst as low as 1.5 mT, in contrast to (static) out-of-plane fields of half a Tesla needed so far. Micromagnetic simulations enabled us to explain this novel switching scheme by creation of a vortex-antivortex pair with opposite polarization in respect to the original vortex and annihilation of the antivortex with the original vortex. At the end a vortex with opposite polarization remains [1]. By improving our experiments we now are able to directly observe the reversal of the out-of-plane magnetization of the vortex core rather than monitoring a change in the sense of gyration. In addition, a strong distortion was observed in the spin distribution of the moving vortex core with an asymmetry in the motion for a core pointing up and down respectively.

[1] B. Van Waeyenberge, A. Puzic, H. Stoll, K. W. Chou et al., Nature 444, 461 (2006)

MA 19.6 Wed 16:30 H23

Picosecond spin dynamics of Gd(0001) studied by linear dichroism of 4f shell. A time-resolved experiment combined laser and synchrotron radiation — •Helena Prima Garcia[1], Alexev Melnikov[2], Martin Lisowski[2], Roland Schmidt[1], Uwe Bovensiepen[2], and Martin Weinelt[1,2] — [1]Max-Born-Institute, Berlin, Germany. — [2]Freie Universität , Berlin, Germany

We have studied ultrafast magnetization dynamics in Gd(0001) films alignment by time-resolved X-ray photoemission spectroscopy. Absorption of a 50 fs laser-pump-pulse at 800 nm leads to optical excitation of the Gd valence electrons. We probe the relaxation dynamics by linear dichroism in photoemission from the Gd 4f electrons using a 60 eV, 50 ps probe-pulse at the synchrotron user facility BESSY, Germany. Linear dichroism in photoemission is proportional to the magnetic moment of the $4f^7$ electrons. The breakdown of the magnetic ordering upon fs laser excitation has been reported based on magneto-optical studies to occur within 100 fs. The recovery of the equilibrium magnetization is driven by cooling of the lattice and spin-lattice interaction. It proceeds on a 100 ps time scale [2]. Here we show the breakdown of the magnetic moment after laser excitation within the probe pulse duration and the subsequent recovery to the equilibrium value. As linear dichroism is a measure of the alignment of the Gd 4f moments, its breakdown is a further proof of laser-induced desmagnetization.

[1] Oleg Krupin, Phd thesis, Fachbereich Physik Freie Universität Berlin, Germany.

[2] A. Vaterlaus, et.al. Phys. Rev. Lett. 67, (1991) 3314.

MA 19.7 Wed 16:45 H23

Current-Induced Excitations in Single Ferromagnetic Layer Nanopillars — •Malte Scherff, Anne Parge, Tore Niermann, Michael Seibt, and Markus Münzenberg — IV. Phys. Inst., Universität Göttingen

So far the focus of angular momentum transfer studies has usually been put on ferromagnet/ normal magnet/ ferromagnet trilayer junctions. Our work also includes transport experiments in junctions with only a single ferromagnetic layer.

All experiments have been performed on nanopillars with a diameter of ˜80 nm,which are fabricated in a simplified one step process: Holes are created into a thin PMMA film by e-beam lithography and filled with different metal layers by evaporation. The remaining PMMA serves as an insulating template between the Au bottom- and the Cu top-contact.

To improve the preparation parameters, structural analysis has been done by simple cross sectional views as well as accurate TEM measurements of lamella-samples prepared by focused ion beam.

The transport properties were obtained in a four point measurement configuration, where the differential resistance dV/dI was measured by a lock-in technique in an external magnetic field. For sufficiently large DC current densities anomaly changes of resistance were observed in trilayers (up to 3%) and single layers (up to 1.5%). They are related to dynamic excitations and static changes in magnetic configuration, respectively.

This work was supported by DFG, SPP 1133.

MA 19.8 Wed 17:00 H23

Spin transfer torque studies using focused-ion-beam assisted nanostencil mask fabrication — •Nicolas Müsgens[1], Mohamed Tarik[1], Coen Smits[1], Georg Richter[1], Bernd Beschoten[1], Gernot Güntherodt[1], Alexander Schwedt[2], and Joachim Mayer[2] — [1]II. Physikalisches Institut, RWTH Aachen, 52056 Aachen, and Virtual Institute of Spinelectronics (VISel), Jülich/Aachen — [2]Gemeinschaftslabor für Elektronenmikroskopie, RWTH Aachen, 52065 Aachen

The transfer of a spin torque of a spin-polarized current onto a macroscopic magnetization has been investigated in confined magnetic nanostructures. Focused-ion-beam (FIB) is used to fabricate nanostencil masks with lateral device dimensions below 100 nm. Afterwards the nanopillar stack (Co/Cu/Co) is deposited in theses templates. The current-induced switching is demonstated with a giant

magneto-resistance effect up to 1.6 % at room temperature.

The systematic current-induced behavior of the junctions has been investigated by studying differential resistance versus bias-current characteristics at various external magnetic fields. In addition to a hysteretic switching behavior and the appearance of resistance peaks at high magnetic fields and current densities of j $\sim 10^8 \frac{A}{cm^2}$, we found pronounced dips, which shift to lower currents with increasing external magnetic fields.

Work supported by DFG through SPP 1133

MA 19.9 Wed 17:15 H23

Magnetic damping in all-optical pump-probe experiments — •J. Walowski[1], G. Müller[1], M. Djordjevic Kaufmann[1], M. Münzenberg[1], and M. Kläui[2] — [1]IV. Phys. Inst., Universität Göttingen, Germany — [2]Fachbereich Physik, Universität Konstanz, Germany

Magnetization dynamics of ferromagnetic films (FM) was studied with the help of an amplified 80 fs Ti:Sapphire laser system. The sample located in an external magnetic field H_{ext} is demagnetized by an intensive pump laser pulse ($> 40 \frac{\mathrm{mJ}}{\mathrm{cm}^2}$). The magnetization relaxation is traced with a probe beam up to 1 ns after excitation.

The magnetic damping constant is investigated in the case of emission of spin currents on FM/NM interfaces (non-local damping) and spin scattering on nonmagnetic (NM) dopants.

For the non-local damping wedge shaped samples with Ni and Py are investigated for various spin sinks (Cu, Pd, Dy). It is found that the damping increases up to three times at thicknesses < 10 nm of the FM layer.

In the case of spin scattering permalloy samples alloyed with low concentration of Dy and Pd were studied. The results show that the damping parameter depends on the alloy material and its percentage.

The nature of the different dissipation processes is further investigated.

Research is supported by DFG SPP 1133.

MA 19.10 Wed 17:30 H23

Slow recovery of magnetic anisotropy following ultrafast optical excitation of a spin-reorientation transition — •Thomas Eimüller[1], Andreas Scholl[2], Edward Amaladass[3], Bernd Ludescher[3], Gisela Schütz[3], Michael Binder[4], and Christian Back[4] — [1]Ruhr-University of Bochum, Junior Research Group Magnetic Microscopy — [2]Advanced Light Source, LBNL, Berkeley, CA, USA — [3]Max-Planck-Institute for Metals Research, Stuttgart — [4]University of Regensburg, Experimental and Applied Physics

Multilayered Fe/Gd systems, showing a spin reorientation transition (SRT) from in-plane to out-of-plane magnetization with rising temperature, have been studied by x-ray photoemission electron microscopy (X-PEEM). We found a continuous, i.e., second order transition between in-plane and out-of-plane domains, with a coexistence of both types in a temperature interval of about 25 K. The dynamics of this SRT has been investigated in an optical pump - x-ray-probe experiment. A short laser pulse raises the temperature of the sample by about 25 K. By scanning the delay time between 0 and 8 ns the dynamic response of the Fe and Gd magnetic moments has been recorded with X-PEEM, resulting in a temporal resolution below 100 ps and a spatial resolution below 100 nm. We found large time dependent XMCD effects generated by a damped spin precession, superposed to a slow relaxation (> 8 ns) of the easy axis back into the sample plane. This relaxation is way longer than the measured and simulated heat diffusion time and may shade new light into the transport of torque form the spin into the lattice system.

MA 19.11 Wed 17:45 H23

Brillouin light scattering observations of a magnetodielectric wave in thin ferrite films — •Timo Neumann[1], Natalia Sergeeva[1,2], Thomas Schneider[1], Alexander Serga[1], and Burkard Hillebrands[1] — [1]TU Kaiserslautern, Kaiserslautern, Germany — [2]Elektrotechnical University, St. Petersburg, Russia

We report on optical observations of a thermally excited mode detected above the region of existence of dipolar dominated spin waves in thin, in-plane magnetized YIG-films. The possibility to amplify this mode by means of longitudinal parametrical pumping is demonstrated.

In experiments with 7 μm thick YIG-films in a tangentially applied, static magnetic bias field, a thermally excited mode was observed for field strength H_0 varying from below 100 Oe to 4300 Oe using the Brillouin light scattering spectroscopy technique. A linear dependence of the mode frequency ω, which lies above the frequency of Damon-Eshbach modes, on the external magnetic field was found.

Effective parametric amplification was realized in the case when the pumping frequency ω_P equalled approximately twice the frequency ω of the mode. In contrast, no significant amplification of the signal was noted for other ratios $2 > \omega_P/\omega > 0,7$ considered. In particular, direct perpendicular force excitation with $\omega_P = \omega$, as can be easily achieved for magnetic modes, did not take place.

We associate the observed thermal mode to a magnetodielectric wave localized in the sample.

Financial support by the MATCOR "Graduate Class of Excellence", GRK 792, and DAAD Grant 6205-A0556601 is recognized gratefully.

MA 19.12 Wed 18:00 H23

X-ray imaging of current driven stochastic domain-wall motion — •Guido Meier[1], Markus Bolte[1], René Eiselt[1], Ulrich Merkt[1], Benjamin Krüger[2], Daniela Pfannkuche[2], Dong-Hyun Kim[3], and Peter Fischer[4] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstr. 11, 20355 Hamburg — [2]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstrasse 9, 20355 Hamburg — [3]Department of Physics and Institute for Basic Science Research, Chungbuk National University, Cheongju 361-763, South Korea — [4]Center for X-Ray Optics, LBNL, Berkeley, CA 94720, USA

Magnetic transmission x-ray microscopy is used to directly visualize the influence of a spin-polarized current on domain walls in curved permalloy wires. Pulses of nanosecond duration and high current density up to $1.0 \times 10^{12} A/m^2$ are used to move and to deform the domain wall. The current pulse drives the wall either undisturbed, i.e., as a composite particle through the wire or causes structural changes of the magnetization. Repetitive pulse measurements reveal the stochastic nature of current induced domain-wall motion. From the experiments we estimate the ratio $\xi/\alpha = 0.96 \pm 0.02$ between the degree of nonadiabaticity ξ and the Gilbert damping parameter α. This indicates the importance of the nonadiabatic contribution to current driven domain-wall motion. Supported by the DFG via SFB 668 and GK 1286 as well as by the U.S. DOE Contract No. DE-AC02-05-CH11231.

MA 19.13 Wed 18:15 H23

Magnetization dynamics of a single cross-tie wall — •Karsten Kuepper[1], Daniel Markó[1], Matthias Buess[2], Jörg Raabe[2], Christoph Quitmann[2], and Jürgen Fassbender[1] — [1]Forschungszentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, Bautzner Landstr. 128, D-01328 Dresden — [2]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, - PSI, Switzerland

We report the imaging of the magnetic excitation spectrum of a single cross-tie wall by means of x-ray magnetic circular dichroism - photoemission electron microscopy (XMCD-PEEM). The permalloy rectangle was excited by a short magnetic in plane pulse with a maximum field value of about 20 Oe. The high temporal and lateral resolution allows a detailed quantitative analysis of the magnetodynamic excitations. We find new eigenmodes in the frequency domain which are characteristic for the vortex-antivortex interaction in a single cross-tie wall. We discuss our experiment along micromagnetic simulations.

MA 19.14 Wed 18:30 H23

Effect of parametric pumping on phase profiles of dipolar spin waves in YIG film — •Natalia Sergeeva[1,2], Timo Neumann[1], Thomas Schneider[1], Alexander Serga[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik, TU Kaiserslautern, Kaiserslautern, Germany — [2]St. Petersburg Electrotechnical University, St. Petersburg, Russia

The phase profile of a spin wave (SW) packet propagating through the area of parametric pumping in a longitudinally magnetized yttrium-iron-garnet (YIG) film waveguide was studied. The magnetic media was influenced by spatially localized microwave parallel pumping of double frequency. The phase profile of the SW packet was measured by means of phase-sensitive time- and space-resolved Brillouin light scattering spectroscopy as well as by conventional microwave technique. The influence of pumping power, pumping duration and moment of application of pumping on the phase profiles was investigated. It was observed that a nonlinear phase accumulation process significantly distorts the initially flat phase profile of the SW packet. The mentioned effect is caused by the magnetic barrier formed by exchange dominated magnons, which were parametrically excited from the thermal level in the pumping area.

Financial support by the DFG (Graduiertenkolleg 792 and Grant

No. Hi 380/13) and DAAD (Grant 6205-A0556601) is gratefully acknowledged.

MA 19.15 Wed 18:45 H23

Time-, Spin- and Energyresolved photoemission microscopy of 3d transition metals — •Bernd Heitkamp, H. A. Dürr, and W. Eberhardt — Albert-Einstein-Strasse 15, 12489 Berlin

Understanding ultrafast de- and remagnetization processes are of considerable interest, since it allows to shorten the read/write-cycles in magnetism based memories.

Our approach is to combine the nm-spatial resolution of a photoelectron emission microscopy (PEEM) with a fs time-resolution using the pump-probe technique. Magnetic sensitivity is obtained by detecting the spin of the emitted photoelectrons.

Experiments on Nickel and Cobalt show a demagnetization below one picosecond. Electron- and Spindynamics strongly depend on the dielectric response of the nanostructures.

MA 20: Magnetic Thin Films II

Time: Wednesday 15:15–18:45 Location: H5

MA 20.1 Wed 15:15 H5

Electronic transport in Co_2FeSi thin films — •Horst Schneider and Gerhard Jakob — Johannes Gutenberg-Universität, Institut für Physik, Mainz, Germany

Recently it has been discussed whether the Heusler compound Co_2FeSi is a half-metallic system. The comparison of band structure calculations with experimental results indicate that electron correlations play an inportant role in this question. In order to gain further insight into the electronic structure of this material, we have prepared thin epitaxial as well as disordered films of Co_2FeSi. Subsequent patterning of these samples allowed the precise investigation of their anisotropic transport properties. Measurements of magnetoresistance and Hall effect will be presented and compared to the structural and magnetic properties of the films. Possible explanations for the observed behaviour will be given.

MA 20.2 Wed 15:30 H5

Epitaxial Heusler alloy cobalt iron silicide films on GaAs — •Jens Herfort, Masahiko Hashimoto, Hans-Peter Schönherr, Achim Trampert, and Klaus Ploog — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

Heusler alloys are promising candidates for spintronic and magnetotunneling applications due to their high Curie temperatures, compatibility with compound and elemental semiconductors and their possibly half-metallic behavior. However, atomic ordering and interface quality have a significant influence on their structural, electrical and magnetic properties. Here, we present our results on the fabrication as well as the structural, electrical and magnetic properties of single-crystal Co_2FeSi/GaAs(001) heterostructures grown by molecular-beam epitaxy at various growth temperature T_G. As evidenced by double crystal X-ray diffraction (DCXRD) and transmission electron microscopy (TEM) measurements, ferromagnetic layers with high crystal and interface perfection can be obtained. The exact stoichiometry of the Heusler alloy films can be achieved for almost lattice matched films. From DCXRD, TEM and resistivity measurements we find an optimum T_G, near 200°C, to obtain layers with high crystal and interface perfection as well as high a degree of atomic ordering. It is important to note that this optimum T_G is considerably higher than that for Fe and Co on GaAs(001). The layers are ferromagnetic at room temperature with the easy axis of magnetization within the film plane. The dependence of the magnetic in-plane anisotropy on the stoichiometry as well as on the atomic ordering will be addressed.

MA 20.3 Wed 15:45 H5

Magnetism and magnetoelectric properties of multiferroic $HoMnO_3$ thin films — •Jong-Woo Kim[1], Kathrin Dörr[1], Konstantin Nenkov[1], Ludwig Schultz[1], Bas B. van Aken[2], and Manfred Fiebig[2] — [1]Institute for Metallic Materials, IFW Dresden, Postfach 270116, 01171 Dresden, Germany — [2]HISKP, Universität Bonn, Nussallee 14-16, 53115 Bonn, Germany

Hexagonal $HoMnO_3$, one of the most promising single-phase multiferroics, has received much interest because of its strong magnetoelectric effect [1,2]. We have grown twin-free epitaxial $HoMnO_3$ films of thicknesses from 25 nm to 240 nm on (111) Y:ZrO_2 (YSZ) substrates by pulsed laser deposition. Ferroelectric polar order and Mn antiferromagnetism of the films has been observed by optical second harmonic generation [3]. Magnetization measurements reveal magnetic Ho ordering which is, with subtle deviations, similar to that of bulk crystals.

For the investigation of magnetoelectric properties, trilayer capacitor structures using an epitaxial Pt bottom electrode have been prepared. Measurements of the electric polarization at such trilayers demonstrate ferroelectric switching at 300 K, inspite a certain degree of leakage. Measurements of the magnetoelectric response in both ways, i. e. of the electric polarization vs. magnetic field and of the magnetization vs. electric field are in progress.

[1] F. Yen, et al., Phys. Rev. B 71, 180407 (2005)
[2] T. Lottermoser, et al., Nature 430, 541 (2004)
[3] J.-W. Kim et al., Appl. Phys. Lett. (in press)

MA 20.4 Wed 16:00 H5

Morphology and electronic structure of Cobalt islands grown on Pd(111) — •Marta Waśniowska[1], Wulf Wulfhekel[1,2], Marek Przybylski[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120, Halle, Germany — [2]Physikalisches Institut, Universität Karlsruhe, 76128 Karlsruhe, Germany

We have investigated Co islands grown on Pd(111) at three different temperatures, i.e. 180 K, 300 K, 550 K. The island shapes and electronic structure of these Co islands were studied with scanning tunneling microscopy and scanning tunneling spectroscopy. Depending on the growth temperatures, monolayer or double layer islands are formed in the early stages of growth. On the hexagonal double layer islands formed at 300 K a Moiré pattern appears. The unit cell of the Moiré pattern contains Co in fcc and hcp stacking, as well as Co in the bridge or on top position. Both fcc and hcp regions show similar features in dI/dU spectra. However, the surface state peak positions are slightly shifted. Triangular monolayer high islands formed at 550 K either continuous in fcc or hcp stacking. The position of the surface state peak depends on stacking of the island, as well. The magnetic structure of the islands was investigated by means of spin polarized scanning tunneling spectroscopy. The measurements reveal a spin contrast reflecting the out-of-plane magnetization of the islands.

MA 20.5 Wed 16:15 H5

Ripple Induced Modifications of Magnetic Properties. — Maciej Oskar Liedke, Adrian Keller, Stefan Facsko, and •Jürgen Fassbender — Forschungszentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, D-01314 Dresden

Self-organized ripple formation during ion erosion of a Si wafer is used to create a template system with a well defined roughness of uniaxial symmetry. By using special buffer layers subsequent thin magnetic film deposition by molecular beam epitaxy leads to a periodically modulated magnetic thin film with drastically modified magnetic properties with respect to a nominally flat film of the same thickness. In the case of Permalloy thin films, an enhancement of the uniaxial in-plane anisotropy by approximately a factor of 20 is observed. The enhancement can be explained by a combination of step induced dipolar and magnetocrystalline surface anisotropy contributions. If a ferromagnet/antiferromagnet-bilayer is deposited a superposition of ripple-induced uniaxial anisotropy and exchange coupling induced unidirectional anisotropy is observed. Since the direction of the unidirectional anisotropy depends only on the magnetic field direction during a field cooling procedure any angle between both anisotropy contributions can be set.

MA 20.6 Wed 16:30 H5

Investigation of the crystallographic structure of hydrogenated (Ga,Mn)As — •Christoph Bihler[1], Hans Huebl[1], Bastian Galler[1], Martin Brandt[1], Gema Martinez-Criado[2], Gianluca Ciatto[2], Aldo Amore Bonapasta[3], Francesco Filippone[3],

Wladimir Schoch[4], and Wolfgang Limmer[4] — [1]Walter Schottky Institut, TU München, Am Coulombwall 3, 85748 Garching — [2]ESRF, 6 rue J. Horowitz, Boite Postale 220, 38043 Grenoble, France — [3]ISM, Via Salaria, CP 10, 00016 Monterotondo Stazione, Italy — [4]Institut für Halbleiterphysik, Universität Ulm, 89069 Ulm

The lattice expansion of (Ga,Mn)As samples after deuteration $\Delta V_D/V_{\mathrm{Mn-As}} \approx 0.14$ obtained from x-ray diffraction (XRD) agrees best with that expected for a complex with the D atom bond-centered (BC) between the Mn and a neighboring As atom, but the difference to the volume expansion expected for the antibonding (AB) configuration is too small to draw unambiguous conclusions. However, the absence of a second peak or shoulder in the Fourier transform of the Mn K-edge extended x-ray absorption fine structure (EXAFS) χ function corresponding to the first coordination shell of deuterated samples, as well as the comparison of the corresponding x-ray absorption near-edge structure (XANES) with simulations of the different complexes strongly suggests that the BC complex predicted by theoretical calculations can be excluded in the deuterated samples. Rather, both EXAFS and XANES spectra can be explained by the formation of AB complexes or complexes in which the D atom is not bound to a nearest As neighbor, but a more distant As atom.

MA 20.7 Wed 16:45 H5

Magneto-optics in the vicinity of the $M_{2,3}$ and $L_{2,3}$ edges of iron — •Armin Kleibert[1], Joachim Bansmann[2], Ponpandian Nagamony[1], and Karl-Heinz Meiwes-Broer[1] — [1]Institut für Physik, Universität Rostock, Universitätsplatz 3, D-18051 Rostock — [2]Institut für Oberflächenkatalyse, Universität Ulm, D-89069 Ulm

Soft x-ray and EUV based experimental techniques are powerful and very sensitive methods in order to investigate the properties of systems with low dimensions such as ultrathin films or clusters. In particular magnetic linear and circular dichroism effects in the vicinity of element-specific resonances have attracted much attention. While respective absorption experiments are frequently applied in order to study the properties of magnetic nanostructures reflectivity-based techniques are still comparably rare to find. However, the reflectivity as well as the absorption properties of a material are determined by one dielectric tensor and thus yield the same information. In this contribution, we present the full dielectric tensor of iron in the vicinity of the $M_{2,3}$ as well as the $L_{2,3}$ edges obtained from absorption experiments as well as from reflectivity data. The data are then used in order to simulate magneto-optical effects occuring in absorption, transmission as well as in reflection of polarized radiation in both energy ranges. Characteristic properties are discussed for some practically relevant situations in respective experiments.

MA 20.8 Wed 17:00 H5

Magnetic orbital moment and uniaxial anisotropy in tetragonally distorted $Fe_{1-x}Co_x$ films — Fikret Yildiz, •Marek Przybylski, Feng Luo, Carsten Tieg, Radu Abrudan, and Jurgen Kirschner — Max-Planck-Institut fur Mikrostrukturphysik, Halle, Germany

The quenching of the orbital moment, which occurs in high lattice symmetries, can be removed by a symmetry reduction. The unquenched orbital magnetization is accompanied by a significant anisotropy of the orbital moment itself, which in turn induces a strong magnetic anisotropy owing to spin-orbit coupling. Previously we have shown that the $Fe_{1-x}Co_x$ alloy films of the composition around $x = 0.5 - 0.6$ show a clear out-of-plane easy axis of magnetization when their fcc lattice is tetragonally distorted. Rectangular polar magneto-optical Kerr loops were measured up to a thickness d_c, which was found to depend strongly on the film composition. Here we report on the magnetic circular dichroism in soft x-ray absorption measurements of the same $Fe_{1-x}Co_x$ tetragonally distorted films, which were carried out at the UE56/2-PGM2 beamline at BESSY in Berlin. In contrast to fcc-crystals of cubic symmetry where the orbital moment is almost completely quenched, a strong enhancement of the Co orbital moment is found - depending on composition - with a maximum value at $x = 0.6$. This dependence of the orbital moment coincides well with the composition dependence of the d_c, which is a measure of the volume magnetocrystalline anisotropy.

MA 20.9 Wed 17:15 H5

Electronic structure of chemically disordered FePt films — •Hans-Gerd Boyen[1], Sven Bornemann[2], Ulf Wiedwald[1], Anitha Ethirajan[1], Gerd Kästle[1], Paul Ziemann[1], Jan-Ulrich Thiele[3], David Bachelor[4], Kai Fauth[5], Jan Minar[2], Hubert Ebert[2], Andriy Romanyuk[6], and Peter oelhafen[6] — [1]Institut für Festkörperphysik, Univ. Ulm — [2]Abteilung Physikalische Chemie, LMU München — [3]Hitachi Global Storage Technologies, San Jose Research Center, San Jose — [4]BESSY GmbH, Berlin — [5]MPI für Metallforschung, Stuttgart — [6]Institut für Physik, Univ. Basel

FePt nanoparticles deposited as two-dimensional arrays on top of suitable substrates are currently in the focus of interest because they offer the potential to be used as ultra-high density data storage media in magnetic recording applications. In order to better understand the electronic properties and, finally, the resulting complex magnetic behaviour of such nanoscaled systems, corresponding bulk alloys have been prepared as reference systems in the chemically disordered state allowing to systematically analyze their electronic structure over a wide range of compositions. Synchrotron radiation induced photoemission (photon energy 180-900eV) is used as a tool to access the element-specific densities of states within the different alloys. Experimental valence-band spectra will be compared to theoretical spectra predicted for the various photon energies and alloy compositions on the basis of band structure calculations performed within the framework of a scalar-relativistic Korringa-Kohn-Rostocker approach using the Coherent Phase Approximation.

MA 20.10 Wed 17:30 H5

fcc and fct FePt: magnetic moments, magnetic moment anisotropy and their relation to magnetocrystalline anisotropy — •Kai Fauth[1], Carolin Antoniak[2], Sven Bornemann[3], Jan-Ulrich Thiele[4], Ulf Wiedwald[5], Marina Spasova[2], Fabrice Wilhelm[6], Andrei Rogalev[6], Hans-Gerd Boyen[5], Jan Minar[3], Hubert Ebert[3], Paul Ziemann[5], Michael Farle[2], and Gisela Schütz[1] — [1]MPI für Metallforschung, D-70569 Stuttgart — [2]Universität Duisburg-Essen, Fachbereich Physik, D-47048 Duisburg — [3]LMU München, Department Chemie und Biochemie, D-81377 München — [4]Hitachi Global Storage Technologies, San Jose Research Center, San Jose, CA 95135, USA — [5]Universität Ulm, Abteilung Festkörperphysik, D-89069 Ulm — [6]ESRF, Polygone Scientifique Louis Néel, F-38000 Grenoble

The transition from the disordered fcc FePt alloy to the the chemically ordered fct $L1_0$ phase is accompanied by the occurrence of very large magnetocrystalline anisotropy. $L_{3,2}$ edge X-ray magnetic circular dichroism was used to investigate Fe and Pt magnetic moments as well as their anisotropy for both, disordered and ordered FePt, respectively. The orbital magnetic moments at both, Fe and Pt sites are maximized along the easy magnetization axis in the $L1_0$ phase. Calculated magnetic moments were determined from fully relativistic band structure calculations and display the same anisotropy behaviour. In addition, the calculations indicate that chemical ordering is the dominant contribution to magnetocrystalline anisotropy as compared to tetragonal lattice distortion.

MA 20.11 Wed 17:45 H5

Non-collinear magnetism of magnetic 3d-monolayers on Cu and Ag (111) surfaces — •Robert Wieser, Elena Vedmedenko, and Roland Wiesendanger — Institut für Angewandte Physik, Jungiusstr. 11, 20355 Hamburg

It has been recently shown that in low-dimensional, 3d transition metal films on noble metal substrates or at the metal-metal interface complex non-collinear spin structures are possible (P. Kurz et al., PRL **86**, 1106, (2001)). Understanding of the magnetic ordering in 3d metals on non-magnetic substrates is important as non-collinear structures have been proposed to play a key role for the exchange bias. The magnetic non-collinearity arises due to the delocalized nature of the electrons responsible for magnetic properties of itinerant magnets and super-exchange interactions via the substrate. These phenomena cannot be described in the framework of the simple Heisenberg Hamiltonian. To describe the non-collinear magnetism we generalize the classical Heisenberg spin model by addition of the contributions coming form exchange interaction up to 3rd nearest neighbor, biquadratic exchange and four-spin interactions. In this presentation the results of classical Monte Carlo calculations for monolayers of Mn on Cu(111) and V on Ag(111) will be shown. All interaction parameters come from the first principles calculations. Magnetic ordering of both systems is found to be non-collinear. The low-temperature, stable configuration of Mn/Cu(111) is a 3Q magnetic state. For V/Ag(111) we find a magnetic phase transition between two different stable configurations at $T \sim 20K$. Interestingly both structures are uncompensated.

MA 20.12 Wed 18:00 H5

Spin-dependence of the Ni *d*-band transition in inverse photoemission on ultrathin Ni films on Cu(001) — •Volker Renken and Markus Donath — Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Ultrathin Ni films on Cu(001) represent one of the most studied magnetic thin-film systems. The spin-dependent bulk band structure of Ni(001) shows that only minority *d*-bands exist above the Fermi level, while the majority *d*-bands are completely occupied. This makes Ni a strong ferromagnet. Consequently, spin- and angle-resolved inverse photoemission measurements of Ni(001) and of thick Ni films on Cu(001) show a spectral feature just above the Fermi level, which results from transitions into the unoccupied *d*-bands and appears for minority spin only. In contrast, for ultrathin Ni films on Cu(001) the corresponding spectral feature appears for both minority spin and majority spin. At this, the spectral feature resulting from the *d*-bands is affected by several factors, which are discussed within this talk: the influence of the Cu(001) substrate, additional quantum-well states, a reduced magnetization in thin films and at room temperature, a change of the magnetic anisotropy, and a two-dimensional band structure which is different from the bulk one.

MA 20.13 Wed 18:15 H5

Real time optical monitoring of ultrathin magnetic film growth on Cu(110) — •Richard Denk, Michael Hohage, L.D. Sun, and Peter Zeppenfeld — Institut für Experimentalphysik, Johannes Kepler Universtät Linz, A-4040 Linz, Austria

Reflectance Difference Spectroscopy (RDS) has been used to monitor the growth of thin Ni films on Cu(110)(2x1)O and to characterise them. Whereas the regular optical anisotropy signal originates from the morphology of the film, the RD-spectrometer may sense additionally the out of plane magnetisation of the film via polar Magneto-Optical Kerr Effect (MOKE) [1]. The RD-spectrometer allows conducting spectroscopic measurements of the films at photon energies between 1.5 eV and 5.5 eV. To perform the magnetic measurements the UHV chamber is equipped with an in-situ electromagnet. As the magnetic signal is superimposed onto the regular anisotropy signal, applying the RD-technique at opposite magnetisation (M^+,M^-) of the film, the pure RDS signal ($\Delta r/r(M^+) + \Delta r/r(M^-)$)/2 can be separated from the MOKE signal ($\Delta r/r(M^+) - \Delta r/r(M^-)$)/2. Using RD- transients at a fixed wavelength hysteresis curves at any desired photon energy between 1.5 eV and 5.5 eV can be recorded. For film characterization, in addition to RDS, the chamber is equipped with a STM and a LEED/AES system. A major focus of the study has been the effect of adsorption on the magnetic properties of ultrathin Ni films, as well as the way how the remanent polar magnetisation develops within the ultrathin Ni films. References [1] M. Wahl, Th. Herrmann, N. Esser, and W. Richter, phys. stat. sol. c, 3002 (2003)

MA 20.14 Wed 18:30 H5

Das Einsetzen von Ferromagnetismus in ultradünnen epitaktischen ^{57}Fe-Filmen auf GaAs(001)-(4x6) — •Ellen Schuster[1], Robert Peters[1], Werner Keune[1], Heiko Wende[1], Andreas Westphalen[2] und Hartmut Zabel[2] — [1]Fachbereich Physik, Universität Duisburg-Essen, D-47048 Duisburg — [2]Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

Ultradünne ^{57}Fe(001)-Filme wurden bei Raumtemperatur (RT) auf GaAs(001)-(4x6) epitaktisch aufgewachsen und ihre Struktur mittels RHEED untersucht. Unterhalb einer Dicke von $t_{Fe} \sim 3$ ML (Monolagen) wurde Inselwachstum beobachtet. Die magnetischen Eigenschaften wurden in-situ im UHV (unbedeckte Filme) und ex-situ nach Pt-Bedeckung mittels Mössbauerspektroskopie (CEMS) ermittelt. Unbedeckte Fe-Filme mit $t_{Fe} \sim 2$ ML und ~ 3 ML besitzen magnetische Übergangstemperaturen weit unterhab RT und zeigen einen steilen linearen Abfall des magnetischen Hyperfeinfeldes B_{hf} mit T, was auf superparamagnetisches Verhalten von Fe-Clustern hinweist. Nach Pt-Bedeckung steigen die magnetischen Übergangstemperaturen drastisch an, bei RT wird das Einsetzten von langreichweitigem Ferromagnetismus bei $t_{Fe} = 2.5 \sim 3$ ML beobachtet, und B_{hf}(T) weist auf 2D-Verhalten hin. Dies ist eine Folge der magnetischen Kopplung der Fe-Cluster über die Pt-Schicht. Gefördert durch die DFG (SFB 491)

MA 21: Invited Talk (joint session with TT)

Time: Thursday 9:30–10:00 Location: H10

Invited Talk MA 21.1 Thu 9:30 H10

To Be Announced. *(Talk by Zachary Fisk was withdrawn.)* — •XXX XXX —

MA 22: FV intern Symposium: "Heusler Alloys" Invited Talks Kübler/Yamamoto/Inomata/Silvia Picozzi

Time: Thursday 10:15–13:15 Location: H10

Invited Talk MA 22.1 Thu 10:15 H10

Thermal properties of magnets from *ab initio*. — •Jürgen Kübler — Technische Universität Darmstadt

The local spin-density functional approximation (SDFA) is being successfully used for materials applications such as predicting structural and magnetic properties in the ground state. The ability to model low-lying magnetic excitations in the SDFA by means of non-collinear spin configurations together with well-established techniques from statistical mechanics also allows a determination of thermal properties of itinerant-electron magnets from *ab initio*. The Curie temperature, for instance, can be estimated quite reliably using the spherical approximation. This is demonstrated for a sizable number of Heusler compounds and other magnets for which theoretical predictions constitute an important tool in materials development. *I gratefully acknowledge helpful discussions with Claudia Felser and Gerhard Fecher (Universität Mainz). I am, furthermore, indebted to Claudia Felser and Burkhard Hillebrands for their support.*

Invited Talk MA 22.2 Thu 10:45 H10

Highly spin-polarized tunneling in fully epitaxial magnetic tunnel junctions with a Co-based full-Heusler alloy thin film and a MgO barrier — •Masafumi Yamamoto, Takao Marukame, Takayuki Ishikawa, Ken-ichi Matsuda, and Tetsuya Uemura — Division of Electronics for Informatics, Hokkaido University, Sapporo 060-0814, Japan

Co-based full-Heusler alloy (Co_2YZ) thin films are highly preferable ferromagnetic materials in spintronic devices. This is because of the half-metallic ferromagnetic nature theoretically predicted for some of these alloys, and because of their high Curie temperatures, which are well above room temperature (RT). We developed fully epitaxial magnetic tunnel junctions (MTJs) with a Co_2YZ thin film and a MgO tunnel barrier (Refs. 1-3), and showed a relatively high tunnel magnetoresistance ratio of 109% at RT (317% at 4.2 K) for $Co_2Cr_{0.6}Fe_{0.4}Al$/MgO/$Co_{50}Fe_{50}$ MTJs (Ref. 3). Furthermore, the bias voltage dependence of differential conductance of Co_2MnSi/MgO/$Co_{50}Fe_{50}$ MTJs for the parallel and antiparallel magnetization configurations suggested the existence of a basic energy gap structure for the minority-spin band of the Co_2MnSi electrode (Ref. 2). These results confirm the promise of epitaxial MTJs as a key device structure for utilizing the potentially high spin polarization of Co_2YZ thin films. 1) T. Marukame *et al.*, *Appl. Phys. Lett.* 88, 262503 (2006). 2) T. Ishikawa *et al.*, *Appl. Phys. Lett.* 89, 192505 (2006). 3)

T. Marukame *et al.*, to be published in *Appl. Phys. Lett.*

Invited Talk MA 22.3 Thu 11:15 H10

giant tunnel magnetoresistance at room temperature using Co2Fe(SiAl) full Heusler alloy electrodes — •KOICHIRO INOMATA[1,2,3], NAOMICHI IKEDA[2], and NOBUKI TEZUKA[2,3] — [1]National Institute for Materials Science, Tsukuba, Japan — [2]Tohoku University, Sendai , Japan — [3]CREST-JST, Saitama, Japan

Half-metallic ferromagnets (HMFs) are a key material for spintronics, which have a band gap at the Fermi level (EF) for one spin direction and thus exhibit 100% spin polarization at the EF. Full Heusler alloys, in particular, are promising as a half metal, because a number of which have been predicted to be HMFs and have a high Curie temperature. Here we report the giant TMR observation at room temperature (RT) for the MTJ using Co2Fe (Si,Al) (CFSA) electrodes. We first investigate the structure of the sputtered CFSA films on a Cr-buffered MgO (001) substrate in an ultrahigh vacuum by post annealing at various temperatures. Next we fabricate the epitaxially grown spin-valve type MTJs on a Cr-buffered MgO (001) substrate with Co2FeSi0.5Al0.5 full-Heusler alloys for top and bottom electrodes and an MgO barrier with different thicknesses. The bottom CFAS film is post-annealed at 673 K after the deposition at RT, followed by the deposition of the other films at RT. The junctions are the annealed at various temperatures, and then microfabricated into 100 mm2 using the electron beam lithography and Ar ion milling. We have successfully grown the highly ordered CFSA full-Heusler films for top and bottom electrodes. As a result we have attained the giant TMR over 200% at RT.

Invited Talk MA 22.4 Thu 11:45 H10

First-principles study of ferromagnetic Heusler alloys: an overview — •SILVIA PICOZZI — CNR-INFM CASTI Regional Lab, 67010 L'Aquila (Italy)

On the basis of ab-initio results, I will review several aspects of ferromagnetic Co2MnX (X = Si, Ge and Sn) Heusler alloys, predicted to be half-metallic and, as such, promising candidates for spin-injection purposes. In particular, I will focus on:

i) Bulk magneto-optical properties: after a brief review of their electronic and magnetic properties, a careful analysis of magneto-optical spectra, in comparison with experiments, will be presented.

ii) Polarization reduction mechanisms. Our results show that in Heusler compounds a) intrinsic point-defects can be detrimental for half-metallicity and b) when joined to mainstream semiconductors, the presence of interface states at the Fermi level can degrade their performances. In particular, I will focus on Co2MnSi and Co2MnGe, in the presence of intrinsic defects (such as stoichiometric atomic swaps as well as non-stoichiometric antisites) and interfaced with GaAs and Ge. Antisites, due to their low formation energies, can easily occur, consistently with experiments; however, only Co antisites give rise to defect-states at the Fermi level. As for the [001]-ordered interfaces, the strong hybridization at the junction gives rise to broad interface states which locally destroy half-metallicity. Finally, in the context of multiferroic tunnel junctions, preliminary results for Heuslers interfaced with ferroelectrics will also be presented.

MA 22.5 Thu 12:15 H10

Huge magneto-optical Kerr effect and its modification by ion irradiation in the Co_2FeSi Heusler compound — •J. HAMRLE[1], O. GAIER[1], S. BLOMEIER[1], H. SCHNEIDER[2], G. JAKOB[2], B. REUSCHER[3], A. BRODYANSKI[3], M. KOPNARSKI[3], C. FELSER[4], and B. HILLEBRANDS[1] — [1]FB Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, E.-Schrödinger-Str. 56, D-67663 Kaiserslautern — [2]Institut für Physik, J.-Gutenberg-Universität, Staudinger Weg 7, D-55128 Mainz — [3]IFOS TU Kaiserslautern, E. Schrödinger-Str. 56, D-67663 Kaiserslautern — [4]Institute of Chemistry, J.-Gutenberberg-Universität, Staudingerweg 9, D-55128 Mainz

Heusler alloys are promising candidates for spintronics devices providing 100% spin polarization. We report on magnetic and magneto-optical properties of thin Co_2FeSi (CFS) Heusler films measured by means of magneto-optical Kerr effect (MOKE). CFS films sputtered on MgO(100) grow in the fully ordered $L2_1$ structure. MOKE hysteresis loops measured on CFS films exhibit a large quadratic (QMOKE) and longitudinal MOKE (LMOKE) contribution, resulting in asymmetrical MOKE loops. The amplitude of the QMOKE is 30 mdeg, the largest QMOKE found so far. It is a hint of an unusually large second-order spin-orbit (SO) coupling in CFS films. We studied the effect of structural disorder on the magnetic properties by irradiating the CFS samples with different fluences of 30 keV Ga^+ ions. Results shows that small doses reduce the second-order SO coupling while keeping unmodified the first order SO coupling. Supported by the DFG in the FG 559 and by the Japanese government in the NEDO 2004IT093.

MA 22.6 Thu 12:30 H10

Structural characterization of Heusler compounds using NMR — •SABINE WURMEHL[1], MAREK WOJCIK[2], GERHARD FECHER[1], BENJAMIN BALKE[1], VADIM KSENOFONTOV[1], VERENA JUNG[1], and CLAUDIA FELSER[1] — [1]Johannes Gutenberg - Universität, 55099 Mainz, Germany — [2]Institute of Physics, Polish Academy of Sciences, 02-668 Warszawa, Poland

The $L2_1$ ordered Heusler alloys $Co_2Mn_{1-x}Fe_xSi$ with $0 \leq x \leq 1$ attracted much scientific interest, as they are predicted to show high spin polarisation at the Fermi-energy.

Therefore $Co_2Mn_{1-x}Fe_xSi$ samples were investigated using spin echo nuclear magnetic resonance (NMR) measurements. This method provides a tool to measure the hyperfine fields. The hyperfine fields represent a very sensitive local probe to order-disorder phenomena.

The NMR measurements of polycrystalline Co_2FeSi samples exhibit a two-peak spectrum with an additional shoulder. This additional signals are attributed to second-order quadrupole splitting, a so called asymmetric line broadening and might be caused by tension within the structure (strain). This effect occurs even in highly ordered systems. Thus previous structural results are corroborated, demonstrating even locally a very high degree of order in Co_2FeSi.

The NMR spectra of the series $Co_2Mn_{1-x}Fe_xSi$ ($(0.1 \leq x \leq 0.9)$ exhibit multiplet structures. These might be explained by quadrupole splitting and statistical distribution of Mn and Fe atoms on the Mn site. In summary, the high degree of order in $Co_2Mn_{1-x}Fe_xSi$ is shown.

(This work is funded by the DFG in FG 559.)

MA 22.7 Thu 12:45 H10

Heusler compounds implemented in magnetic tunnel junctions: basic properties and applications — •JAN SCHMALHORST, ANDY THOMAS, ANDREAS HÜTTEN, and GÜNTER REISS — Bielefeld University, Department of Physics, Thin Films and Nanostructures, P.O. Box 100131, 33501 Bielefeld, Germany

The implementation of half-metallic materials like Heusler compounds [1] in magnetic tunnel junctions for spintronic applications is of highest technological relevance [2]. The major challenge is the preparation of defect free thin Heusler compound films and high quality electrode - barrier interfaces. In this talk, we will compare transport as well as magnetic and chemical bulk and interface properties of tunnel junctions with Co2MnSi, Co2FeSi, Co2FeMnSi or CoMnSb electrodes and Al-O or Mg-O barrier. Especially, we will focus on the bias voltage dependent inversion of the tunnel magnetoresistance [3, 4], which can be utilized for programmable logic devices [5]. The author gratefully acknowledge financial support by DFG and EU and the opportunity to perform soft X-ray absorption spectroscopy at the Advanced Light Source, Berkeley, USA.

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

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

[3] D. Ebke, J. Schmalhorst et al., Appl. Phys. Lett. 89 (2006) 16250

[4] J. Schmalhorst et al., Phys. Rev. B, accepted

[5] A. Thomas et al., Appl. Phys. Lett. 89 (2006) 012502

MA 22.8 Thu 13:00 H10

Electronic structure and high energy valenceband photoemission of Heusler compounds — •GERHARD H. FECHER and CLAUDIA FELSER — Institute for Inorganic and Analytical Chemistry, Johannes Gutenberg - Universität, 55099 Mainz, Germany

This work reports on high resolution photoelectron spectroscopy of the valence band of $Co_2Mn_{1-x}Fe_xSi$ ($x = 0, 0.5, 1$) excited by photons of 8 keV energy. The measurements show a good agreement to calculations of the electronic structure using the LDA+U scheme. It is shown that the high energy spectra reveal the bulk electronic structure better compared to low energy XPS spectra. The high resolution measurements of the valence band close to the Fermi energy indicate the existence of the gap - or at least a pronounced minimum - in the minority states for all three alloys.

The role of the composition for the position of the Fermi energy and the stability of the half-metallic ferromagnetism is discussed for the iso-electronic Heusler compound $Co_2FeAl_{1-x}Si_x$. The energy dependence of high energy photoelectron spectroscopy will be discussed with an example of spectra taken at 1.2-5 keV from the $C1_b$ compound CoTiSb.

(Financial support by the Deutsche Forschungsgemeinschaft in FG 559 (TP 7) is gratefully acknowledged.)

MA 23: Micro- and Nanostructured Magnetic Materials I

Time: Thursday 10:15–12:45 Location: H22

MA 23.1 Thu 10:15 H22

Sub 20nm structures with perpendicular magnetization — •Holger Stillrich[1], Sabine Pütter[1], Andreas Frömsdorf[2], and Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg, Germany

Magnetic nanostructures with perpendicular magnetic anisotropy are fabricated using SiO_2 nanoparticles. SiO_2 filled diblock copolymer micelles are deposited as a single layer on a Co/Pt multilayer film with perpendicular easy axis of magnetization. The polymer shell is removed in an oxygen plasma which yields a SiO_2 particle array that is used as mask for ion milling. Two kinds of diblock copolymers with different polymer length are used. The mean particle diameter is 12 and 20nm and the mean particle distance is 30 and 80nm, respectively, which was determined via AFM and SEM investigations. After sputtering a replica in the Co/Pt film is produced with slightly reduced dot size.

The magnetic properties of both films and magnetic dot arrays are investigated via the magneto-optical Kerr effect.

We find that the 20nm dots are ferromagnetic at room temperature and the perpendicular easy axis of the Co/Pt multilayer is preserved. The 12nm dots are superparamagnetic at room temperature. The influence of ion energy, number of Co/Pt-bilayers and size distribution of magnetic dots on the average magnetic properties is discussed.

Funding by the DFG via SFB 508 is gratefully acknowledged.

MA 23.2 Thu 10:30 H22

TEM investigations of the magnetization patterns of sagged Permalloy microstructures — •Christian Dietrich[1], Michael Huber[1], Dieter Weiss[1], Josef Zweck[1], and Riccardo Hertel[2] — [1]Institut für Experimentelle und Angewandte Physik der Universität Regensburg, Germany — [2]Forschungszentrum Jülich, Germany

For Lorentz transmission electron microscopic investigations of patterned magnetic specimens, the electron beam has to transmit the sample. Therefore the specimens are usually grown onto thin Si_3N_4 membranes. Due to mechanical tension the magnetic layers are not perfectly flat but sagged. Performing AFM measurements we found that the topography of the specimens is in a good approximation paraboloidally sagged with the center about 20-30 nm below the edges (for a micron sized specimen). When only in-plane magnetic fields are applied, the magnetization pattern behaves as expected for flat specimens. However, when an out-of-plane magnetic field is applied, the magnetization patterns change remarkably. For Permalloy squares with Landau domain structure the domain walls bend while for disks the vortex displacement due to an applied in-plane field deviates from the usual behaviour. The results can be explained by energy considerations and are of importance in the investigation of vortex motion, when perpendicular magnetic fields are present. Once more, the sensitive reaction of micromagnetic patterns on the specimen's geometry is confirmed.

MA 23.3 Thu 10:45 H22

Magnetization Reversal of Microstructured Kagomé Lattices — •Andreas Westphalen[1], Alexandra Schumann[1], Arndt Remhof[1], Thorsten Last[2], Ulrich Kunze[2], Thomas Eimüller[3], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Institut für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [3]Nachwuchsgruppe, Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

We report on magneto-optical Kerr effect (MOKE) investigations of microstructured rectangular islands (thickness: 20 nm, lateral size: 4.7 $\times$ 0.3 μm^2 to 2.7 $\times$ 0.15 μm^2) arranged as Kagomé lattices. The magnetization reversal was studied by regular longitudinal vector MOKE in specular geometry as well as in Bragg MOKE geometry, using the diffraction spots from the grating for hysteresis measurements. The measurements are compared with the results of micromagnetic simulation, which allow a detailed interpretation of the experimental data. We find that the remagnetization process in an external magnetic field strongly depends on the size and the interparticle spacing between the islands. The magnetization in remanence is imaged using magnetic force microscopy and photoemission electron microscopy. It shows a well ordered state even for sample orientations where strong magnetic frustration has been excepted.

We acknowledge financial support through SFB 491.

MA 23.4 Thu 11:00 H22

Magnetization Reversal of Microstructured Fe spirals — •Andreas Westphalen, Arndt Remhof, and Hartmut Zabel — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

A magnetic spiral structure (thickness: 20 nm, radius 2.8 μm, linewidth 100 nm) is used as a base for four different structure patterns. In contrast to a ring structure, in a spiral the magnetization cannot exhibit a closed flux configuration during the remagnetization process . Therefore, the process should prefer domain formation. The remagnetization processes in the spiral patterns are investigated with vector and Bragg MOKE in combination with micromagnetic simulations. We found that the magnetic reversal is the same in all four patterns. No notches, slits or other defects are introduced in the spiral which could influence the domain configuration during the magnetic reversal process. But the arrangement of the spiral patterns has an influence on the coercive field of the hysteresis curve. In the remanent state the micromagnetic simulations predict an onion-like state of the magnetization: the magnetization is divided at the horizontal axis, which is parallel to the applied magnetic field, in a lower and in an upper part where the magnetization follows the curvature of the spiral building magnetic poles at the horizontal axis. From the Bragg MOKE measurements we concluded that the switching process of the domains during the remagnetization is driven by domain wall movement.

We acknowledge financial support through SFB 491.

MA 23.5 Thu 11:15 H22

Longitudinal Bragg- and Vector-MOKE investigation on the rotational sense of vortices in Permalloy Nanodots — •Min-Sang Lee[1], Andreas Westphalen[1], Arndt Remhof[1], Alexandra Schumann[1], Thorsten Last[2], Ulrich Kunze[2], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik IV (Festkörperphysik), Ruhr-Universität Bochum, 44780 Bochum — [2]Institut für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 44780 Bochum

We have used the Bragg-MOKE technique in longitudinal geometry (L-MOKE) for the first time to study the rotational sense of vortices in Py nanodots. The dots were shaped such that only one uniqely defined rotational sense was present in the whole dot array. Due to the fact that the rotational sense manifests itself in the sign of the imaginary part of magnetic form factors, we have been able to show that the rotational sense can be extracted from the hysteresis loops recorded for positive and negative diffraction order. We have also developed a formalism describing the relation between the magnetic form factor and the Bragg-MOKE signal. This theoretical work has been needed because there is no such formalism regarding the L-MOKE applied to dot arrays. The validity of our formalism is tested by comparsion with the measurement results on the Py dots, which shows a good agreement. We conclude that the L-MOKE is an eligible method for studying the rotational sense of vortices. This work was financially supported by the SFB 491.

MA 23.6 Thu 11:30 H22

Magnetic antidot arrays with perpendicular or in-plane magnetization orientation — •Sabine Pütter[1], Holger Stillrich[1], Andreas Frömsdorf[2], and Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Jungiusstr. 11, 20355 Hamburg — [2]Institut für Physikalische Chemie, Grindelallee 117, 20146 Hamburg

Hexagonal magnetic antidot arrays with periods below 100 nm are

fabricated utilizing self organized patterns of diblock copolymer micelles as masks. Two methods for antidot array production in Co/Pt multilayers are presented. In the first method, the Co/Pt films are grown on top of the micelles preserving the morphology of the height modulated micelle pattern. Via Ar^+ sputtering at grazing incidence the film on the micelle caps is removed. Alternatively, micelles filled with SiO_2 are deposited on the magnetic film. Ion milling at normal incidence produces an antidot array due to preferred sputtering of the SiO_2 cores.

Varying the Co or Pt thickness of the multilayers the easy axis of magnetization of the antidot array is tuned to be in-plane or out-of-plane. For ion milling at normal incidence, however, high Ar^+ ion energies (> 500 eV) cause a reorientation of the magnetization from out-of-plane to in-plane during structuring.

We have investigated the morphology and topography of the arrays by SEM and AFM. The results of the afore mentioned studies are correlated with the magnetic behaviour observed via the magneto optical Kerr effect.

Funding by the DFG via SFB 508 is gratefully acknowledged.

MA 23.7 Thu 11:45 H22

Lorentz microscopy studies of cross-tie states in multi-scale NiFe elements — •Nils Wiese[1], Stephen McVitie[1], John Chapman[1], Felix Otto[2], Stefan Müller[3], and Antonio DeSimone[4] — [1]University of Glasgow, Dept. for Physics & Astronomy, Glasgow, United Kingdom — [2]Institut für Angewandte Mathematik der Universität Bonn, Germany — [3]Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany — [4]Intern. School for Advanced Studies, Trieste, Italy

Modelling of the magnetic structure and magnetisation processes in discrete thin films is routinely achieved using micromagnetic methods. However, in certain cases micromagnetics may not give accurate predictions and a particular example where this can apply is for structures containing extended domain walls, e.g. cross-tie walls. In such cases, analytical models provide an alternative route for predicting the behaviour on the micromagnetic scale.

We have fabricated elongated rectangular permalloy elements of varying thickness and with in-plane dimensions down to 100nm in order to investigate variation in the cross-tie wall structure due to edge proximity compared to that in an infinite film. Domain structures have been characterised in remanent states and during in-situ magnetising experiments in the transmission electron microscope. Our results show that the cross-tie density depends on the element width although the basic geometry of the wall remains unaltered. Results will be presented showing the variation of the wall structure over a large range of lengthscales, and a comparision with analytical models will be made.

MA 23.8 Thu 12:00 H22

Direct laser interference patterning of perpendicular Co/Pd multilayer films — •Philipp Leufke, Stephen Riedel, Paul Leiderer, Johannes Boneberg, and Manfred Albrecht — University of Konstanz, Department of Physics, D-78457 Konstanz, Germany

We report on direct laser interference patterning of Co/Pd multilayer films. The as-grown films show a high perpendicular magnetic anisotropy caused by interfacial effects. When exposed to nanosecond laser pulses the film stack will be annealed locally and as a consequence mixed chemically. This intermixing effect, in particular at the interfaces, will result in a reduction of magnetic anisotropy [1].

Multi-beam laser interference patterning is performend using two, three, and four beams of a Nd:YAG laser system at a wavelength of 532 nm. By altering the angle of incidence or polarization of the beams, different patterns of light intensity can be created [2]. The formed dot or stripe patterns are magnetically softer than the surrounding untreated film material affecting in particular the magnetic reversal mechanism. The latter is being investigated locally by magnetic force microscopy and compared to the hysteresis loops as measured by polar magneto-optical Kerr effect and superconductive quantum interference device magnetometry.

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

[1] C. Schuppler *et al.*, *Appl. Phys. Lett.* **88**, 012506 (2006).
[2] A. Aktag *et al.*, *J. Appl. Phys.* **99**, 093901 (2006).

MA 23.9 Thu 12:15 H22

Magnetic Patterning by Focused Ion Beam Irradiation — •Stefan Tibus[1], Denys Makarov[1], Charles T. Rettner[2], Thomas Thomson[3], Bruce D. Terris[3], and Manfred Albrecht[1] — [1]University of Konstanz, Department of Physics, D-78457 Konstanz, Germany — [2]IBM Almaden Research Center, 650 Harry Road, San Jose, CA 95120, USA — [3]Hitachi San Jose Research Center, 650 Harry Road, San Jose, CA 95120, USA

The magnetic properties, i.e. magnetization, coercivity and initially perpendicular magnetic anisotropy, of a granular CoCrPt film can be tuned by Ga irradiation, depending on exposure dose [1]. Focused ion beam irradiation is used to generate a periodic pattern of exposed strips which are magnetically soft, separated by magnetically hard unexposed areas [2]. Investigation with magnetic force microscopy and magneto-optical Kerr effect measurements show several stabilization regions of magnetic domain configurations, which are due to strong magnetic coupling between the strips. The magnetic reversal behavior and domain configurations are investigated by micromagnetic simulations and a comparison with the experimental findings is presented.

[1] Charles T. Rettner et al, *IEEE Trans. Magn.* **38**, 1725–1730 (2002)

[2] Manfred Albrecht et al, *Appl. Phys. Lett.* **83**, 4363–4365 (2003)

MA 23.10 Thu 12:30 H22

Ordering phenomena in focused ion beam structured Co/Pt multilayers. — Markus Becherer[1], •Gyorgy Csaba[2], Rainer Emling[1], Lili Ji[3], Wolfgang Porod[3], Paolo Lugli[2], and Doris Schmitt-Landsiedel[1] — [1]Lehrstuhl für Technische Elektronik, TU München — [2]Lehrstuhl für Nanoelektronik, TU München — [3]Center for Nanoscience and Technology, University of Notre Dame, USA

Computation by field-coupled nanomagnetic dots is a novel computational paradigm on the nanoscale. In the so-called 'magnetic quantum cellular automata', information is represented by the orientation of nanomagnetic dots and the signal is propagated by their magnetic interactions.

We investigate the feasibility of ion-beam patterned Co/Pt multilayers as a possible realization of magnetic field-coupling. We sputtered 40 bilayers of Co/Pt in an rf-magnetron system and employed SQUID measurements to characterize perpendicular anisotropy. The films are patterned with a 50 keV Ga^+ focused ion beam (FIB) into 'checkerboards' of (200x200)nm^2 dot-size. They are demagnetized and in a remanent state mapped by a magnetic force microscope (MFM).

The arrays of 48x48-dots show antiferromagnetic ordering that extends to hundreds of dots without frustration. This indicates strong interdot coupling and small switching field variations from dot to dot, showing that these multilayers are indeed a promising implementation possibility for field-coupling. We will present the first experimental results about strongly coupled dots and will outline the design of logic gates based on them.

MA 24: Spindynamics / Switching II

Time: Thursday 10:15–12:45 Location: H23

MA 24.1 Thu 10:15 H23

Non-ballistic precessional magnetic random access memories. — •F. Porrati and M. Huth — Physikalisches Institut, J. W. Goethe-Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main

We present a novel magnetic random access memory (MRAM) architecture, the non-ballistic precessional MRAM, and a related bit addressing scheme based on the sequential application of two unipolar magnetic field pulses. We perform micromagnetic simulations to study the magnetization trajectories and the stability of the states obtained after switching of the magnetization direction. Despite the presence of damped oscillations the final states are stable for field pulses of subnanosecond duration.

MA 24.2 Thu 10:30 H23

Magnetization dynamics of $Cr0_2(100)$ thin films — •Georg Müller[1], Jakob Walowski[1], Marija Djordevic[1], Guo-Xing Miao[2], Arunava Gupta[2], and Markus Münzenberg[1] — [1]IV. Phys. Institut, Georg-August-Universität, Göttingen, Germany — [2]MINT, University of Alabama, Tuscaloosa, AL, USA.

Because of its outstanding half metallic electronic properties, the ferrromagnet $Cr0_2$ (100) is an interesting candidate for future spintronic devices. In this study the magnetization dynamics of $Cr0_2$ (100) films are examined by all-optical pump probe technique where precessional motion is induced by an anisotropy field pulse. The sample exhibits a strong magneto-crystalline in-plane anisotropy, which results in a peculiar dependence of the precessional frequency on the applied external field with respect to the anisotropy field. This behaviour can be understood by studying the energy landscape of the sample. Also the precessional damping shows a strong dependence on the applied external field in hard-axis direction. This gives rise to the question of which nature the damping mechanism in this sample is.

Research was supported by the DFG priority program 1133.

MA 24.3 Thu 10:45 H23

Ultrafast magnetization dynamics probed by anisotropic magnetoresistance — •Santiago Serrano-Guisan[1], Hans-Werner Schumacher[1], Karsten Rott[2], and Günter Reiss[2] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116, Braunschweig, Germany — [2]University of Bielefeld, Department of Physics, Universitätsstr. 25, D-33615 Bielefeld, Germany

We study ultrafast magnetization dynamics and relaxation of a single ferromagnetic layer by time resolved measurements of the anisotropic magnetoresistance (AMR). The samples consist of a 5 nm Ta seed layer, 5 nm permalloy (Fe19Ni81) and a 3 nm Al cap layer. The films are microstructured into disks of 4-6 micrometer diameter and are contacted by coplanar wave guides for ultra fast AMR detection. The samples show an AMR ratio around 0.25% and the typical cos2 angular dependence. Ultrafast magnetic excitation field pulses (rise time ˜ 75ps, fall time ˜ 670ps and duration at half maximum ˜ 230ps) are applied using a pulse line on chip. Additionally, in plane static magnetic fields are applied using external coils. The temporal variation of the AMR upon pulse excitation clearly reveals the damped precession of the magnetization of the permalloy disk. From comparison to macro spin simulations we derive a Gilbert damping parameter of 0.008 for the permalloy. This technique can be used to access the dynamics of a wide variety of microstructured magnetic thin film devices showing AMR.

MA 24.4 Thu 11:00 H23

Ultrafast dynamics of the magnetic phase transition on FeRh — •Ilie Radu[1,2], Alexander Weber[1], Paul Ramm[1], Christian Stamm[2], Torsten Kachel[2], Niko Pontius[2], Jan Thiele[3], Hermann Dürr[2], and Christian Back[1] — [1]Institut für Experimentelle Physik, Universität Regensburg, Germany — [2]BESSY GmbH, Berlin, Germany — [3]Hitachi Global Storage Technologies, San Jose, U.S.A.

The laser-induced dynamics of the antiferromagnetic (AFM) to ferromagnetic (FM) phase transition of the FeRh alloy is studied by two complementary experimental techniques: the time-resolved magneto-optical Kerr effect (MOKE) and the time-resolved X-ray circular magnetic dichroism (XMCD). The transient MOKE data reveal an ultrafast onset of the FM ordering within 500 fs after femtosecond laser excitation. This result points to an electronically-driven AFM-FM transition since the lattice heating and the resulting lattice expansion evolve on a longer time scale. From the time-resolved XMCD spectra we obtain a similar dynamics for the Fe and Rh magnetic moments with a rise-time of 100 ps, which seems to contradict the dynamic MOKE data. The possible origin of this discrepancy will be discussed in terms of excitation and detection mechanisms in MOKE and XMCD. Due to the large magnetic moment of FeRh established in the FM state, one can use the ultrafast phase transition to trigger a coherent magnetization precession of a thin ferromagnetic film in contact with FeRh. Here, we present first pump-probe MOKE measurements of such a double layer system of CoPd/FeRh, that show two oscillatory components at 60 GHz and 80 GHz.

MA 24.5 Thu 11:15 H23

Critical damping of precessional magnetization dynamics in microscopic spin valve elements — •Hans-Joachim Elmers[1], Frederik Wegelin[1], Dimitri Valdaitsev[1], Alexander Krasyuk[1], Sergei Nepijko[1], Gerd Schönhense[1], Ingo Krug[2], and Claus M. Schneider[2] — [1]Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

We have studied ultrafast magnetization processes in micropatterned spin valve structures using time-resolved x-ray photoemission electron microscopy combined with x-ray magnetic circular dichroism (XMCD-PEEM). Exciting the magnetodynamics with ultrafast field pulses of 250 ps width, we find the dynamic response of the free layer to strongly depend on the amplitude and repetition rate (0.5 - 1 GHz) of the exciting field pulses. This response can be only roughly described by a single spin model using an unexpectedly high damping constant of $\alpha = 0.025$, which is 2-3 times higher than reported for single ferromagnetic layers and results in a critical damping of the magnetization oscillations. A pulse repetition rate of 1 GHz leads to an oscillatory response thus limiting the available bandwidth of the sensor. Time resolved microscopy reveals that the magnetodynamics does not follow a phase coherent precessional motion. The observed deviations from the single spin model are attributed to the excitation of additional short wavelength standing spin wave modes.

MA 24.6 Thu 11:30 H23

Dynamic Quasi-Particle Behaviour of Geometrically Confined Domain Walls — •Daniel Bedau, Mathias Kläui, and Ulrich Rüdiger — Universität Konstanz, 78467 Konstanz

Magnetic domain walls in laterally confined elements feel the potential landscape generated by notches. Depending on its type the domain wall is either symmetrically pinned inside of the notch (transverse wall) or pinned adjacent to the notch (vortex wall)[1]. This pinning allows to reliably switch magnetic domain walls between different positions, because of the long range of the attractive potential which locks the domain walls to the notch positions. The width of the potential, the depth, corresponding to the pinning strength, and the angular dependence of the pinning potential have been published [2,3,4]. Because of their small lateral extensions domain walls can act like quasi particles oscillating in a potential well, which allows us to study the potential by measuring the oscillation frequency of the domain wall. We have chosen to study magnetic rings, because the ring structure allows precise control of the domain wall spin structure via the lateral dimensions and the thickness of the film. To measure the structure of the potential, a new setup has been built to determine the influence of microwave excitations on the electrical properties of domain walls in the range from 10 MHz up to 20 GHz at low temperatures. [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) [3] M. Kläui et al., Appl. Phys. Lett. **87**, 102509 (2005) [4] D. Bedau et al., J. Appl. Phys., (in press 2007)

MA 24.7 Thu 11:45 H23

Breathing Fermi surface model for noncollinear magnetization: A generalization of the Gilbert equation — •Daniel Steiauf and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart

Within the breathing Fermi surface model the damping of the magnetization dynamics is related to the change of the Fermi surface with changing magnetic configuration, given by the orientations of the atomic magnetic moments: This change requires a scattering of the electrons among the single-electron states in reciprocal space, and this in turn requires time. For a uniform cooperative rotation of all magnetic moments the change of the Fermi surface results from spin-orbit coupling. In this case the theory yields a Gilbert-type equation of motion for the magnetization with the damping scalar of the original Gilbert equation replaced by a damping matrix which depends on the momentary orientation of the magnetization. The change of a non-collinear magnetization configuration leads to an even stronger change of the Fermi surface resulting from the interatomic exchange interactions. The damping then is described by a damping matrix which is different for different sites and which depends on the momentary magnetization configuration of the whole system, i.e., the equation of motion is nonlocal.

MA 24.8 Thu 12:00 H23

Temperature dependent magnetization switching — •Alexander Sukhov and Jamal Berakdar — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle/Saale, Germany

Recenlty, it has been shown [1] that the switching behaviour of magnetic nanoparticles can be well controlled by means of time-dependent magnetic fields. Motivated by these findings, we study in this the-

oretical work the spin-dynamics and the switching properties of a magnetic nanoparticles (Stoner-particles) using the Landau-Lifshitz-Gilbert equation extended for the case of finite temperatures, a task which has not been tacked by previous studies [2]. In particular, we are interested in the minimal amplitudes of the switching fields and the corresponding reversal times of the magnetic moment of the nanoparticle both for static and time-dependent external fields depending on the damping. Optimal parameters for the magnetization reversal and their temperature dependence are worked out.

References:

[1] C. Thirion, W. Wernsdorfer and D. Mailly, Nat. Mater. **2**, 524 (2003).

[2] Z. Z. Sun and X. R. Wang, Phys. Rev. Lett. **97**, 077205 (2006).

MA 24.9 Thu 12:15 H23

Spin transfer induced magnetization dynamics using the Ag/Fe(100) interface — •Ronald Lehndorff, Daniel E. Bürgler, and Claus M. Schneider — Institut für Festkörperforschung and cni - Center of Nanoelectronic Systems for Information Technology, Forschungszentrum Jülich GmbH, D-52425 Jülich

Spin-polarized currents in magnetic nanostructures induce magnetization dynamics, which differ strongly from magnetic field induced dynamics [1, 2]. The Ag/Fe(100) interface has been predicted to have a strong spin dependence of the interface resistance and should therefore be a good spin polarizer [3] and give strong spin transfer effects. We study spin transfer induced magnetization dynamics in single-crystalline, layered systems grown by molecular beam epitaxy. The layer sequence is 2 nm Fe/ 6 nm Ag/ 20 nm Fe. The topmost layer is structured by e-beam lithography and ion beam etching into a circle of 65 to 85 nm in diameter. To characterize the structures we measure the current-perpendicular-plane giant magnetoresistance. Current induced switching and current driven high-frequency excitations of the free layer are recorded under different angles of the magnetic field with respect to the crystal axes of the Fe(100) layers.

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[3] D. Stiles, A. Zangwill, Phys. Rev. B **66**, 014407 (2002)

MA 24.10 Thu 12:30 H23

Ferromagnetic resonance study of the interlayer exchange coupled NiFe/Ru/NiFe films — •Mohamed Belmeguenai, Tobias Martin, Georg Woltersdorf, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

Ferromagnetic bilayers exchange coupled through a non-magnetic metallic layer are used in magnetic recording devices. Their dynamics at 1 to 10 GHz which present a fundamental limit to increasing data rates have been studied in this work. We used conventional ferromagnetic resonance (FMR) and vector network analyzer FMR to study the different excited dynamic modes in exchange coupled Si/Ta/NiFe(30 nm)/Ru(dRu)/NiFe(30 nm)/Ta films with variable Ru thicknesses dRu. The interlayer exchange coupling (IEC) constants are determined by VSM and MOKE. The dynamic measurements show the existence of an optic and an acoustic precession mode. Their resonance frequencies and therefore the IEC are found to oscillate as a function of dRu with a period of 8.5 Å. The frequency oscillations of the optic mode are coupling-dependent while those of the acoustic mode are indirectly related to coupling via the canting angle of the layer magnetizations. The FMR measurements carried out at 22 and 35 GHz revealed clearly different behaviors of the FMR linewidths as a function of dRu for the optic and acoustic modes and we observed perpendicular standing spin-waves. The FMR linewidth of the different excited modes increases with the microwave frequencies and typical damping constants of 0.0073 have been measured.

MA 25: Invited Talks Michels / Fuchs

Time: Thursday 14:00–15:00 Location: H10

Invited Talk MA 25.1 Thu 14:00 H10

Magnetische Wechselwirkungen in nanokristallinen Ferromagneten: Untersuchungen mit Neutronenstreuung — •Andreas Michels — Technische Physik, Universität des Saarlandes, Saarbrücken

Verglichen mit konventionellen Ferromagneten zeichnen sich nanokristalline magnetische Materialien durch eine stark inhomogene magnetische Mikrostruktur aus. Die wesentliche Ursache dieser intrinsischen Inhomogenität im Spinsystem ist die räumlich inhomogene Verteilung des magnetischen Anisotropiefeldes, welches auf einer charakteristischen Längenskala von der Größenordnung der mittleren Kristallitgröße $D = 10\,\mathrm{nm}$ zufällig in Stärke und/oder Orientierung variiert. In meinem Vortrag wird gezeigt werden, wie man mittels magnetfeldabhängiger Neutronenkleinwinkelstreuung (NKWS) die magnetischen Wechselwirkungen in Nanomagneten quantifizieren kann. Insbesondere wird ein auf der Theorie des Mikromagnetismus basierendes Modell für den NKWS-Streuquerschnitt vorgestellt, welches es erlaubt, Austauschkonstante, Anisotropiefeld, magnetostatisches Streufeld und eine charakteristische Spinfehlorientierungslänge zu bestimmen. Messungen an der zweiphasigen Fe-basierten Legierung Nanoperm zeigen eine erstmals beobachtete „kleeblattförmige“ Winkelanisotropie auf, die mit der Existenz von dipolaren Korrelationen erklärt werden kann.

Invited Talk MA 25.2 Thu 14:30 H10

Strain induced ferromagnetic order in undoped $LaCoO_3$ thin films — •Dirk Fuchs[1], Christian Pinta[1,2], Thorsten Schwarz[1,2], Peter Scheiss[1], Peter Nagel[1], Stefan Schuppler[1], Rudolf Schneider[1], Michael Merz[3], Georg Roth[3], and Hilbert von Löhneysen[1,2] — [1]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, 76021 Karlsruhe — [2]Physikalisches Institut, Universität Karlsruhe, 76128 Karlsruhe — [3]Institut für Kristallographie, Rheinisch-Westfälische Technische Hochschule Aachen, 52066 Aachen

Despite the well established nonmagnetic low spin (S = 0) ground state of $LaCoO_3$ there are many publications reporting on the existence of either long- or short-range ferromagnetic order. For example, Yan et al.[1] have found a ferromagnetic component with a $T_c = 85$ K and have suggested a ferromagnetic coupling of surface cobalt atoms. In the presence of the conflicting results the origin of the observed ferromagnetism in $LaCoO_3$ is still a challenging question and motivated this work. In order to scrutinize the proposed surface ferromagnetism by Yan et al. we have carried out experiments on thin films prepared by pulsed laser deposition which inherently show an extremely large surface/volume ratio. In contrast to polycrystalline $LaCoO_3$ films which did not show ferromagnetism down to T = 5 K epitaxial films with the same surface/volume ratio showed clear ferromagnetic order at $T_c =$ 85 K. We discuss this surprising result in terms of ferromagnetic order induced by epitaxial strain.

[1] J. Q. Yan et al., Phys. Rev. B 70, 014402, (2004).

MA 26: Exchange Bias

Time: Thursday 15:15–18:30 Location: H10

MA 26.1 Thu 15:15 H10

Anisotropy and interlayer exchange coupling in thin magnetic films: beyond the Landau-Lifshitz evaluation of spin wave spectra — •Stephan Schwieger[1], Jochen Kienert[2], Fritz Körmann[2], and Wolfgang Nolting[2] — [1]Technische Universität Ilmenau, Theoretische Physik I, Postfach 10 05 65, 98684 Ilmenau, Germany — [2]Festkörpertheorie, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

We present a general theory to determine the temperature-dependent magnetic anisotropies and interlayer exchange coupling in thin films from experiments probing collective spin excitations. Unlike the classical evalutation based on the Landau-Lifshitz equations our approach, by using the quantum Heisenberg model, considers self-consistently the effects of thermally activated spin waves. The close correspondence to the Landau-Lifshitz formulas for T→0 is demonstrated and the benefits of the theory for T>0 are worked out.

We show results on the magnetic reorientation transition due to a Cu cap layer in thin Ni films. For thin Ni and Co films we derived the T-dependence of the lattice and shape anisotropies. We finally discuss the evaluation of FMR experiments on exchange coupled Ni/Cu/Co trilayer systems. Here, for the first time, it was possible to separate *quantitatively* the two main sources of the temperature dependence of IEC, namely magnetic excitations and spacer layer effects.

We propose our method as a general tool to properly include finite temperature in the evaluation of anisotropy effects and IEC in experiments yielding spin wave spectra.

MA 26.2 Thu 15:30 H10

Interlayer exchange interaction in local-moment systems: doping-induced switching of the coupling — •Jochen Kienert and Wolfgang Nolting — Festkörpertheorie, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

We present an RKKY study of the interlayer exchange coupling (IEC) between localized magnetic moments for layered structures of finite thickness. Whereas the main focus in the work on IEC has been put on the oscillatory spatial dependence using bulk-like spacers and considering large spacer thickness [1-3], we investigate the influence of reduced dimensionality, small separations of the magnetic layers, and charge carrier density. The interplay between the localized perturbing potential and confinement effects leads to a strong dependence of the interlayer interaction on the charge carrier density/doping. Most drastically, we observe a switching of the IEC tunable by interlayer hopping and band filling, and there is a complete magnetic interlayer decoupling for certain band occupations. The inclusion of correlations beyond perturbation theory in the Kondo lattice (or sd-, sf-, double exchange) model and their consequences for IEC are discussed.The dependence of the interlayer coupling on the charge carrier density is of current interest in diluted magnetic semiconductor heterostructures and in manganite bilayer systems.

[1] P. Bruno, J. Phys.: Condens. Matter **11**, 9403 (1999)
[2] M.D. Stiles, in: *Ultrathin Magnetic Structures III*, Springer 2005
[3] Y. Yafet, Phys. Rev. B. **36**, 3948 (1987)

MA 26.3 Thu 15:45 H10

Multiferroically composed exchange bias systems — •Pavel Borisov, Andreas Hochstrat, and Wolfgang Kleemann — Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Magnetoelectric (ME) antiferromagnetic Cr_2O_3, being exchange coupled to a ferromagnetic multilayer $(Pt/Co/Pt)_n$, $n \geq 1$, is treated as a multiphase multiferroic material with sophisticated multifunctional properties. It is shown that the exchange bias (EB) of the ferromagnetic hysteresis loop cannot only be controlled by the magnetic freezing field, $H_{\rm fr}$, but additionally also by an external electric freezing field, $E_{\rm fr}$, via the ME effect of Cr_2O_3. Apart from the well-known gradual shift on the magnetic field axis also complete switching from $-H_{\rm EB}$ to $+H_{\rm EB}$ is possible [1]. Based on the latter effect novel electrically controlled spintronic applications like ME MRAM (MERAM) and XOR logic cell (MEXOR) devices have been proposed [2]. These require a proper downscaling of the Cr_2O_3 component into the nanometer region. We report on recent progress in the preparation of thin films of chromium oxide and corresponding exchange bias systems. Thickness dependences of structural, magnetic and magnetoelectric properties of Cr_2O_3 thin films are discussed.

[1] P. Borisov *et al.*, Phys. Rev. Lett. **94**, 117203 (2005).
[2] X. Chen *et al.*, Appl. Phys. Lett. **89**, 202508 (2006).

MA 26.4 Thu 16:00 H10

Néel Temperature Shifts Due to Magnetic Proximity Effects in Ni/Fe_xMn_{1-x} Bilayers — •K. Lenz, S. Zander, and W. Kuch — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

We present a study of the ordering temperature of an ultrathin antiferromagnetic film in the proximity of a ferromagnetic layer. Magneto-optical Kerr effect measurements have been used to monitor the Néel temperature of a single-crystalline antiferromagnetic Fe_xMn_{1-x} film on Cu(001) in contact to a ferromagnetic Ni layer. The Néel temperature was determined from the discontinuity in the coercivity as a function of temperature. This ordering temperature decreases by up to 60 K if the magnetization axis of the ferromagnet is switched from out-of-plane to in-plane by deposition of a Co overlayer. As the application of the Co overlayer does not alter the antiferromagnet/ferromagnet interface, these results give clear evidence for a magnetic proximity effect in which the coupling to the ferromagnetic layer substantially influences the ordering temperature of the antiferromagnetic layer.

MA 26.5 Thu 16:15 H10

Orthogonal exchange bias directions in FeMn/NiFe microstructures — •Patrizio Candeloro[1], Georg Wolf[1], Stefan Trellenkamp[2], Christian Dautermann[2], Sandra Wolff[2], Helmut Schultheiss[1], Hans Nembach[1,3], and Burkard Hillebrands[1] — [1]FB Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Nano+Bio Center, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [3]NIST, Boulder, Colorado 80305

The exchange bias effect, arising in ferromagnetic(F)/ antiferromagnetic(AF) bilayers, can be described as an additional unidirectional anisotropy in the F layer. Recently several works have investigated the interplay between unidirectional and uniaxial anisotropies [1,2].

In this work we explore the interplay between exchange bias and twofold shape anisotropy. For this purpose, L-shaped and cross shaped FeMn/NiFe microstructures are fabricated by means of lithographic techniques. Exploiting the shape anisotropy, two orthogonal exchange bias directions are initialized inside the same microstructure via a zero-field cooling technique. MOKE measurements confirm the presence of two biasing directions, parallel to the arms of the structures. Furthermore an unusual angular dependence of the bias field and coercivity is observed, due to the interplay between the twofold unidirectional and shape anisotropies.

Financial support by the EU-RTN NEXBIAS is acknowledged.

[1] S. H. Chung et al., Phys. Rev. B 71 (2005) 214430
[2] S. Brück et al., Adv. Mater. 17 (2005) 2978

MA 26.6 Thu 16:30 H10

Analysis of effective magnetic anisotropies in exchange-coupled bilayer systems — •Daniel Markó[1,2], Jeffrey McCord[2], Rudolf Schäfer[2], Rainer Kaltofen[2], and Ludwig Schultz[2] — [1]Forschungszentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, Bautzner Landstr. 128, D-01328 Dresden — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, Helmholtzstraße 20, D-01069 Dresden

We have investigated the effective magnetic anisotropies in FM/AFM exchange-coupled $Ni_{81}Fe_{19}/Ir_{19}Mn_{81}$ bilayers with constant FM and varying AFM layer thickness. The samples have been prepared by either RF or DC magnetron sputtering to study the effect of different AFM grain sizes. In addition, the influence of thermally activated processes in the AFM layer has been investigated by annealing the samples with varying temperature, durations, and cooling rates. By using two magnetometric methods with different experimental time scales, a separation of different anisotropy contributions was possible. Quasistatic measurements yield the coercivity H_C and the exchange-bias field $H_{eb,eq}$. From the dynamic experiment the exchange-bias field $H_{eb,dyn}$, the rotatable anisotropy H_{rot}, the ferromagnetic resonance

frequency f_{res}, and the effective magnetic damping parameter α were determined. Moreover, magnetization processes have been observed by means of Kerr microscopy. Our experimental results were compared with models for exchange-bias and are in agreement with the models of Malozemoff, Fulcomer and Charap, and McMichael and Stiles.

MA 26.7 Thu 16:45 H10

X-ray magnetic circular dichroism and X-ray resonant magnetic scattering investigations of IrMn/NiFe exchange bias bilayer — •Florin Radu, Shrawan Mishra, Detlef Schmitz, Enrico Schierle, Hermann Dürr, and Wolfgang Eberhardt — BESSY GmbH, Albert-Einstein Strasse 15, D-12489,

We have employed Soft X-ray Magnetic Circular Dichroism(XMCD) and Soft X-ray Resonant Magnetic Scattering (XRMS) to study the magnetic interface of an antiferromagnet/ferromagnet (AF/F) exchange bias $Si(100)/SiO_2/Cu(5\ nm)/Ni_{81}Fe_{19}(7.5\ nm)/Ir_{20}Mn_{80}(2.5\ nm)/Cu(2.5\ nm)$ bilayer. The XMCD curves for the AF layer measured at the Mn L3 and L2 edges show a non-vanishing weak signal. In the positive magnetic saturation the Mn XMCD signal is different in magnitude and shape with respect to the one measured in the negative magnetic saturation. By comparison, the XMCD signals measured at the Ni L2 and L3 edges are equal for both magnetization orientations. This suggests that two types of uncompensated AF spins behave differently upon magnetization reversal. The frozen-in AF spins do not change sign upon magnetization reversal whereas the rotatable AF spins do follow the rotation of the F spins. Element specific reflectivity curves measured at the Mn L3 edge with circular polarized light for both helicities exhibits a deviation at the minima of the reflectivity curves. This might indicate that the uncompensated AF spins are localized at the F/AF interface. The depth profile can be retrieved after numerical analysis which is under consideration.

MA 26.8 Thu 17:00 H10

Ultrathin planar domain-wall in NiO/Fe_3O_4(110) — •Ingo Peter Krug[1], Franz Ulrich Hillebrecht[1], Helen Gomonaj[2], and Claus M. Schneider[1] — [1]Institut für Festkörperforschung IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Bogolyubov Institute for Theoretical Physics NAS of Ukraine, st.Metrologichna, 14-b, 03143, Kiev, Ukraine

Despite numerous experimental and theoretical studies, the details of exchange-mediated interface coupling and their consequences for technologically relevant effects like exchange bias are still not sufficiently understood. The work presented here is aimed at clarifying the magnetic proximity effect in both a ferrimagnetic (Fe_3O_4) and antiferromagnetic material (NiO), when brought into contact. The magnetic structure at the interface is altered by the interfacial exchange interaction, leading to an ultrathin planar domain-wall (3-4 ML) in the antiferromagnet as well as a small spin-reorientation in the ferrimagnet, as was observed by PEEM measurements using soft x-rays. The antiferromagnet couples spin-flop to the ferrimagnet, as is expected for the compensated (110) interface. These results are well described by a theoretical model based on continuum theory, also yielding an estimation of the interfacial superexchange coupling, which is in the order of 10 meV, close to the value in bulk NiO.

MA 26.9 Thu 17:15 H10

Magnetic depth profiling of an exchange bias system: x-ray resonant magnetic reflectivity of FeMn/Co. — •Sebastian Brück, Valeriano Ferreras-Paz, Eberhard Goering, and Gisela Schütz — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, D-70569 Stuttgart

X-ray Resonant Magnetic Reflectivity (XRMR) extends reflectivity by the x-ray magnetic circular dichroism as additional contrast thus providing element selective magnetic depth information. This makes it a perfect tool to investigate magnetic coupling effects in multi-layered systems. Such systems are for example ferromagnet-antiferromagnet bilayers which can show an exchange coupling between the two layers, the so called exchange bias effect. We present results on Co/FeMn bilayers which have been investigated by XRMR at the BESSY II synchrotron, Berlin. The bilayers were prepared by molecular beam epitaxy on a Cu (100) single crystal which ensures epitaxial growth of both FeMn (in the antiferromagnetic phase) and Co. The magnetic depth profile for room temperature and for 120 K is investigated with respect to changes of the exchange coupling.

MA 26.10 Thu 17:30 H10

Tuning exchange bias in thin Fe/CoO bilayers by introducing a Cr dusting layer — •Yuriy Yanson[1], Florin Radu[2], Kurt Westerholt[1], and Hartmut Zabel[1] — [1]Department of Physics, Ruhr-University Bochum, D-44780 Bochum, Germany — [2]BESSY GmbH, Albert-Einstein-Str. 15, 12489 Berlin, Germany

We investigated the change of the hysteresis loop shift and the coercive field of exchange biased Fe/CoO bilayers as a function of the Cr dusting layer thickness at the interface. Cr layers were grown at room temperature to ensure layer-by-layer growth. Magnetic properties of the system were measured using MOKE and SQUID. Above the Cr-thickness of one monolayer the coercive field and the exchange bias field decay exponentially as expected from the distance dependence of the exchange interaction. For submonolayer Cr-thickness, however, significant deviations of the behavior of the coercive field and the exchange bias field were observed. For that thickness range coercivity decays much more rapidly than the exchange bias field. This suggests that Cr atoms prefer to cover defect locations on the CoO surface and neutralize them. These defects are responsible for domain wall pinning and determine the coercivity. We show that by choosing certain growth temperatures and Cr dusting layer thicknesses one can tune the magnetic properties of the exchange biased system by setting the coercive field and the exchange bias field independently.

MA 26.11 Thu 17:45 H10

Effects of nonmagnetic dilutions in metallic antiferromagnets on exchange bias — •Marian Fecioru-Morariu[1], Syed Rizwan Ali[1], Cristian Papusoi[2], Martin Sperlich[1], and Gernot Güntherodt[1] — [1]Physikalisches Institut (IIA), RWTH Aachen, 52056 Aachen, Germany — [2]SPINTEC, CEA/CNRS, 38054 Grenoble Cedex 9, France

The effects of dilution of metallic antiferromagnets by nonmagnetic elements on the exchange bias are investigated in bilayers of $Co_{70}Fe_{30}/(Ir_{22}Mn_{78})_{1-x}Cu_x$ from a structural, magnetic and Monte Carlo simulation point of view. The nonmagnetic dilution by Cu throughout the volume of the antiferromagnet (AFM) $Ir_{22}Mn_{78}$ gives rise to an enhanced exchange bias field (H_{EB}). At the same time, lattice matched Cu dilutions give rise to a reduction of the AFM grain size and hence of the blocking temperature (T_B). The enhancement and maximum of H_{EB} as a function of Cu dilution is found to result from the competition of the increased number of uncompensated AFM moments and the reduction of T_B. The thermoremanent magnetization (M_{TRM}) of the diluted AFM-only, is also enhanced and decreases with increasing temperature in qualitative agreement with H_{EB}. This indicates the underlying close connection between H_{EB} of the FM/AFM bilayer and M_{TRM} of the AFM only. Our experimental results are in very good agreement with Monte Carlo simulations based on a Heisenberg model. The financial support through the EU Research Training Network NEXBIAS (Contract No. HPRN-CT-2002-00296) is gratefully acknowledged.

MA 26.12 Thu 18:00 H10

Magnetic order in exchange bias patterns in a continuous film — •Katharina Theis-Bröhl[1], Boris Toperverg[1], Ulrich Rücker[2], Jeffrey McCord[3], Andreas Westphalen[1], Volker Höink[4], Jan Schmalhorst[4], Tanja Weis[5], Dieter Engel[5], Arno Ehresmann[5], Maximilian Wolff[1], and Hartmut Zabel[1] — [1]Ruhr-University, 44780 Bochum — [2]Forschungszentrum, 52425 Jülich — [3]Leibniz Institute for Solid State and Materials Research, 01169 Dresden — [4]University of Bielefeld, 33615 Bielefeld — [5]University of Kassel, 34132 Kassel

Understanding and controlling competing exchange bias (EB) and exchange coupling effects is an important issue in the design of advanced AF-coupled hard disks with increasing storage density. For this purpose we used magnetic patterning by ion bombardment and designed a model system of alternating EB stripes. This creates an alternating frozen-in interfacial EB field competing with the external field in the course of re-magnetization. It was found that at magnetic fields applied along and at an angle with respect to the EB axis parallel to stripes the re-magnetization processes goes through a variety of different stages. Each of those magnetic states is quantitatively characterized via the comprehensive analysis of data on specular and off-specular polarized neutron reflectivity. The results are interpreted within the phenomenological model containing a few parameters which can readily be controlled designing systems with desired configuration of magnetic moments of micro- and nano-elements.

We acknowledge funding by DFG, SFB 491 and BMBF O3ZA6BC1.

MA 26.13 Thu 18:15 H10

Size dependent scaling of perpendicular exchange bias in nanostructures — •Ildico Guhr[1], Olav Hellwig[2], Gregory Malinowski[3], Sebastiaan van Dijken[3], and Manfred Albrecht[1] — [1]University of Konstanz, Dept. of Physics, Konstanz, Germany — [2]Hitachi San Jose Research Center, HGST, USA — [3]SFI Trinity Nanoscience Laboratory, Trinity College, Dublin, Ireland

A magnetic nanopattern created by depositing Co/Pd or Co/Pt multilayers onto 2D arrays of self-assembled nanoparticles [1] will be introduced. The magnetic nanostructures formed on top of the particles are in a magnetically exchange-isolated quasi-single-domain state. This nanoscale system is quite distinct from the classical geometries. Here the deposited film is extended over a wide region of the sphere and thus shows substantial curvature. The film thickness varies and so do the intrinsic magnetic properties most notable the magneto-crystalline anisotropy [2]. This magnetic nanopattern is used to study the size-dependent scaling of exchange bias in nanostructures. [Pd/Co]-CoO and [Pt/Co]-IrMn layers with perpendicular magnetic anisotropy were deposited onto different arrays of monodisperse PS nanospheres with a diameter ranging from 58 to 320 nm. Below the blocking temperature we find for both systems a strong increase of the exchange bias field compared to continuous films. Interestingly, the exchange bias field increases drastically with decreasing particle size and shows a strong dependence on the applied cooling fields and training.

[1] M. Albrecht et al., Nature Material 4, (2005) 203.
[2] T. Ulbrich et al., Phys. Rev. Lett. 96, (2006) 077202.

MA 27: Micro- and Nanostructured Magnetic Materials II

Time: Thursday 15:15–18:30 Location: H22

MA 27.1 Thu 15:15 H22

Magnetostatic interactions in patterned CoPt films embedded in a Permalloy matrix — •Sven Schnittger[1], Sebastian Dreyer[1], Christian Jooss[1], Sibylle Sievers[2], and Uwe Siegner[2] — [1]Institut für Materialphysik, Universität Göttingen — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

In order to study magnetostatic interactions in magnetic arrays, a two-dimensional pattern of hard magnetic (001) $L1_0$ CoPt squares embedded into a Permalloy matrix was fabricated. The structural and magnetic properties of arrays with different interelement distances were characterized by magneto-optical measurements, atomic force and magnetic force microscopy. The hard magnetic squares are not exchange-coupled to the soft magnet, yet a magnetostatic coupling was observed. This dipolar coupling modifies the domain structure of the Permalloy matrix. In periodic arrays of embedded CoPt squares, the stray-field interaction induces a symmetry-breaking, long-range ordered domain pattern in the soft magnetic matrix and short-range correlations of edge domains in adjacent CoPt squares.

S. Schnittger, S. Dreyer, Ch. Jooss, S. Sievers, and U. Siegner, submitted

MA 27.2 Thu 15:30 H22

Artifical domain structures in hybrid magnetic property patterned ferromagnetic thin films — •Jeffrey McCord[1], Christina Hamann[1], Rainer Kaltofen[1], Ingolf Mönch[1], Rudolf Schäfer[1], Ludwig Schultz[1], Jürgen Fassbender[2], Andreas Gerber[3] und Eckhard Quandt[3] — [1]IFW Dresden, Institut für Metallische Werkstoffe, D-01171 Dresden — [2]Forschungszentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, D-01314 Dresden — [3]Forschungszentrum Caesar, D-53175 Bonn

The magnetic response of ferromagnetic thin films is normally determined by the material properties like magnetic moment, uniaxial anisotropy, and coercivity. Here, we locally modify and tune the magnetic anisotropies and magnetic moment by laterally resolved modification of these parameters in ferromagnetic thin films systems. Periodic magnetic structures, consisting of regions of alternating anisotropy axis and strength, or varying magnetic moment are generated using photolithographic processing. Fundamentally new types of 'hybrid' materials are generated with intriguing magnetic domain configurations and magnetization reversal features, as for example a lateral exchange spring effect. The observed domain states have no counterpart in conventional thin films.

MA 27.3 Thu 15:45 H22

Imaging Switching Behavior of Magnetic Nanostructures by resonant X-Ray Holography — •Christian Günther[1], Stefan Eisebitt[1], Olav Hellwig[2], Andreas Menzel[1], Florin Radu[1], William Schlotter[3,4], Manfred Albrecht[5], Jan Lüning[4], and Wolfgang Eberhardt[1] — [1]BESSY m.b.H., Albert-Einstein-Str.15, 12489 Berlin, Germany — [2]Hitachi Global Storage Technologies, 650 Harry Road, San Jose, California 95210, USA — [3]SSRL, SLAC, 2575 Sand Hill Road, Menlo Park, California 94025, USA — [4]Department of Applied Physics, Stanford University, Stanford, CA 94305-4090, USA — [5]Department of Physics, University of Konstanz, 78457 Konstanz, Germany

We report on studies of the switching behavior of magnetic nanostructures via x-ray spectro-holography. On the basis of a coherent scattering experiment and using a nanostructured mask, it is possible to couple a reference beam to the object wave, which allows to solve the phase problem in a holographic approach. By scattering resonantly at the Co L edge we exploit XMCD contrast in order to image the switching behavior of magnetic multilayers on polystyrene spheres of 58 nm diameter. The magnetic caps on the spheres form exchange isolated magnetic islands with perpendicular anisotropy. The magnetic state of each nanosphere is imaged holographically as a function of applied field strength as well as of the direction of the applied field with respect to the anisotropy axis. We observe a reduction of the switching field with increasing included field angle. Furthermore, we find evidence for dipolar interactions between the nanoparticles.

MA 27.4 Thu 16:00 H22

Ferromagnetic Nanotubes by Atomic Layer Deposition — •Mihaela Daub, Mato Knez, Julien Bachmann, Ulrich Gösele, and Kornelius Nielsch — Max Planck Institute of Microstructure Physics, Halle, Germany.

Magnetic nanotubes are a new class of anisotropic ultifunctional nanoobjects. By coating the inner or outer nanotube wall with oxides or metals, a range of physical and chemical properties can be realized within a single nanoobject. Atomic Layer Deposition (ALD) is a very versatile technology for the conformal coating of Al2O3 membranes. Due to the low reactivity of molecular hydrogen and in comparison to the ALD deposition of metal oxides (0.5-2 Å/cycle), most processes for transition metals, e.g. Ni, Co, Cu, based on the reaction of hydrogen and a metal-organic precursor, are rather slow (0.03-0.2 Å/cycle). We propose a three-step process for the ALD deposition of transition metals. When the ALD cycle starts, the sample is exposed to the metal-organic precursor. After the removal of the excess recursor molecules, the chemisorbed precursor molecules on the sample surface are exposes to an oxidizing gas specious, e.g. ozone or water. In the final step of the ALD cycle the sub-monolayer of metal oxide is transferred into a pure metallic layer by a hydrogen exposure. The arrays of cobalt nanotubes exhibit a preferential magnetisation direction along the nanowire axis, whereas the Ni nanotubes show a nearly isotropic magnetic behaviour. The authors thanks the German Ministry of Education and Research (BMBF) for financial support (FKZ: 03N8701).

MA 27.5 Thu 16:15 H22

Switching behaviour of patterned SmCo thin films investigated by magnetic force and magneto optical microscopy — •Ulrike Wolff[1], Sebastian Dreyer[2], Aarti Singh[1], Christian Jooss[2], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, Helmholtzstr. 20, D-01069 Dresden, Germany — [2]Institute for Materials Physics, University Göttingen, Germany

$SmCo_5$ thin films with a strong magnetic anisotropy are prepared epitaxially on Cr buffered MgO(110) and MgO(100) substrates either with a unique alignment of the c-axis throughout the film or with two perpendicular orientations of the easy axes in the film plane [1]. For magnetic force microscopy (MFM) and magneto optical indicator film (MOIF)measurements, patterned elements were magnetized up to 4 T to adjust different remanent states and afterwards the domain structure was imaged. In the thermally demagnetized state magnetic con-

trast is visible on a length scale of 200 nm, which is about 4-5 times larger than the size of the individual grains. Thus, one has to describe the magnetic state by interaction domains originating from exchange or dipolar coupling of neighbouring grains. Upon applying an external field, the stray field contrast inside the element reduces and magnetic charges of opposite sign build up at the two edges of the squares perpendicular to the field direction. The domain structure resolved by MFM is compared with the quantitative stray field measurements obtained by MOIF.

[1] A. Singh et al, APL 87, 072505 (2005)

MA 27.6 Thu 16:30 H22

Domain structure of epitaxial magnetite films with weak magnetic coupling — •Ivo Knittel[1], Ulrike Wolff[2], Volker Neu[2], Louise McGuigan[3], Yang Zhou[3], Sunil Arora[3], Igor Shvets[3], and Uwe Hartmann[1] — [1]Fachbereich Experimentalphysik, Im Stadtwald, Geb. C6.3, 66041 Saarbrücken — [2]IFW Dresden, P.O. Box: 270116, 01171 Dresden — [3]CRANN, Trinity College Dublin, College Green, Dublin 2, Ireland

In epitaxial magnetite films, an unsual domain structure is produced by slight post-oxidation. The resulting domain pattern could be explained by application of the theory of weak stripe domains, presupposing a perpendicular anisotropy. The strong local magnetization disorder and dipolar magnetization reversal events have been related to antiferromagnetic coupling across antiphase boundaries (APB). We report on magnetic force microscopy imaging over the full magnetization curve, and measurements of the magnetic anisotropy by ferromagnetic resonance. Results are best described not by antiferromagnetic coupling, but by a weakened exchange across APB. Our epitaxial magnetite film with APB can therefore be regarded as a partly exchange-isolated nanocrystalline material.

MA 27.7 Thu 16:45 H22

Influence of nanocrystallinity on the critical behavior of Gadolinium — •Anne-Catherine Probst[1], Andreas Michels[1], Sharika Nandan Kaul[2], and Rainer Birringer[1] — [1]Technische Physik, Universität des Saarlandes, Saarbrücken, Germany — [2]School of Physics, University of Hyderabad, Hyderabad, India

The critical behavior of *single crystalline* Gadolinium (Gd) at the ferromagnetic-to-paramagnetic phase transition has been experimentally investigated by Srinath, Kaul, and Kronmüller [1] by means of high-resolution magnetic susceptibility and magnetization measurements. Their analysis established that Gd belongs to the uniaxial dipolar universality class with a Curie transition temperature $T_C = 292.77\,\mathrm{K}$ and an asymptotic critical regime $\epsilon = \frac{|T-T_C|}{T_C} \leq 10^{-3}$. This contribution reports on the influence of internal interfaces, in particular, in the form of grain boundaries on the critical behavior of *nanocrystalline* bulk Gd prepared by the inert-gas condensation technique. Within this context we present and discuss near-T_C magnetization data (ac-susceptibility, critical isotherm) on a nanocrystalline Gd sample with an average crystallite size of 15 nm.

[1] S. Srinath, S.N. Kaul, H. Kronmüller, *Phys. Rev. B* **59**, 1145 (1999).

MA 27.8 Thu 17:00 H22

Contribution moved to MA 7.6 — •XXX XXX —

MA 27.9 Thu 17:15 H22

On the analysis of results from x-ray magnetic reflectometry for magnetic multilayer systems — •Manfred Fähnle, Daniel Steiauf, Larry Martosiswoyo, Eberhard Goering, Sebastian Brück, and Gisela Schütz — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart

The resonant magnetic x-ray reflectometry is sometimes used to determine the orientations and the magnitudes of magnetic moments in crystallographically inequivalent layers of a multilayer system. We comment on the use of this method to investigate the magnitudes of the magnetic moments, in particular on the basic assumption that the layer-resolved magnetic contributions to the optical constants are proportional to the magnetic moments in these layers. Within the two-step model of magnetic x-ray dichroism it is discussed under what circumstances this assumption may be at least approximately valid. Results of explicit calculations within the framework of the ab-initio density functional electron theory are reported for the multilayer system (Co_2Pt_7).

MA 27.10 Thu 17:30 H22

Hard magnetic $L1_0$ - FePt thin films and nanopatterns — •Achim Breitling and Dagmar Goll — MPI für Metallforschung, Stuttgart, Germany

FePt is a promising candidate for ultra high-density data storage based on patterned media due to its large uniaxial magnetocrystalline anisotropy ($K_1 = 6.6 \cdot 10^6\ \mathrm{J/m^3}$) and its high corrosion resistance.

Therefore FePt thin films of thicknesses varying between 5 nm and 200 nm were sputter deposited on MgO(100) single crystal substrates. The ordered $L1_0$ phase can be obtained either directly by deposition on heated substrates or by post-annealing. Below a critical film thickness the films split into an accumulation of isolated particles of irregular shape resulting in large coercivities up to $\mu_0 H_C = 4.5$ T.

By using electron beam lithography patterned $L1_0$ FePt nanostructures have been produced. The influence of patterning on the magnetic properties of hard magnetic $L1_0$ FePt thin films has been investigated.

MA 27.11 Thu 17:45 H22

Current induced magnetization switching — a possible application for SP-STM? — •Stefan Krause[1], Luis Berbil-Bautista[1,2], Gabriela Herzog[1], Matthias Bode[1], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Department of Physics, University of California at Berkeley, USA

In present MRAM devices magnetic nanostructures are switched by magnetic fields. Due to their non-local character, however, cross-talk between adjacent nanomagnets may occur. An elegant method to circumvent this problem is magnetization switching by spin-polarized currents, as observed in GMR [1] as well as in TMR [2] devices. However, the layered structures of these devices do not provide any insight to the details of the spatial distribution of the switching processes.

Spin-polarized scanning tunneling microscopy (SP-STM) is a well-established tool to reveal the magnetic structure of surfaces with spatial resolution down to the atomic scale. Besides, SP-STM takes advantage of a perfect TMR junction consisting of a vacuum barrier separating two magnetic electrodes, which are represented by the foremost tip atom and the sample. This configuration excludes undesirable influences of layer intermixing and lattice imperfections which may play an important role in MBE-grown TMR junctions. We will report on our SP-STM experiments to switch the magnetization by the injection of a spin-polarized current.

[1] J. A. Katine *et al.*, Phys. Rev. Lett. **84**, 3149 (2000).
[2] Y. Liu *et al.*, Appl. Phys. Lett. **82**, 2871 (2003).

MA 27.12 Thu 18:00 H22

Untersuchung von magnetischen Nanopartikeln mittels temperaturabhängiger Magnetorelaxometrie — •Frank Schmidl, Markus Büttner, Thomas Müller, Stefan Prass, Peter Weber, Alexander Steppke, Christoph Becker und Paul Seidel — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Germany

Wir stellen eine Möglichkeit vor, magnetische Nanopartikel mittels Untersuchungen zur temperaturabhängigen Neel-Relaxation zu charakterisieren. Dabei wird das magnetische Signal der zu untersuchenden Probe von einem SQUID-Gradiometer zweiter Ordnung (Arbeitstemperatur 4,2 K) detektiert. Das ermöglicht die Messung der Proben in unabgeschirmter Laborumgebung. Die Probentemperatur kann dabei durch einen entsprechenden Antikryostaten im Bereich von 4,2 K bis 325 K variiert werden. Aus der gemessenen Temperaturabhängikeit des Relaxationssignals erhält man die Energiebarrierenverteilung der untersuchten Proben. Unter Einbeziehung weiterer magnetischer Messverfahren lassen sich damit, neben der Bestimmung von mittleren Teilchengrößen auch Aussagen über die Größenverteilung der Teilchen selbst gewinnen. Es werden Messungen an verschiedenartigen Materialsystemen sowie Fraktionen mit unterschiedlichen Teilchendurchmessern, die mit anderen physikalischen Verfahren analysiert wurden, vorgestellt. Die daraus resultierenden Möglichkeiten und Grenzen dieses Verfahrens für die Charakterisierung magnetischer Nanopartikel werden diskutiert.

Die Arbeiten werden im Rahmen des EU-Projektes Biodiagnostics gefördert.

MA 27.13 Thu 18:15 H22

Elektronischer Transport in Co Leiterbahnstrukturen mit Engstellen — •Patryk Krzysteczko[1] und Günter Dumpich[2] — [1]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld — [2]Experimentalphysik, Universität Duisburg-Essen, 47048 Duisburg

Der elektronische Transport in ferromagnetischen Nanokontakten wird im Hinblick auf das Auftreten des ballistischen Magnetowiderstandes (BMR) untersucht. Die Nanokontakte entstehen durch Engstellen in polykristallinen, T-förmigen Kobalt-Leiterbahnstrukturen, die mit Hilfe von hochauflösender Elektronenstrahllithografie und Elektronenstrahlverdampfung hergestellt werden. Es ist uns gelungen, die Breite des Nanokontaktes auf 6 nm zu minimieren. Der Einfluss des Nanokontaktes auf den elektronischen Transport wird zunächst qualitativ durch einen Vergleich unterschiedlich breiter Nanokontakte bestimmt. Hierbei zeigt sich, dass das Ummagnetisierungsverhalten der Leiterbahnstrukturen durch den anisotropen Magnetowiderstand (AMR) dominiert wird. Für eine quantitative Auswertung der Magnetowiderstandskurven wird die Anisotropiekonstante, die Koerzitivfeldstärke, der anisotrope Magnetowiderstandseffekt und der Engstellenwiderstand bestimmt. Alle diese Parameter zeigen keine eindeutige Abhängigkeit von der Breite des Nanokontaktes. Daher kann kein signifikanter, auf dem ballistischen Magnetowiderstandseffekt beruhender Beitrag zum Magnetowiderstandsverhalten der Untersuchten Leiterbahnstrukturen abgeleitet werden.

MA 28: Surface Magnetism

Time: Thursday 15:15–19:00 Location: H23

MA 28.1 Thu 15:15 H23

Magnetic Exchange Force Microscopy — •Uwe Kaiser, Alexander Schwarz, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg

Magnetic Exchange Force Microscopy (MExFM) is a new technique that was proposed to perform magnetic imaging of insulating or conducting surfaces with atomic resolution. It is based on conventional atomic force microscopy, but uses a magnetic tip, which is approached very closely to a magnetic sample in order to detect the magnetic exchange interaction. To prove the magnetic exchange interaction between the magnetic moments of tip and sample, surfaces with an antiferromagnetic arrangement of spins have been proposed as test systems.

Theoretical calculations indicate the feasibility of MExFM and several attempts have been made to perform such an experiment, however, no clear evidence for successful MExFM imaging has been reported so far.

We succeeded performing MExFM on the antiferromagnetic insulator NiO(001), using the dynamic mode with frequency modulation in the non-contact regime. The images show surface atoms with an additional atomic scale modulation originating from the row-wise antiferromagnetic arrangement of the Ni spins. We discuss experimental prerequisites to perform MExFM and present different tests to unambiguously assign the additional modulation to the magnetic exchange force.

MA 28.2 Thu 15:30 H23

Spin-Polarised Scanning Tunneling Spectroscopy as a tool to study magnetic excitations — •Timofey Balashov[1,2], Albert F. Takács[2], Wulf Wulfhekel[1,2], and Jürgen Kirschner[1] — [1]MPI für Mikrostrukturphysik, Weinberg 2, 06108 Halle — [2]Physikalisches Institut, Universität Kalrsuhe (TH), Wolfgang-Gaede Str. 1, 76131 Karlsruhe

Electron scattering processes play an important role in modern spin electronics. In magnetic materials electrons can scatter and create magnons. We used inelastic tunneling spectroscopy (ITS) to laterally resolve magnon excitations.

ITS was performed at 4K in ultra-high vacuum on paramagnetic (Cu) and ferromagnetic (Fe, Co) surfaces. While no inelastic peaks were observed on Cu, ferromagnets exibit inelastic peaks on the d^2I/dU^2 curve in the vicinity of the Fermi energy. We prove that these excitations are of magnetic origin by spin-polarised scanning ITS with ferromagnetic tips. The inelastic peak intensities depend on the relative orientation of tip and sample magnetisations, i.e on the spin of the tunneling electron, indicating that the observed excitations are indeed magnons. We demonstrate that the cross section of magnon creation in these materials is high enough to allow direct observation (≈27% for bulk Fe and ≈2% per monolayer of Co on Cu(111)). Mapping the magnon yield as function of the tip position allows lateral imaging of magnon excitations.

MA 28.3 Thu 15:45 H23

Spin- and angle-resolved inverse photoemission of h-BN/Ni(111) — •Karen Zumbrägel[1], Christian Eibl[1], Kathrin Wulff[1], Matthias Hengsberger[2], and Markus Donath[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität, Münster, Germany — [2]Physik-Institut, Universität Zürich, Switzerland

There is great interest in ultrathin insulating films on metal surfaces. One example, which has been already studied in some detail [1, 2], is boron nitride on Ni(111). A monolayer of hexagonal boron nitride (h-BN) is formed in a reaction of borazine $(HBNH)_3$ with the hot Ni(111) surface. The ferromagnetic Ni(111) surface as well as the bulk insulator boron nitride are well-studied systems. We added new information about the unoccupied electronic structure of h-BN/Ni(111) by performing spin- and angle-resolved inverse photoemission experiments. We detected four spectral features: A nickel bulk state at 0.1 eV, two BN-interface-states at 1.7 eV and 2.2 eV and an image-potential surface state at 3.0 eV above the Fermi level. For the interface states, we determined their spin splitting and their energy dispersion $E(k_{||})$ with the corresponding effective mass. Our results are discussed in the context of theoretical and experimental work available in the literature.

[1] W. Auwärter, T.J. Kreutz, T. Greber, J. Osterwalder, Surf. Sci. **429**, 229 (1999) [2] G.B. Grad, P. Blaha, K. Schwarz, W. Auwärter and T. Greber, Phys. Rev. B **68**, 085404 (2003)

MA 28.4 Thu 16:00 H23

YCo_2: Intrinsic magnetic surface of a paramagnetic bulk material — •Yury Dedkov[1], Clemens Laubschat[1], Sergii Khmelevskyi[2], Josef Redinger[2], Peter Mohn[2], and Michael Weinert[3] — [1]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Center for Computational Materials Science, Vienna University of Technology, Vienna, Austria — [3]Departament of Physics, University of Wisconsin-Milwaukee, P. O. Box 413, Milwaukee, Wisconsin 53201, USA

Here we report on results of a spin-resolved photoelectron spectroscopic (SRPES) study of YCo_2 thin films (150Å-thick) grown on a W(110) substrate. The films were prepared by co-deposition of stoichiometric amounts of Y and Co on to a clean W surface followed by thermal annealing leading to (2×2) overstructure with respect to W(110) in the low-energy electron diffraction pattern indicated formation of a structurally ordered YCo_2(111) surface. While no clear spin-asymmetry was observed for bulk sensitive SRPES data taken at $h\nu = 1253.6$eV, the surface sensitive SRPES data obtained at $h\nu = 21.2$eV photon energy revealed a clear spin-asymmetry probing the validity of the recent theoretical prediction [1].

[1] S. Khmelevskyi, P. Mohn, J. Redinger, and M. Weinert, Phys. Rev. Lett. 94, 146403 (2005).

MA 28.5 Thu 16:15 H23

Spin-dependence of Ce $4f$ hybridization in magnetically ordered systems: A spin-resolved photoemission study of Ce/Fe(110) — •Yury Dedkov[1], Mikhail Fonin[2], Yury Kucherenko[3], Serguei Molodtsov[1], Ulrich Rüdiger[2], and Clemens Laubschat[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [3]Institute for Metal Physics, National Academy of Sciences of Ukraine, 03142 Kiev, Ukraine

Spin- and angle-resolved resonant (Ce $4d \rightarrow 4f$) photoemission spectra of a monolayer Ce on Fe(110) reveal spin-dependent changes of the Fermi-level peak intensities. That indicate a spin-dependence of $4f$ hybridization and, thus, of $4f$ occupancy and local moment. The phenomenon is described in the framework of the periodic Anderson model by $4f$ electron hopping into the exchange split Fe $3d$ derived bands that form a spin-gap at the Fermi energy around the G point of the surface Brillouin zone.

MA 28.6 Thu 16:30 H23

Strong Even-Odd Effects in Non-collinear Magnetism of Nanochains — •Samir Lounis, Peter Dederichs, and Stefan Blügel — IFF, Forschungszentrum Jülich, D-52425 Jülich, Germany

Parity of number of adatoms in finite antiferromagnetic nanowires is shown to be crucial in predicting whether the magnetic ground state is non-collinear or collinear. Using the full-potential Korringa-Kohn-Rostoker method for non-collinear magnetism [1, 2, 3] and a Heisenberg model we show that nanochains with an even number of adatoms are always magnetically non-collinear while an odd number of adatoms leads under given conditions to a collinear ferrimagnetic ground state. Very large chains are predicted to be always non-collinear independently from the parity.

[1] S. Lounis, Ph. Mavropoulos, P. H. Dederichs, S. Blügel, Phys. Rev. B **72**, 224437 (2005).
[2] S. Lounis, M. Reif, Ph. Mavropoulos, L. Glaser, P. H. Dederichs, M. Martins, S. Blügel and W. Wurth, submitted to Phys. Rev. Lett., cond-mat/0608048.
[3] S. Lounis, Ph. Mavropoulos, R. Zeller, P. H. Dederichs and S. Blügel, submitted to Phys. Rev. B, cond-mat/0608481.

MA 28.7 Thu 16:45 H23

Low-spin phase in bi-atomic chains grown on vicinal Pt(997) surfaces — •Jan Honolka[1], Klaus Kuhnke[1], Tae-Yon Lee[1], Violetta Sessi[1], Pietro Gambardella[3], Sandra Gardonio[2], Diego Repetto[1], Axel Enders[1], and Klaus Kern[1] — [1]Max-Planck Institute for Solid State Research, Stuttgart, Germany — [2]Catalan Institute for Research and Advanced Studies, Barcelona, Spain — [3]Instituto di Struttura della Materia, Trieste, Italy

For 3d metal nanostructures on surfaces, magnetic properties such as the magnetic anisotropy and the magnetic exchange interaction are strongly dependent on the symmetry of coordination as well as the hybridization with the substrate atoms. In particular Fe nanostructures on Pt surfaces are of interest due to the strong hybridization of Fe-3d and Pt-5d states leading to large magneto-crystalline anisotropy energies observed for example in FePt L10 bulk structures. In this paper we show the results of extensive X-ray magnetic circular dichroism (XMCD) measurements of in-situ grown Fe stripes, which self-assemble along the steps of Pt(997) surfaces as described elsewhere[1]. We observe a dramatic decrease of the average spin-moment between monoatomic chains and bi-chains by about a factor 4. At the same time the magnetic easy axis rotates from the in-plane to the out-of plane direction. When the stripes become even larger in width the spin-moment recovers gradually and reaches Fe bulk values at coverages of ˜ 0.8ML. The results are discussed in terms of a possible antiferromagnetic coupling of the adjacent chains within the bi-chain structure depending on the interchain distance.

MA 28.8 Thu 17:00 H23

Two-dimensional antiferromagnetism of the Co monolayer on W(001) — •Paolo Ferriani[1], Andre Kubetzka[1], Stefan Heinze[1], Matthias Bode[1], Gustav Bihlmayer[2], Stefan Blügel[2], Kirsten von Bergmann[1], Oswald Pietzsch[1], and Roland Wiesendanger[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

The technological call for smaller devices boosted nanomagnetism. In surface magnetism, this led to the study of magnetic materials at mono- and submonolayer coverages. In this regime, the effect of the adjacent substrate on the magnetic properties can become crucial. E.g., it has been lately found that one monolayer (ML) Fe, the prototypical ferromagnet (FM), surprisingly exhibits antiferromagnetic (AFM) order on W(001) [1]. An even more complex nanoscale magnetic structure was discovered for the Fe ML on Ir(111) [2]. The question arises whether the magnetic order of other ferromagnetic metals can be changed as well if their ML is grown on strongly hybridizing substrates.

Here we give strong evidence of unexpected AFM order for 1 ML Co/W(001) by a combination of *ab-initio* calculations and scanning tunneling microscopy. The electronic structure close to the Fermi level of 1 ML Co/W(001) prevents a direct imaging of the AFM state, at variance with 1 ML Fe/W(001) [1]. However, the dI/dU spectrum and the dispersion of a surface state extracted by dI/dU maps of standing wave patterns fit the theoretical results for the AFM state, but not for the FM one. [1] A. Kubetzka *et al.*, Phys. Rev. Lett. **94**, 087204 (2005) [2] K. von Bergmann *et al.*, Phys. Rev. Lett. **96**, 167203 (2006).

MA 28.9 Thu 17:15 H23

Non-collinear magnetic order in one monolayer Fe on Ru(0001) — •Björn Hardrat[1], Paolo Ferriani[1], Marjana Ležaić[2], and Stefan Heinze[1] — [1]Institute of Applied Physics and Microstructure Research Centere, University of Hamburg, 20355 Hamburg, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

Two-dimensional (2D) antiferromagnetic systems on hexagonal lattices are expected to exhibit non-collinear order due to the inherent topological frustration of exchange interaction. We propose one ML Fe on Ru(0001) as a good candidate for the observation of a non-collinear magnetic structure in a 2D system. Experimentally, no long range ferromagnetic order was observed down to a temperature of 100K [1]. Surprisingly, density functional theory (DFT) calculations based on the local density approximation found a row-wise antiferromagnetic ground state [2]. We have performed calculations of the Fe ML on Ru(0001) in the generalized gradient approximation of the DFT, using the full-potential linearized augmented plane wave method, as implemented in the FLEUR code (www.flapw.de). We have explicitly taken non-collinear states such as spin-spirals into account. Among all solutions of the Heisenberg model, we obtain the Néel state with an angle of 120° between magnetic moments of adjacent atoms as the magnetic ground state. We have further determined the Heisenberg exchange constants and considered the effect of higer order spin interactions such as the biquadratic and four-spin interaction.

[1] Liu *et al.* PRB **41** 553 (1990) [2] Wu *et al.* PRB **44** 4449 (1991)

MA 28.10 Thu 17:30 H23

Growth and Magnetism of Fe on vicinal Au(111) — •Tobias Allmers and Markus Donath — Physics Institute, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

We investigated the growth and the magnetism of Fe on the Au(11 12 12) surface, which is vicinal to Au(111), by scanning tunnelling microscopy, spin- and angle-resolved photoemission and magneto-optical Kerr effect (MOKE). We observe the same growth behavior as on Au(788) in the range between 0.02 and 0.3 monolayers (ML) which has been investigated by Shiraki *et al.* [1]. The terraces are wider on Au(11 12 12) then on Au(788) but the reconstruction pattern is the same [2]. For higher coverage, the film topography shows similarities to Fe films grown on a vicinal Cu(111) surface [3]. In our MOKE investigations performed at 160 K we found that the paramagnetic limit of Fe on vicinal Au(111) is reached for a film thickness below 2 ML. We deduced the inelastic mean free path (IMFP) for Fe by photoemission. Our result is in agreement with other measurements for Fe on different substrates but disagrees with measurements on Au(788) [4]. In addition, we studied the magnetic $3d$ bands of Fe.

[1] S. Shiraki *et al.*, Appl. Surf. Science **237**, 284 (2004)
[2] S. Rousset *et al.*, J. Phys. Condens. Matter **15**, S3363 (2003).
[3] J. Shen *et al.*, Phys. Rev. **B 56**, 11134 (1997)
[4] H. Fujisawa *et al.*, Surf. Interface Anal. **37**, 124 (2005)

MA 28.11 Thu 17:45 H23

Large wave vector spin wave and dispersion in 2 monolayers Fe on W(110) by spin polarized electron energy loss spectroscopy — •Wen Xin Tang, Yu Zhang, Ioan Tudosa, Jacek Prokop, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik

Spin polarized electron energy loss spectroscopy (SPEELS) is a unique technique to probe the surface large wave vector spin waves [1]. Recently the spin wave dispersion of 8 monolayer (ML) fcc Co/Cu(001) and 8 ML hcp Co/W(110) were observed[2,3]. In this report, We present SPEEL-spectra of surface spin wave in 2 monolayers Fe deposited on W(110) at room temperature. The pronounced features of large wave vector spin wave peaks are detected. For the first time the full spin wave dispersion of an Fe film is obtained up to the surface Brillioun Zone boundary along the Fe[001] direction. The measurements are compared and discussed with the theoretical results known from the literature. The broadening of the widths of the spin waves peak is attributed to the Stoner damping.

[1] M. Plihal,D. L. Mills, and J. Kirschner, Phys. Rev. Lett. 82, 2579 (1999).
[2] R. Vollmer, M. Etzkorn,P.S. Kumar, H. Ibach, and J. Kirschner, Phys. Rev. Lett. 91, 147201 (2003).
[3] M. Etzkorn, P.S. Kumar, W. X. Tang, Y. Zhang and J. Kirschner,

Phys. Rev. B 72, 184420 (2005).

MA 28.12 Thu 18:00 H23

First-principles calculations of domain-wall orientations: Double-layer Fe on W(110) — •Marcus Heide, Gustav Bihlmayer, and Stefan Blügel — IFF, Forschungszentrum Jülich, Germany

A double layer of Fe atoms deposited on the W(110) surface exhibits ferromagnetic domains. These domains form long stripes that are predominantly aligned along a certain crystallographic direction. The mesoscopic shape (step edges, etc.) of the sample hardly influences the domain pattern [e.g. 1,2]. In order to understand this anisotropic behavior in more detail, we compare the energies of differently oriented domain walls with the aid of ab initio calculations. These calculations show, that the preferred wall orientation cannot be ascribed to the anisotropy of the spin stiffness. Instead, we identify the Dzyaloshinskii-Moriya interaction as the reason for the observed wall orientation. This interaction appears in structures without inversion symmetry, e.g. on surfaces. Thus, it is of particular importance in ultrathin surface films like in the studied system. This work is supported by DFG, grant BI 823/1-1.

[1] Bode et al., Phys. Rev. Lett. 89, 237205 (2002)
[2] Vedmedenko et al., Phys. Rev. Lett. 92, 077207 (2004)

MA 28.13 Thu 18:15 H23

Magnetic ordering and switching of iron porphyrin molecules mediated by ferromagnetic films — •H. Wende[1,2], M. Bernien[2], J. Luo[2], C. Sorg[2], N. Ponpandian[2], J. Kurde[2], J. Miguel[2], M. Piantek[2], X. Xu[2], Ph. Eckhold[2], W. Kuch[2], K. Baberschke[2], P.M. Panchmatia[3], B. Sanyal[3], P.M. Oppeneer[3], and O. Eriksson[3] — [1]Angewandte Physik, Fachbereich Physik, Universität Duisburg-Essen, Lotharstr. 1, D-47048 Duisburg, Germany — [2]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany — [3]Department of Physics, Uppsala University, Box 530, S-751 21 Uppsala, Sweden

We studied the structural and magnetic ordering of paramagnetic Fe-based porphyrin molecules on Ni and Co films on Cu(100) by means of X-ray absorption spectroscopy. Angle-dependent NEXAFS spectra at the C and N K-edges reveal that for a coverage of 1 ML the porphyrin molecules lie flat on the surface. With XMCD measurements at the Fe, Co and Ni $L_{2,3}$ edges we show that the Fe magnetic moment is always aligned parallel to the magnetization of the ferromagnetic layers. This allows to switch the Fe magnetic moment in all four cartesian directions relative to the molecular plane. The experimental results are combined with density functional theory to analyze the nature of the magnetic coupling. Thereby we show that the coupling is not due to a trivial direct exchange between the Fe atom and the Ni or Co films. The dominant mechanism is a 90 degree indirect exchange via the N-ligands yielding a magnetic polarization of the Fe. Supported by BMBF (05 KS4 KEB 5) and DFG (Sfb 658, Heisenberg-Programm).

MA 28.14 Thu 18:30 H23

Exchange-split surface state on Gd(0001) revisited — •Michael Budke, Juliet Correa, and Markus Donath — Physikalisches Institut, Wilhelm-Klemm-Str. 10, 48149 Münster

The behavior of the spin-split surface state on Gd(0001) close to the Curie temperature T_C has been controversially discussed: spin-resolved inverse photoemission (SR-IPE) has identified an empty minority state and a partially empty majority state [1]. While the majority state shifts to higher energies upon approaching T_C the minority state shifts to lower energies and seems to become partially occupied. This Stoner-like behavior is in contradiction to early results from spin-resolved photoemission (SR-PE), where the surface state shows up at 0.2 eV binding energy, exhibiting spin-mixing behavior upon approaching T_C [2]. In the last years a mixture of these two behaviors is becoming more and more accepted [3]. However, SR-PE does not see a peak crossing the Fermi energy E_F as seen before in IPE. To solve this discrepancy we performed SR-PE and -IPE measurements on a 30 ML Gd film grown on Y(0001). To exclude preparation-dependent effects, the measurements were performed in the same chamber on the same sample preparation. While the spectral features in PE do not strongly depend on the film preparation, the IPE spectral features show a significant dependence on the film quality. We present temperature-dependent measurements of a well-defined film to contribute to the understanding of the magnetism of the Gd(0001) surface. [1] Donath *et al.* Phys. Rev Lett. **77**, 5138 (1996) [2] Li *et al.* Phys. Rev. B **51**, 13895 (1995) [3] Fedorov *et al.* Phys. Rev. B **65**, 212409

MA 28.15 Thu 18:45 H23

Intrinsically nonmagnetic surface on a magnetic bulk: Sm(0001) vs. Eu/Gd(0001) — •Daniel Wegner and Günter Kaindl — Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin

Samarium is a lanthanide metal with unusual electronic structure: While the bulk is trivalent with five electrons in the 4f shell, the (0001) surface is known to be divalent (six 4f-electrons). According to Hund's rule, spin and orbital moment cancel each other. This opens the possibility of a nonmagnetic surface layer, whereas the trivalent bulk is antiferromagnetic. We performed cryogenic scanning tunneling microscopy and spectroscopy on a thin Sm(0001) film grown on a W(110) single crystal. STM reproduces the well known hexagonal surface reconstruction. STS reveals a so far unknown unoccupied surface state that is not exchange-split. We interpret this as evidence that the surface layer is nonmagnetic. We compare the results with the electronically similar monolayer Eu/Gd(0001) that is known to couple ferromagnetically to the Gd substrate. Also the divalent Eu monolayer exhibits an unoccupied surface state. However, this state is clearly exchange-split due to the ferromagnetic ordering of the surface layer with non-vanishing magnetic moment.

MA 29: Magnetic Measuring Methods / Sensors / Actuators

Time: Thursday 15:15–16:30 Location: H5

MA 29.1 Thu 15:15 H5

Interpreting magnetization from Faraday rotation in birefringent, magnetic media — •Simon Woodford, Andreas Bringer, and Stefan Blügel — Forschungszentrum Juelich, Juelich, Deutschland

The Faraday effect is an extremely useful probe of magnetization dynamics on an ultrafast scale. However, the measured Faraday rotation is difficult to interpret in birefringent media. We investigate the link between magnetization and Faraday rotation by solving Maxwell's equations in a magnetically-ordered, birefringent material. We find that the Faraday rotation can depend nonlinearly on the magnetization, meaning that symmetric magnetic oscillations may lead to asymmetric Faraday measurements. Furthermore, sample alignment becomes important — if the incident light is not polarized along a birefringence axis of the sample, the Faraday rotation may be strongly enhanced or weakened, and the interpretation of the magnetization amplitude may be wrong by an order of magnitude.

MA 29.2 Thu 15:30 H5

Three-dimensional Reconstruction of Magnetic Fields by Electron-Holographic Tomography — •Daniel Wolf[1], Petr Formanek[1], Hannes Lichte[1], and Ann Marie Hirt[2] — [1]Triebenberg Laboratory, Institute of Structure Physics, Technische Universität Dresden, D-01062 Dresden — [2]Institute of Geophysics, ETH-Hönggerberg, CH 8093 Zurich, Switzerland

The phase of an electron wave propagated through a magnetic material represents both the enclosed flux of the magnetic field and the electric potential. Off-axis electron holography combined with tomography allows reconstructing the electron wave in 3 D. At a lateral resolution of about 10nm, we measured the magnetic field in- and outside of magnetite crystals embedded in a magnetotactic bacterium Magnetospirillium gryphiswaldense. Holographic tomography is performed in the following steps: First, we record a tilt series of electron holograms between -60 and +60 degrees in 2 degrees steps. Second, we reconstruct the respective 2D-object exit waves from every electron hologram by usual Fourier analysis. Third, the 3D structure of the phase is built up by weighted back-projection. For separation of the magnetic part from the electric part, we record a second tilt series of

the same bacterium magnetized in opposite direction and reconstruct the 3D-wave accordingly. The difference of both 3D-phases contains only the magnetic phase shift produced by the object and, hence, we can determine the three components of the magnetic field. The DFG is kindly acknowledged for funding our Holographic-Tomography project.

MA 29.3 Thu 15:45 H5

A novel method for a measurement of magneto-optical effects in thin self-supporting foils — •T. Weber, H. Backe, W. Lauth, P. Kunz, and A. Sharafutdinov — Institut für Kernphysik, Universität Mainz, Germany

A novel interferometric method for the measurement of the magneto optical rotation (MOR) of rare earth elements and 3d transition metals as Fe, Co, Ni was developed at Mainzer Mikrotron MAMI. The strong absorption lines resulting from allowed dipole transitions between the $2p_{3/2}$ ($2p_{1/2}$) core states and empty 3d valence states are accompanied by a strong X-ray magnetic circular dichroism (XMCD) effect wich can be used to probe the magnetic properties of materials. The experiment arrangement consists of two collinear undulators and a grating spectrometer. The second undulator can be both, moved along and also be rotated around the electron beam axis. A magnetized foil placed between the undulators causes a phase shift and an attenuation of the oscillation amplitude. Due to the XMCD and MOR effect the coherent linear polarized light from the first undulator suffers a helicity dependent rotation and absorption resulting in elliptical polarized light. The second undulator acts as an analyzer, and no additional polarization state analyzer is required. The method has been validated by a measurement of $\Delta\delta(\omega)$ and $\Delta\beta(\omega)$ of the complex index of refraction $n\pm = (\delta_0 \pm \Delta\delta) + i\ (\beta_0 \pm \Delta\beta)$ at the $L_{2,3}$-absorption edges of nickel. This work has been supported by DFG under contract BA 1336/1-3.

MA 29.4 Thu 16:00 H5

Noise in anisotropic magnetoresistive sensor elements — •Thomas Heuer, Jörg Wolff, Haibin Gao, and Uwe Hartmann — Fachrichtung Experimentalpysik, Universität des Saarlandes, Postfach 151150, 66041 Saarbrücken

The field resolution of magnetometers based on anisotropic magnetoresistive (AMR) sensors is mainly limited by noise. Besides environmental factors, the main source of noise is the sensor element itself. Thus, knowledge of the mechanisms producing noise and the factors influencing it is essential.

The detector noise has been found to be strongly influenced by the peak magnitude of periodic magnetic field pulses perpendicular to the sensor's sensing direction ("flipping"). Other factors, as temperature and pulse width, also affect the sensor noise, albeit to a much lower degree. It is well established that domain wall-related processes, e.g. Barkhausen noise, are the primary source of noise in magnetoresistive sensors. Thus removing the domain walls by applying field pulses strong enough to fully saturate the sensor will result in a significant noise reduction.

Sensors of same type but from different batches have been found to exhibit considerable differences in their characteristics, with sensor noise varying by several orders of magnitude for identical conditions. It is believed that variations of the magnetic and electric properties of the magnetoresistive films play a key role. Thus detector noise is being examined with respect to its dependence on pulse parameters and sensor temperature in order to deduce differences in material properties.

MA 29.5 Thu 16:15 H5

High field cryogen free vibrating sample magnetometer — •Jeremy Good — 30 Acton Park Industrial Estate, London W3 7QE

Cryogenic Ltd. have extended their expertise in Cryogen Free Technology to the development of a High Field Vibrating Sample Magnetometer (VSM). The VSM allows measurements of the DC magnetic moment or AC magnetic susceptibility of a sample. Sensitivity is to 10-6 emu with a suitable averaging time. The standard temperature range is 1.6K to 325K with fields up to 18 Tesla. The VSM measures the magnetic moment by moving the sample between two pick-up coils at a frequency of 1 to 100Hz. As the sample moves into one of the coils, the flux through this coil increases and an e.m.f is generated.

It is now possible to operate the VSM without requiring expensive liquid helium to cool down the magnet and the insert. We offer a choice of cryocoolers with cooling powers to suit the application. The Gifford McMahon (GM) cycle cryocooler has the advantage of a greater thermodynamic efficiency and reliable operation in any orientation. The pulse-tube (PM) cryocooler is quieter, has a longer service interval and low servicing costs, but must operate in the vertical mode only.

MA 30: Invited Talk Margaret Ahmad

Time: Friday 10:15–10:45 Location: H10

Invited Talk MA 30.1 Fri 10:15 H10

Response of plants and animals to magnetic fields with cryptochrome, a field sensitive blue light photoreceptor — •Margaret Ahmad[1], Paul Galland[2], Thorsten Ritz[3], Roswitha Wiltschko[4], and Wolfgang Wiltschko[4] — [1]Univeristé Paris VI, Paris France — [2]Philipps-Universitaet, Marburg, Germany — [3]UC Irvine, Irvine, California USA — [4]J.W. Goethe Universitaet, Frankfurt, Germany

Birds are known to use a light-dependent magnetic compass that is based on a radical pair mechanism. The cryptochrome blue light photoreceptor of birds is postulated to form the radical pairs and therefore function as magnetic field sensor. Cryptochromes are found not only in birds, but also in higher plants, where they mediate a number of blue-light dependent developmental and growth responses. Upon absorption of blue light, cryptochrome 1 of Arabidopsis generates radical pairs, suggesting the possibility that cryptochrome-controlled responses in plants could also be affected by magnetic fields. Here we report an increased plant growth response to blue light in the model plant Arabidopsis thaliana in the presence of a 500 microT magnetic field. Therefore, the plants can respond to magnetic field in a way that depends on the function of the plant cryptochrome photoreceptor. These results support the possibility that magnetic field may be sensed by cryptochrome in migratory birds.

MA 31: Bio- and Molecular Magnetism

Time: Friday 11:00–12:45 Location: H10

MA 31.1 Fri 11:00 H10

Enhanced magnetocaloric effect in frustrated magnetic molecules with icosahedral symmetry — •Jürgen Schnack[1] and Johannes Richter[2] — [1]Universität Bielefeld, Fakultät für Physik, PF 100131, D-33501 Bielefeld — [2]Universität Magdeburg, Institut für Theoretische Physik, PF 4120, D-39016 Magdeburg

Antiferromagnetic finite-size spin systems with icosahedral symmetry constitute very interesting frustrated materials with rather unusual magnetic properties. Among such properties are jumps to the saturation magnetization in the cuboctahedron and the icosidodecahedron as well as metamagnetic phase transitions at zero temperature for instance in the icosahedron and dodecahedron. Some of these properties, for instance the large magnetization jump to saturation, are as well present in the Kagome or other lattice antiferromagnets. In this contribution we investigate the magnetocaloric properties of certain spin clusters with icosahedral symmetry that turn out to be interesting as well. The most striking feature is that the magnetocaloric effect is largely enhanced compared to bipartite antiferromagnets.

MA 31.2 Fri 11:15 H10

A first-principles DFT study of magnetic exchange paths in a BH_4^--bridged dinickel(II) complex — •Claudia Loose — TU-Bergakademie Freiberg, Institut for Theoretical Physics, Leipziger Str. 23, 09599 Freiberg, Germany

We studied the BH_4^--bridged dinickel(II) complex $[(L)Ni_2BH_4]^+$, with L the dinucleating hexaaza-dithiophenolate ligand by first-principles DFT as implemented in the all-electron NRLMOL code. Our calculations find in agreement with experiment a ferromagnetic coupling between the two Ni-atoms resulting in an $S = 2$ magnetic ground state of the complex. It is shown that exchange through the bridging BH_4^- contributes 2/3 of the total ferromagnetic exchange. This exchange proceeds through the p-states of BH_4^- which are energetically well aligned with the d-states of the magnetic ions. The remaining ferromagnetic exchange is partly derived from crossed interactions mediated by sulfur atoms from the ligand and partly by direct interaction of the two Ni^{2+}-ions. Replacing BH_4^- by halides increases the ferromagnetic coupling. On the other hand in case of isoelectronic CH_4 or noble gases the magnetic exchange path vanishes completely which supports the importance of the energetic position of the p-states. This opens the possibility to control the magnetic coupling by these p-states. Further, we predict that this complex will have a negative zero field splitting parameter D, so that it should eventually behave like a single molecule magnet. We would like to thank Prof. Kersting for providing the crystal data of the complex used in our studies.

MA 31.3 Fri 11:30 H10

Growth and electronic structure of tetracyanoethylene on noble metals studied by scanning tunneling microscopy — •Daniel Wegner, Ryan Yamachika, Yayu Wang, and Mike Crommie — Department of Physics, University of California at Berkeley, and Materials Science Division, Lawrence Berkeley National Laboratory, Berkeley, California, USA.

Tetracyanoethylene (TCNE) is a π-electron acceptor with a very strong electron affinity that easily forms charge-transfer complexes with other organic molecules and metals. We have performed STM and STS of isolated TCNE molecules and ordered sub-monolayer coverages on noble-metal surfaces in order to study the competition between intermolecule and molecule-substrate interactions, and the impact this might have on film-growth and electronic structure. HOMO and LUMO peaks were observed for single TCNE molecules on Ag and Au substrates using STS, but not for Cu substrates which react more strongly with TCNE. The spatial distribution of the TCNE HOMO, as observed in dI/dV maps, fits well with DFT calculations and shows that TCNE is in a negatively charged state on these metal substrates. dI/dV maps of ordered TCNE arrays indicate that neighboring TCNE molecules interact strongly with each other in some cases.

MA 31.4 Fri 11:45 H10

Magnetic properties of organometallic complexes studied by XMCD — •Paolo Imperia[1], Maria Benedetta Casu[2], Michael Martins[1], and Thomas Chassé[2] — [1]Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg — [2]Universität Tübingen, Institut für Physikalische und Theoretische Chemie, Auf der Morgenstelle 8, 72076 Tübingen

The magnetic properties of molecular based magnets can be tuned playing with the constituent blocks and growing parameters. Strategies used to achieve high magnetic moments imply the correct positioning of electronegative atoms, like oxygen and nitrogen, leading to large occupation probability by an unpaired electron, simultaneously achieving intermolecular magnetic order without destroying the intramolecular properties. To understand their magnetic properties the knowledge of the internal magnetic structure is of paramount importance and the key question, which element in the compound shows magnetic ordering and which orbital acquires a magnetic moment, needs to be answered. Absorption spectroscopy with its elemental specificity can help in resolving such problem. Here, we present and discuss first results of x-ray magnetic circular dichroism (XMCD) measurements done at the Mn and Ni L2,3 edges and N K edge of a selection of organic stable compounds like manganese tricyanomethanide (Mn[C(CN)3]2) which due to the tridentate nature of the C(CN)3 forms a triangular lattice and exhibits magnetic frustration, and MnNi(NO2)4(en)2 (en = ethylendiamine), a bimetallic chain compound where the ferromagnetically coupled Mn and Ni ions linked by NO2 molecules alternate.

MA 31.5 Fri 12:00 H10

Magnetic properties of high-spin tetranuclear Nickel(II) molecular complex — •Christian Golze[1], Rüdiger Klingeler[1,2], Bernd Büchner[1], Vladislav Kataev[1], Michel Goiran[2], Jean M. Broto[2], Harison Rakoto[2], and Berthold Kersting[3] — [1]IFW Dresden, Germany — [2]LNCMP Toulouse, France — [3]Institute for Anorganic Chemistry Leipzig, Germany

Electron spin resonance and magnetization data of a novel multicenter magnetic molecular complex are reported. In this compound two Ni(II) ions are coupled to a dimer via a diaminthio-bridge and a pair of dimers is coupled in a single molecule via a $\mu_{1,3}$ azide bridge. Thus a single molecule spin cluster of a quadrangular shape comprising four Ni(II) spins each with $S = 1$ is formed. Magnetization measurements in fields $< 52\,\mathrm{T}$ evidence a high-spin ground-state with $S = 4$. ESR has been measured on the polycrystalline sample to determine the zero field splitting of the spin-levels and the g-factor of the resonating spins. Moreover, we have been able to orient the crystallites of the powder in high magnetic fields due to the magnetic anisotropy of the complex. Hence it has been possible to compare experimental quasi single-crystal and powder-averaged ESR data with the theoretical model which yields an accurate determination of the parameters of the spin-Hamiltonian.

MA 31.6 Fri 12:15 H10

Electronic structure of Mn_{12}-complexes chemically grafted on Au(111) — •Mikhail Fonin[1], Sönke Voss[1], Michael Burgert[2], Yury Dedkov[3], Ulrich Groth[2], and Ulrich Rüdiger[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]Fachbereich Chemie, Universität Konstanz, 78457 Konstanz, Germany — [3]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden, Germany

Electronic properties of monolayers of Mn_{12}-complexes chemically grafted on the Au(111) surface have been studied in detail by means of scanning tunneling microscopy (STM) and spectroscopy (STS) as well as by x-ray absorption spectroscopy (XAS) and photoemission spectroscopy (PES). XAS measurements reveal a significant deviation of spectra obtained from molecular monolayers from those obtained from single crystals indicating a partial fragmentation of the Mn_{12} cores on the Au(111) surface. However, a large amount of Mn_{12}-molecules seems to retain their structural integrity upon surface deposition by using an appropriate combination of Mn_{12} cluster and substrate functionalization. The Mn 3d partial density of states for the occupied states were extracted from the resonant PES spectra of Mn_{12}-complexes whereas the unoccupied states near E_F were probed by STS. The obtained density of states within E_F shows a very good agreement with previously reported LDA+U calculations [1].

[1] D. W. Boukhvalov *et al.*, J. Electron Spectrosc. Relat. Phenom. **137-140**, 735 (2004).

MA 31.7 Fri 12:30 H10

High field level crossing studies on spin dimers in the low dimensional quantum spin system $Na_2T_2(C_2O_4)_3(H_2O)_2$ with T=Ni,Co,Fe,Mn — •Christopher Mennerich[1], Hans-Henning Klauss[1], Anja Wolter[1], Stefan Süllow[1], Jochen Litterst[1], Christian Golze[1], Vladik Kataev[2], Rüdiger Klingeler[2], Vladik Kataev[2], and Daniel Price[3] — [1]Institut of Condensed Matter Physics, TU Braunschweig, Mendelssohnstr.3, D-38106 Braunschweig, Germany — [2]Leibniz-Institute for Solid State and Materials Research IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [3]WestCHEM,Department of Chemistry, University of Glasgow, Glasgow, G12 8QQ, UK

We demonstrate the application of high magnetic fields to study the magnetic properties of low dimensional spin systems. We present a case study on the series of 2-leg spin-ladder compounds $Na_2T_2(C_2O_4)_3(H_2O)_2$ with T = Ni, Co, Fe and Mn. In all compounds the transition metal is in the T^{2+} high spin configuation. The localized spin varies from S=1 to 3/2, 2 and 5/2 within this series. The magnetic properties were examined experimentally by magnetic susceptibility, pulsed high field magnetization and specific heat measurements. The data are analysed using a spin hamiltonian description. Although the transition metal ions form structurally a 2-leg ladder, an isolated dimer model consistently describes the observations very well. All compounds exhibit magnetic field driven ground state changes which at very low temperatures lead to a multistep behaviour in the magnetization curves.

MA 32: Magnetic Imaging

Time: Friday 11:00–13:00 Location: H22

MA 32.1 Fri 11:00 H22

Simulation of Spin-Polarized Scanning Tunneling Microscopy Images of Nanoscale Non-Collinear Magnetic Structures — •Stefan Heinze — Institut für Angewandte Physik, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Spin-polarized scanning tunneling microscopy (SP-STM) allows to image magnetic structures with a resolution down to the atomic scale. The interpretation of such measurements is often not trivial and relies on an accurate description of the electronic and magnetic structure of the sample typically provided by density functional theory (DFT) calculations. However, such computationally demanding calculations can become prohibitive on the nanoscale.

Here, we use a simple approach based on the spin-polarized version of the Tersoff-Hamann model and the concept of atom superpositions to simulate SP-STM images [1]. It requires only the knowledge of the atomic scale magnetic structure. In spite of its simplifications, calculated SP-STM images of periodic collinear and non-collinear magnetic structures are in many cases in excellent agreement with experiments and DFT calculations. Especially for surfaces of chemically equivalent atoms the atomic scale SP-STM images are dominated by the magnetic structure and depend much less on the specific electronic structure. This suggests the application of the method to more complex non-collinear magnetic structures such as domain walls in antiferromagnets, spin-spiral states, spin glasses, or disordered states. Based on the model, we study SP-STM images of helical spin-spiral states in ultra-thin films. [1] S.Heinze, Appl. Phys. A 85, 407 (2006).

MA 32.2 Fri 11:15 H22

Strong increase in the perpendicular magnetic anisotropy by growing Fe/Gd thin films on nanospheres — •Edward Amaladass[1], Thomas Eimüller[2], Tolek Tyliszczak[3], Bernd Ludescher[1], and Gisela Schütz[1] — [1]Max-Planck-Institute for Metals Research, Heisenbergstr. 3, 70569 Stuttgart — [2]Ruhr-University of Bochum, Junior Research Group Magnetic Microscopy, — [3]Advanced Light Source, 1 Cyclotron Road, Berkeley, CA 94720, USA

A defined altering of the properties of magnetic materials is of great importance both from a fundamental and technological point of view. Fe/Gd multilayers are studied on flat silicon substrates and on self assembled silica nanospheres with diameters varying from 160 to 800 nm. A drastic change in the shape of the hysteresis loop, which is due to the strong increase in the perpendicular magnetic anisotropy, is observed by polar MOKE measurements for the film on nanospheres. The fact that the film is separated in isolated islands of equal size leads to a very pronounced squareness of the magnetization loop with a coercive field in the order of a few mT. The micromagnetic behavior was probed with a high lateral resolution by scanning transmission x-ray microscopy (STXM) and x-ray photoemission electron microscopy (X-PEEM) using x-ray magnetic circular dichroism (XMCD). STXM images taken in an in-plane magnetic field show different magnetization reversal behavior for the system on flat surface and on the nanospheres.

MA 32.3 Fri 11:30 H22

Imaging spin reorientation in Co/Pt multilayers on nanospheres — •Thomas Eimüller[1], Edward Amaladass[2], Till Ulbrich[3], Ildico Guhr[3], Tolek Tyliszczak[4], and Manfred Albrecht[3] — [1]Ruhr-University of Bochum, Junior Research Group Magnetic Microscopy — [2]Max-Planck-Institute for Metals Research, Stuttgart — [3]University of Konstanz, Department of Physics — [4]Advanced Light Source, LBNL, Berkeley, CA, USA

Co/Pt multilayers have been deposited on arrays of self-assembled polystyrene particles with diameters of 270 nm and 720 nm. The film thickness of the produced nanocaps varies in radial direction and so do the magnetic properties, most notable the magneto-crystalline anisotropy. Since the easy axis of a Co/Pt multilayer changes from parallel to perpendicular to the film plane below a critical thickness a spin reorientation transition (SRT) across the particle surface has been predicted. We used high resolution scanning transmission x-ray microscopy (STXM) and magnetic circular dichroism (XMCD) as a magnetic contrast to investigate this transition. The magnetization reversal of the nanocaps could be studied in detail by sweeping an applied in-plane magnetic field. The obtained results are compared with micromagnetic simulations.

This work is funded by the DFG through the SFB491, Nachwuchsgruppe N1, the SFB 513, the Emmy-Noether program and the country Baden-Württemberg via the Kompetenznetz "Magnetic Nanostructures".

MA 32.4 Fri 11:45 H22

Quantitative imaging of stray fields and magnetization distributions in hard magnetic element arrays — Sebastian Dreyer[1], •Christian Jooss[1], Jonas Norpoth[1], Sibylle Sievers[2], and Volker Neu[3] — [1]IInstitut für Materialphysik, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]Physikalisch-Technische Bundesanstalt,Bundesallee 100, 38116 Braunschweig — [3]IFW Dresden, Postfach 270016, 01171 Dresden

In order to determine magnetic stray field and magnetization distributions of thin magnetic patterns and arrays, we developed a new quantitatitive imaging technique based on magneto-optical indicator films (MOIF) combined with inverse magnetostatic methods and magnetic force microscopy (MFM). The method is applied to hard magnetic FePt and $PrCo_5$ films which exhibit out-of-plane and in-plane easy magnetization axes, respectively. The films are patterned with standard electron beam lithography into square shaped elements with sizes between 10μm and 500 nm. The magnetization values obtained from the MOIF method are in excellent agreement with those of SQUID measurements. Field, sensor and force transfer functions for quantitative imaging are derived for both imaging methods, representing a general concept for calibration of a MFM.

MA 32.5 Fri 12:00 H22

Complex surface spin structure of equiatomic NiMn alloy — •Chunlei Gao[1], Aimo Winkelmann[1], Arthur Ernst[1], Jürgen Henk[1], Wulf Wulfhekel[1,2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik Weinberg 2, D-06120 Halle, Germany — [2]Physikalisches Institut, Universität Karlsruhe, Wolfgang-Gaede Strasse 1, 76131 Karlsruhe, Germany

Chemically ordered equiatomic NiMn thin films were epitaxially grown on Cu(001) by co-evaporation with Mn and Ni atoms occupying alternating atomic sheets perpendicular to the surface. In our experiments, the structure of NiMn/Cu(001) was investigated with low energy electron diffraction (LEED) and scanning tunneling microscopy (STM). A p(2 × 2) reconstruction of the surface atoms was found with I-V LEED and atomically resolved STM measurements. The surface spin structure was studied with spin-polarized STM (Sp-STM) operating in the differential magnetic mode. The spin contrast arising from the different spin polarizations of Ni and Mn atoms was observed on the atomic scale. A strong voltage dependence of the spin unit cell was found which implies a complex noncollinear spin structure of the surface. Ab-initio calculations of the magnetic structure of NiMn thin films give a good agreement with the experimental observations.

MA 32.6 Fri 12:15 H22

Suggestion for a depth-resolved magnetic microscopy via the circular magnetic dichroism in two-photon absorption — •Jonas Seib and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

The 4π-confocal-STED-microscopy based on an two-photon absorption is a very powerful tool for the depth-resolved microscopy of non-magnetic materials like biological systems and semiconductor devices, with a vertical resolution of up to 30nm in the optical regime. It is suggested to use this technique in combination with the circular magnetic dichroism for a depth-resolved magnetic microscopy.

For a more quantitative underpinning of this suggestion we have performed calculations for the simplest possible model system which exhibits magnetic circular dichroism, i.e., a Dirac atom in an external magnetic field, yielding a dichroism also in two-photon absorption. It is discussed under which circumstances this type of microscopy is feasible, and it is suggested to investigate the threedimensional structure of closure domains in magnetic semiconductors by this technique.

MA 32.7 Fri 12:30 H22

Magnetic Imaging with the PolLux Soft X-ray Scanning Transmission Microscope at the SLS — •Jörg Raabe[1], George Tzvetkov[1,2], Uwe Flechsig[1], Rainer Fink[2], and Christoph

Quitmann[1] — [1]Paul Scherrer-Institut, CH-5232 Villigen, Switzerland — [2]Physikalische Chemie II, Universität Erlangen-Nürnberg, D-91058 Erlangen, Germany

Spectromicroscopy on length scales below 50 nm offers new experimental possibilities in the field of soft materials, for environmental research and for micromagnetic objects. The PolLux microspectroscope, is installed at a bending magnet beamline of the SLS planned to be a user friendly zone plate based microspectroscope. We will present first results from ferromagnetic systems imaged by using the x-ray magnetic circular dichroism as contrast mechanism at this recently installed instrument.

MA 32.8 Fri 12:45 H22

Spin-resolved photoelectron microscopy of magnetic nanostructures — •R. Ovsyannikov, F. Kronast, H. A. Dürr, and W. Eberhardt — BESSY GmbH, Albert-Einstein-Straße 15, 12489 Berlin, Germany

Magnetic nanostructures are at the heart of modern data storage technology. Typical dimensions of magnetic bits are in the sub-100nm region. In addition novel magnetoelectronics devices such as magnetic random access memory junctions are operated on the sub-μm scale. An understanding magnetic properties of such low-dimensional structures is only accessible to spectro-microscopy tools capable of appropriate lateral resolution. A new nanospectroscopy end-station at BESSY aims for that goal by combining a novel spin-resolved photoemission microscope (SPEEM) with a dedicated microfocus beamline with full x-ray polarization control. The end-station is equipped with a commercial PEEM (Elmitec GmbH) capable of 20nm spatial resolution for synchrotron light excitation. Two Mott polarimeters allow analysis of all three photoelectron spin components with sub-μm lateral resolution. The spin-polarization provides complementary information which is not accessible to the x-ray circular dichroism, e.g. the spin polarization at the Fermi level. Such information will be especially interesting for systems which are predicted to be half-metallic. In this talk we will present this unique instrument and give several commissioning results on soft magnetic alloys and nanostructures.

MA 33: Spindynamics / Switching III

Time: Friday 11:00–13:00 Location: H23

MA 33.1 Fri 11:00 H23

Time-resolved magneto-optics in the sub-ps regime with a modified Sagnac interferometer — •Andreas Goris, Andreas Bauer, and Günter Kaindl — Freie Universität Berlin, Institut für Experimentalphysik

In near-field imaging of magnetic nanostructures, the Sagnac interferometer has been shown to be a powerful tool for increasing image quality and magnetic contrast [1,2]. We have carried on this successful concept to the study of magneto-optical effects on the sub-ps timescale. The system studied was a 35-ML film of Ni/Cu(100) that was heated by the light pulse from a Ti:sapphire laser. The drop in magnetization of the film in less than 1 ps and the subsequent relaxation process was followed in real time, using a pump-probe setup with a modified Sagnac interferometer and - for comparison - a conventional crossed-polarizer setup.

[1] B.L. Petersen et al., Appl. Phys. Lett. **73**, 538 (1998).
[2] G. Meyer et al., Phys. Rev. B **68**, 212404 (2003).

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Present address of 1st author: Max-Born-Institut, Berlin

MA 33.2 Fri 11:15 H23

Spin Dynamics Probed by Femtosecond X-ray Pulses — •Christian Stamm, Niko Pontius, Torsten Kachel, Marko Wietstruk, Hermann A. Dürr, and Wolfgang Eberhardt — BESSY, Albert-Einstein-Str. 15, 12489 Berlin

When a ferromagnetic sample is highly excited by an intense fs laser pulse, the energy is first absorbed by the electronic system. Subsequently, energy is transferred to the lattice and spin subsystems on the fs time scale. This leads to a disordered spin system: ferromagnetic order is lost within several 100 fs. As the total angular momentum is conserved, the moment previously carried by the spins has to be transferred to other reservoirs on the same time scale.

Utilizing x-ray magnetic circular dichroism (XMCD), we observe the evolution of the magnetic moments as a function of time delay between laser pump and x-ray probe pulses. XMCD sum rules allow determining the contribution of spin and orbital moments separately. Our goal is to get new insight into the transfer mechanisms of energy and angular momentum during ultrafast demagnetization of thin ferromagnetic films.

The experiments were performed at the BESSY slicing source having a time resolution better than 150 fs. The available x-ray energies give access to x-ray absorption edges of the 3d transition elements and rare-earth elements (L and M edges, respectively), covering the important ferromagnetic elements Fe, Co, Ni, and Gd.

MA 33.3 Fri 11:30 H23

Ultrafast demagnetization dynamics in Fe, Co, and Ni films observed by THz emission spectroscopy — •Jan Nötzold, Tobias Kampfrath, Christian Frischkorn, and Martin Wolf — Freie Universität Berlin, Arnimalle 14, 14195 Berlin

The excitation of ferromagnetic thin films with ultrashort laser pulses results in an ultrafast drop of the magnetization, which is accompanied by the emission of electromagnetic radiation in the THz frequency range [1]. In our work, we excite 10nm thick ferromagnetic films of Fe, Co, and Ni with intense laser pulses ($\sim 1\,\mathrm{mJ\,cm^{-2}}$ fluence, 20fs duration, 800nm center wavelength) and measure the subsequently emitted radiation in the frequency window from 0.5 to 40 THz. The electric *field* is directly detected in the time domain via free-space electro-optic sampling. We discuss the origin of the emitted THz pulse and its relationship to the magnetization dynamics of the sample. No frequency components are found above 10 THz, which indicates that the laser induced demagnetization takes place on time scales larger than ~ 100 fs.

[1] E. Beaurepaire, G. M. Turner, S. M. Harrel, C. Beard, J.-Y. Bigot, and C. A. Schmuttenmaer, Appl. Phys. Lett. **84**, 3465 (2004)

MA 33.4 Fri 11:45 H23

Microwave assisted switching of micron-sized magnetic elements — •Georg Woltersdorf, Christian Back, and Dieter Weiss — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany

We use time resolved magneto optic Kerr effect microscopy to study the magnetic resonance and the switching of micron and sub-micron sized magnetic elements. The Permalloy microstructures have a uniaxial shape anisotropy and are prepared on a coplanar waveguide using e-beam lithography and dry etching. The thickness of the magnetic elements is kept below 2.5 nm to ensure that the single domain state is the ground state. In addition to the dynamic response the time resolved Kerr microscopy combined with synchronized microwaves allows one to measure static hysteresis loops on individual magnetic elements: in the experiment the synchronized microwaves are chopped and lock-in detection is used. The phase of the magnetic response to the microwaves changes by 180 degrees and hence the signal changes sign when the magnetization switches. Monitoring the signal as function of the applied magnetic field therefore allows one to measure the magnetic hysteresis for individual elements as small as 100 nm.

Hysteresis loops are measured as a function of microwave frequency and power. At large microwave powers these measurements show a strong reduction of the coercive fields. The effect is strongest at the resonance frequency of the magnetic element. At sufficiently large microwave powers the hysteresis loop collapses entirely.

MA 33.5 Fri 12:00 H23

Propagation of Spin-Waves in Ferromagnetic Thin Films — •Korbinian Perzlmaier, Georg Woltersdorf, and Christian Back — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstr. 31, 93040 Regensburg

In our aim to investigate the behaviour of spin-waves in interaction with different magnetic or topological potentials, we have observed the propagation of spin-waves and packets of spin-waves in a continuous 20nm thick $Ni_{80}Fe_{20}$ film upon microwave excitation. A magnetic

in-plane bias field is applied to the sample in the Damon-Eschbach (DE) or Magneto Static Backward Volume Modes (MSBVM) geometry. Time Resolved Scanning Kerr Microscopy (TRSKEM) is used to detect the out-of plane component of the magnetization. The propagation of DE- and MSBVM- modes was optically detected over a range of some 50μm. In doing so, we are able to directly determine the phase- and group velocity of spin-waves and spin-wave packets propagating in a ferromagnetic thin film.

MA 33.6 Fri 12:15 H23

Magnetization dynamics in rare earth doped NiFe films — •Matthias Kiessling[1], Georg Woltersdorf[1], Jan-Ulrich Thiele[2], Manfred Schabes[2], and Christian Back[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]Hitachi Global Storage Technologies, 3403 Yerba Buena Road, San Jose, CA 95135, U.S.A.

The influence of rare earth dopants on the damping parameter and the resulting possibility to control this parameter were investigated. In our experiments NiFe films were doped with Dysprosium, Holmium, Terbium, and Gadolinium. The magnetization dynamics of these rare earth doped films was mainly studied by means of ferromagnetic resonance (FMR) and network-analyzer ferromagnetic resonance.

It is demonstrated that the doping of a NiFe film by a small amount of rare earth elements (Holmium, Terbium and Dysprosium) greatly effects its magnetic relaxation rate. This additional damping is proportional to the doping level. Compared to the pure NiFe film it is possible to increase the damping parameter of the magnetic film by two orders of magnitude. On the other hand Gadolinium as a dopant has no influence on the damping parameter. For small dopant concentrations the in and out-of-plane FMR measurements at various frequencies can be well described by the same damping parameter. This is expected for the Gilbert damping term in the equation of motion. Therefore the increased damping can be attributed to an increased rate of transfer of angular momentum from the spin system to the lattice.

MA 33.7 Fri 12:30 H23

Linear and nonlinear phase accumulation of dipolar spin waves propagating in yttrium-iron-garnet films — •Thomas Schneider[1], Alexander A. Serga[1], Burkard Hillebrands[1], and Mikhail P. Kostylev[2] — [1]Fachbereich Physik, TU Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany — [2]School of Physics, M013, University of Western Australia, 35 Stirling Highway, Crawle, WA 6009, Australia

We report on phase resolved investigations of dipolar spin waves propagating in Yttrium-Iron-Garnet spin-wave waveguides. Microwave excited spin-wave packets with different intensities have been observed using space, time and phase resolved Brillouin light scattering spectroscopy. The phase sensitivity of our system allows the measurement of the phase profiles (i.e., the time dependent phase difference between the exciting microwave signal and the spin wave at any given point) and thus the phase accumulation over the complete propagation range. Changing the power of the input microwave signal gives the possibility to excite either linear or nonlinear spin-wave pulses. In the latter case we were able to investigate the influence of the spin-wave amplitude on the spin-wave phase. Nonlinear phase splitting between the peak and the tail of nonlinear spin-wave pulses was observed. An interpretation of this effect is presented.

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MA 33.8 Fri 12:45 H23

Ultrafast Spin Dynamics in GaMnN — •Nils Janssen[1], Tim Thomay[1], Markus Beyer[1], Ulrich Rüdiger[1], Mario Gjukic[2], Tobias Graf[2], Martin Brandt[2], and Rudolf Bratschitsch[1] — [1]Fachbereich Physik und Centrum für Angewandte Photonik, Universität Konstanz, D-78457 Konstanz, Germany — [2]Walter Schottky Institut, Technische Universität München, D-85784 Garching, Germany

We perform time-resolved Faraday rotation measurements on epitaxial GaN layers doped with Manganese in concentrations of the order of 10^{20} cm^{-3}. Optical absorption and electron spin resonance studies indicate that the majority of Manganese is built into the GaN host crystal either as Mn^{3+} ions or as "Mn^{2+} + hole"complexes.

With circularly polarized ultraviolet pump pulses resonant to the fundamental bandgap, we excite spin-polarized electrons and holes. The spin of these carriers precesses in an externally applied transverse magnetic field. The time-dependent magnetization is detected via polarization rotation of a delayed probe pulse transmitted through the sample. By slightly tuning the excitation energy above the absorption edge, we are able to selectively address Mn states, most likely resulting in the formation of "Mn^{2+} + hole"complexes. These data show a strongly temperature dependent g-factor.