

MA 19 Mikro- und nanostrukturierte magn. Materialien I

Zeit: Montag 10:30–13:00

Raum: TU EMH225

MA 19.1 Mo 10:30 TU EMH225

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

The remagnetization process of a remanent magnetic multi-bilayer system with a gradient in the bilayer thicknesses was studied by reflectivity and off-specular scattering of polarized neutrons with polarization analysis performed on the HADAS reflectometer located at the research reactor FRJ-2 in Jülich. From the specular reflectivity, it is figured out that, by increasing the external magnetic field $\mu_0 H$, the magnetizations inside the ferromagnetic (FM) layers orient sequentially along $\mu_0 H$, from the bottom-most, thinnest FM layer to the top-most, thickest FM layer. This thickness dependency of the coercive field can be related to an evolution of the grain size. Also, the net magnetizations inside the FM layers that have not yet flipped have reduced magnitude with respect to their saturation value. The off-specular data lead to a more accurate description of the magnetization arrangement. They reveal that the reduced net magnetizations are a consequence of lateral fluctuations of both components of the magnetizations, perpendicular and parallel to $\mu_0 H$. Those interpretations are confirmed by simulations of the data in the framework of the Distorted Wave Born Approximation (DWBA).

MA 19.2 Mo 10:45 TU EMH225

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

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

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

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

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

MA 19.3 Mo 11:00 TU EMH225

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

Unser Ziel ist die Untersuchung der Dimensionsreduzierung magnetischer Halbleiter. Magnetische Nanostrukturen mit wohldefinierter Größe im Bereich von 2 bis 12nm können innerhalb hochgradig geordneter, mesoporöser SiO_2 Strukturen mit scharfen Porenverteilungen synthetisiert werden. Unter Verwendung der Elektronenspinresonanz (ESR) präsentieren wir die Veränderung des magnetischen Verhaltens solcher MnS Nanostrukturen und zeigen die weitgehende Unterdrückung des Ma-

gnetismus in den kleinsten Strukturen im Vergleich zum bulk Material. Zu den beobachteten Effekten zählen die Verschiebung des Curie-Weiss-Parameters in die Nähe von $\theta = 0\text{K}$, sowie das Verschwinden der antiferromagnetischen Ordnung, sichtbar in ESR-Linienbreite und Intensität. Optische Messungen komplettieren die Ergebnisse, indem sie das Nachlassen langreichweitiger Ordnung dokumentieren, wohingegen die Nahordnung erhalten bleibt.

MA 19.4 Mo 11:15 TU EMH225

Schaltverhalten amorpher, nanostrukturierter CoFeB-Elemente — ●N. WIESE^{1,2}, T. DIMOPOULOS¹, M. RÜHRIG¹, J. WECKER¹, H. BRÜCKEL² und G. REISS² — ¹Siemens AG Corporate Technology, CT MM 1, Paul-Gossen-Str. 100, 91052 Erlangen — ²Universität Bielefeld, Nano Device Group, Universitätsstr. 25, 33615 Bielefeld

Magnetische Tunnelbarrieren mit Elektroden aus amorphem $\text{Co}_{60}\text{Fe}_{20}\text{B}_{20}$ zeigen hohe TMR Effekt-Amplituden von mehr als 50%, eine erhöhte thermische Stabilität des TMR Effektes und sehr gute weichmagnetische Eigenschaften.[1] Sie eignen sich daher als Alternative zu Elektroden aus polykristallinen Materialien (wie NiFe, CoFe) in magnetischen Tunnelbarrieren.

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

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

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

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

MA 19.5 Mo 11:30 TU EMH225

Structure and Magnetic Properties of Nanocrystalline $\text{Fe}_{100-x}\text{Pt}_x$ Powders — ●JULIA LYUBINA, OLIVER GUTFLEISCH, KARL-HARTMUT MÜLLER, and LUDWIG SCHULTZ — IFW Dresden, Institute for Metallic Materials, P.O. Box 270016, D-01171 Dresden, Germany

The ordered tetragonal L_{10} FePt phase has excellent intrinsic magnetic properties ($K_1 = 6.6 \text{ MJm}^{-3}$, $J_s = 1.43 \text{ T}$, $T_c = 750 \text{ K}$), good mechanical properties and corrosion resistance. The combination of these unique properties makes it interesting both from the scientific and application points of view. Here we report on the preparation of nanocrystalline hard magnetic $\text{Fe}_{100-x}\text{Pt}_x$ ($x = 39.5; 45; 50; 55; 60$) powders by mechanical ball milling at 77 K followed by annealing (450 °C). According to Rietveld refinement of x-ray data, annealed powders contain a mixture of the highly ordered L_{10} FePt and disordered cubic A1 FePt, as well as Fe_3Pt and FePt_3 . The amount of the A1 FePt phase remains almost unchanged (6-10 vol. %), whereas the fraction of the L_{10} FePt, Fe_3Pt and FePt_3 phases varies with Pt concentration x . Coercivity $\mu_0 H_c$ was found to increase with Pt concentration from 0.33 T ($x = 39.5$) to 0.95 T ($x = 60$), whereas remanence J_r reduce: from 0.8 T ($x = 39.5$) to 0.4 T ($x = 60$). In Fe-rich powders exchange-spring behaviour was observed. The evolution of magnetic properties is discussed in terms of phase composition, distribution of the phases and degree of chemical order.

MA 19.6 Mo 11:45 TU EMH225

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

The L_{10} transition temperatures for chemical ordering in FePd and FePt intermetallic alloys may be substantially reduced by ion irradiation [1]. Alignment of the strong magnetic axis normal to the surface layer was achieved. Recently, we showed via kinetic Monte Carlo simulations [2] that (i) ion-beam-induced reduction of the L_{10} transition temperature may be understood in terms of vacancy-assisted atomic ordering and

that (ii) superstructure alignment results from a small initial directional short range order (DSRO). In this contribution (i) we present systematic studies of the ion-irradiation-induced L_{10} ordering in thin layers, (ii) we predict the evolution of chemical ordering in layers with well-designed initial DSRO, (iii) we study in non-stoichiometric alloys (e.g. Fe_{1-x}Pd_x) the competition of L_{10} ordering (FePd) with L_{12} ordering (Fe₃Pd), and (iv) we evaluate the influence of interfaces in nanostructures on the ordering process.

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

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

MA 19.7 Mo 12:00 TU EMH225

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

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

MA 19.8 Mo 12:15 TU EMH225

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

Exchange biased CoFe/MnIr films are magnetically patterned with He-ion bombardment into two magnetic regions (stripes) with oppositely aligned exchange bias. The longitudinal magnetization reversal occurs through head-on domain wall motion and partial penetration of magnetization from neighboring stripes. It is highly asymmetric and involves ripple-like domain structures and incoherent rotation of magnetization. This was measured using Kerr microscopy and polarized neutron reflectivity methods. For the quantitative analysis of our data we applied a theoretical model using the Distorted Born Wave Approximation which provides us with a set of parameters quantifying the magnetization arrangement in the magnetic pattern. This all together gives access to a detailed understanding of the magnetization arrangement and the magnetization reversal. We acknowledge funding by DFG, SFB 491 and BMBF 032AE8BO.

MA 19.9 Mo 12:30 TU EMH225

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

The Fe_{65.5}Cr₄Mo₄Ga₄P₁₂C₅B_{5.5} bulk metallic glass (BMG) exhibits good soft magnetic properties. However, the maximum achievable diam-

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

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

MA 19.10 Mo 12:45 TU EMH225

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

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

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

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

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