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 contrast 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 ($K_1 = 6.6 \cdot 10^6$ 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.