MA 16: Micro- and Nanostructured Magnetic Materials II

Time: Wednesday 10:15–12:45 Location: H23

MA 16.1 Wed 10:15 H23

Preparation and magnetic characterization of electrodeposited Fe and FePd nanowires — •Veronika Haehnel[1,2], Heike Schlörb[1], Sebastian Fähler[1], and Ludwig Schultz[1,2] — [1]IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany — [2]TU Dresden, Faculty of Mechanical Engineering, 01062 Dresden, Germany

Periodic arrays of high aspect ratio magnetic nanowires deposited in self-organised nanoporous templates have recently attracted much attention in fundamental and applied research. Scientific interest focuses on these low dimensional nanostructures, as significant changes in terms of chemical and physical properties compared to bulk material are expected. Fe nanowires are of particular interest due to their high magnetization promising high shape anisotropy. FePd alloys have unique magnetic and material properties. Around the composition $Fe_{70}Pd_{30}$ they are interesting candidates with regard to the magnetic shape memory effect (MSM). Preparing MSM-active nanowires, magnetically driven nanoactuators are conceivable.

In this study we show Fe nanowires electrodeposited into nanoporous alumina membranes. The electrodeposition process was optimized in order to approach an ideal behaviour of smooth and continuous Fe nanowires. Thereon saturation polarization and an anisotropy field up to 70% compared to pure Fe were measured. By Mössbauer spectroscopy and magnetic measurements we have found that shape anisotropy aligns the preferential magnetization axis along the long axis. Furthermore, we show the first results of structural and magnetic characterization of electrodeposited FePd nanowires.

MA 16.2 Wed 10:30 H23

Magnetic Properties of Fe Wires on Vicinal Cu(111) at Finite Temperatures — •Hossein Hashemi[1], Guntram Fischer[1], Wolfram Hergert[1], Valeri S. Stepanyuk[2], Hasan Sadat Nabi[3], and Rossitza Pentcheva[3] — [1]Department of Physics, University of Halle, Von-Seckendorff-Platz 1, 06120 Halle, Germany — [2]MPI for Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [3]Departments of Earth and Environmental Sciences, University of Munich, Theresienstrasse 41, 80333 Munich, Germany

Vicinal surfaces on metals are very suitable templates to grow one-dimensional nanowires. It is known that Fe nanostripes grow on the upper terrace of a stepped Cu(111) surface. Mo, Guo et al. [1,2] have shown that, Fe adatoms form an atom chain embedded into the Cu substrate behind a row of Cu atoms at the descending step. Then a second chain of Fe atoms is formed on top of the embedded Fe chain. In this work, density functional theory (DFT) is applied to describe the structural and magnetic properties of Fe chains and wires consisting of two Fe chains embedded in the Cu(111) surface. We determine both the direct exchange interaction within the Fe wires as well as the indirect exchange interactions between parallel Fe chains as a function of the interchain distance. Furthermore, the magnetocrystalline anisotropy energy is calculated. Exchange interactions and anisotropy extracted from the ab initio calculations are used in a classical Heisenberg model. Monte Carlo simulations are done to investigate the finite temperature properties of the systems. [1] Yina Mo, et al., PRL 94, 155503 (2005). [2] J. Guo et al., Phys. Rev. B 73, 193405 (2006).

MA 16.3 Wed 10:45 H23

Switching of individual Fe_3C nanowires with transverse magnetization — •Matthias U. Lutz, Uhland Weissker, Franziska Wolny, Markus Löffler, Thomas Mühl, Albrecht Leonhardt, Rüdiger Klingeler, and Bernd Büchner — Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Germany

Iron carbide nanowires contained within a multiwalled carbon nanotube feature a transverse remanent magnetization where the magnetization vectors are perpendicular to the long wire axis. TEM studies on the CVD-grown nanotubes reveal that the fillings are single crystal Fe_3C nanowires with the crystallographic b-axis along the hollow of the tube, causing the magnetic easy c-axis to be perpendicular to the long axis of the wire. Comparing the magneto-crystalline and the shape anisotropy indicates that the former dominates. The two anisotropy contributions are orthogonal, resulting in a weak effective anisotropy favouring a transverse magnetization. The remanent magnetization as well as the switching behaviour are studied with the aid of a hr-MFM with an in-situ perpendicular magnetic field. The Fe_3C wires switch at around 30 mT. The mechanism of magnetization reversal is discussed along with possible applications of the system.

MA 16.4 Wed 11:00 H23

Spin-Wave Interference in Rolled-Up Permalloy Microtubes — •Felix Balhorn, Sebastian Mansfeld, Andreas Krohn, Simon Jeni, Jesco Topp, Wolfgang Hansen, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg

Strained semiconductor bilayers can be utilized in order to fabricate rolled-up mictrotubes [1, 2]. We have used these structures as templates to roll up permalloy films with multiple rotations to form Rolled-Up Permalloy Microtubes (RUPTs) [3]. Here, we investigate the spin-wave spectra of RUPTs in axial magnetization geometry by means of broadband microwave absorption spectroscopy. The RUPTs show up to four resonances which exist in the experimentally accessible field range. The resonances are attributed to constructively interfering Damon-Eshbach like spin waves propagating around the circumference of the tube. This interpretation is confirmed by fitting the experimental data according to an analytical model. The fit matches the experimental data almost perfectly if we express the dipolar coupling between the magnetic layers by an effective layer thickness and allow for an anisotropy field. This field considers demagnetization effects caused by the curved structure of a RUPT [3] and can be measured independently in hard axis configuration. We acknowledge financial support by the SFB668, GrK 1286, and the Cluster of Excellence *Nanospintronics.*

[1] V. Y. Prinz et al., Physica E **6**, 828 (2000); [2] O. G. Schmidt, and K. Eberl, Nature **410**, 168 (2001); [3] S. Mendach et al., Appl. Phys. Lett. **93**, 262501 (2008)

MA 16.5 Wed 11:15 H23

Saturation magnetization modulated stripes embedded in a ferromagnetic matrix — •Thomas Strache[1], Sebastian Wintz[1], Mohammed Abdul Basith[2], Norbert Martin[3], Monika Fritzsche[1], Ingolf Mönch[3], Maciej Oskar Liedke[1], Michael Körner[1], Daniel Markó[1], Jörg Raabe[4], Stephen McVitie[2], Jeffrey McCord[3], and Jürgen Fassbender[1] — [1]Forschungszentrum Dresden-Rossendorf, Dresden, Germany — [2]University of Glasgow, Glasgow, U.K. — [3]Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden, Germany — [4]Swiss Light Source, Paul Scherrer Institut, Switzerland

Lateral patterning of thin magnetic films allows structuring on dimensions below certain intrinsic length scales like the domain wall width. By means of magnetic patterning using local ion irradiation periodic patterns of stripes with alternating saturation magnetization value were created in a ferromagnetic $Ni_{80}Fe_{20}$ matrix. The domain configuration during magnetization reversal was investigated using Kerr microscopy, scanning transmission x-ray microscopy, as well as Lorentz microscopy. The reversal mechanisms in the stripe panels are influenced by the domain configuration of the surrounding film. Starting from 1 μm stripe width, changes in the micromagnetic behavior with respect to decreasing width are investigated. Special emphasis is put on the formation of 180° walls between adjacent stripes with different saturation magnetization, on the orientation of the magnetization inside the stripes with respect to the stripe axis orientation, as well as on the transition of the patterned material to an effective medium.

MA 16.6 Wed 11:30 H23

Two distinct magnetic switching events in core-shell nanowires with fully controlled geometric parameters — Yuen Tung Chong, Detlef Görlitz, Stefan Martens, Kornelius Nielsch, and •Julien Bachmann — Institut für Angewandte Physik, Universität Hamburg

A preparative strategy that combines atomic layer deposition (ALD) with electrodeposition in a porous template (anodic alumina) enables one to arrange a nickel core with an iron oxide shell coaxially in biphasic magnetic nanowires. The wires have large aspect ratios (>100), they are ordered in parallel arrays, and in each of them, a non-magnetic silica spacer layer physically separates core from shell. The thickness of each layer is adjustable between 3 and 30 nm or so, thus, given a fixed outer diameter of 150 nm, the core diameter may be varied between approximately 50 and 100 nm.

In the presence of a sufficiently thick non-magnetic spacer, core and shell revert their magnetization separately from each other, and the switching fields are determined mostly by the respective geometric parameters. The two distinct reversal events are characterized by magnetometric measurements on the ensembles: the hysteresis loops strongly depend on systematic changes in geometry and temperature.

MA 16.7 Wed 11:45 H23

Semiconductor-ferromagnet core-shell nanowires grown by molecular beam epitaxy — •Maria Hilse, Yukihiko Takagaki, Jens Herfort, Claudia Herrmann, Manfred Ramsteiner, Steffen Breuer, Lutz Geelhaar, and Henning Riechert — Paul-Drude-Institut für Festkörperelektronik, Berlin

The special geometry of nanowires (NWs) offers the possibility to elastically absorb lattice mismatch strain. Thus, axial and radial NW heterostructures consisting of dissimilar materials can be grown with high quality. In addition, spin dependent functionalities are introduced to NW devices when a ferromagnet is incorporated into these heterostructures. MnAs is one of the attractive materials as it is ferromagnetic at room temperature (the Curie temperature is about 40 °C). In this work, we combine GaAs and MnAs in a NW core-shell geometry by means of molecular beam epitaxy (MBE). The GaAs NWs were grown using the Au-assisted vapor-liquid-solid mechanism on GaAs(111)B substrates. The MnAs growth took place under the typical conditions for planar growth on GaAs. A curving of the NWs is observed if the sample stage is not rotated during MnAs overgrowth, evidencing the diffusion length of Mn being less than the perimeter of the NWs. By analyzing the planar film and NW shell thicknesses, we demonstrate the MnAs growth to take place by direct deposition on the NW sidewalls. NWs exhibit a hexagonal cross section indicating the c-axis, i.e., the magnetic hard axis of MnAs to be parallel to the NW axis. This orientation is confirmed by magnetization measurements and magnetic-force microscopy.

MA 16.8 Wed 12:00 H23

Domain walls in bent nanowires — •André Kobs, Sebastian Hankemeier, Robert Frömter, and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

We have investigated the magnetic fine structure in remanence and the appearance of domain walls in bent nanowires depending on their geometrical properties by means of scanning electron microscopy with polarization analysis (SEMPA). The wires were carved from 18 nm thick soft-magnetic $Co_{39}Fe_{54}Si_7$ film via Focused Ion Beam (FIB) milling. By gradually decreasing the angle of the bend we find the transition from vortex wall to transverse wall via the so called asymmetric transverse wall. For the vortex walls, the vortex core is not exactly aligned with the mirror axis of the wire, but is slightly shifted into one of the two arms of the wire. The direction of the magnetic field that is used to seed the domain wall determines which of the energetically degenerated vortex wall states occur. More important, the chirality is linked to the location of the vortex wall and is therefore also experimentally accessible. Micromagnetic simulations verify these results and show in addition that the polarity can be tuned on purpose by applying a moderate out of plane field during vortex core nucleation. The ability to control the chirality and the polarity is a necessary prerequisite for new storage concepts based on vortex walls in combination with current induced domain wall movement, like in the racetrack memory device.

MA 16.9 Wed 12:15 H23

Hall micromagnetometry of current-assisted domain-wall motion in permalloy nanowires — •Stephan Marauska, Peter Lendecke, Guido Meier, and Ulrich Merkt — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg, Germany

We use ballistic Hall micromagnetometry to analyze the effect of current-injection on domain-wall (DW) depinning in permalloy nanowires. DW motion controlled by current is a key function for the magnetic racetrack memory proposed by Stuart Parkin. The domain walls are pinned in constrictions defined by a triangularly shaped notch in one edge of the wires. The high sensitivity of the Hall sensors to local stray fields allows non-invasive detection of individual DWs pinned at spezific locations in a nanowire [1, 2]. We determined the dependence of the depinning fields on parameters such as current-pulse length and current density by injecting nanosecond current pulses at temperatures below 2 K. The reduction of the depinning fields is commonly explained due to spin-torque interaction. Hall micromagnetometry allows to investigate DW depinning with a high capability to acquire enough statistics.

[1] P. Lendecke, R. Eiselt, G. Meier and U. Merkt, J. Appl. Phys. 103, 073909 (2008)
[2] P. Lendecke et al., JMMM, in press (2009)

MA 16.10 Wed 12:30 H23

Preparation and characterisation of regularly arranged MnAs nanoclusters and chains on (111)B-GaAs substrates — •Matthias T. Elm[1], Shingo Ito[2], Hans-Albrecht Krug von Nidda[3], Shinjiroh Hara[2], and Peter J. Klar[1] — [1]1. Physikalisches Institut, Justus-Liebig University, Heinrich-Buff-Ring 16, 35392 Giessen — [2]Research Center for Integrated Quantum Electronics, Hokkaido University, Sapporo, Japan — [3]Experimentalphysik V, University of Augsburg

Ordered arrangements of ferromagnetic MnAs nanoclusters and cluster chains were obtained by selective-area MOVPE on pre-patterned (111)B-GaAs substrates. Using this new method it is possible to control the position, the size and the shape of the nanoclusters on the surface in the growth process, which offers interesting opportunities to tune the properties of individual nanoclusters and the interaction of the clusters with the carriers of the surrounding semiconducting matrix. Several cluster arrangements and cluster chains were grown consisting of nanoclusters with a length of 690 nm and a width of 290 nm. The quality of the cluster growth was investigated by SEM and AFM. The magnetic properties were probed by MFM and FMR in order determine the magnetic anisotropy and the domain formation of the clusters. The samples were also investigated by angle-dependent magneto-transport measurements in the temperature range from 20 to 280 K in external magnetic fields up to 10 T. The transport properties were correlated with the cluster arrangement of the samples and the magnetization orientation.