MA 29: Micro- and Nanostructured Magnetic Materials II

Time: Wednesday 11:00–13:15 Location: HSZ 103

MA 29.1 Wed 11:00 HSZ 103

Magnetostatic interaction of single NiFe nanostructures — •Mahmoud Reza Rahbar Azad, André Kobs, Hendrik Spahr, Björn Beyersdorff, Daniel Stickler, Robert Frömter, and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The magneto-static interaction between submicron $Ni_{80}Fe_{20}$ rectangles with aspect ratio of two has been investigated by means of magnetotransport measurements using anisotropic magneto resistance (AMR). The structures have been carved into a Cr(10nm)/$Ni_{80}Fe_{20}$(20nm)/Pt(2,5nm) trilayer utilizing a highly focused ion beam (FIB). The material surrounding the rectangles has been milled paramagnetic by applying a Ga^+-ion dose of 6000 $\mu C/cm^2$, which destroys ferromagnetism but guarantees an adequate electric conductivity. The contacting of the submicron rectangles was performed *in situ* via a tungsten tip attached to a micromanipulator [1]. Microcircuit milled by FIB enables us to measure the magnetic behavior of one single element of an array of rectangles [2]. Due to the high flexibility of our setup [1] we could systematically vary the distance between the rectangles as well as the size. Besides determining the magnetic energy of the micro-magnetic states, i.e. the Landau state of an individual rectangle [2], we can measure the strength of the magneto-static interaction between the rectangles.

[1] Daniel Stickler et al., Rev. Sci. Instr. **79**, 103901 (2008)
[2] André Kobs et al., Phy. Rev. B **80**, 134415 (2009)

MA 29.2 Wed 11:15 HSZ 103

Cobalt-based magnetic nanostructures grown by focused-elctron-beam-induced deposition. — •Evgeniya Begun, Johannes Schwenk, Fabrizio Porrati, and Michael Huth — Physikalisches Institut, Goethe-Universität, D-60438 Frankfurt am Main, Germany

The fabrication of magnetic nanostructures by means of the direct-writing technique focused-electron-beam-induced deposition (FEBID) is an alternative to more conventional lithographic methods. We have grown magnetic cobalt structures by FEBID using the precursor dicobaltoctacarbonyl $Co_2(CO)_8$. The obtained structures have a large metal content of about 85 at.% as compared to other metal-based deposits grown by the same technique, such as tungsten-based structures with 34 at.% maximum tungsten content and platin-based structures with about 24 at.% maximum platin content. We present a growth strategy for cobalt structures with tunable metal content. In particular, we show the influence of different combinations of electron-beam energy and current, the dwell time and the refresh time on the deposit composition, which was determined by energy-dispersive X-ray spectroscopy (EDX) at 5 keV.

First results of magnetotransport measurements on these cobalt-based structures are presented.

MA 29.3 Wed 11:30 HSZ 103

Magnetic behaviour of embedded antiferromagnetic elements in remanence — •Roland Neb[1], Peter Andreas Beck[1], Thomas Sebastian[1], Philipp Pirro[1], Stefan Pofahl[2], Rudolf Schäfer[2], Bernhard Reuscher[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [3]Institut für Oberflächen- und Schichtanalytik, IFOS, Trippstadter Straße 120, 67663 Kaiserslautern, Germany

We investigate small elements with ferromagnetic interlayer coupling in an antiferromagnetically coupled environment. These elements are created by focused ion beam irradiation on an antiferromagnetically coupled Fe/Cr/Fe-trilayer. We show that the behavior of these elements is dominated by rectangular edge domains of a constant size, independently of the size of the surrounding square. These domains impose a lower limit for the size of the elements, beyond which the antiferromagnetic coupling vanishes completely. A symmetry breaking is observed by finding the edge domains only on two of the four sides. Different thicknesses of the magnetic layers do not alter the properties of the domains, giving rise to the assumption that this is not an anisotropy effect, but only due to exchange coupling.

MA 29.4 Wed 11:45 HSZ 103

Magnetic pinning in self-assembled sub-200nm antidot arrays — •Felix Häring, Ulf Wiedwald, Karsten Küpper, and Paul Ziemann — Universität Ulm, Institut für Festkörperphysik

Self-assembled and isotropically etched Polystyrene (PS) nanoparticles serve as template for the subsequent deposition of magnetic thin films. In this way, films with ordered arrays of antidots are obtained, which can be fine-tuned with respect to their diameters and distances. Both of these parameters are kept within the sub-200nm range. Applying SQUID-magnetometry and magnetotransport measurements, a strong dependence of the magnetic film properties is found on these structural parameters and the film-thickness. For example, an antidot array with a periodicity of 200 nm, antidot diameter of 150 nm within a permalloy film of 20 nm thickness shows a coercive field of 250 Oe, which is an enhancement by a factor of 80 as compared to continuous reference films (3 Oe). This increase is due to domain wall pinning at antidot sites caused by local variations of shape anisotropy. Scanning Transmission X-Ray-Microscopy (STXM) and micromagnetic simulations give further insight into this type of pinning.

MA 29.5 Wed 12:00 HSZ 103

Extremely high coercivity of Co Islands on Ir(111) probed by spin-resolved scanning tunneling microscopy — •Jessica Bickel, Focko Meier, Jens Brede, Kirsten von Bergmann, and Roland Wiesendanger — Insitute of Applied Physics, University of Hamburg, Hamburg, Germany

As length scales continue to decrease, surfaces and small atomic clusters and islands play an increasingly large role in determining material properties. Thus it is imperative to study and understand the properties of small islands in order to further our fundamental understanding of reduced dimension properties and to exploit these properties for device applications.

Co islands on Ir(111) were examined by spin-resolved scanning tunneling microscopy (SPSTM) and spectroscopy. The Co islands grow pseudomorpically on the Ir substrate, forming triangular shaped islands with no regular dislocation structure and are magnetized perpendicular to the Ir surface. The islands have a high coercivity and require a field of B=5T to fully align all the islands in a magnetic field applied along the easy magnetization axis. Effects of the stray field of the SPSTM tip on island switching will be discussed.

MA 29.6 Wed 12:15 HSZ 103

Electric field as a switching tool for magnetic states in atomic-scale nanostructures — •Nikolay Negulyaev[1], Valeri Stepanyuk[1], Wolfram Hergert[2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle, Germany — [2]Fachbereich Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

One of the most promising candidates for the construction of ultra-high-density storage media are low-dimensional magnetic nanostructures exhibiting magnetic bi- or multi-stability. This property is peculiar to magnets that have two or more stable magnetic states characterized by a relatively small energy difference between them (of the order of tens of meV) [1]. In this work we propose a novel route of locally controlling and switching magnetism in such structures: our ab initio studies give clear evidence that applying an external electric field it is possible to switch a nanostructure between its different magnetic states. We first examine a system exhibiting magnetic bi-stability, a Mn dimer on a non-magnetic Ag(001) substrate, and then generalize our statements by extending the reasoning onto the case of a multi-stable system, a Mn dimer on a magnetic Ni(001) surface. We also reveal that by applying an external electric field one can rotate the direction of atomic spins for a certain magnetic state of a nanostructure.

[1] R. Sessoli et al., Nature 365, 141 (1993); L. Thomas et al., Nature 383, 145 (1996).

MA 29.7 Wed 12:30 HSZ 103

Magnetic reversal in a laterally structured spin valve system with one tunable magnetic layer — •Frank Brüssing, Melanie Ewerlin, Radu Abrudan, and Hartmut Zabel — Department of Physics, Ruhr-University Bochum, 44780 Bochum, Germany

We investigated the magnetization reversal of interacting Co islands and how their behavior is altered after switching on the interlayer exchange interaction to a second magnetic layer with different magnetic domain structure and different coercivity values. As a test system we grew via MBE an epitaxial magnetic heterostructure comprising two ferromagnetic layers, one with a high Curie temperature (T_C) (Co) and one with a T_C below room temperature (RT) ($Fe_{1-x}Cr_x$), and a mediating Cr layer in between. This heterostructure was patterned via e-beam lithography and ion beam etching in the lateral direction. We have investigated the magnetization reversal of Co at RT and of the combined system at low temperature, using x-ray resonant magnetic scattering (XRMS), which allows element selective investigations of the magnetic behavior by tuning the x-ray energy to the respective L-edges of Co and Fe. As reference we also investigated the same heterostructure before patterning. The lateral periodic pattern gives raise to new in-plane Bragg reflections, revealing the structural and magnetic correlation between the islands. We have used a CCD camera for investigating the magnetic Bragg peaks and magnetic diffuse scattering as a function of temperature above and below the T_C of $Fe_{1-x}Cr_x$. Furthermore, by varying the field we followed the domain formation during the magnetization reversal for the respective layers.

MA 29.8 Wed 12:45 HSZ 103

Investigation of magnetic nanostructures by means of neutron-polarisation analysis — •Dirk Honecker[1], Frank Döbrich[1], Charles Dewhurst[2], Albrecht Wiedenmann[2], Cristina Gómez Polo[3], Kiyonori Suzuki[4], and Andreas Michels[1] — [1]Laboratory for the Physics of Advanced Materials, University of Luxembourg, Luxembourg — [2]Institut Laue-Langevin, Grenoble, France — [3]Departamento de Física, Universidad Pública de Navarra, Pamplona, Spain — [4]Department of Materials Engineering, Monash University, Clayton, Australia

Small-angle neutron scattering (SANS) is a very powerful technique for the investigation of magnetic nanostructures since it provides information from within the bulk of the material and on a length scale of a few to some hundred nanometres. SANS is commonly utilised with an unpolarised or a polarised incident neutron beam, where an analysis of the spin state of the neutron after the scattering process is not performed. Due to the recent development of efficient ^{3}He spin filters, it becomes possible now to perform routinely longitudinal neutron-polarisation analysis (POLARIS) in a SANS experiment. In this contribution, we discuss the equations of the non-spin-flip and spin-flip cross sections for bulk ferromagnets along with typical angular anisotropies and asymmetries. In order to demonstrate the potential of the POLARIS technique, we present results on nanocrystalline cobalt and on Fe based soft magnetic nanocomposites.

MA 29.9 Wed 13:00 HSZ 103

Preparation and Analysis of Ni Nanowires on Si Gratings — •Wolfgang Kreuzpaintner[1], Boris P. Toperverg[3], Dieter Lott[2], Michael Störmer[2], Volker Neu[4], Christine Bran[4], Birgit Wiedemann[1], Andreas Schreyer[2], and Peter Böni[1] — [1]Technische Universität München, Physik-Department E21, James-Franck-Straße, 85748 Garching — [2]Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH, Max-Planck-Straße 1, 21502 Geesthacht, Germany — [3]Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [4]IFW Dresden, Institute for Metallic Materials, Dpt. Magnetic Microstructures, Helmholtzstraße 20, 01069 Dresden, Germany

Ni nanowires with a nominal cross-section of approx. 10 nm × 10 nm, a wire spacing of 750 nm and a length of several cm were deposited homogeneously on a prestructured Si-surface area of approx. 4 cm^2. The structural and magnetic properties of this sample as obtained from SEM imaging and AFM and MFM micrographs will be shown. Emphasis will be given on the lateral periodicity over a macroscopic distance and the buried sample structures, which were probed by off-specular x-ray scattering and analysed using Distorted-Wave Born Approximation (DWBA). An excellent agreement between the measured and simulated off-specular intensity distribution could be achieved. Furthermore, polarised off-specular neutron scattering on this sample was also carried out to probe the magnetic nature of the sample using the NERO reflectometer at the GENF facility in Geesthacht and will briefly be presented.