MA 29: Micro- and Nanostructured Magnetic Materials

Time: Wednesday 15:00–18:00 Location: H23

MA 29.1 Wed 15:00 H23

On the correlation between material morphology, cation distribution and magnetic properties in nanocrystalline $ZnFe_2O_4$ — •Christian Reitz, Christian Suchomski, and Torsten Brezesinski — Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen

Magnetic materials exhibiting both a high saturation magnetization and low coercivity are of interest to researchers from a wide range of disciplines, including information technology, biomedicine and so forth. Inverse spinel ferrites, in which the Fe^{3+} ions are distributed equally among the octahedral and tetrahedral binding sites, constitute a promising class of materials for such applications. Bulk zinc ferrite (ZFO), by contrast, is known to adopt a normal spinel structure, which leads to antiferromagnetic behavior. Nonetheless, in recent years it has been shown that the cation distribution and, thus, also the magnetic properties of ZFO and related spinel ferrites can be effectively tailored by changing the material morphology and by reducing the grain size to the nanometer level. Here we report facile synthetic routes for the preparation of sub 10 nm diameter nanoparticles and ordered mesoporous thin films of partially inverted ZFO. These oxide materials exhibit magnetic characteristics that strongly depend on the morphology, grain size and the cation distribution. The latter was determined by both XPS and Mössbauer spectroscopy.

MA 29.2 Wed 15:15 H23

Preparation and investigation of individual MnAs nanoclusters and nanocluster arrangements — •Martin Fischer[1], Matthias T. Elm[1], Shinjiro Hara[2], Christian Heiliger[1], and Peter J. Klar[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, D-35392 Gießen — [2]Research Center for Integrated Quantum Electronics, Hokkaido University, North 13 West 8, Sapporo, Japan 060-8628

Selective-area MOVPE-grown ferromagnetic MnAs nanoclusters are very interesting building blocks for completely new miniaturized magnetoelectronic devices in planar geometry. Due to the cluster growth on pre-patterned substrates, it is possible to tune their size, shape and position with high accuracy. This yields a high degree of freedom in the growth of various MnAs nanocluster devices for new planar magnetoelectronic applications. We report on the preparation of contacted, single MnAs nanoclusters and nanocluster arrangements consisting of clusters of different size and shape as well as the investigation of their structural and magnetotransport properties.

MA 29.3 Wed 15:30 H23

Magneto-plasmonic properties of Ni anti-dot nano-arrays in the presence of an external magnetic-field — •Evangelos Papaioannou[1,2], Burkard Hillebrands[1], Vassilios Kapaklis[2], Emil Melander[2], Erik Östman[2], and Björgvin Hjörvarsson[2] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — [2]Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden

Magneto-plasmonics offer unique possibilities to manipulate light by the use of external magnetic fields. The magnetic field can provide the means to control surface plasmons polaritons (SPPs), as it has been predicted for noble metals, and explored experimentally in hybrid structures composed of noble and magnetic metals/dielectrics. However no study has been devoted to pure magnetic metals. Here, we present the case of a pure magnetic metal, such as Ni patterned in a two-dimensional hexagonal lattice. The patterned Ni thin film supports the excitation of SPPs both at the air/Ni interface and Ni/substrate interface. The dispersion relation of SPPs defined by the hexagonal pattern can be modified with an application of a transverse magnetic field. This is revealed by the modulated reflectivity measured by the Transverse Magneto-optic Kerr Effect (TMOKE). The perspective of developing new ways to use combined magnetic field, magneto-optic and surface plasmon effects for manipulation of light is addressed.

MA 29.4 Wed 15:45 H23

Nanopatterning of linear GMR spin valves by FIB milling — •Benjamin Riedmüller, Felix Huber, and Ulrich Herr — Universität Ulm, Institut für Mikro- und Nanomaterialien

In this work we present a detailed investigation of a focused-ion-beam (FIB) nanopatterning process for linear spin valves consisting of $Si/SiO_2[300]/Ta[5]/NiFe[6]/Co[1]/Cu[4]/Co[4]/FeMn[20]/Ta[5]$ (numbers are thickness in nm) to widths down to 150 nm. Our results show that without any further protective layer the spin valves show a drastic decrease in magneto-resistive (MR) properties after the FIB cutting even for widths >1 μm. This is accompanied by a decrease of interlayer exchange coupling (J_{ex}) at the AFM/FM interface. These results can be explained by a Ga bombardment near the cutting edges with stray irradiation of the ion beam which limits the process and does not allow a successive nanopatterning of the MR devices. The observed decrease in MR functionality can be correlated with a lateral ion irradiation that shows a similar decrease of the GMR-ratio and an increase in spin valve resistance for doses higher than $1 \cdot 10^{13}/cm^2$. For protecting the spin valves from the unwanted ion damage a 50 nm SiO_2 cover layer is deposited by ion beam evaporation on the spin valves. After FIB cutting a smaller decrease of the MR ratio and AFM/FM coupling can be seen which proves the protective function of the SiO_2 layer and therefore allows sensor dimensions < 200 nm. The nanostructuring is accompanied by a drastic change in the magnetic reversal and switching behaviour of the magnetic layers which can be understood as a consequence of the small widths of the sensor elements.

MA 29.5 Wed 16:00 H23

Magnetic domain walls in patterned exchange bias domains — •Alexander Gaul[1], Alla Albrecht[1], Hans Peter Oepen[2], Sebastian Hankemeier[2], and Arno Ehresmann[1] — [1]Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [2]Institute of Applied Physics and Microstructure Advanced Research Center, University of Hamburg, Jungiusstr. 11, D-20355 Hamburg

Arbitrary micro magnetic domain structures are fabricated by ion bombardment induced magnetic patterning (IBMP) [1] of exchange bias layer systems, where the size of magnetic domains together with the value and direction of the anisotropy parameter in adjacent domains can be deliberately set. These domain walls were probed by magnetic force microscopy (MFM) and scanning electron microscopy with polarization analysis (SEMPA) to reveal the detailed magnetic structure of the domain walls. Different structures like cross tie, zig zag and asymmetric domain walls were found depending on the properties of the nearby domains.

[1] Ehresmann, A., Engel, D., Weis, T., Schindler, A., Junk, D., Schmalhorst, J., Höink, V., et al. (2006). Fundamentals for magnetic patterning by ion bombardment of exchange bias layer systems. Phys. Stat. Sol. (B), 243(1), 29-36. doi:10.1002/pssb.200562442

MA 29.6 Wed 16:15 H23

Propagation of magnonic spin-wave modes in CoFeB waveguide — •Maria Mansurova, Benjamin Lenk, Stephan Shishkin, and Markus Münzenberg — I. Physikalisches Institut, Universität Göttingen, Germany

The understanding of guiding mechanisms of spin waves is highly important for the development of spin-wave logic gates. In this work, femtosecond laser pulses are used to optically excite (pump) and subsequently measure (probe) magnetization dynamics and spin wave propagation on a magnonic waveguide, which consists of a 16 μm wide defect line in a rectangular CoFeB antidot lattice, oriented either perpendicularly or at 45° to the bias magnetic field.

For each orientation of the magnetic field, spin wave spectra of the waveguide show the same modes as rectangular CoFeB antidot lattice, namely, Damon Eschbach (DE) surface mode, perpendicular spin standing wave (PSSW) and Kittel uniform precession (90° orientation only). These modes propagate both into the waveguide and continuous film, although DE mode is not normally present in the continuous CoFeB thin film spectra. Moreover, at 45° to the bias magnetic field orientation, the DE mode propagation length into the waveguide is larger compared to 90° orientation case.

15 min. break

MA 29.7 Wed 16:45 H23

Simultaneous measurement of AMR and observation of magnetic domains — Julia Osten[1,2], •Manuel Langer[1,2], Kilian Lenz[1], Jürgen Lindner[1], and Jürgen Fassbender[1,2] — [1]HZDR Institute of Ion-Beam Physics and Materials Research P.O. Box 510119, 01314 Dresden, Germany — [2]TU Dresden Helmholtzstr. 10, 01069 Dresden, Germany

Anisotropic magneto resistance (AMR) sensors are widely used in daily life. Nevertheless, the influence of magnetic domains on the AMR is still not fully understood. AMR depends on the angle between applied current and the direction of the internal magnetization, which is equal to the sum of all magnetic domains. For the understanding of the AMR it is important to know the domain structure.
In this experiment Kerr microscopy is used for the observation of the magnetic domains while at the same time the AMR is measured. The investigated permalloy films are stripe patterned by Cr^+ implantation. Amongst other effects the implantation leads to a lower saturation magnetization in the implanted stripes compared to the non-implanted ones.
Our measurements show a clear correlation between AMR and the magnetic domain structure. It is also possible to correlate stripe parameters to different domain types.

This work is supported by DFG grant FA316/3-2.

MA 29.8 Wed 17:00 H23

Studying the magnetization reversal of a permalloy antidot array by magnetic force microscopy — •Steffen Nothelfer, Felix Haering, Ulf Wiedwald, Berndt Koslowski, and Paul Ziemann — Ulm University, Institute of Solid State Physics, D-89069 Ulm, Germany

We study the magnetization of hexagonally arranged antidot arrays in permalloy thin films by analyzing the stray field of such films by means of magnetic force microscopy (MFM) in a variable magnetic field. Our investigations focus on such systems for which the magnetization behavior is governed by a spin ice rule, typically observed for lattice constants below 500nm and antidot diameters above 330nm. In this case, a simple magnetization model provides the possibility of reconstructing the magnetization pattern of the film from MFM images depending on the external magnetic field. A good correspondence of measurements employing MFM and X-ray magnetic circular dichroism [1,2] is found. Additionally, the controlled magnetization reversal of the film enables an isolation of the magnetic interaction from other interactions, e.g., the van der Waals interaction. We find a surprising exponential decay of the field perpendicular to the surface in the range of 0.03-0.3 lattice constants of the antidot lattice. This result agrees well with micromagnetic simulations.

[1] E. Mengotti, L. Heyderman, A. Fraile Rodríguez, F. Nolting, R. V. Hügli, and Hans-Benjamin Braun, Nature Physics 7, (2011).
[2] F. Hearing, U. Wiedwald, T. Häberle, L. Han, A. Plettl, B. Koslowski, P. Ziemann, submitted to Nanotechnology.

MA 29.9 Wed 17:15 H23

Magnetic stray field landscape design due to tailored magnetic domain wall charges between in-plane magnetic domain configurations — •Dennis Holzinger, Norbert Zingsem, Iris Koch, Alexander Gaul, Christoph Schmidt, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Ion bombardment induced magnetic pattering (IBMP)[1] of exchange bias layer systems is for the first time used as an outstanding tool for the deliberate design of arbitrary magnetic stray field landscapes. Thermally stable in-plane micro magnetic domain configurations with long-range translational symmetry are fabricated, differing in their individual domain properties concerning the magnitude and direction of anisotropy parameters, domain size, charge accumulation and domain wall angle within the same material system. Since the angle between the in-plane magnetized domains in adjacent domains can be precisely tailored by IBMP, the amount of magnetic net charges within the domain walls and hence, the strength and spatial distribution of the correlated magnetic stray field can be purposefully designed.

[1] Ehresmann, A., Engel, D., Weis, T., Schindler, A., Junk, D., Schmalhorst, J., Höink, V., Sacher, M. D. and Reiss, G. (2006), Fundamentals for magnetic patterning by ion bombardment of exchange bias layer systems. Phys. Status Solidi B, 243: 29-36. doi: 10.1002/pssb.200562442

MA 29.10 Wed 17:30 H23

How to make $La_{0.7}Sr_{0.3}MnO_3$ nanostructures without losing the magnetization — •Martin Wahler[1], Bastian Büttner[1], Hans-Helmuth Blaschek[1], Nico Homonnay[1], Olga Wid[1], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Heinrich-Damerow-Str. 4, 06120 Halle, Germany

The ferromagnetic oxide $La_{0.7}Sr_{0.3}MnO_3$ has a high spin polarization and T_C>300 K. It is thus a good candidate for all-oxide microelectronic devices exploiting effects like the spin transfer torque and spin pumping. For state-of-the-art microelectronics applications, however, lateral dimensions are in the sub-100 nm regime and suitable patterning processes need to be developed. For ferromagnetic oxides this can be complicated. Many dry etching processes like Ar ion milling can achieve a reasonable pattern geometry, however, at the cost of a loss of magnetization in the nanostructures because of process induced defects. We have developed a process in which a resist mask is defined by e-beam lithography. Using a chlorine-based RIE step an array of about 70 million rectangles with dimensions of each approximately 100 nm times 230 nm is fabricated from a 20 nm thick LSMO layer. The magnetic properties are measured using a SQUID vibrating sample magnetometer and show no loss of magnetization compared to the unpatterned layer. Ferromagnetic resonance measurements indicate that the patterning also overcomes the built-in crystalline anisotropy of the LSMO layer. We acknowledge the support by the EU-project IFOX.

MA 29.11 Wed 17:45 H23

Fabrication of high-density magnetic storage elements bylow-dose ion beam irradiation — •Roland Neb[1], Thomas Sebastian[1], Philipp Pirro[1], Stefan Pofahl[2], Rudolf Schaefer[2], Bernhard Reuscher[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Research Center Optimas, TUKaiserslautern, 67663 Kaiserslautern, Germany — [2]Leibniz-Institutfür Festkörper- und Werkstoffforschung Dresden, IFW Dresden, 01069 Dresden,Germany — [3]Institut für Oberflächen- und Schichtanalytik,IFOS, 67663 Kaiserslautern, Germany

A new scheme of fabricating magnetic storage elements is proposed. We irradiate an antiferromagnetically coupled Fe/Cr/Fe trilayer with a focused low-dose 30 keV Ga^+-ion beam. The irradiation leads to ferromagnetic coupling in the affected areas, rendering them capable of storing information. The working principle is demonstrated for a storage array with a bit density of 7 Gbit/inch^2. We also investigate the possibilities of increasing the bit density by numerical simulation and theoretical calculation, showing that from a physical point of view bit densities of over 1 Tbit/inch^2 are feasible.