MA 23: Micro- and Nanostructured Magnetic Materials

Time: Wednesday 9:30–12:15 Location: HSZ 403

MA 23.1 Wed 9:30 HSZ 403

A new template for in-situ characterization of electrodeposited nanowires using a sub-100 nm nanochannel array presented at the example of electron magnon scattering in iron nanowires — •Philip Sergelius, Josep M. Montero Moreno, Wehid Rahimi, Martin Waleczek, Robert Zierold, Detlef Görlitz, and Kornelius Nielsch — Institute of Applied Physics: University of Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany

We present a new generation of templates for nanowire growth and their in-situ characterization. Using Interference Lithography, Reactive Ion Etching and ALD, a flexible template consisting of cm-long parallel nanochannels with rectangular cross section and other dimensions as small as 40 nm can be created. In an illustration system, pulsed electrodeposition is carried out creating square shaped Fe nanowires (80x80x20000 nm). By design, the grown wires are in contact with an electrode system on both sides directly after the deposition. No further processing steps are required for electrical characterization. The surrounding oxide template remains intact during measurement, providing protection against breaking and oxidation. The developed chip enables us to conduct high field R(T,B)-measurements on electroplated Fe nanowires for the first time. We report values for the magnon mass renormalization which are in good agreement with literature.

Using the presented approach, we believe that electrical characterization of nanowires will be a lot easier in the future. Additionally it opens up the possibility to create stable transversal magnetic anisotropy in multisegmented magnetic nanowires.

MA 23.2 Wed 9:45 HSZ 403

Ab initio study of selected fibred configurations in Fe-Pd and Fe-Pt systems — •Martin Zouhar[1] and Mojmír Šob[1,2,3] — [1]Central European Institute of Technology, CEITEC MU, Brno, Czech Republic — [2]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic — [3]Department of Chemistry, Faculty of Science, Masaryk University, Brno, Czech Republic

We perform a first-principles theoretical study of fibred magnetic configurations in ordered Fe-Pd and Fe-Pt face-centered cubic based intermetallics with low Fe content, namely FeX_3, FeX_7 and FeX_{15} (X = Pd or Pt), that contain iron fibres in the platinum or palladium matrix. The pseudopotential code VASP (Vienna Ab initio Simulation Package) is used to determine the equilibrium lattice parameters of the structures and corresponding total energies. Nonmagnetic, ferromagnetic and selected antiferromagnetic arrangements are considered and the configurations with the lowest energies are discussed in detail, including concentration dependence of both equilibrium volumes and magnetic moments.

MA 23.3 Wed 10:00 HSZ 403

Magnetic order triggered by hydrogenation of Li-doped ZnO microwires — •Israel Lorite[1], Benjamin Straueb[2], Parmod Kumar[1], Carlos Zandalazini[2], Hendrik Ohldag[3], Silvia de Heluani[2], and Pablo Esquinazi[1] — [1]Division of Superconductivity and Magnetism, University of Leipzig, Leipzig, Germany — [2]Laboratorio de Fisica de Solido, Universidad de Tucuman, Tucuman, Argentina — [3]SLAC National Accelerator Laboratory, Menlo Park, Stanford University, CA, USA

Cation and oxygen vacancies, as well as hydrogen can play an important role in the magnetic order observed in nominally non-magnetic oxides like ZnO, a phenomenon called nowadays as defect-induced magnetism (DIM). In this work we have produced microwires of ZnO, pure and doped with 1...7 atom.% Li. The magnetic characterization of the wires has been realized using magnetoresistance, superconducting quantum interferometer device (SQUID), photoconductivity and x-ray magnetic circular dichroism (XMCD). Photoluminescence spectroscopy was performed to elucidate the incidence of defects. Our results indicate that hydrogenation of pure ZnO microwires triggers magnetic order at temperatures below 100K. Room temperature magnetic order is observed after hydrogenation of Li-doped ZnO with a Li concentration above 1%, in agreement with the expected minimum distance between localized defects necessary to trigger magnetic order. Hydrogenation is a simpler and more effective way to trigger DIM in nominally non-magnetic oxides microstructures, paving the way for possible future applications of this phenomenon.

MA 23.4 Wed 10:15 HSZ 403

Electric field effects on magnetic properties of transition-metal impurities on monolayer graphene — •Karla Türschmann[1], Jesús Dorantes-Dávila[2], and Gustavo M. Pastor[1] — [1]Institut für theoretische Physik, Universität Kassel, Kassel, Germany — [2]Instituto de Física, Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico

The manipulation of the magnetic properties of nanoscale materials with external electric fields is of considerable interest both as fundamental research subject and in view of developing nanoscale magnetoelectronic devices. Two-dimensional monolayer graphene (MLG) with its unique electronic properties is one of the most promising materials for future applications. Therefore, using MLG as a substrate for magnetic 3d transition metal (TM) nanoclusters should offer new opportunities in spintronics. This contribution presents the results of *ab-initio* density-functional theory of the magnetic properties of 3d TM adatoms and dimers on MLG as a function of applied external electric field E. Special attention is paid to field-induced changes of the magnetic order, the magnetic anisotropy energy and of the orientation of magnetization. For instance, in the case of Co dimers on MLG the electric field induces a transition from FM to AFM ordering as well as a change of the direction of the easy axis. Trends for other TMs are also discussed.

MA 23.5 Wed 10:30 HSZ 403

Scanning-Hall-Probe-Microscopy on perpendicular stray-fields of Head-To-Head-Exchange-Bias-Layers — •Arno Ehresmann[1], Stefan Pofahl[2], Florian Ahrend[1] und Norbert Zingsem[1] — [1]Universität Kassel, Experimentalphysik 4, D-34419 Kassel — [2]IFW-Dresden, Leibniz-Institut für Festkörper- und Werkstoffforschung

Exchange-bias-multilayer-systems with CoFe and IrMn as main components were patterned by ion-bombardment in 5mu-head-to-head-domains. On those systems scanning-hall-probe-microscopy was carried out, to measure the height dependent z-component of the stray field arising from the domainwalls. Comparison with existing theory on domain- and fieldstructure showed qualitatively good agreement, but also quantitative hints that an adjustment of that theory might be necessary.

15 min. break

MA 23.6 Wed 11:00 HSZ 403

Switching modes in a self-assembled antidot array — Felix Haering[1], •Ulf Wiedwald[1,2], Steffen Nothelfer[1], Berndt Koslowski[1], Paul Ziemann[1], Lorenz Lechner[3], Andreas Wallucks[4], Kristof Lebecki[4], Ulrich Nowak[4], Joachim Gräfe[5], Eberhard Goering[5], and Gisela Schütz[5] — [1]Institute of Solid State Physics, Ulm University, 89069 Ulm — [2]Faculty of Physics, University of Duisburg-Essen, 47057 Duisburg — [3]Electron Microscopy Group of Materials Science, Ulm University, 89069 Ulm — [4]Department of Physics, University of Konstanz, 78457 Konstanz — [5]Max Planck Institute for Intelligent Systems, 70569 Stuttgart

We study the magnetic reversal in a self-assembled, hexagonally ordered Fe antidot array (period 200 nm, antidot diameter 100 nm) which was prepared by nanosphere lithography [1]. Direction-dependent information in such a self-assembled sample is obtained by measuring the anisotropic magnetoresistance (AMR) through constrictions processed by focused ion beam milling in nearest neighbor and next nearest neighbor directions [2]. We show that such an originally integral method can be used to investigate the strong 6-fold in-plane anisotropy introduced by the antidot lattice. In-field magnetic force microscopy, Kerr microscopy and micromagnetic simulations are employed to correlate the microscopic switching to features in the AMR signal. We thank the Baden-Württemberg Stiftung for financial support. [1] F. Haering et al., Nanotechnology 24, 055305 (2013). [2] F. Haering et al., Nanotechnology 24, 465709 (2013).

MA 23.7 Wed 11:15 HSZ 403

Magnetisation Reversal of In-Plane and Out-of-Plane Magnetised Antidot Lattices — •Joachim Gräfe[1], Felix Häring[2], Ulf Wiedwald[4], Paul Ziemann[2], Kristof Lebecki[3], Ulrich Nowak[3],

Gisela Schütz[1], and Eberhard Goering[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [2]Department of Solid State Physics, Ulm, Germany — [3]Department of Physics, Konstanz, Germany — [4]Faculty of Physics, Duisburg, Germany

Antidot lattices allow tailoring of important magnetic properties like coercivity and magnetic anisotropy. Angular and spatially resolved MOKE measurements as well as magnetic x-ray microscopy (MAXYMUS) were conducted in order to gain insight into magnetisation properties of in-plane (Fe) and out-of-plane (GdFe) antidot systems. These studies were complemented by first order reversal curve (FORC) measurements and micromagnetic simulations. The magnetisation behaviour of in-plane antidot lattices is dominated by domain wall pining in the narrow bridges between the holes. Domain walls run along the antidot rows and sudden domain wall motion occurs for a critical field applied along the nearest neighbour direction. For the next nearest neighbour direction the magnetisation reversal follows a rotational mechanism via an intermediate easy axis. Out-of-plane systems do not suffer from additional stray field losses at the antidots as in-plane systems do. Nevertheless, we found a significant influence on the coercivity and the shape of the hysteresis loops of thin films with perpendicular magnetic anisotropy and antidot structuring. FORC measurements reveal an interplay between exchange and dipole interactions.

MA 23.8 Wed 11:30 HSZ 403

Thermal excitations of artificial spin ice in square-lattice dipolar arrays — •Danny Thonig[1,2], Stephan Reissaus[2], and Jürgen Henk[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

Frustration in magnetic systems is a topic of particular interest in condensed matter physics. Recent experiments on artificial two-dimensional spin ice reveal thermal magnetic excitations, reminiscent of Dirac strings and magnetic monopoles [1]. We report on a theoretical investigation of artificial spin ice in square-lattice dipolar arrays, using a geometry adopted from recent experiments [2], applying conventional and kinetic Monte Carlo methods.

The number of thermal string excitations with quasi-monopoles ± 4 can be drastically increased by a vertical displacement, a change of the island's thickness and variation of the magnetization of rows and columns. The increase is especially large at low temperatures. Addressing the thermal stability of these excitations, we provide time scales for their experimental observation. Furthermore, the excitations can be pinned by defects, which allows to control position and length of the string excitations.

[1] E. Mengotti *et al.*, Nature Phys. **7** (2011) 68-74
[2] A. Farhan *et al.*, Nature Phys. **9** (2013) 375.

MA 23.9 Wed 11:45 HSZ 403

Transport Measurements on Individual Ferromagnetic MnAs Nanocluster Arrangements — •Martin Fischer[1], Matthias T. Elm[1], Shinya Sakita[2], Shinjiro Hara[2], 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

The ongoing progress in the development of nano-magnetoelectronic devices is strongly connected to the exploration of novel, nanostructured magnetic materials. This contribution reports on transport measurements on ferromagnetic manganese arsenide nanoclusters and nanocluster arrangements grown by Selective-Area Metal-Organic Vapor Phase Epitaxy (SA-MOVPE), which offer a wide choice of pattern designs combined with a convenient processability.

The results of the transport measurements, even in zero magnetic field, show jump-like changes of the resistance. These changes are caused by magnetoelectric effects in the nanoclusters. The relative angle between the magnetization directions of neighbored domains determines the resistance of their boundary. Furthermore, domain wall dynamic effects occur depending on the sample temperature, which results in changes of the resistance. The impact of external influences, such as an external magnetic field or the sample temperature on the transport characteristics will be discussed. In addition, possible ways towards a theoretical description of the experimental findings will be discussed.

MA 23.10 Wed 12:00 HSZ 403

Field assisted sintering of nanostructured iron oxide composites — •Kerstin Witte, Wiktor Bodnar, and Eberhard Burkel — Institute of Physics, University of Rostock, August-Bebel-Str. 55, 18055 Rostock, Germany

The behaviour of magnetic materials depends strongly on their domain structure. For nanoparticles and thin films a broad range of interesting effects like superparamagnetism or giant magnetoresistance have been observed, while the behaviour of nanostructured bulk materials is still widely unknown. Various physical properties of bulk materials and composites can be significantly affected by the careful control of both composition and nanoscale grain structure. The rather novel field assisted sintering technique (FAST) is a promising tool for the consolidation and synthesis of such nanostructured bulk materials. During FAST a pulsed direct electric current and mechanical load are applied on precursor powder placed in a graphite die, leading to rapid heating of the densified powder. Advantages of FAST are short process times and the possibility of keeping nanostructured grains. To study changes in the behaviour of magnetic materials, soft magnetic iron oxides are an ideal system due to their metastability, as well as the large single domain size of magnetite and maghemite. In this study a stoichiometric mixture of hematite and iron was processed by FAST. The composition and other various physical properties of the obtained composites were determined using high energy X-ray diffraction, scanning electron microscopy and Mößbauer spectroscopy.