MA 52: Magnetic Thin Films II

Time: Friday 9:30–12:45 Location: H 1012

MA 52.1 Fri 9:30 H 1012

Magnetic anistropy energy of thin Fe layers on GaAs surface - the influence of defects — •Karel Carva and Ilja Turek — Charles University in Prague, Ke Karlovu 5, Prague 12116, Czech Republic

For thin Fe layers on top of GaAs surface an in-plane magnetic anisotropy energy (MAE) has been predicted, with an unusually high value. The experimental values vary by more than an order of magnitude here, which may be linked to the presence of defects, since the interface structure is not characterized sufficiently. We examine primarily the influence of intermixing between Fe and GaAs at the interface on the MAE. Interestingly, the calculated MAE does not only reduce its value with disorder, but may also change the sign. We examine more deeply the origin of this in-plane anisotropy. Layer-resolved calculations show that for this interface the contribution from the layer at the interface can be exceeded by that from more distant layers, which puts emphasis on the calculation precision.

We employ fully relativistic first-principles theory of metallic ferromagnetic systems. The theory is based on the all- electron tight-binding linear muffin-tin orbital (LMTO) method and the coherent potential approximation (CPA) is used to treat chemically disordered systems. Particular attention is devoted here to the spin and orbital magnetic moments, total energies, and transport properties. Data storage technology may significantly benefit from an increase of MAE allowing a higher data density. Understanding the dependence of MAE on various parameters allows to control it with a high precision.

MA 52.2 Fri 9:45 H 1012

Spin spirals and skyrmions in ultrathin films and in-plane magnetic fields investigated by SP-STM — •Lorenz Schmidt, Pin-Jui Hsu, Christian Hanneken, Andre Kubetzka, Kirsten von Bergmann, and Roland Wiesendanger — Department of Physics, Universität Hamburg

Ultrathin magnetic films can exhibit topologically non-trivial spin textures as a result of competing magnetic interactions. Former spin-polarized scanning tunneling microscopy experiments (SP-STM) showed that a bilayer of palladium and iron on Ir(111) shows spin spirals in zero field and the application of a perpendicular magnetic field leads to the formation of skyrmions. It was also demonstrated that individual skyrmions can be written and deleted by local injection of electrons [1].

Here we investigate the changes inflicted by in-plane magnetic fields on the propagation direction of spin spirals and the switching behavior of skyrmions with SP-STM in a vectorial magnetic field. The propagation direction of the spin spiral is determined by the shape of the island and not changed by in-plane magnetic fields up to 1 T. Furthermore we examine if the switching rate and asymmetry between the ferromagnetic and skyrmionic states depend on in-plane magnetic fields.

[1] N. Romming *et al*, Science **341**, 636 (2013)

MA 52.3 Fri 10:00 H 1012

Epitaxial growth and characterization of Mn_2Au thin films for antiferromagnetic spintronics — •Helge Bräuning, Mathias Kläui, and Martin Jourdan — Institut für Physik, Johannes Gutenberg Universität, Staudingerweg 7, 55128 Mainz, Germany

The antiferromagnetic compound Mn_2Au is characterized by large spin-orbit coupling, which makes it a promising material for novel antiferromagnetic spintronics (see e.g. [Bar13, Zel14]).

We prepared thin films of Mn_2Au by RF-sputtering from a stoichiometric target on MgO and Al_2O_3 substrates using different buffer layers. Epitaxial samples with different growth directions such as [100], [001], and [101], were obtained. The samples were characterized by x-ray diffraction, magnetometry, AFM and SEM. Additionally, magnetotransport investigations will be presented.

[Bar13] V.M.T.S. Barthem et al. Nat. Commun. 4, 2892 (2013).

[Zel14] J. Zelezny et al. Phys. Rev. Lett. 113, 157201 (2014).

MA 52.4 Fri 10:15 H 1012

Magneto-transport in Sr2IrO4 epitaxial thin films — •Chengliang Lu[1,2], Dietrich Hesse[1], and Marin Alexe[3] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle (Saale), Germany — [2]School of Physics, Huazhong University of Science and Technology, Wuhan 430074, China — [3]Department of Physics, Warwick University, Coventry CV4 7AL, United Kingdom

The 5d iridates have been the subject of much recent attention due to the predictions of a large array of novel electronic phases driven by twisting strong spin-orbit coupling and Hubbard correlation. As a prototype, the single layered perovskite Sr2IrO4 was first revealed to host a Jeff=1/2 Mott insulating state. In this material, the approximate energy scale of a variety of interactions, involving spin-orbit coupling, magnetic exchange interaction, and the Mott gap, allows close coupling among the corresponding physical excitations. Here, we systematically investigate the magneto-transport in Sr2IrO4 thin films grown on various substrates inducing different strain states. We found an abnormal magnetoresistance which exhibits no apparent correlation with the magnetization, and interesting crossover behavior in the anisotropic magnetoresistance which probably can be associated with an isospin reorientation. In addition, the strain was revealed to play an important role in mediating the magneto-transport in Sr2IrO4 thin films, which is probably due to the modulation of the Jeff=1/2 state as predicted by Zhang et al. (PRL 111, 246402).

MA 52.5 Fri 10:30 H 1012

Structural, electronic, and magnetic properties of perpendicularly magnetised Mn_2RhSn thin films. — •Olga Meshcheriakova[1,2], Albrecht Köhler[1], Siham Ouardi[1], Yukio Kondo[3], Tahakide Kubota[3], Chandra Shekhar[1], Stanislav Chadov[1], Gerhard H. Fecher[1], Shigemi Mizukami[3], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [2]Max Planck Institute of Microstructure Physics, 06120 Halle, Germany — [3]WPI-Advanced Institute for Materials Research (WPI-AIMR), Tohoku University, Sendai 980-8577, Japan

Epitaxial thin films of Mn_2RhSn were grown on MgO(001) substrate by magnetron co-sputtering of the constituents. An optimized range of temperature for heat treatment was used to stabilize the tetragonal structure and to prevent the capping Rh layer from diffusing into the Heusler layer. Electronic and magnetic properties were analyzed by hard X-ray photoelectron spectroscopy as well as field- and temperature-dependent Hall and resistivity measurements. The measured valence spectra are in good agreement with the calculated density of states. The measured saturation magnetization corresponds to a magnetic moment of $1\mu_B$ in the primitive cell. The magnetization measurements revealed an out–of–plane anisotropy energy of 89 kJ/m^3 and a maximum energy product of 45.3 kJ/m^3. The magnetoresistance ratio is 2% for fields of 9 T. The lattice parameter of the compound has a very small mismatch with MgO, which makes it promising for coherent electron tunnelling phenomena.

MA 52.6 Fri 10:45 H 1012

Annealing Effects on Sputtered La0.67Sr0.33MnO3 Thin Films on Silicon (111) — •Manuel Monecke, Peter Richter, Peter Robaschik, Sreetama Banerjee, Georgeta Salvan, and Dietrich R.T. Zahn — Semiconductor Physics, Technische Universität Chemnitz, D-09107 Chemnitz, Germany

La1-xSrxMnO3 (LSMO) is a promising electrode material for spintronic devices. The electrodes are typically deposited by pulsed laser deposition on single crystalline substrates with similar lattice constants, e.g. SrTiO3 [1], to obtain single crystalline layers. Here we investigate LSMO films deposited by pulsed radio frequency magnetron sputtering at room temperature on silicon (111) substrates with native oxide. Afterwards the films were annealed in ambient atmosphere at different temperatures in the range from 600 °C to 875 °C. In order to understand how the LSMO film properties change with annealing temperature we evaluated spectroscopic ellipsometry and magneto-optical Kerr effect spectroscopy data to obtain the diagonal and off-diagonal elements of the dielectric tensor. Furthermore we measured Raman spectroscopy to investigate the phonon fingerprint of the LSMO layer and of the interface layer formed between the silicon substrate and the LSMO layer. Finally we determined the Curie temperature and the hysteresis loop parameters of the films via SQUID-VSM measurements. The results show that the magnetic properties improve with higher annealing temperatures. However, interdiffusion is observed for

annealing temperatures higher than 775 °C. [1] W. Xu et al. Applied Physics Letters 90 (2007) doi: 10.1063/1.2435907

15 min. break

MA 52.7 Fri 11:15 H 1012

Charge Carrier Doping in Electrolyte-Gated Mesostructured $La_{1-x}Ca_xMnO_3$ and $La_{1-x}Sr_xMnO_3$ Thin Films with Cubic Pore Symmetry — •Christian Reitz, Philipp Moritz Leufke, Horst Hahn, and Torsten Brezesinski — Institute of Nanotechnology, Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

Here, we report on the preparation of mesostructured perovskite-type thin films of $La_{1-x}Sr_xMnO_3$ (LSMO) and $La_{1-x}Ca_xMnO_3$ (LCMO) from common sol-gel precursors by taking advantage of the superior templating properties of polyisobutylene-*block*-poly(ethylene oxide) diblock copolymers. We show that the overall sample preparation process is straightforward and both oxides are well defined in terms of structure and morphology after calcination, with complex percolation pathways for electron transport. We also show that the charge carrier density in electrolyte-gated LSMO and LCMO thin films can be modulated electrostatically to a large extent. This kind of doping allows for reversible "tuning" of the magnetization. Charge induced modulations of up to 5% at 300 K and 9% at 230 K can be achieved for LSMO and LCMO, respectively. These values are the highest thus far reported for electrolyte-gated mixed-valence manganese oxides with perovskite-type structure, thus emphasizing the benefits of nanoscale porosity. Overall, we will focus on the unique magnetic and magneto-transport properties as well as on the surface charge induced magnetization changes in polymer-templated LSMO and LCMO thin films with nanocrystalline walls.

MA 52.8 Fri 11:30 H 1012

Magnetoelectric coupling at the $La_{1-x}Sr_xMnO_3$/ionic liquid interface — •alan molinari, philipp leufke, christian reitz, robert kruk, and horst hahn — Karlsruhe Institute of Technology (KIT), Institute of Nanotechnology (INT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

In the last years electric-field control of magnetism has been in the focus of an intense research activity, not only for fundamental research studies but also for the potential realization of novel-low power consumption microelectronic devices. $La_{1-x}Sr_xMnO_3$ (LSMO) is a half-metallic complex oxide with a Curie temperature above room temperature and a para-ferromagnetic transition correlated with the metal-insulator transition. A LSMO thin film has been combined with an ionic liquid in a plate capacitor-like geometry in order to investigate magnetoelectric coupling phenomena upon electrostatic surface charging. High quality epitaxial LSMO thin films have been grown on $SrTiO_3$ substrates by large-distance sputtering and characterized with atomic force microscopy, high-resolution x-ray diffraction and superconducting quantum interference device magnetometry. In situ measurements of magnetization response upon modulation of surface charge carriers have been performed in the 230-325 K temperature range by using a LSMO thin film as working electrode, a carbon cloth as counter electrode and an ionic liquid as charging medium.

MA 52.9 Fri 11:45 H 1012

Magnetoelectric MEMS sensors based on the ΔE-effect — Sebastian Zabel[1], Christine Kirchhof[2], Eckhard Quandt[1], and •Franz Faupel[2] — [1]Chair for Multicomponent Materials, Faculty of Engineering, Christian-Albrechts-University at Kiel, Kaiserstraße 2, D-24143 Kiel — [2]Chair for Inorganic Functional Materials, Faculty of Engineering, Christian-Albrechts-University at Kiel, Kaiserstraße 2, D-24143 Kiel

We present new developments of integrated MEMS magnetic field sensors based on the ΔE-effect, which extends our previous approach [Gojdka et al., Appl. Phys. Lett. 99, 223502 (2011); Nature 480, 155 (2011)]. This effect describes a change of elastic modulus in magnetostrictive materials upon application of a magnetic field. The change of elastic modulus is measured by the change of resonance frequency of a one side clamped cantilever. The 1 x 3 mm Si cantilever is 50 μm thick and coated with a 2 μm thick piezoelectric AlN layer on the top and a 2 μm thick magnetostrictive FeCoSiB amorphous film on the bottom. The piezoelectric layer is used for excitation of the first (7.6 kHz) or second (47 kHz) resonant bending mode as well as the readout of amplitude and phase by current measurements. The sensor shows linear amplitude response from several μT down to the limit of detection at 200 pT/Hz^1/2. High resonance frequencies enable a bandwidth of 60 Hz and prevent coupling to acoustic noise. Vector field capability is achieved by anisotropy control. In order to maximize sensitivity a bias field of 0.7 mT has to be applied.Funding by the DFG is gratefully acknowledged.

MA 52.10 Fri 12:00 H 1012

Anisotropy control in magnetic multilayer devices — •Kai Schlage[1], Denise Erb[1], Lars Bocklage[1,2], Hans-Christian Wille[1], Jade Comfort[1], and Ralf Röhlsberger[1,2] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

Spintronic multilayer devices are employed ubiquitously in modern magnetic data storage and sensor technology. Tremendous efforts were made to further improve these devices; however, the conventional RKKY coupling approach imposes fundamental limitations on the tunability of the magneto-electronic response.

In this contribution we describe a novel class of layered materials with magneto-electronic properties that can be almost arbitrarily tailored. A recently developed thin-film deposition technique, based on oblique incidence deposition, uniquely allows us to prepare multilayers with custom-designed magnetic properties for the first time [1]. Sample systems are characterized via magneto-optical Kerr and magneto-resistive measurements as well as with nuclear resonant reflectometry of synchrotron radiation [2].

[1] K. Schlage, D. Erb, H.-C. Wille, L. Bocklage, D. Schumacher and R. Röhlsberger, European Patent P91642 (2014) [2] K. Schlage and R. Röhlsberger, J. Electron. Spectrosc. Relat. Phenom. 189, 187 (2013)

MA 52.11 Fri 12:15 H 1012

In-situ thin-film electrodeposition in a SQUID magnetometer - a novel tool for studying the evolution of the magnetism during growth of Co films — •Stefan Topolovec[1], Heinz Krenn[2], and Roland Würschum[1] — [1]Institute of Materials Physics, Graz University of Technology, Graz, Austria — [2]Institute of Physics, University of Graz, Graz, Austria

Recently magnetic films formed by electrodeposition have attracted considerable attention [1]. To monitor the evolution of the magnetic moment m during the electrodeposition of thin Co films, we have designed a 3-electrode electrochemical cell for operation in a commercial state-of-the-art SQUID magnetometer, which enables the simultaneous measurement of magnetization and cyclic voltammograms [2,3].

With this new in-situ technique, a precise cancellation of the background signal of the cell and substrate is possible. This gives direct experimental access to the magnetic moment which arises exclusively from the electrodeposited film.

In-situ measurement cycles during growth and subsequent dissolution of Co films of different thicknesses yield evidence of an enhanced magnetic moment in the regime of a few monolayers in agreement with results obtained from theory and measurements of circular dichroism (XMCD) [4].

[1] P. Allongue et al., Surf. Sci. 603 (2009) 1831.
[2] S. Topolovec et al., J. Magn. Magn. Mater. 329 (2013) 43.
[3] E.-M. Steyskal et al., Beilstein J. Nanotechnol. 4 (2013) 394.
[4] M. Tischer et al., Phys. Rev. Lett. 75 (1995) 1602.

MA 52.12 Fri 12:30 H 1012

An in-situ μGISAXS investigation of growth of magnetic nanowires on rippled Si substrates — •Sarathlal Koyiloth Vayalil[1], Ajay Gupta[2], Gonzalo Santoro[1], Peng Zhang[1], and Stephan V. Roth[1] — [1]Photon Science, Deutsches Elektronen-Synchrotron, Notkestrasse-85, 22607, Hamburg, Germany — [2]Amity Center for Spintronic Materials, Amity University, Sector 125, NOIDA, 201313, India

Nanostructured magnetic thin films have gained significant relevance due to their applications in magnetic storage and recording media. Self-organized arrays of nanoparticles and nanowires can be produced by depositing metal thin films on nano-rippled substrates. The substrate topography strongly affects the film growth giving rise to anisotropic properties (optical, magnetic, electronic transport). Ion-beam erosion (IBE) allows for large area patterning of substrates and to tailor the pattern length scale by the ion beam parameters.

We investigated in real time the growth mechanism of magnetic thin films of Co and Permalloy thin films on such tailored nano-rippled Si (100) substrates using in-situ micro grazing incidence small-angle X-

ray scattering (μGISAXS). In the very low thickness regime, the film replicates the morphology, rather an increase in the thickness lead to growth of nanowires in an orientation nearly 55^0 from the surface. The annealing followed by the deposition generates large range ordered nanowires. We are able to correlate observed magnetic anisotropy with anisotropic nanostructure deduced from GISAXS.