MA 28: Magnetic Materials I

Time: Wednesday 15:00–17:45 Location: HSZ 04

MA 28.1 Wed 15:00 HSZ 04

Thickness and strain dependent electric transport in Sr2IrO4 thin films — •Chengliang Lu[1], Dietrich Hesse[1], and Marin Alexe[1,2] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [2]Department of Physics, Warwick University, Coventry CV4 7AL, United Kingdom

Sr2IrO4, which is highly analogous to the p-wave superconductor Sr2RuO4 and Fermi liquid metal Sr2RhO4 in the crystalline structure, is an unexpected weak ferromagnetic insulator. The cooperation of strong spin-orbit coupling (˜0.5 eV) and on-site Coulomb repulsion is responsible for the insulating ground state. Recently, a giant magnetoelectric effect and a lattice-driven magnetoresistance were evidenced in Sr2IrO4 bulk single crystals, and the magnetic field modulated Ir-O-Ir bond angle was proposed to be the origin, which suggests a high sensitivity of the physical properties of Sr2IrO4 to the lattice modulation. Here we investigate the thickness and strain dependent electric transport behavior in Sr2IrO4 thin films grown on various substrates. The electric transport of all samples can be well fitted by the variable-range-hopping model. Interestingly, the magnetoresistance behavior of the films is distinct from the bulk counterpart, which implies the strong coupling of spin, lattice, and orbit in Sr2IrO4.

MA 28.2 Wed 15:15 HSZ 04

Double exchange via t_{2g} orbitals and Jahn-Teller effect in ferromagnetic $La_{0.7}Sr_{0.3}CoO_3$ probed by epitaxial strain — •Dirk Fuchs, Michael Merz, Peter Nagel, Rudolf Schneider, Stefan Schuppler, and Hilbert von Löhneysen — Karlsruhe Institute of Technology, Karlsruhe, Germany

The magnetic exchange in hole-doped ferromagnetic cobaltates is investigated by studying the magnetic and electronic properties of $La_{0.7}Sr_{0.3}CoO_3$ films as a function of epitaxial strain. We found a strong-coupling double exchange mechanism between Co^{3+} and Co^{4+} high-spin states mediated by t_{2g} electrons in contrast to the moderate coupling provided by the e_g-exchange in manganites. The strong sensitivity of the Curie temperature T_C to the bulk compression can be explained by the small bandwidth of the t_{2g}-derived states. A strain-induced Jahn-Teller effect is likewise observed. The experimental results clarify the magnetic exchange mechanism in the cobaltates.

MA 28.3 Wed 15:30 HSZ 04

Fe-Co-X films with spontaneous strain and increased magnetocrystalline anisotropy — •Ludwig Reichel[1,2], George Giannopoulos[3], Martin Hoffmann[1,2], Steffen Oswald[1], Dimitris Niarchos[3], Ludwig Schultz[1,2], and Sebastian Fähler[1,4] — [1]IFW Dresden, PF 270116, 01171 Dresden — [2]TU Dresden, 01069 Dresden — [3]Demokritos NCSR, 15310 Athens, Greece — [4]TU Chemnitz, 09107 Chemnitz

Permanent magnets are ubiquitous. Within the last years, abundance of the rare-earth based alloys has been questioned, but alternatives are still missing. Fe-Co alloy was considered a promising candidate as it provides a very high magnetic moment. A remarkable magnetocrystalline anisotropy (MCA), which is a condition for permanent magnets, is proposed when its cubic unit cell is strained tetragonally [1]. However, in thin films, the strain relaxes within few monolayers. Recently, it was proposed that a low fraction of carbon atoms stabilises the strain and leads to a high MCA [2].

In this study, interstitials as C and B were alloyed to Fe-Co. The films were prepared using PLD. In situ RHEED allowed for an investigation of film relaxation. It was observed, that the relaxation stopped at a c/a ratio of approx. 1.03 i.e. tetragonally distorted. This residual strain is also present in films of thicknesses up to 100 nm and indicates the formation of spontaneously strained Fe-Co-X films. Magnetic measurements demonstrate the influence of strain on magnetic anisotropy.

[1] Burkert et al. Phys. Rev. Let. 93 (2004) 027203
[2] Delczeg-Czirjak et al. submitted (2013)

MA 28.4 Wed 15:45 HSZ 04

Annealing influence on the Gilbert damping parameter and the exchange constant of CoFeB thin films — •Andres Conca, Evangelos Th. Papaioannou, Stefan Klingler, Jochen Greser, Thomas Sebastian, Britta Leven, and Burkard Hillebrands — FB Physik und Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

The search for materials with low-damping properties is very active due to their importance for many fields such as spin-waves experiments, STNOs or for other purposes in magnon spintronics. In this sense, CoFeB is a very promising material with low damping constant values. It is known that an annealing step is required to induce a crystallization of the as-deposited amorphous CoFeB thin films.

A low damping value of $\alpha = 0.0042$ and an exchange constant of $A = 1.5\times10^{-11}$ J/m for as-deposited $Co_{40}Fe_{40}B_{20}$ thin films have been recently reported by us [1]. Now, we report on the influence of the annealing temperature on these and other film properties.

The films were studied by measuring the ferromagnetic resonance using a strip-line vector network analyzer (VNA-FMR). The results are shown for 78 nm thick films annealed at 200-400°C during 30 min. The meaning of the results and the correlation with the crystallization process measured by x-ray diffraction is discussed.

Support by the state of Rhineland-Palatinate (MBWWK and MWKEL) and by the ERDF programm in the frame of the Spintronic Technology Platform (STeP) is gratefully acknowledged.

[1] J. Appl. Phys. **113**, 213909 (2013).

MA 28.5 Wed 16:00 HSZ 04

Buffer-free iron nitride epitaxial thin films — Daniel Bick, Jose Kurian, •Imants Dirba, Oliver Gutfleisch, and Lambert Alff — Institute of Materials Science,Technische Universität Darmstadt, Darmstadt, Deutschland

α''-$Fe_{16}N_2$ is one of the most intensively discussed candidates of rare-earth free permanent magnet materials. We use molecular beam epitaxy for evaluating iron nitride phases in order to understand their magnetic behavior. In current literature, such films are often grown on Fe buffer layers which makes it difficult to exactly determine their magnetization. Here we report on buffer-free or direct growth of Fe nitride phases on oxide substrates. Depending on the nitridation condition using a nitrogen radical source we have successfully grown epitaxial thin films of Fe, FeN, Fe_4N and α'-Fe_8N. Due to the tiny thermodynamic phase space where α''-$Fe_{16}N_2$ forms, it is difficult to obtain this phase without post-deposition annealing. Our preliminary magnetization measurements indicate a reduced magnetic saturation of α'-Fe_8N as compared to literature values.

15 min. break

MA 28.6 Wed 16:30 HSZ 04

Tunnel magnetoresistance in double barrier magnetic tunnel junctions with different free layer deposition conditions — •Ciarán Fowley[1], Wen Feng[1], Huadong Gan[1], René Hübner[1], Annette Kunz[1], Jürgen Lindner[1], Jürgen Fassbender[1,2], JMD Coey[3], and Alina Deac[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, POB 51 01 19, 01314 Dresden, Germany — [2]Institute for Physics of Solids, TU Dresden, Zellescher Weg 16, 01069 Dresden, Germany — [3]School of Physics, Trinity College Dublin, Ireland

Double barrier magnetic tunnel junctions (DB-MTJs) allow for operation at higher bias voltages than their single barrier counterparts, but their total tunnelling magnetoresistance (TMR) ratio is still less than in the single barrier case.[1] Here, we prepare CoFeB/MgO-based DB-MTJs with differing free layer deposition conditions. The deposition conditions for the outer CoFeB electrodes and the MgO barriers were kept the same. The middle CoFeB layer was deposited at differing sputtering power densities (from 1.3 to 4.4 W/cm^2) to vary the B concentration.[2] Contributions of the upper and lower junction to the total TMR were compared as a function of sputtering power density and annealing temperature. As the sputtering power density of the free layer is increased the TMR response of the upper and lower junctions is opposite, indicating that the growth of both MgO on CoFeB as well as CoFeB on MgO is sensitive to B content. This is attributed to the suppression of B diffusion which is confirmed by transmission electron microscopy analysis. [1] T. Nozaki et al., Appl. Phys. Lett., 86, 082501 (2005). [2] H.D. Gan et al., IEEE Trans. Magn. 47, 1567 (2011).

MA 28.7 Wed 16:45 HSZ 04

Substrate polarization dependent magnetic and microstructural properties of high-quality Fe_3O_4/ZnO interfaces — •Michael Zapf[1], Ozan Kirilmaz[1], Sebastian Brück[1], Nadezda Tarakina[1], Nina-Juliane Steinke[2], Eberhard Goering[3], He Tian[4], Jo Verbeeck[4], Michael Sing[1], and Ralph Claessen[1] — [1]Physikalisches Institut and Röntgen Research Center for Complex Materials Systems, Universität Würzburg, Germany — [2]Rutherford Appleton Laboratory, Chilton, UK — [3]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [4]Electron Microscopy for Materials Science, University of Antwerp, Belgium

Magnetite (Fe_3O_4) is among the most promising materials for use as a spin injector into a semiconducting host such as, e.g. ZnO. We present a detailed study of the interface characteristics of epitaxial MBE-grown Fe_3O_4 films in dependence of the ZnO substrate polarization. We were able to prepare flat terraced surfaces for both Zn- and O-polar (0001) oriented substrates by *ex situ* annealing procedures. X-ray photoemission evidences that the films are phase-pure and stoichiometric. The growth mechanism and bulk film properties have already been investigated in previous publications. We discuss our recent data from polarized neutron and X-ray reflectometry, transmission electron microscopy TEM) and magnetometry on the influence of the chosen substrate termination on magnetism and atomic ordering at the interface of our samples. Furthermore a comprehensive TEM study shows local strain fields arising from the lattice mismatch of Fe_3O_4 and ZnO that lead to a modulated Fe valency at the interface.

MA 28.8 Wed 17:00 HSZ 04

The effect of strain on the orbital occupation of Mn atoms in thin films of $La_{1-x}Sr_{1+x}MnO_4$ — Mehran Vafaee[1], •Philipp Komissinskiy[1], Roberto Kraus[2], Valentina Bisogni[2], Mehrdad Baghaie Yazdi[1], Jochen Geck[2], and Lambert Alff[1] — [1]Institute for Materials Science, Technische Universität Darmstadt, Alarich-Weiss-Straße 2, 64287 Darmstadt, Germany — [2]Leibniz Institute for Solid State and Materials Research, Helmholtzstrasse 20, D-01171 Dresden, Germany

We have investigated the correlation between orbital and lattice degrees of freedom in thin films of single-layered insulating antiferromagnet $La_{1-x}Sr_{1+x}MnO_4$ ($x = 0.0$, 0.5) using linear polarized X-ray absorption spectroscopy at Mn $L_{2,3}$-edges. Lattice parameters of the $La_{1-x}Sr_{1+x}MnO_4$ films are controlled by in-plane compressive and tensile strain induced via their epitaxial growth on $LaSrAlO_4$ and $NdGaO_3$ substrates, respectively [1]. Positive sign of the linear dichroism measured for the films with $x = 0.0$ indicates the preferential out-of-plane $d_{3z^2-r^2}$ orbital occupation for Mn^{3+} cations. Occupation of the in-plane-oriented orbitals in the films with $x = 0.0$ may be possible at the tensile strain larger than 1.9 % used in our experiments. Tetragonal lattice distortions in the strained LSMO films with $x = 0.5$ promote preferential occupation of the out-of-plane-oriented Mn orbitals instead of the $d_{3x^2-r^2}$ and $d_{3y^2-r^2}$ in-plane-oriented ones previously reported for $La_{1-x}Sr_{1+x}MnO_4$ single crystals with similar doping level.

[1] M. Vafaee, M. Baghaie Yazdi, A. Radetinac, G. Cherkashinin, P. Komissinskiy, and L. Alff, J. Appl. Phys. **113**, 053906 (2013).

MA 28.9 Wed 17:15 HSZ 04

X-ray absorption magnetic circular dichroism study on ferromagnetic $SrRuO_3$ — •Stefano Agrestini[1], Zhiwei Hu[1], Nils Hollmann[1], Chang-Yang Kuo[1], Qiang Liu[1], Eric Pellegrin[2], Pierluigi Gargiani[2], Philipp Gegenwart[3], Melanie Schneider[3], Sebastian Esser[3], Alexander Komarek[1], and Liu Hao Tjeng[1] — [1]Max Planck Institut CPfS, Dresden, Germany — [2]CELLS-ALBA, Barcelona, Spain — [3]I. Physikalisches Institut, Georg-August-Universität, Göttingen, Germany

$SrRuO_3$ have received intensive research interest because it is one of the very few ferromagnetic metallic 4d transition metal oxides, with a high Curie temperature of T_c=160 K, as well as unusual negative spin polarization and magnetoresistive properties. Ru^{4+} has S=1 spin state, however, very recently it has been suggested that a high spin state (S=2) of Ru^{4+} could be stabilized on compressively in-plane strained $SrRuO_3$ films.

Here we report a study of x-ray magnetic circular dichroism (XMCD) in x-ray absorption (XAS) on the Ru-L2,3 edge on $SrRuO_3$ thin films with different substrate orientations, the (111) and (001) surfaces of $SrTiO_3$. Only a very small directional dependence was found. The XMCD spectra of a $SrRuO_3$ single crystal has been recorded and shows good agreement with the spectral line shape of the thin films. We could not find evidence of the stabilization of a high spin S=2 state. Applying the XMCD sum rules, it can be seen that the orbital momentum of the Ru ions is almost quenched. This surprising finding could be explained by an itinerant character of the Ru electrons.

MA 28.10 Wed 17:30 HSZ 04

Formation of nanostructured NiFe alloy thin films by glancing incidence sputter deposition on nano-rippled Si substrates: an in-situ uGISAXS study — •Sarathlal Koyiloth Vayalil[1], Ajay Gupta[2], Gonzalo Santoro[1], Peng Zhang[1], Shun Yu[1], and Stephan V Roth[1] — [1]Photon Science, Deutsches Elektronen-Synchrotron, Notkestrasse-85, Hamburg, Germany, 22607 — [2]UGC-DAE Consortium for Scientific Research, University Campus, Khandwa Road, Indore, India, 452001.

In this work, growth of potentially important soft magnetic thin films of NiFe alloy on nano-rippled Si substrates at two different deposition geometries (i) normal incidence (ii) glancing angle deposition have been described. The results have been compared with the deposition on pristine Si substrates. Grazing incidence small angle measurements coupled with highly sophisticated sputtering chamber enabled a detailed growth study at nanoscale with time resolution in the order of milliseconds[1]. It has been found that, growth is highly anisotropic along and normal to the ripple wave vectors in both the cases. The annealing followed by the deposition generates large range ordered nanowires of NiFe. Further, ex-situ magnetic measurements have been done using magneto-optical Kerr effect by rotating the sample in azimuthal direction. The mechanism of the observed magnetic anisotropy has been explained by correlating with the GISAXS results.

[1]Dörhmann et al. Rev. Sci. Instrum. 84, 043901 (2013)