MA 17: Magnetic Thin Films I

Time: Wednesday 10:15–12:45 Location: HSZ 04

MA 17.1 Wed 10:15 HSZ 04

Magnetocrystalline anisotropy of strained FeCo alloys — •Stephan Schönecker, Carsten Neise, Manuel Richter, Klaus Koepernik, and Helmut Eschrig — IFW Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany

Tetragonally distorted $Fe_{1-x}Co_x$ alloys recently attracted interest due to their potential application as new media for high density recording, combining both a large uniaxial magnetocrystalline anisotropy (MAE) and a large saturation magnetisation for certain chemical composition x and tetragonal distortion. Volume relaxation was neglected in earlier calculations [1], which is however present at epitaxially grown layers and may alter the concluded magnetic properties of these alloys.

By considering the epitaxial Bain path, which provides a reasonable description of tetragonally distorted films on substrates (e.g. [2]), we investigated the influence of volume relaxation on the MAE and on the magnetic moment of $Fe_{1-x}Co_x$ alloys and on the ordered $L1_0$ phase ($Fe_{0.5}Co_{0.5}$). We employed density functional calculations in the implementation of the full potential local orbital program package FPLO [3]; disorder was described within the virtual crystal approximation.

[1] T. Burkert, L. Nordström, O. Eriksson, and O. Heinonen, Phys. Rev. Lett. **93**, 027203 (2004)
[2] P. M. Marcus, F. Jona, and S. L. Qiu, Phys. Rev. B **66**, 064111 (2002)
[3] K. Koepernik and H. Eschrig, Phys. Rev. B **59**, 1743 (1999); http://www.fplo.de

MA 17.2 Wed 10:30 HSZ 04

On origin of perpendicular anisotropy in $Fe_{1-x}Co_x$ alloy films grown on Pd(001), Ir(001) and Rh(001) substrates — •Fikret Yildiz, Marek Przybylski, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

We have shown that the $Fe_{1-x}Co_x$ alloy films of the composition around x = 0.5 show a maximum perpendicular anisotropy when their cubic lattice is tetragonally distorted by growing the films on mismatching substrates like Pd(001), Ir(001) and Rh(001) [1,2]. The easy magnetization axis reorients at different temperatures showing that the perpendicular anisotropy depends on distortion of cubic symmetry, i.e. on the c/a ratio. For the same composition the uniaxial anisotropy reaches maximum for the $Fe_{0.5}Co_{0.5}$ films grown on Rh(001) (c/a = 1.24). To verify this hypothesis we have grown a buffer layer of Pd a few ML thick on Rh(001). Low energy electron diffraction (LEED) pattern shows that the spots are exactly at the same positions as for the clean Rh(001) substrate which proves that the lattice constant of the Pd-buffer is the same as the one of the Rh(001) substrate. The hysteresis loops of the $Fe_{0.5}Co_{0.5}$ films grown on top of it are just the same as the loops measured for the films grown directly on the Rh(001) substrate. This confirms that the strong perpendicular anisotropy originates from an appropriate tetragonal distortion.

[1] A. Winkelmann, M. Przybylski, F. Luo, Y. Shi, J. Kirschner, Phys. Rev. Lett. 96, 257205 (2006) [2] F. Yildiz, F. Luo, C. Tieg, R. Abrudan, X. L. Fu, A. Winkelmann, M. Przybylski, J. Kirschner, Phys. Rev. Lett. 100, 037205 (2008)

MA 17.3 Wed 10:45 HSZ 04

Tailoring the FePt orientation on amorphous substrates by magnetron sputtering - Structural and magnetic investigations — •valentina cantelli, johannes von borany, jörg grenzer, and jürgen fassbender — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, Dresden, Germany

High magnetocrystalline (001) oriented $L1_0$ FePt layers are widely studied for perpendicular recording magnetic media. We will report about the tuning of FePt (001) orientation using Ar and Xe gases, onto a-SiO_2/Si substrates by magnetron sputtering deposition at 0.3 Pa. Layer-by-layer and co-deposition were investigated comparatively. Thin (∼12 nm) $Fe_{55}Pt_{45}$ layers were deposited at RT, subsequently annealed at 750°C to induce the A1-$L1_0$ ordering transformation. Sputtering in Ar delivers energetic particles (∼ 12 eV sputtered Fe or Pt atoms and ∼ 100 eV Ar reflected neutrals from Pt target). This energy budget enhances surface adatom mobility, creates vacancies [1], and supports vertical intermixing into the layer, during deposition. At RT, a randomly oriented crystalline FePt A1 structure is produced. After annealing, the $L1_0$ phase is obtained with coercive field H_C = 20 kOe and weak (001) orientation, irrespective of deposition methods. Sputtering in Xe significantly reduces energetic impacts from backscattered neutrals. Using a layer-by-layer deposition, $L1_0$ films have H_C = 5.6 kOe with the lowest (∼ 2.5°) angular dispersion around the (001) direction. [1] V. Cantelli, J. von Borany, A. Mucklich, Shengqiang Zhou, J. Grenzer, Nucl. Instr. and Meth. B 257, (2007) 406

MA 17.4 Wed 11:00 HSZ 04

Investigation of the magnetic properties in thin Fe50Pt50-xRhx films by neutron diffraction — •J. Fenske[1], D. Lott[1], G.J. Mankey[2], W. Schmidt[3], K. Schmalzl[3], E. Tartakowskaya[4], and A. Schreyer[1] — [1]GKSS Research Centre — [2]The University of Alabama, MINT Center — [3]Jülich Research Centre — [4]Institute for Magnetism, National Accademy of Science

FePt-based alloys are typically the material of choice for magnetic information storage media. The high magnetic moment of Fe gives a large magnetization and the large atomic number of Pt results in a high magnetic anisotropy. This combination enables the written bits to be smaller than ever before, since magnetic grains with a high magnetic anisotropy are more thermally stable. One way to control the magnetic properties in these materials is through the introduction of a third element into the crystal matrix, e.g. Rh. When Rh is added to replace Pt in the equiatomic alloy, new magnetic phases emerge. Bulk samples of Fe50Pt40Rh10 for example, studied by magnetization measurements refer to an antiferromagnetic (AF)/ferromagnetic (FM) phase transition at about 150K when heated[1]. Additional magnetostriction measurements indicate that the phase transition could also be induced by applying a magnetic field[2]. Here we present results on several Fe50Pt50-xRhx films. These films were examined by neutron diffraction in dependence of temperature and magnetic field. The observed magnetic behaviours differ significant from the behaviour of the bulk system. [1] S. Yuasa, H. Miyajima and Y. Otani, J. Phys. Soc. Jpn. 63 (8), 1994 [2] P.A. Algarabel, et. al, J.Appl. Phys. 79 (8), 1996

MA 17.5 Wed 11:15 HSZ 04

Trends in exchange interactions for bcc Fe/TaW(001) — •Martin Ondráček[1], Josef Kudrnovský[1], Olivier Bengone[2], Ilja Turek[3,4], and František Máca[1] — [1]Institute of Physics ASCR, Prague — [2]University of Strasbourg, IPCM, Strasbourg — [3]Institute of Physics of Materials ASCR, Brno — [4]Department of Condensed Matter Physics, Charles University, Prague

A recent study of Ferriani et al. [1] investigated the possibility of tuning the magnetic order of the Fe monolayer on the disordered bcc-Ta(x)W(1-x)[001] surface. We will further extend this study by constructing the effective two-dimensional Heisenberg Hamiltonian, which describes exchange interactions in the iron monolayer in detail. We will investigate the behavior of exchange integrals as a function of the composition of the alloy substrate, but also as a function of distance (damping due to disorder) and the dependence on the crystallographic directions in the overlayer. The calculated exchange integrals allow us to estimate the spin stiffness and the corresponding critical temperatures. We also wish to investigate the crossover between the ferromagnetic and antiferromagnetic state from the point of view of the stability of the Heisenberg Hamiltonian with respect to magnon excitations. The present study will help us to deeper understand the character of magnetic phase transition of the Fe overlayer due to disorder in the alloy substrate.

[1] P. Ferriani, I. Turek, S. Heinze, G. Bihlmayer, and S. Blügel, Phys. Rev. Lett. 99 (2007) 187203.

MA 17.6 Wed 11:30 HSZ 04

Properties of the Fe/GaAs(110) interface investigated by ab inito calculations — •Anna Grünebohm, Heike C. Herper, and Peter Entel — Fachbereich Physik, Universität Duisburg-Essen, Duisburg

Fe/GaAs is a widely used system for spintronic devices. For example the small lattice mismatch (<2%) and the cheap preparation of layered systems are promising. Because of this many studies on Fe/GaAs have been performed in the last decades mostly on the (001) direction. Recently the (110) direction has attracted plenty of attention as the free GaAs(110) surface doesn't reconstruct and allows to grow flat interfaces. Unfortunately, diffusion and alloy formation occur at both interfaces which may lead to reduced spin injection and magnetic inactive regions.

To get an insight into the interface properties we do calculations within the PAW method using VASP [1] adopting the GGA/PBE form for the exchange-correlation potential. To simulate the free surface the slap method is used thereby one side of the slab is passivated through pseudo-hydrogen to guarantee a bulk-like behavior in a moderate sized slap. The adsorption of single Fe-atoms as well as the first monolayers of iron are investigated with respect to the energy landscape for different structures and the magnetic moments. While diffusion of atoms through the interface was shown to be low in energy no magnetic inactive phase could be observed. Hence our results don't show any fundamental limitations for spintronic applications.

[1] G.Kresse and J.Furthmüller, Phys. Rev. B 54, 11169 (1996)

MA 17.7 Wed 11:45 HSZ 04

Stress, structure and magnetism of epitaxial Fe monolayers on Ir(100)-(1x1) — •Zhen Tian, Dirk Sander, Fikret Yildiz, Marek Przybylski, and Jürgen Kirschner — Max-Plank Institute of Microsctructure Physics, 06120, Halle, Germany

We have performed combined LEED, stress and magneto optic Kerr effect (MOKE) measurements on Fe monolayers on Ir(100). Our experimental results indicate pseudomorphic growth of Fe layers from 0 to 10 ML. The large mismatch of −5.3% between Fe and the Ir(100) substrate leads to a bct Fe lattice under compressive stress of −10 GPa[1]. Ferromagnetic hysteresis loops are observed for Fe thickness above 4 ML at room temperature, with an easy magnetization axis in plane. The Curie temperature of 4 ML Fe is around 200 K. MOKE measurements are performed with both longitudinal and polar geometry from 300 K down to 5 K. Up to 3 ML, the film does not show a ferromagnetic responses in magnetic fields of up to 0.5 T. These results are discussed in view of results on the related system of Fe on Rh(001)[2], and also in view of a possible 2 ML fcc Fe precursor on Ir(100)[1].

[1]V. Martin et al. Phys. Rev. B, 76 (2007) 205418 [2]K. Hayashi et al. Phys. Rev. B, 64 (2001) 054417

MA 17.8 Wed 12:00 HSZ 04

Magnetoelectric phase transition in Fe/Cu(111) — •Lukas Gerhard[1], Toyo K. Yamada[1], Timofey Balashov[1], Albert F. Takács[1], Arthur Ernst[2], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Universität Karlsruhe (TH), Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

Both the crystallographic and the magnetic structure of Fe exhibit a rich phase diagram. Two different crystallographic phases, fcc and bcc, have been reported to coexist in Fe islands on Cu(111) [1]. Comparing our scanning tunnelling spectroscopy to ab-initio calculations, we identified the magnetic ordering of these two phases as layer-wise antiferromagnetic and ferromagnetic. Surprisingly, we observed transitions between these two phases during our STM measurements at 4 K. A systematic study of the tunnelling parameters revealed the electric field of the STM tip as the origin. Applying different electric fields, we could switch between the two different phases on nm scale. The observed coupling of the crystallographic and magnetic structure with an external electric field is explained by a difference in the work function of the two phases and thus evidences Fe/Cu(111) as a multiferroic system.

[1] A. Biedermann, W. Rupp, M. Schmid and P. Varga, Phys. Rev. B 73, 165418 (2006)

MA 17.9 Wed 12:15 HSZ 04

Topological defects and remanent states in antiferromagnetically coupled multilayers with perpendicular anisotropy — •Nikolai S. Kiselev[1,2], U.K. Rössler[1], A.N. Bogdanov[1], and O. Hellwig[3] — [1]IFW Dresden — [2]Donetsk Institute for Physics and Technology — [3]Hitachi GST, San Jose

In antiferromagnetically coupled multilayers with strong perpendicular magnetic anisotropy the antiferromagnetic state may include complex networks of "antiferromagnetic domain walls". In contrast to bulk antiferromagnets these defects are determined by a close competition between antiferromagnetic interlayer exchange and dipolar coupling [1,2]. Within a phenomenological theory [1,2] we have classified the topological magnetic defects in the antiferromagnetic ground state. Depending on the material parameters and the magnetic history the antiferromagnetic remanent monodomain state may include sharp domain walls, "trapped" strips of ferro and antiferro defect domains within the wall, and various metastable isolated defects formed from remanent domains with internally ferrimagnetic state. The metastable domain wall of the antiferromagnetic monodomain state can acquire a certain width as ferro strips, which exist either in single domain state or split into a system of domains creating "tiger-tail"patterns. We have calculated equilibrium parameters of ferro strips with tigertail textures and determined the conditions of their transition into the single domain state.

[1] N.S. Kiselev, U. K. Rößler, A. N. Bogdanov, O. Hellwig Appl. Phys. Lett. **93** 132507 (2008). [2] N.S. Kiselev, et al. arXiv: cond-mat/0811.2378.

MA 17.10 Wed 12:30 HSZ 04

Microscopic theory of spin waves in ferromagnetic films — •Andreas Kreisel, Francesca Sauli, and Peter Kopietz — Institut für Theoretische Physik, Universität Frankfurt, Max-von-Laue Straße 1, 60438 Frankfurt/Main

Motivated by experiments on finite ferromagnetic films consisting of Yttrium iron garnet (YIG), we have used a microscopic method of calculating the spin-wave spectrum in those systems. Both the long range magnetic dipole-dipole interactions and the Heisenberg exchange interactions are taken into account in our approach. We calculate the spin wave energy as well as the magnon states and compare our results with predictions based on the phenomenological Landau-Lifshitz equation and with experiments on YIG films.