MA 29 Magnetic Thin Films IV

Time: Thursday 15:15–18:15 Room: HSZ 03

MA 29.1 Thu 15:15 HSZ 03

Critical Thickness and Critical Field of magnetic multilayered structures — •Hartmut Hafermann[1] and Mikhail I. Katsnelson[2] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg — [2]University of Nijmegen, Toernooiveld 1, NL 6525 ED Nijmegen, The Netherlands

For magnetic thin films and multilayers the phase transition from the homogeneous magnetization to the domain structure occurs at a critical thickness. For supercritical films, the phase transition occurs at a critical field applied in the film plane.

By investigating the stability conditions of a linearized Landau-Lifshitz torque equation, we are able to calculate numerically the critical thickness and critcal field for magnetic multilayered structures, consisting of alternating magnetic layers or magnetic and nonmagnetic layers. In addition we obtain information on the spin wave dispersion relation as well as the domain structure and domain period close to the phase transition.

We studied the influence of volume and surface anisotropies as well as interlayer exchange coupling between magnetic and across nonmagnetic spacer layers on the critical thickness and the critical field.

MA 29.2 Thu 15:30 HSZ 03

Magnetic coupling in Gd/Ni-layered films — •Alexander Barth[1], Frank Treubel[1], Jacek Jaworski[2], Marta Marszalek[2], Manfred Albrecht[1], and Günter Schatz[1] — [1]Universität Konstanz, Fachbereich Physik, Konstanz — [2]The H. Niewodniczanski Institute of Nuclear Physics, Krakau

In this study the magnetic interaction of the rare earth metal Gadolinium and the transition metal Nickel was examined. In the first approach the materials were deposited under UHV conditions onto sapphire and silicon nitride substrates. In order to investigate the coupling mechanism of the two layers the Nickel thickness was varied. Then measurements by SQUID and XMCD were used to resolve magnetic properties. The structure was examined by XRD and MEED and the composition during evaporation by AUGER-spectroscopy. Due to the huge size of the Gd-atoms and their thereby low mobility on the substrate surface the layer grows amorphous from the first monolayer on. In order to suppress interdiffusion with the Ni-layer the sample was cooled to -175°C. But still a strong tendency to intermixing could be observed on sapphire but not on the silicon nitride. The system shows a variety of magnetic coupling phenomena between the two layers with a strong temperature dependence due to an amorphous Gd/Ni-alloy forming inbetween.

MA 29.3 Thu 15:45 HSZ 03

Exchange-coupled Sm-Co trilayer systems — •Katrin Häfner, Ajit Patra, Volker Neu, Steffen Oswald, and Ludwig Schultz — IFW Dresden, P.O. Box: 270116, 01171 Dresden, Germany

Exchange-coupled Sm-Co trilayers have been prepared by pulsed laser deposition on Cr buffered MgO(110) substrates at elevated temperature. Soft magnetic layers of Fe and Fe-Co were sandwiched between two hard magnetic Sm-Co layers of 25 nm thickness and their influence on the magnetic properties was investigated. Film architecture, texture and magnetic properties of the films have been investigated by x-ray photo electron spectroscopy, pole figure measurements and vibrating sample magnetometry. The texture investigations show that the Sm-Co/Fe/Sm-Co and Sm-Co/Fe-Co/Sm-Co trilayers grow epitaxially throughout the whole layer stack with the following relationship: Sm-Co(100)[001]|| Fe/Fe-Co(211)[01-1]||Sm-Co(100)[001]||Cr(211)[01-1]||MgO(110)[001]. By varying the soft layer thickness d_s the magnetic behaviour of the trilayer changes from a completely coupled system with high coercivity of 1.5 T for $d_s = 5$ nm to a partially coupled regime with coercivities decreasing down to 0.8 T for d_s= 15 nm. The epitaxial growth of Sm-Co/Fe-Co/Sm-Co trilayers has been observed for the first time and is a very promising approach for fully coupled, remanence enhanced permanent magnet multilayers.

MA 29.4 Thu 16:00 HSZ 03

Coexistence of collinear and non-collinear magnetic domains in an [Er|Tb] superlattice — •Jörg Voigt, Emmanuel Kentzinger, Ullrich Rücker, Amitesh Paul, and Thomas Brückel — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

The off-specular neutron scattering from an [Er|Tb] superlattice reveals the correlation length of co-existing magnetic structures. From wide angle neutron diffraction, the phase diagram has been deduced earlier, showing commensurate und incommensurate correlations in the same temperature range $T < 60$ K [1]. Polarized neutrons allow to distinguish between collinear ferromagnetic correlations and non-collinear helical correlations. We have studied the formation of the different domains as a function of magnetic field, temperature and magneto-thermal history of the sample.

[1] J.Voigt et al.,Europhys. Lett., 65 (4) , pp. 560-566 (2004)

MA 29.5 Thu 16:15 HSZ 03

New magnetic order in Fe/Fe-oxide superlattices — •Th. Diederich[1], R. Röhlsberger[1], S. Stankov[2], and R. Rüffer[2] — [1]Deutsches Elektronen Synchrotron DESY, Notkestr.85, 22607 Hamburg — [2]European Synchrotron Radiation Facility ESRF, B.P. 220, 38042 Grenoble Cedex, France

We have studied the magnetic structure of multilayer systems consisting of Fe and native Fe-oxide. The Fe layers have been produced by magnetron sputtering. Native oxide layers on the Fe were prepared by subsequent dosage of oxygen into the chamber. The samples have been prepared in an UHV system and were analysed in-situ by Nuclear Resonant Scattering (NRS). Ultrathin layers of ^{57}Fe are used to probe the magnetic structure of the Fe and the Fe-oxide layers with very high spatial resolution. Surface oxide layers coupled to the metallic Fe appeared to be nonmagnetic at room temperature. After deposition of another Fe layer one observes a ferromagnetically ordered component in the Fe-oxide layer that increases with growing thickness of the iron capping layer. This results in a relatively high magnetization of these buried oxide layers [1]. In an Fe/^{57}Fe-oxide superlattice we discovered a new type of interlayer coupling that results in superstructure Bragg peaks of the nuclear resonant reflectivity [2]. These observations point to an antiferromagnetically ordered spin arrangement within the lattice of Fe-oxide layers.

[1] G.S.D. Beach et al. Phys. Rev. Lett. 91, 267201 (2003).
[2] Th. Diederich, R. Röhlsberger et al., to be published.

MA 29.6 Thu 16:30 HSZ 03

Effect of hydrogen on the magnetism in Fe/V superlattices — •Arndt Remhof[1], Gregor Nowak[1], Alexei Nefedov[1], Matts Björk[2], Martin Pärnaste[2], Björgvin Hjörvarsson[2], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik / Festkörperphysik, Ruhr-Universität Bochum, Germany — [2]Department of Physics, Uppsala University, Sweden

We report on the increase of the Fe magnetic moment within Fe/V superlattices upon H-uptake. At the Fe/V interface of pristine, ferromagnetically coupled Fe/V superlattices the V atoms acquire a magnetic moment, antiparallel aligned to the Fe moments [1]. Upon hydrogen loading the saturation magnetization was found to increase [2]. We employed element specific X-ray resonant magnetic scattering to investigate the response of the Fe and the V moments separately. An epitaxial [Fe(2ML)/V(16ML)]×30 superlattice was employed, ensuring a high number of V neighbors of each Fe atom. The soft x-ray measurements were carried out using the ALICE diffractometer at BESSY II in Berlin, Germany. The data clearly show a strong increase of the Fe moment upon H-loading. No change of the magnetic asymmetry at the V edge could be recognized. Our measurements confirm nicely the theoretical model by Uzdin et al. [3], predicting an increase of the Fe moment and a stable V moment in H loaded Fe/V superlattices.

This project founded by the DFG under contract no. RE 2203/1-1.

[1] A. Scherz et. al. Phys. Rev. B 68, 140401(R) (2003).
[2] D. Labergerie, et al. J. Magn. Magn. Mater. 225, 373 (2001).
[3] V. Uzdin, et al., Phys. Rev. B 68, 214407 (2003).

MA 29.7 Thu 16:45 HSZ 03

Synthetic metamagnetism: reorientation effects and multidomain states in perpendicular antiferromagnetic superlattices — •U.K. Rössler and A.N. Bogdanov — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Recently synthesized antiferromagnetically coupled multilayers with strong perpendicular magnetic anisotropy, like [CoPt]/Ru, [CoPt]/NiO, Co/Ir, or Fe/Au, represent a new class of magnetic materials. These synthetic metamagnets are characterized by a cascade of metamagnetic

phase transitions, extended regions of metastable states and complex multidomain structures [1,2]. Within a phenomenological theory, we have classified and analyzed the wide variability of magnetic field-driven reorientation transitions and accompanying multidomain states in these synthetic metamagnets. In contrast to other bulk and nanomagnetic systems, the magnetic states are determined by a close competition between antiferromagnetic interlayer exchange and dipolar couplings. The theory of this phenomenon allows to explain the unusual switching processes and specific transformation of the domain patterns observed in these synthetic metamagnets.

[1] O. Hellwig et al., Nature Mater. 2 (2003) 112. [2] U. K. Rößler, A. N. Bogdanov, JMMM 269 (2004) L287.

MA 29.8 Thu 17:00 HSZ 03

Comparison of sputter-techniques for Co/Pt-multilayer-growth — •H. Stillrich[1], S. Pütter[1], D. Lott[2], R. Frömter[1], A. Schreyer[2], and H.P. Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]GKSS-Forschungszentrum Geesthacht, Institut für Werkstoffforschung, Max-Planck-Str., 21502 Geesthacht, Germany

Co/Pt-Multilayers are well known to show high perpendicular magnetic anisotropy (PMA) and magneto-optic response. Therefore there has been great interest in this system over the last decades. In general these films are grown either by MBE or by magnetron sputtering.

In the work presented here ECR-sputtering was used as growth process to guarantee kinetic growth conditions. The films reported in this study show high quality Pt(111)-texture which is crucial for high perpendicular surface anisotropies. The films show PMA for Pt-buffer-layers as thin as 4 nm and Co-layers from 0.4 to 0.7 nm.

We have investigated the magnetic, magneto-optic and structural properties from single Co-layers to Co-multilayers. The magnetic properties are studied by magneto-optic Kerr effect (MOKE) and scanning electron microscopy with polarization analysis (SEMPA). Structural analysis was carried out by x-ray diffraction and reflectometry. The films grown by ECR-sputtering show interface intermixing and the surface anisotropy is reduced compared to MBE or magnetron sputtered films. For comparison we have also grown Co/Pt-films by magnetron sputtering. The influence of the growth technique on film properties is discussed.

MA 29.9 Thu 17:15 HSZ 03

Electrodeposition and magnetic properties of multilayered Fe-Pt films — •Karin Leistner, Heike Schlörb, Sebastian Fähler, and Ludwig Schultz — IFW Dresden

The $L1_0$ FePt phase exhibits a very high magnetocrystalline anisotropy and a high saturation magnetisation. These properties make FePt films suitable for micromagnets in micro electromechanical systems. There, films with thicknesses in the μm range are needed which could be economically produced by electrodeposition. Up to now homogeneous FePt films have been deposited potentiostatically. During post annealing in hydrogen, the $L1_0$ phase is formed and coercivities up to 1.1 T have been achieved [1]. However, oxygen is incorporated into the films during electrodeposition and cannot be fully removed during annealing. Oxide impurities are thus limiting the remanence. Less oxygen is incorporated when depositing the single elements. It has been shown that by alternating the deposition potential, Fe/Pt multilayers with a significantly lower oxygen content can be obtained. Annealing of these multilayers leads to complete intermixing and the formation of the $L1_0$ phase. Coercivities as high as 1 T are obtained.

[1] K. Leistner, H. Schlörb, J. Thomas, M. Weisheit, S. Fähler, L. Schultz, APL 85(16), 3498 (2004)

MA 29.10 Thu 17:30 HSZ 03

On the temperature driven reorientation in Au/Co/Au: the influence of the structure — •E. Holub-Krappe[1], A. Hahlin[2], H. Maletta[1], C. Andersson[2], O. Karis[2], J. Hunter Dunn[3], and D. Arvanitis[2] — [1]Hahn-Meitner-Institut, Berlin, Germany — [2]Department of Physics, Uppsala University, Sweden — [3]MAX-lab, Lund University, Sweden

We present X-ray Magnetic Circular Dichoism (XMCD) results to characterize the Spin Reorientation Transition (SRT) in ex-situ prepared epitaxial Au/Co sandwich structures [1]. The Co thickness is kept 1.9 nm, the Au cap thickness is 2 nm. The temperature is varied between 170 K and 300K. The in-plane response is characterized by element specific hysteresis loops taken in the resonant reflectivity mode. Below 200K only an out-of-plane remanence is stable. At 300K the out-of-plane remanence decreases to zero. Between 200 and 300K both an in- as well as an out-of-plane remanence can be stabilized. A canted magnetization is excluded using angle dependent XMCD. The same values are found for the in- and out-of-plane spin moment. In contrast, the orbital moment exhibits a variation between the in-and out-of-plane phases. In the transition region the in- and out-of-plane remanence correspond to different values of the orbital moment. The SRT has been linked to the strong temperature dependence of the Co/Au interface anisotropy constants. Our results highlight the importance of structural modifications to the temperature induced SRT.

[1] R. Sellmann, H. Fritzsche, H. Maletta et al. Phys. Rev. B 64, 054418 (2001)

MA 29.11 Thu 17:45 HSZ 03

Magnetic domains and spin structure in single-crystalline NiMn/Co bilayers on Cu(001) — •Carsten Tieg[1], Radu Abrudan[1,2], Matthias Bernien[2], Wolfgang Kuch[2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle — [2]Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin

The magnetic domain structure in epitaxial single-crystalline bilayers of antiferromagnetic NiMn and ferromagnetic Co on Cu(001) was studied by photoelectron emission microscopy using the element selective x-ray magnetic circular dichroism as a contrast mechanism. We observed that the Co domain structure changes from a large domain configuration into a small domain configuration as the thickness of the NiMn layer exceeds a critical thickness of 8–10 monolayer (ML) at $T = 300$ K. The occurrence of small domains in the Co layer is attributed to the magnetic phase transition in the NiMn layer from para- to antiferromagnetic (AFM). The spin structure of NiMn deposited on magnetically saturated Co was investigated by x-ray magnetic linear dichroism (XMLD) spectroscopy. A non-vanishing XMLD signal was found at the Mn L_3 absorption edge obtained from a 20 ML NiMn/6 ML Co/Cu(001) sample. This indicates a certain degree of collinearity of the Mn moments in the NiMn layer. The angular dependence of the XMLD signal suggests a non-bulk-like AFM spin structure of NiMn. The XMLD spectra can be explained by a small twist of the bulk AFM spin axes towards the Co magnetisation direction.

MA 29.12 Thu 18:00 HSZ 03

Magnetoelastic waves in multilayered structures — •Zukhra Gareyeva — IMCP,prospect Octyabrya 151, Ufa , Russia

The presented paper reports investigation of dynamic properties of magnetoelastic and elastic waves in confined layered structure representing a system made of magnetostrictive thin films deposited on nonmagnetic substrates. Application area of such structures is wide and encounters sensors and actuators for bulk and microelectromechanical devices, devices for delay lines, angular motion, torque generation, magnetic labels etc. In this article we draw attention to frequencies of vibrations induced by variable magnetic field in composed films-substrate system and peculiarities of their behavior under the change of intrinsic and external parameters. We show dispersion law of composite system differs from the case of thin magnetic film. It reveals in peculiarities of dimensional resonant frequencies behaviour. Results of investigation are expected to be important both from theoretical and practical point of views: to predict behaviour of magnetostrictive systems subjected to magnetic dynamic loads, to determine elastic and magnetoelastic properties of materials from dynamic experiments, to control dimensional resonances frequencies in composite oscillator devices, to contribute to the laminated plate theory.