MA 7 Magnetische dünne Schichten II

Zeit: Freitag 15:15–18:30 Raum: TU H1012

MA 7.1 Fr 15:15 TU H1012

Fully oriented Nd-Fe-B films grown on MgO(100) substrates — •Ah-Ram Kwon, Ullrich Hannemann, Sebastian Fähler, Volker Neu, Bernhard Holzapfel, and Ludwig Schultz — IFW Dresden, Helmholtzstr. 20, 01069 Dresden and SFB 463

For both, applications and the study of their anisotropic intrinsic properties, well textured $Nd_2Fe_{14}B$ film are required. This can be achieved by epitaxial film growth, which is controlled by a suitable choice of buffer and substrate materials as well as deposition conditions. Nd-Fe-B films were prepared by pulsed laser deposition on Ta buffer layer using different substrates: amorphous SiN, Al_2O_3 (0001) and MgO(100) substrates in order to control the texture in the films. On all substrates, Nd-Fe-B films possess an out-of-plane c-axis texture with a high remanence to saturation magnetization ratio of around 0.95 and high coercivities between 1.3 T and 2.0 T. However, whereas films on SiN grow with a fiber texture, the films on MgO(100) have a single in-plane orientation of the NdFeB crystallites, growing epitaxially on the substrate. A detailed comparison of microstructure and magnetic properties is presented together with in-plane anisotropy measurements of these films through the spin reorientation transition.

MA 7.2 Fr 15:30 TU H1012

Epitaxial Sm-Co thin films with uniaxial in-plane anisotropy — •Aarti Singh[1], Roland Tamm[2], Volker Neu[1], Sebastian Fähler[1], Ludwig Schultz[1], Werner Skrotzki[2], and Bernhard Holzapfel[1] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden — [2]Institut für Kristallographie und Festkörperphysik, TU Dresden, 01062 Dresden

This contribution reports on the epitaxial growth of Sm-Co films on MgO single crystal substrates with (100) and (110) orientation. The films were deposited with pulsed laser deposition. A thin layer of Cr was used as buffer and cover layer. On MgO(100) at deposition temperatures of 400 °C, the films have an in-plane texture and have their c-axis oriented only along the MgO[100] and MgO[010] with MgO(001)[100] ∥ Cr(001)[110] ∥ SmCo(11$\bar{2}$0)[001]. Coercivities of the order of 2.7 T are obtained on these substrates. Varying the film composition leads to strongly increased magnetisation values while the crystallographic texture and the coercivity remain almost constant. On MgO(110) single crystal substrates, Sm-Co grows with the epitaxial relation MgO(110)[001] ∥ Cr(211)[110] ∥ SmCo(10$\bar{1}$0)[001]. This restricts the c-axis of the Sm-Co to grow with only one orientation on the substrate. The buffer (Cr) microstructure and texture are important in controlling the texture of the Sm-Co layer. For optimised conditions highly anisotropic films with coercivities of more than 3 T have been deposited.

MA 7.3 Fr 15:45 TU H1012

Thickness dependent T-MOKE and XAS study at the 2p edges of ultrathin Co(0001) films on W(110) — •Armin Kleibert[1], Joachim Bansmann[1], Volkmar Senz[1], and Peter Oppeneer[2] — [1]Universität Rostock, Universitätsplatz 3, 18051 Rostock — [2]Department of Physics, Uppsala University, Box 530, S-75121 Uppsala, Sweden

X-ray magnetic resonant scattering (XMRS) is a powerful and element-specific tool for investigations on complex, nanoscaled magnetic samples. In the past these studies involved mainly *ex-situ* prepared samples or multilayers, where the capping layer has not been taken into account. In this contribution we present recently obtained results on the thickness dependence of the transverse magneto-optical Kerr-effect (T-MOKE) on *in-situ* prepared atomically smooth ultrathin hcp Co(0001) films on W(110) with thicknesses ranging from several monolayers down to the submonolayer. We observe strong interference effects in the overall reflectivity that are nicely reproduced by magneto-optical calculations. Simultaneously recorded X-ray absorption spectra (XAS) reveal strong changes in the shape of the submonolayer absorption spectra. The corresponding reflectivity is reproduced by simulations based on recalculated optical constants taking into account the reduced atomic density of the submonolayer. Moreover, these Co films possess a strong uniaxial magnetic in-plane anisotropy with the easy axis along the W[1$\bar{1}$0] direction. Thus, one may expect anisotropic orbital magnetic moments which give rise to an anisotropy in the T-MOKE response when rotating the sample around its surface normal. Based on simulations and experimental data we will show the possibility of the observation of such an anisotropy.

MA 7.4 Fr 16:00 TU H1012

Magneto-optical signal superposition in ultra-thin Co/Pd structures — •M. Przybylski, M. Nyvlt, and J. Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Magnetism of ultrathin Co films grown on clean and atomically flat surfaces of Pd single crystals was studied by magneto-optical (MO) Kerr rotation. The films show very similar behavior independently of the crystallographic orientation of the Pd-substrate surface. Polar MO loops change sign of the MO signal at certain critical thickness, t_c, which varies for different substrate planes and growth conditions. This effect is attributed to a competition between two MO components with different signs originating from the Co-Pd interface and from the inner part of the Co film. At t_c these two contributions cancel each other. For the Co films grown on the "open" Pd(110) surface reversed polar MO loops are detected at low Co coverage after deposition at room temperature and t_c slightly increases with increasing annealing temperature. For Co grown on the most densely packed Pd(111) the same behavior is observed after growing the film above 400 K. The critical thickness at which the polar loops change polarity relates to the Co/Pd interface and does not vary with the expanding thickness range at which the out-of-plane magnetization is kept.

MA 7.5 Fr 16:15 TU H1012

Polar contribution to longitudinal magneto-optical Kerr signal — •M. Przybylski, M. Nyvlt, J. Barthel, A. Winkelmann, and J. Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Magneto-optical Kerr rotation loops were measured for Co films on single crystal Pd substrates. Variation of the Kerr signal with the Co thickness showed an abnormal behavior in the range where a perpendicular magnetization component is detected in polar geometry. Such a component appears in the low Co thickness limit due to an out-of-plane anisotropy of the Co/Pd system caused by hydrogen adsorption. The abnormal behavior of the Kerr signal arises from the polar contribution to the longitudinal effect. When the magnetic field is applied perfectly in the film plane, the perpendicular component of magnetization cannot be reversed. Consequently, no polar contribution should be detected. A small misalignment between the field and the sample plane is sufficient to produce a small polar field (with respect to the longitudinal one) which can reverse the perpendicular magnetization component. Actually, the applied field must be quite strong in order to achieve its sufficient polar projection. The fact that the "coercivity" of the abnormal longitudinal loops scales with the coercivity of the polar loops supports the above interpretation. The coercivity scaling factor increases with the angle by which the magnetization is tilted from the sample plane.

MA 7.6 Fr 16:30 TU H1012

Untersuchung struktureller und magnetischer Eigenschaften ultradünner Fe Schichten auf Cu(001) im Bereich des fcc-bcc Phasenübergangs mittels streifender Ionenstreuung — •M. Baron, T. Bernhard, M. Gruyters und H. Winter — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstrasse 15, 12489 Berlin

Wachstum, Struktur und Magnetismus ultradünner Fe Schichten auf Cu(001) werden mittels streifender Ionenstreuung untersucht. Der Phasenübergang in eine bcc-Struktur wird innerhalb weniger Fe Atomlagen mit Hilfe von Ionenstrahltriangulation beobachtet. Bei dieser Methode wird ausgenutzt, dass sich die ioneninduzierte Elektronenemission ändert, wenn der azimutale Einfallswinkel der Ionen mit einer niederindizierten Gitterrichtung zusammenfällt. Die strukturellen Änderungen werden von Änderungen im magnetischen Verhalten begleitet. Die bei ca. 4 Atomlagen eintretende in-plane Magnetisierung wurde mit Hilfe des Einfangs spin-polarisierter Elektronen in angeregte atomare Zustände des Projektils studiert. Unsere Methoden zeichnen sich durch eine ausgeprägte Empfindlichkeit auf die oberste Atomlage aus und liefern wichtige ergänzende Informationen zu früheren Untersuchungen des Phasenübergangs mit konventionellen Methoden wie LEED und SMOKE.

MA 7.7 Fr 16:45 TU H1012

Spin polarization, structure and chemical composition of ultrathin Rh layers on Fe(100) — •Marco Busch, Markus Gruyters, and Helmut Winter — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstrasse 15, D-12489 Berlin, Germany

We report on spin- and energy-resolved secondary electron emission, induced by grazingly scattered 100 keV protons from ultrathin Rh layers on Fe(100). A finite spin polarization of secondary electrons is observed up to 3 monolayers of Rh. The growth of Rh at room temperature is studied by grazing scattering of 50 keV He+ ions. We find that growth of Rh on Fe(100) deviates from a perfect pseudomorphic layer-by-layer growth. The chemical composition is investigated by Auger electron spectroscopy induced by 5 keV electrons and grazingly scattered 200 keV protons.

MA 7.8 Fr 17:00 TU H1012

Spin-reorientation-transitions in Co films on Pd(110) — •L. Yan, M. Przybylski, J. Barthel, and J. Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

Ultrathin Co films were grown by thermal deposition on an atomically clean and flat surface of Pd(110) and characterized magnetically by means of magneto-optical Kerr effect (MOKE). Immediately after deposition at room temperature (RT) the films are magnetized in plane. Polar MOKE signal appears only after the film is exposed to the residual atmosphere at low temperature. This is most likely due to hydrogen adsorption. With increasing temperature the magnetization rotates back towards the film plane and no polar MOKE signal is again detected at RT. We interpret this effect as a result of desorption of hydrogen above a certain temperature. At the thickness range at which the out-of-plane magnetization appears, an abnormally large longitudinal signal is detected. This is due to the contribution of the polar component to the longitudinal MOKE signal. With increasing Co coverage the polar signal disappears. The magnetization vector rotates towards the film plane, showing an increasing longitudinal component to the total Kerr signal. Also annealing supports the out-of-plane magnetization of the Co/Pd(110) system. However, in this case the magnetic anisotropy of the system is irreversibly changed due to the structural changes experienced by the sample during annealing.

MA 7.9 Fr 17:15 TU H1012

Magnetism of Co and Fe films grown on Pd-monolayer/Cu(001) — •Y. Lu, M. Przybylski, M. Nyvlt, and J. Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle

In order to verify the concept of the Co/Pd interface contribution to the total magneto-optical response from the Co films, a monolayer of Pd was grown by pulsed laser deposition (PLD) on Cu(001) as a template for growth of Co films. Both Co/Pd/Cu(001) and Co/Cu(001) systems prepared under identical conditions have the same slope in the thickness dependence of Kerr rotation. However, a clear increase of the MOKE signal in comparison to the Co films grown directly on Cu(001) is detected. Due to similarity in the structure of Co films on Cu(001) and Pd/Cu(001), any difference in magneto-optical response of both systems could be interpreted as a result of Pd-Co hybridization. When the Pd-buffer layer is thicker than 1 ML, the Kerr rotation from Co is independent of the Pd thickness. This suggests that the second Pd layer does not contribute significantly to the magneto-optical response of the system. A comparison of these Co films on Pd/Cu(001) and Cu(001) is made to the Fe films grown on the same templates. In particular, the sign reversal of the longitudinal Kerr loops with increasing thickness of the Fe films is discussed.

MA 7.10 Fr 17:30 TU H1012

Influence of deposition method on magnetism of Fe and Co films on Pd(001) — •Y. Shi[1], M. Przybylski[1], M. Rams[2], J. Barthel[1], H. L. Meyerheim[1], and J. Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle — [2]Institute of Physics, Jagiellonian University, Reymonta 4, PL-30-059, Krakow

Pd is predicted to be polarized by hybridization within a magnetic neighborhood like Fe and Co. Thus, ferromagnetic order in ultrathin Fe and Co films, mediated by the Pd substrate, could be expected even below the percolation threshold, i.e. in the submonolayer regime. We investigated magnetism of Fe and Co on Pd(001) in a thickness range from 0 to 10 monolayers (ML) for films deposited at room temperature by either thermal deposition (TD) or by pulsed laser deposition (PLD). In-plane Kerr rotation measured in saturation immediately after the film deposition shows similar thickness dependence for Fe and Co, with differences between PLD- and TD-grown films below a thickness of 2 ML. In particular, PLD Fe films at low temperature (70 K) exhibit long range order starting from a coverage around 0.2 ML, while the onset of ferromagnetism in Fe films prepared by TD is observed only at 0.5 ML, which is about the percolation threshold. Linear extrapolation of the magneto-optical response at higher film thickness to zero thickness reveals an offset in Kerr rotation equivalent to the signal of more than one ML for PLD films, but less than one ML for TD films. MOKE results for PLD Fe/Pd(001) are discussed in comparison to SQUID measurements of the same system.

MA 7.11 Fr 17:45 TU H1012

Structural effects on the magnetic behavior of ultrathin Co films on Cu(001) at the T_C jump — •M. Gruyters, T. Bernhard, M. Baron, and H. Winter — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstrasse 15, 12489 Berlin, Germany

The magnetic ordering in ultrathin Co films on Cu(001) has been investigated via the polarization of light emitted after capture of spin-polarized electrons into excited atomic terms during grazing He scattering. A strong increase in the Curie temperature and the remanent spin polarization has been observed at a critical Co thickness of about 1.7 ML. In agreement with a recent study on the same heteroepitaxial system, this behavior is attributed to the percolation of Co islands. For growth at an elevated temperature of 410 K, hysteresis loops reveal a strong increase in the irreversibility field at which the loop closes. This behavior is explained by an inhomogeneous distribution of growth-induced local magnetic anisotropies which make a complete reversal of the magnetization more difficult.

MA 7.12 Fr 18:00 TU H1012

On the correlation of intrinsic properties, microstructure and hard magnetic properties of FePt films — •Sebastian F ähler, Martin Weisheit, Volker Neu, and Ludwig Schultz — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

Epitaxial, $L1_0$ ordered FePt films can reach a coercivity up to 5.6 T, a fraction of about 50% of the anisotropy field of 11.6 T. This is significant higher than the fraction of 30% typically reached at best in permanent magnets. Thus these granular films are ideally suited to study the switching behaviour of permanent magnets.

Thin FePt films had been prepared by pulsed laser deposition. In order to vary microstructure and intrinsic magnetic properties, films had prepared at different temperature, composition and film thickness. Resulting magnetic properties are strongly correlated to these growth conditions. For a detailed analysis, the domain pattern of some films had been measured by MFM and angular and temperature dependence of coercivity is analysed. These results show that domain reversal in FePt films reaching the highest coercivity is governed by nucleation.

MA 7.13 Fr 18:15 TU H1012

Hard magnetic electrodeposited FePt films — •Karin Leistner, Andreas Krause, Heike Schlörb, Martin Weisheit, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

FePt is a promising material for hard magnetic films in MEMS or magnetic data storage due to its high magnetocrystalline anisotropy and saturation magnetization. Electrodeposition of FePt films would be a low cost alternative to physical vapor deposition techniques. As deposited films are amorphous and a large fraction of oxygen is incorporated. Quartz microbalance studies have been carried out in order to gain knowledge about the deposition processes and the mechanism of oxygen incorporation. The oxygen content is reduced when annealing in hydrogen, and as a result magnetization values are increased. Microstructure evolution during annealing has been studied and can be correlated to the hard magnetic properties. Coercivities up to 1.1 T can be achieved after annealing at 600°C in hydrogen.