MA 35 Magnetic Thin Films V

Time: Friday 10:45–12:45 Room: HSZ 03

MA 35.1 Fri 10:45 HSZ 03

Mode-of-growth dependent interface contribution to magneto-optical response from ultrathin Co films grown on (001), (110) and (111) surfaces of Pd — •Marek Przybylski, Miroslav Nyvlt, Yisheng Shi, Feng Luo, Jan Zukrowski, Jochen Barthel, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

We have grown ultra-thin epitaxial Co films on three low-index surfaces of Pd. Their magnetic properties studied by magneto-optical Kerr effect are correlated with surface morphology analyzed by scanning tunneling microscopy. A perpendicular magnetic anisotropy in the films appeared after exposure to residual gas atmosphere at low temperature, after coverage with an Au overlayer, or after annealing at 370 K and above. Reversed polar Kerr rotation loops with respect to those of thicker Co films were observed for 1 and 2 ML-thick films. This is due to a negative contribution from the Co/Pd interface dominating over the positive contribution from the non-interface part of the Co film. Reversed loops are not seen when the Co films grow in a three-dimensional mode. This indicates a clear correspondence between the mode of growth and the magneto-optical response. Near the film thickness where the Kerr rotation changes sign a remarkable temperature behavior is observed which is discussed as superposition of two different magneto-optical contributions. The results qualitatively agree with the available ab-initio band-structure calculations for Co/Pd multilayer structures with variable thickness of the Co layers.

MA 35.2 Fri 11:00 HSZ 03

The relevance of dipolar coupling for the stability of ferromagnetism in ultrathin films — •Roland Meier, Frank Bensch, Wolfgang Kipferl, Joseph Biberger, Dieter Weiss, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universitätsstraße 31, 93040 Regensburg

It has been rigorously shown by Mermin and Wagner [1] that ferromagnetic order cannot exist in two-dimensional systems at any temperature $T > 0$ provided the magnetic interactions are short-range and isotropic. However, it is empirically known that even single atomic layers can have a Curie temperature above 200 K. These contradictory facts are reconciled if we note that real ferromagnetic films are never free from magnetic anisotropy and are subject to long-range dipolar interaction. In order to investigate the relevance of dipolar interactions, the Curie temperature Tc was measured for ultrathin Fe(001) films (about 3 atomic layers) epitaxially grown on GaAs(001) and in arrays of sub-micrometer circular dots and parallel stripes prepared by electron beam lithography and ion etching. It is found that Tc decreases drastically with decreasing thickness, with decreasing dot diameter and with increasing dot separation. A quantitative analysis of the results provides convincing evidence that indeed the long-range dipolar coupling strongly enhances the stability of ferromagnetic order against thermal spin excitations in ultrathin epitaxial films magnetized in the film plane.

[1] N.D. Mermin and H. Wagner, Phys. Rev. Lett. 17 (1966) 1133

MA 35.3 Fri 11:15 HSZ 03

Correlation of Structure and Magnetism in pulsed laser deposited Co/Pd(001) — •Holger L. Meyerheim, M. Przybylski, Y. Shi, and J. Kirschner — MPI f. Mikrostrukturphysik, Weinberg 2, 06120 Halle

The study of growth, structure and magnetism of ultra-thin Co-films on Pd(001) is of considerable interest due to the possible technological applications of CoPd-alloys for magnetic storage device applications involving perpendicular magnetic anisotropy (PMA). Using surface x-ray diffraction (SXRD), scanning tunneling microscopy and magneto-optic Kerr effect (MOKE) measurements we have investigated the correlation of structure and magnetism in Co-films deposited on Pd(001) by using pulsed laser deposition (PLD).

Up to a coverage of about 3 monolayers (ML, 1ˆML=1.32x10$ˆ{15}$ atoms/cm$ˆ{2}$)Co grows in a layer-by-layer mode on Pd(001) forming disordered fct-CoPd-alloy layers. Based on MOKE experiments, as deposited samples do not exhibit PMA. Sample annealing at 600K induces PMA for Co-coverages up to about 5 ML. PMA is directly correlated with structural ordering characterized by the formation of the L1_{0} (CuAu)-structure with alternating Pd-and Co-layers.

The results are discussed in the context of current theories relating structural ordering with PMA.

MA 35.4 Fri 11:30 HSZ 03

Temperature and thickness dependence of magnetic parameters in uncapped Fe monolayers on {4×6}GaAs(001) — •Kh Zakeri, Th Kebe, J Lindner, and M Farle — Fachbereich Physik, Experimentalphysik-AG Farle,Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany.

Epitaxial 3-20 monolayers of Fe have been grown by molecular beam epitaxy on 4×6 surface reconstructed GaAs(001) at room temperature. Both, the temperature and thickness dependence of the magnetic anisotropy and of the magnetization were determined by means of *in situ* Ferromagnetic Resonance (FMR) and *in situ* SQUID magnetometry in ultrahigh vacuum (UHV). The measured anisotropy contributions were quantitatively explained by using a magneto-elastic model considering the magneto-elastic coupling constants of the iron films on GaAs(001). The magnetization M (T$\longrightarrow$0 K) is found to be reduced for d<7 ML. The cubic anisotropy contribution become very small for d = 5 ML , and we find that the independently measured second-order, out-of-plane uniaxial anisotropy $K_{2\perp}$(T) and the magnetization M(T) obey the Callen-Callen power law $K_{2\perp}(T)/K_{2\perp}(0) \propto (M(T)/M(0))^{\Gamma}$ with $\Gamma = 2.9 \pm 0.2$. The extrapolation of the temperature dependence (40-400 K) of the volume ($K^{v}_{2\perp}$) and the surface/interface ($K^{s,\mathrm{eff}}_{2\perp}$) contributions to T$\longrightarrow$0K yields $K^{s,\mathrm{eff}}_{2\perp}(T \longrightarrow 0) = 1.26 \pm 0.1 \times 10^{-3}$ J/m^2 (649 ± 51.5 μeV/atom) and $K^{v}_{2\perp}(T \longrightarrow 0) = 4 \pm 9 \times 10^{4}$ J/m^3(3± 6.7 μeV/atom) which can be compared to *ab initio* band structural calculations. Supported by DFG, SFB 491 TPA9.

MA 35.5 Fri 11:45 HSZ 03

The effect of oxygen adsorption on the magnetization of Fe monolayers on (4×6) GaAs(001) — •Th. Kebe, Kh. Zakeri, J. Lindner, and M. Farle — Universität Duisburg-Essen

The absolute remanent magnetization of uncapped Fe monolayers grown on GaAs(100) [1] which have been exposed to oxygen doses up to 25000 Langmuir (pressures between 1×10^{-8} to 1×10^{-5} mbar) at RT were measured by *in situ* scanning SQUID magnetometry in UHV. The magnetization and the effect of the oxygen exposure could be monitored with sub monolayer sensitivity. The Fe films exhibit a thickness dependent surface roughness due to a Volmer-Weber growth which is largest for thinner layers. We find that 8 ML Fe still exhibit a ferromagnetic signal after 25000 Langmuir dosage, while the remanent magnetization disappears in a 5 ML Fe film at about 400 Langmuir already. The Fe oxide phase has been identified as Fe_20_3 using Auger spectroscopy. Low temperature (T=40K) oxygen adsorption showed that the oxide formation of a 8 ML Fe film could be totally suppressed after chemisorption of a surface oxygen layer. Supported by DFG, Sfb 491.

[1] Kh. Zakeri et al., J. Magn. Magn. Mater. in press

MA 35.6 Fri 12:00 HSZ 03

Interface tuning of magnetic interactions of the Fe monolayer on 5*d* metal substrates — •Paolo Ferriani[1], Ilja Turek[2], Stefan Heinze[1], Gustav Bihlmayer[3], and Stefan Bluegel[3] — [1]Institute of Applied Physics and Microstructure Research Center, University of Hamburg, Hamburg, Germany — [2]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic — [3]Institute für Festkörperforschung, Forschungszentrum Jülich, Jülich, Germany

Magnetic systems play a central role in today's information technology. Stabilising a magnetic state is essential for possible applications of a material. The capability of controlling the magnetic order of a specific material would be of great advantage in this respect, but it remains a challenge. Low-dimensional systems offer new possibilities to tune the magnetic interactions. Recently, it has been proved that an antiferromagnetic structure can be stabilised for a monolayer of Fe, the prototypical ferromagnetic material, by growing it on the W(001) surface [1].

In this work, we deal with the interface tuning of the exchange interaction as a way to control the magnetic order. Based on density functional theory calculations, we show how the magnetic state of an Fe monolayer can be selected by a proper choice of the substrate composition. We demonstrate that the magnetism of an Fe monolayer on W(001) depends on the substrate *d*-band filling. By alloying the W substrate with Ta,

the neighboring element of W, it is thus possible to tune the exchange interaction in the overlayer and stabilise novel magnetic states.
[1] A. Kubetzka *et al.*, Phys. Rev. Lett. 94, 087204 (2005)

MA 35.7 Fri 12:15 HSZ 03

Novel magnetic structure in the Fe monolayer on Ir(111) — •Kirsten von Bergmann[1], Stefan Heinze[1], Matthias Bode[1], Elena Y. Vedmedenko[1], Gustav Bihlmayer[2], Stefan Blügel[2], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, Germany

The magnetic properties of thin films have been in the focus of recent research. Up to now only two different magnetic ground states of homoatomic monolayers have been found experimentally: while the ferromagnetic state is accessible by various surface sensitive techniques it is much more challenging to prove antiferromagnetic order such as the c(2×2)-antiferromagnetic state [1,2].

Using spin-polarized scanning tunneling microscopy we have observed a much more complex magnetic structure in the pseudomorphic Fe monolayer on Ir(111). The two-dimensional magnetic unit cell is of nanometer-size and the shape is nearly square with one diagonal along a close-packed row of the hexagonal atom arrangement. This symmetry relation gives rise to three rotational domains, all of which are observed experimentally. First-principles calculations verify that the magnetic state proposed on the basis of the experimental data is indeed lower in energy than the ferromagnetic state and indicate that the unusual magnetic structure is induced by the strong Fe-Ir hybridization.

[1] S. Heinze *et al.*, Science **288**, 1805 (2000).
[2] A. Kubetzka *et al.*, Phys. Rev. Lett. **94**, 087204 (2005).

MA 35.8 Fri 12:30 HSZ 03

Thickness-dependent domain structure of ferromagnetic Dy(0001)/W(110) studied by spin-polarized STM — •Luis Berbil-Bautista, Stefan Krause, Matthias Bode, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstraße 11, Hamburg

Below the Curie temperature $T_C = 85$ K bulk dysprosium (Dy) is ferromagnetic with an easy direction along the $\langle 2\bar{1}\bar{1}0\rangle$ directions, i.e. within basal (0001) planes. In this contribution we present a spin-polarized scanning tunneling microscopy (SP-STM) study on the growth and magnetic domain structure of flat epitaxial Dy films on W(110). At low thickness (coverage $\Theta \leq 10$ ML) patches with two different stackings can be found on the W(110) surface which exhibit a diameter of about 100 nm and which are separated by grain boundaries. With increasing thickness these grain boundaries become unstable and transform into double screw dislocations. Spin-resolved data reveal that the domain size and shape is strongly affected by both the thickness and the amount and type of defects on the Dy surface.