O 63: [MA] Surface magnetism III

Time: Thursday 11:00–13:00 Location: HSZ 103

O 63.1 Thu 11:00 HSZ 103

Spin reorientation related changes of the electronic structure in ultrathin Fe/Mo(110) films — •Torsten Methfessel and Hans-Joachim Elmers — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudingerweg 7, D-55099 Mainz

The magnetic easy axis in ultrathin Fe/Mo(110) films changes from a perpendicular easy axis at low temperatures to an in-plane easy axis at hight temperatures at the transition point around 13 K. We investigated this spin reorientation (SRT) using spin-resolved scanning tunneling microscopy (STM) and spectroscopy (STS). Magnetic domain patterns remain stable near the SRT. We measured domain wall widths versus temperature resulting in a measurement for the temperature dependent anisotropy. The electronic structure of the mono (ML) and double layer (DL) Fe/Mo(110) shows a variation with the reorientation of the magnetic easy axis. The spin averaged tunneling conductivity of the DL Fe shows a distinct increase with rising temperature clearly below the transition temperature which can be attributed to a magnetization along a magnetic hard axis. The SRT of Fe/Mo(110) can be identified as a discontinuous reorientation transition, revealing two simultaneous minima of the free energy in a certain temperature range.

O 63.2 Thu 11:15 HSZ 103

Uniaxial anisotropy in Fe/GaAs(001): oriented bonds versus magneto-elastic interaction. — •Günther Bayreuther[1,2], Jörg Premper[1], Matthias Sperl[2], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Inst. für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, Germany

Ultrathin Fe films epitaxially grown on GaAs(001), in addition to their thickness-dependent cubic anisotropy, show a pronounced in-plane uniaxial magnetic anisotropy with the easy axis along [110], controversially attributed either to oriented interface bonds or to a magneto-elastic interaction. In order to check the relevance of magneto-elastic contributions we performed MOKE and magneto-elastic stress measurements on MBE-grown Fe(001) and $Fe_{32}Co_{68}$(001) films on GaAs(001). The uniaxial anisotropy constant K_U has the same sign for Fe and $Fe_{32}Co_{68}$. The magneto-elastic coupling coefficients B_2 of the films were measured using a cantilever method [1] and resulted to be of opposite sign for Fe and $Fe_{32}Co_{68}$ films, respectively. As all the films are under compressive strain with a lattice misfit of -1.16 % for Fe and -0.41 % for $Fe_{32}Co_{68}$ the magneto-elastic anisotropy contribution to K_U is expected to be of opposite sign for both materials, based on the respective values of B_2. The observed identical sign of K_U in both cases means that a magneto-elastic interaction is not the main origin of the uniaxial magnetic anisotropy in ultrathin Fe(001) films on GaAs(001).

[1] D. Sander, Rep. Prog. Phys. 62, 809 (1999)

O 63.3 Thu 11:30 HSZ 103

Influence of the growth temperature on the electronic structure of ultrathin cobalt films studied by spin-resolved photoemission — •Cheng-Tien Chiang, Aimo Winkelmann, Martin Ellguth, Ahmet Akin Ünal, Christian Tusche, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120, Halle (Saale), Germany

We investigate the electronic structure of ultrathin cobalt films grown on Cu(001) by spin-resolved one- and two-photon photoemission (1PPE and 2PPE). A majority quantum well state located at 2.1 eV above the Fermi level and a minority surface resonance state at 0.4 eV below the Fermi level are identified in 6 monolayer thick cobalt films. The photoemission features of the quantum well state and the surface resonance state are strongly suppressed for cobalt films grown at 170 K as compared to films grown at 330 K. 2PPE through the quantum well state increases the photoelectron spin-polarization by about 10%, and in 1PPE a sign reversal of the spin-polarization is observed from the surface resonance state. These observations are applied for electronic state sensitive imaging of magnetic domains in energy- and spin-resolved photoelectron emission microscopy (PEEM).

O 63.4 Thu 11:45 HSZ 103

NiO thickness and temperature dependent coercivity of Fe layers grown on NiO/Ag (100) — •Anita Dhaka, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 061120 Halle (Germany)

We have performed temperature dependent magneto-optical kerr effect (MOKE) measurements in the longitudinal geometry to investigate the coercivity of 6 monolayers (ML) Fe on NiO deposited on Ag (100). MOKE indicates that the coercivity of Fe on NiO strongly depends on the thickness of NiO, and this effect is temperature dependent. We find that the coercivity of 6 ML films deposited on 20 ML NiO of H_c=142 mT at 300 K,which increases to 172 mT at 150 K. For 40 ML NiO, the coercivity is 148 mT at 300 K, and 284 mT at 150 K. 6 ML Fe on Ag (100) show a constant H_c of 9±3 mT from 150 K to 470 K. The change of coercivity with temperature is reversible up to T=470 K. At higher temperature intermixing is found by Auger elctron dpectroscopy, and the magnetic behavior is no longer reversible upon cooling. No increase of coercivity is observed for Fe films on 20 ML and 40 ML NiO at 470 K. Temperature dependence of the coercivity is ascribed to presence of antiferromagnetic NiO, and our data indicate a Neel temperature of 20 ML NiO of approximately 470 K [1]. Financial support by SFB 762 is gratefully acknowledged. [1] D. Alders, L. H. Tjeng, F. C. Voogt, T. Hibma, G. A. Sawatzky, C. T. Chen, J. Vogel, M. Sacchi, S. Iacobucci, Phys. Rev. B **57**, 11623, (1998).

O 63.5 Thu 12:00 HSZ 103

Antiferromagnetic Mn chains on Ni(110) — •Simon Holzberger, Tobias Schuh, and Wulf Wulfhekel — Physikalisches Institut, Karlsruher Institut für Technologie, Germany

A novel even-odd effect has recently been predicted for atomic manganese chains supported by a ferromagnetic substrate [1]. While odd chains possess a net spin that aligns according to the coupling to the substrate resulting in a collinear spin state, even chains display a non-collinear state. To investigate atomic chains experimentally, low-temperature spin-polarized scanning tunneling microscopy (Sp-STM) was used. To favor the growth of linear chains, a ferromagnetic Ni(110) surface was chosen as substrate. While self assembly of chains by thermal diffusion always led to intermixing with the substrate, pure manganese chains could be created by atomic manipulation. The electronic structure of the chains was investigated by scanning tunneling spectroscopy revealing a strong dependence on the length of the chain. This is explained within the model of an unoccupied quasi atomic state in single manganese adatoms. Sp-STM confirmed the predicted collinear antiferromagnetic ground state for linear trimers. In contrast to the calculations, however, there was no indication of an antiferromagnetic or non-collinear spin structure for even-numbered chains. This observation is explained by the degeneracy of the antiferromagnetic ground state highlighting the quantum nature of the magnetic state.

[1] S. Lounis *et al.*, Phys. Rev. Lett. **101**, 107204 (2008)

O 63.6 Thu 12:15 HSZ 103

Spinresolved UPS: Study of the O p(1x1) phase on Fe(100) Using a Novel Multichannel Spinpolarimeter — •Michaela Hahn, Bernd Petereit, Martin Jourdan, Hans-Joachim Elmers, and Gerd Schönhense — Institut für Physik, Staudinger Weg 7, 55128 Mainz

A novel type of multichannel spindetector has been implemented recently, with strongly improved efficiency as compared to modern state-of-the-art single channel spin analysers. By the usage of parallel multichannel detection, it is possible to reduce the measuring time by orders of magnitude [1]. The sample systems Fe/MgO and O/Fe/MgO have been studied as a first application exploiting the detector's efficiency. Epitaxial iron layers were evaporated onto MgO(100) single crystals, oxygen was dosed in small steps.

The O p(1x1) phase on Fe(100) is of particular interest, as for example described in [2]. It is formed at a dosage of 6L oxygen on the clean Fe(100) surface. Due to additional FeO-bands in the surface layer, the spin asymmetry close to the Fermi edge is expected to exhibit new features as compared to clean iron. Our spectra show a strong quenching of the minority peak very close to E_F with increasing oxygen dosage. Furthermore, new features occur in the majority bandstructure.

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[1] M. Hahn et al., this conference

[2] A. Tange et al., Phys. Rev. B 81, 195410 (2010)

O 63.7 Thu 12:30 HSZ 103

Magnetic Properties of Fe-Co alloy films on Ir(001) — •Rantej Bali, Marek Przybylski, and Jürgen Kirschner — Max Planck Institut für Mikrostruktur Physik, Halle, Germany 06120

We report on the magnetic behavior of $Fe_{1-x}Co_x$ alloy films grown on the Ir(001) surface. A variety of properties are observed depending on the Co content and film thickness. The first 4 monolayers (ML) of Fe (x = 0) do not exhibit magnetic hysteresis hinting to the existence of an antiferromagnetic phase, since thicker films are ferromagnetic. Ferromagnetism in the first 4 ML begins to be observed above x = 0.25 and further increase in Co content causes the easy axis to be perpendicular to the film plane [1]. For 10 ML thickness, this perpendicular anisotropy remains larger than the shape anisotropy at least up to the x = 0.6 composition. The increase and decay of the perpendicular anisotropy are observed through spin reorientation transitions that occur between the out-of-plane and in-plane magnetization directions of the film.

The differences in magnetic ordering such as the occurrence of antiferromagnetic and ferromagnetic phases and in-plane and perpendicular easy axes can be caused by the combination of strain induced modification of the electronic structure and the composition dependent adjustment of the Fermi energy.

[1] F. Yildiz *et al.*, J. Appl. Phys. 105, 07E129 (2009).

O 63.8 Thu 12:45 HSZ 103

Qualitative extraction of spin polarization on a single magnetic nanostructure — •Hirofumi Oka, Pavel Ignatiev, Sebastian Wedekind, Guillemin Rodary, Larissa Niebergall, Valeri Stepanyuk, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institute of Microstructure Physics, Weinberg 2, D-06120, Halle, Germany

We present a qualitative extraction of spin polarization on single Co nanoislands using SP-STM. We use low-temperature STM in magnetic fields to manipulate parallel (P) and anti-parallel (AP) states of the magnetization orientation between a Co island on Cu(111) and a magnetic tip [1]. We measure the differential conductance (dI/dV) on the same island in both states as a function of energy, and obtain the asymmetry of the dI/dV, $(dI/dV_{AP} - dI/dV_P)/(dI/dV_{AP} + dI/dV_P)$, which is related to the spin polarization of a sample [2]. We find that the sign and magnitude of the dI/dV asymmetry strongly depend on energy. In conjunction with ab initio calculations, we demonstrate that the dI/dV asymmetry obtained by our method is proportional to the spin-polarization of the sample [3]. We find in the theoretical results a minimum and a maximum spin-polarizations on a Co film at energies of -0.25 and $+0.15$ eV, respectively, which agrees with the energy dependence of the dI/dV asymmetry.

[1] G. Rodary *et al.*, JJAP 47, 9013 (2008). [2] D. Wortmann *et al.*, PRL 86, 4132 (2001). [3] H. Oka *et al.*, Science 327, 843 (2010).

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