O 28: Surface or interface magnetism

Time: Tuesday 10:30–13:00 Location: H48

O 28.1 Tue 10:30 H48

Electron pair emission from ferromagnetic surfaces — •Frank O. Schumann[1], Carsten Winkler[1], Jürgen Kirschner[1], Franz Giebels[2], Herbert Gollisch[2], and Roland Feder[2] — [1]Max-Planck-Institut für Mikrostrukturphysik, 06120 Halle, Germany — [2]Theoretische Festkörperphysik,Universität Duisburg-Essen, 47048 Duisburg, Germany

We present a combined experimental and theoretical study of the electron pair emission from a Fe(001) surface which is excited by a spin-polarized primary electron beam. The aim is to study the spin dependence of the exchange-correlation hole. The in-plane magnetization direction of the Fe sample can be controlled by an external magnetic field. A spin-polarized primary beam hits the Fe(001) surface along the surface normal and the spin polarization of the beam is either parallel or antiparallel to the magnetization direction. The emitted electron pairs are detected via a time-of-flight coincidence set-up. The data are grouped into two subsets for which the spin polarization of the majority electrons is either parallel or antiparallel to the primary beam. We find that the angular distributions of the coincidence intensity are spin dependent. Furthermore, we are able to identify favorable conditions, which ensure that the scattering partner of the primary electron has a high spin polarization. This allows us to separate the contribution of the exchange from the Coulomb correlation to the size of the exchange-correlation hole. We find that the exchange part has a larger extension than the Coulomb part confirming a suggestion by Slater more than 75 years ago.

O 28.2 Tue 10:45 H48

Spin Polarized PES on interface states of MgO/Fe/GaAs(100) — •Daniel Gottlob[1,2], Lukasz Plucinski[2], Carsten Westphal[1], and Claus M. Schneider[2] — [1]Experimentelle Physik 1 - Technische Universität Dortmund, Otto-Hahn-Str. 4, D-44221 Dortmund, Germany — [2]Institurte of Solid State Research - IFF-9 Electronic Properties - Research Center Jülich, D-52425 Jülich, Germany

Spintronics is an important field of current Solid State Research and Magnetic Tunnel Junctions (MTJ's) now are within our grasp. In MTJ's the nature of the electronic structure at the interface determins the tunneling process, and thereby the magnetoresistive potential of the MTJ.

Electronic interface states can have influence on the tunneling process in epitaxial MTJs especially for thinner tunnel barriers. At our ongoing research we will take a closer look at an off-normal surface state of Fe/GaAs(100) and see whether it still exists as an interface state if we cap the Fe by 1-3 monolayers of MgO. We will collect spin-polarized spectra to confirm the spin polarization in this band after the evaporation of MgO.

The measurements take place at Beamline 5 at DELTA, Dortmund, with a unique detector setup. We can acquire 2-dimensional angle resolved data for band mapping and spin-polarized one-dimensional data quasi-simultaneously. Our samples are prepared in-situ by e-beam evaporation and characterized by LEED and Auger spectroscopy.

O 28.3 Tue 11:00 H48

Range of spin-polarization on the (111) surface of platinum induced by the proximity of cobalt stripes — •Focko Meier, Lihui Zhou, Jens Wiebe, and Roland Wiesendanger — Institute of Applied Physics, Hamburg University, Germany

The properties of magnetic nanostructures supported by metallic substrates are strongly governed by the electronic interaction between nanostructure atoms and substrate atoms. For the model system of Co impurities dissolved in Pt it is well known that these interactions lead to induced magnetic moments in the neighbouring Pt atoms forming a so called giant moment systems [1]. Furthermore it has been revealed that Pt conduction electrons mediate an RKKY exchange interaction between localized magnetic moments which relies on a spatially oscillating spin-polarization [2]. However it is yet unclear how these two effects interfere. By applying spin-resolved scanning tunnelling spectroscopy at 0.3 K we investigated how the polarization of Pt is influenced in the vicinity of Co stripes on a Pt(111) surface. Our results show that the Pt density of states near the Fermi energy shows a response to the magnetic orientation of the Co stripe. Interestingly this response can be observed for distances larger than 1 nm from the stripe where the RKKY interaction is already antiferromagnetic.

[1] Graham and Schreiber, PRL 17, 650 (1966) [2] Meier et al., Science 320, 82 (2008)

O 28.4 Tue 11:15 H48

The effect of postgrowth oxygen exposure on the magnetic properties of Ni on the Cu-CuO stripe phase — •Mariella Denk, Richard Denk, Michael Hohage, Lidong Sun, and Peter Zeppenfeld — Institut für Experimentalphysik, Johannes Kepler Universität Linz, A-4040 Linz, Austria

The magnetism and morphology of thin Ni films deposited on clean and oxygen covered Cu(110) has been studied. Scanning Tunneling Microscopy (STM), as well as Reflectance Difference Spectroscopy (RDS) are used to characterise the sample properties. The sensitivity of the RDS to the polar Magneto-Optic Kerr Effect has been exploited (RD-MOKE). Contrary to growth on pristine Cu(110), thin Ni films on oxygen covered Cu(110)-(2x1)O show a spin reorientation transition from in-plane to out-of-plane magnetisation at 9 ML Ni coverage [1], [2]. For Ni films evaporated on the Cu-CuO stripe phase, which consists of a periodic array of (2x1) reconstructed CuO stripes separated by bare Cu, the magnetic easy axis lies completely in-plane up to a coverage of 22.5 ML. Exceeding this coverage, a small remanent magnetisation component pointing out-of-plane evolves. Upon postgrowth oxygen exposure the Ni film becomes completely out-of-plane magnetised. STM images show a fully (2x1)O reconstructed surface after the oxygen exposure, but no morphological changes of the Ni film. We thus conclude that the oxygen strongly modifies the surface magnetic anisotropy.

[1] Th. Herrmann et al., Phys. Rev. B 73, 134408 (2006)
[2] R. Denk et al., Phys. Rev. B 79, 073407 (2009)

O 28.5 Tue 11:30 H48

Nanoscale Iron with Extraordinary Magnetic Anisotropy — •Thomas Lödding[1], Christian Praetorius[1], Greg A. Ballentine[1,4], Kai Fauth[1,3], Armin Kleibert[2,5], Norman Wilken[2], Andris Voitkans[2], and Karl-Heinz Meiwes-Broer[2] — [1]Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Institute of Physics, Rostock University, 18051 Rostock, Germany — [3]MPI for Metals Research, Heisenbergstr. 3, 70569 Stuttgart, Germany — [4]Physics Dpt., Brandon University, 270 18th street, Brandon, Canada R7A 6A9 — [5]Swiss Light Source, Paul Scherrer Institute, 5232 Villigen, Switzerland

We shall show that iron nanocluster ensembles, prepared by deposition of preformed particles onto Cu(111), possess unusual and unexpected features in their magnetic response. We have studied the magnetic moments and response to applied fields using X-ray magnetic circular dichroism as a sensitive element specific probe of the nanocluster magetism. We show that clusters with average diameters of 4 nm and 6 nm not only possess an enhanced magnetization at low temperature but also display an enhanced magnetic anisotropy energy density.

Overmore, a small but non-negligible fraction ($\approx$ 10 %) of the deposited clusters possess extraordinarily large switching fields, i. e. $\mu_0 H_{SW} > 0.5$ T at $T = 12$ K for particles with 6 nm diameter. It is evident from our experiments that these large switching fields correspond to intrinsic properties of individual deposited nanoclusters. We shall discuss possible origins of this behavior.

O 28.6 Tue 11:45 H48

Correlation between stress, intermixing and magnetic anisotropy of Pt/Co/Pt (111) monolayers — •Anita Dhaka, Safia Ouazi, Zhen Tian, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 061120 Halle (Germany)

We present the results of a combined stress, low energy electron diffraction (LEED) and magneto-optical kerr-effect (MOKE) study on the spin reorientation transition (SRT) of Co monolayers (ML) on Pt(111). We observe a SRT from out-of-plane to in-plane with increasing Co thickness at 3 ML at 300 K. The deposition of one layer Pt on top of 5 ML Co induces a SRT from in-plane to out-of plane. Our stress and LEED measurements identify intermixing at the Co/Pt(111) interface [1].Stress measurements reveal a stronger intermixing at 370

K, as compared to growth at 300 K. Co growth at 370 K leads to a shift of the SRT from out-of-plane to in-plane to a larger thickness of 5 ML. Our results suggest that an intermixed Pt-Co interface favors an out-of-plane easy magnetisation direction, whereas a Co-vacuum interface favors an in-plane easy magnetization direction.

[1] O. Robach, C. Quiros, P. Steadman, K. F. Peters, E. Lundgren, J.Alvarez, H.Isern, and S. Ferrer: Phys. Rev. B **65**, 054423 (2002)

O 28.7 Tue 12:00 H48

Switching a single spin on metal surfaces: ab initio studies — •Kun Tao[1], Valeri.S Stepanyuk[1], Wolfram Hergert[2], Ivan Rungger[3], Stefano Sanvito[3], and Patrick Bruno[4] — [1]Max-Planck-Institute of Microstructure Physics, Halle, Germany — [2]Fachbereich Physik, Martin-Luther-University, Halle-Wittenberg, Friedemann-Bach-Platz 6, D-06099 Halle, Germany — [3]School of Physics and CRANN, Trinity College, Dublin 2, Ireland — [4]European Synchrotron Radiation Facility, F-38043 Grenoble Cedex, France

We perform ab initio calculations of the the exchange coupling between single magnetic adatoms adsorbed on metal surfaces and a spin polarized STM tip. We apply density functional theory (DFT) based methods and perform calculations in the fully relaxed geometries for the tip and the substrate. We demonstrate that the spin direction of single adatoms can be controlled by varying the tip-substrate distance. The sign of the exchange energy is determined by the competition of the direct and the indirect interactions between the tip and the adatom[1]. Based the nonequilibrium Green function method, we perform the spin-dependent transport calculations and find a large magnetoresistance of the junction at short tip-substrate distances.

[1] Kun Tao, V.S. Stepanyuk, W. Herget, I. Rungger, S. Sanvito, P. Bruno, Phys. Rev. Lett 103, 057202 (2009)

O 28.8 Tue 12:15 H48

Size-dependent spin structures in individual Fe nanoparticles observed by XPEEM — Arantxa Fraile Rodriguez[1], Armin Kleibert[1], •Joachim Bansmann[2], Laura Heyderman[1], and Frithjof Nolting[1] — [1]Paul Scherrer Institut, Villigen PSI, CH-5232 Switzerland — [2]Institute of Surface Chemistry and Catalysis, Ulm University, D-89069 Ulm

By combining x-ray magnetic circular dichroism (XMCD) with photoemission electron microscopy (PEEM), we present in situ observations of the magnetization orientation of individual Fe nanoparticles in a size range from 5 to 25 nm being in contact with a ferromagnetic Co support. Our results reveal that the magnetic moments of smaller particles (below 8 nm) are aligned parallel to the magnetic domains of the substrate while a non-collinear alignment between particles and substrate is observed for larger sizes. Numerical model calculations reproduce the experimental trend and reveal a transition from an exchange- to an anisotropy-dominated regime: the smaller particles are in a single-domain state collinearly aligned to the substrate while the larger particles exhibit a spiral-like magnetic structure determined by the magnetic anisotropy energy. These results demonstrate that the balance between the local particle-substrate interaction and the individual properties of the particles can lead to unexpected spin arrangements.

O 28.9 Tue 12:30 H48

Intercalation of iron underneath graphene on Ni(111): PES and XMCD study — •Martin Weser, Karsten Horn, and Yuriy Dedkov — Fritz-Haber Institut der Max-Planck Gesellschaft, Berlin, Germany

Magnetic thin films with out-of-plane or perpendicular magnetic anisotropy play an important role in nanotechnology. Such systems can be used as perpendicular recording media, which is predicted to allow information storage densities of up to 1 Tbit/in.^{2} a quadrupling of today's highest areal densities. Along with the widely used materials with out-of-plane magnetic anisotropy such as CoPt or FePt alloys, *fcc* Fe thin films also showing perpendicular magnetic anisotropy have recently attracted considerable interest as possible candidates for applications in novel magnetic data storage devices. Here Fe which originally has *bcc* structure can be stabilized in *fcc* γ-phase at room temperature in thin epitaxial films grown on suitable *fcc* substrates. The aim of the present work is the preparation of a *fcc* Fe-based system with potential out-of-plane magnetic anisotropy which behaves inert against an aggressive environment. Here we demonstrate the possibility to prepare such a system via intercalation of a thin Fe film underneath a graphene layer formed on a Ni(111) substrate. Here, we demonstrate that graphene behaves like a passivation layer conserving the underlying epitaxial Fe film. Electronic and magnetic properties of this system were studied by means of angle-resolved PES and XMCD, respectively.

O 28.10 Tue 12:45 H48

Hard x-ray standing-wave excited photoemission experiments on the MgO/Fe interface — •Sven Döring[1], Frank Schönbohm[1], Ulf Berges[1], Charles S. Fadley[2,3], Daniel E. Bürgler[4], Mihaela Gorgoi[5], Walter Braun[5], Claus M. Schneider[4], and Carsten Westphal[1] — [1]DELTA/Experimentelle Physik I, TU Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany — [2]Materials and Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — [3]University of California, Davis, CA 95616, USA — [4]Institut für Festkörperforschung, IFF-9, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [5]Helmholtz-Zentrum Berlin - BESSY, Albert-Einstein-Str. 15, 12489 Berlin, Germany

For layer systems, photoemission experiments with high and reliable depth resolution are essential in order to distinguish between interface effects and bulk photoemission signals. Here we extend the soft x-ray standing-wave photoemission method into the hard x-ray regime to achieve the required high depth resolution and high probing depth. An Fe wedge was grown on top of a $MoSi_2$/Si multilayer with a period of about 40 Å and subsequently covered by a thin MgO film. By moving the wedge structure with respect to the x-ray beam we were able to observe several cycles of the x-ray standing wave field moving through the sample layers. The analysis of the photoemission intensity modulations results in a well-resolved depth-profile of the sample. At the interface the intermixing of Fe and MgO can be studied due to the enhanced interface sensitivity provided by the x-ray standing field.