MA 9: Surface Magnetism II

Time: Monday 15:15–17:00 Location: HSZ 403

MA 9.1 Mon 15:15 HSZ 403

Correlation between structural, electronic and magnetic properties on nm-small Co islands — •Hirofumi Oka, Guillemin Rodary, Sebastian Wedekind, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120, Halle, Germany

We used spin-polarized low-temperature scanning tunneling microscopy and spectroscopy in field to study the correlation between local magnetic and electronic properties within single Co nano-islands. Differential conductance (dI/dV) hysteresis loops, which we produce by plotting the dI/dV signal while changing the external magnetic field [1], are analyzed. We measured spatially-resolved hysteresis loops as a function of position on single Co islands. Co islands grown on Cu(111) clearly show spin-polarized d_{z^2} resonant states around the center of the island.[2] Strain-induced structural relaxations in the islands affect the energy position of the states close to the edge of the island.[3] Clear ferromagnetic dI/dV hysteresis loops were observed within the area where the Co island show the resonant states. Just around the edge, the resonant states are strongly diminished in intensity and "rim states" [4] develop. We present dI/dV hysteresis loops measured close to the island edge and discuss the results, also in view of recent work [4].

[1] G. Rodary, S. Wedekind, D. Sander, and J. Kirschner, JJAP (in press). [2] L.Diekhöner *et al.*, PRL 90, 236801 (2003). [3] M. V. Rastei *et al.*, PRL 99, 246102 (2007). [4] O. Pietzsch *et al.*, PRL 96, 237203 (2006).

MA 9.2 Mon 15:30 HSZ 403

Magnetic properties of Co and Fe on Pt(111), Rh(111) and Pd(111) : From single atoms to ultrathin films — •Anne Lehnert[1], Stefano Rusponi[1], Markus Etzkorn[1], Géraud Moulas[1], Pietro Gambardella[2], Peter Bencok[3], and Harald Brune[1] — [1]IPN, EPF-Lausanne, Switzerland — [2]CREA and Catalan Institute of Nanotechnology, — [3]ESRF, Grenoble, France

Single atoms of Co on Pt(111) are known to have a giant magnetic anisotropy energy (MAE) of 9.3 meV/atom [1]. This is due to the reduced coordination and the strong spin-orbit coupling of the Pt 5d-states. In order to study the contribution of a highly polarizable substrate to the MAE, we investigated single Co atoms on Pd(111) and Rh(111) using x-ray magnetic circular dichroism (XMCD). We find a decreasing MAE moving from a 5d-substrate (Pt) to 4*d*-substrates (Pd and Rh). Co has a large orbital moment L of about 0.7 independent of the substrate. The easy axis is out-of-plane for Pt(111) and Pd(111) whereas it is in-plane for Co/Rh(111). Fe has on all substrates an out-of-plane easy axis, a very small anisotropy energy, and a L/S ratio of about 0.1. With increasing coverage the coordination number of the adatom increases and generally leads to a reduced MAE and orbital moment compared to the single atom. We measure one monolayer of Co and Fe on Pt(111) and Rh(111) and find MAE values < 0.5 meV/atom [2]. For 1 ML Co we find a substantial decrease in the L/S ratio to 0.19. However, the L/S ratio for 1 ML Fe on both substrates does not change much compared with the Fe single atom. [1] Gambardella *et al.*, Science 300, 1130 (2003); [2] Moulas *et al.* PRB in press

MA 9.3 Mon 15:45 HSZ 403

Magnetic circular dichroism in two-photon photoemission from Co/Cu(001) — •Cheng-Tien Chiang, Aimo Winkelmann, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle(Saale), Germany

Magnetic circular dichroism in photoemission is an important tool in magnetic imaging and investigation of electronic structure of magnetic materials. Using ultrashort laser pulses for excitation, we observe magnetic circular dichroism in two-photon photoemission from Co/Cu(001) at 3.1 eV incident photon energy. The thickness dependence of the dichroic signal of photoemission from near the Fermi level shows a monotonic increase up to 12 ML and then reaches a saturation value of about 10%. For the 12 ML film, the dichroic signal decreases from 10% for photoelectrons from the Fermi level to 2% at 0.7 eV below the Fermi level. We compare our observation with studies employing one-photon photoemission near threshold and to measurements using VUV synchrotron radiation, where significantly smaller intensity asymmetry of 0.5% [1] and 4% [2] are obtained.

[1] T. Nakagawa and T. Yokoyama, Phys. Rev. Lett. **96**, 237402 (2006) [2] C. M. Schneider *et al.*, Phys. Rev. B **44**, 12066 (1991)

MA 9.4 Mon 16:00 HSZ 403

fcc Co/Cu(001): Influence of the morphology on spin-dependent surface states and magnetic switching — •Tobias Allmers and Markus Donath — Physikalisches Institut, Universität Münster, 48149 Münster

The electronic structure and the magnetic properties of fcc Co films on Cu(001) are influenced by the morphology of the film. In our contribution we focus on surface states studied with spin-resolved direct and inverse photoemission and the magnetic reversal behavior studied with magneto-optical Kerr effect. The film morphology was controlled by the substrate temperature during film growth and subsequent annealing at various temperatures. The resulting differences in the film properties were additionally characterized with scanning tunneling microscopy. We found that the intensity of the occupied minority surface state with a binding energy of 0.4 eV [1] depends on the roughness of the surface. The spectral feature is very sharp and pronounced for a flat surface. The exchange-split unoccupied surface state at $\bar{X}$-point is even more sensitive to the roughness of the surface. In addition, we observed that the film morphology influences the shape of the hysteresis curve. While a square-like hysteresis curve was observed for films with a smooth topography, the hysteresis curve for a rough Co surface reflects a more complex switching behavior of the magnetization.

[1] Schmidt *et al.*, J. Phys. D **41** (2008) 164003

MA 9.5 Mon 16:15 HSZ 403

Origin of the spin polarization of magnetic scanning tunneling microscopy tips — •Paolo Ferriani, Cesar Lazo, and Stefan Heinze — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

Spin-polarized scanning tunneling microscopy (SP-STM) is a very powerful tool to study magnetism at the nanoscale. The capability to resolve magnetic structures down to single atoms is often achieved by using tips coated with a magnetic 3*d*-metal, e.g. Fe, Cr. Although SP-STM is a well established technique, there has been a long debate about the origin of the spin-polarization in the vicinity of the Fermi level from such tips. We would intuitively expect the *d*-electrons to provide a large spin-polarization at the tip apex atom, with small contribution coming from *s*- and *p*-electrons. On the other hand, the local density of state (LDOS) in the vacuum region above the apex atom, which is the key quantity for the tunneling current, should be dominated by *s*-electrons. In order to clarify this issue, we performed density functional theory calculations using the FLAPW method. We calculated STM tips formed by 3*d* metal adatoms and pyramids on the (001) and (110) surfaces of Fe. By decomposing the LDOS in the vacuum into the contributions of *s*-, *p*-, and *d*- electrons at the apex atom, we analyzed the origin of the spin-polarization. Surprisingly, the spin-polarization in the vacuum region, is positive for Fe and dominated by *s*-electrons, although the LDOS at the apex atom is dominated by minority *d*-electrons. This result is independent of the surface symmetry and can be explained on the basis of *sd*-hybridization at the tip apex.

MA 9.6 Mon 16:30 HSZ 403

Self-interaction correction in Gd(0001): Surface state and magnetic structure — •Hossein Mirhosseini, Arthur Ernst, and Jürgen Henk — Max Planck Institute of Microstructure Physics, Halle, Germany

A treatment of on-site electronic correlations beyond the local spin-density approximation is essential for the correct description of the electronic and magnetic properties of 4*f*-electron systems. Instead of the LDA+U method, we applied the self-interaction correction (SIC) to paradigmatic Gd(0001). The first-principles calculations were performed within the relativistic Korringa-Kohn-Rostoker framework.

The hybridization of the localized 4*f*-majority states—which have to be SI corrected—with the itinerant *d*-electrons has a sizable effect on the dispersion of the spin-orbit split surface state and on the magnetic properties (e. g. structure and critical temperature). The Slater-Janak transition-state approximation improves the overall agreement with experiment significantly, as compared to SIC.

MA 9.7 Mon 16:45 HSZ 403

Giant orbital moment anisotropy of Cu-Phthalocyanine adlayers at a metal interface — •Sebastian Stepanow[1], Aitor Mugarza[1], Gustavo Ceballos[1], Paolo Moras[2], Julio Criginski Cezar[3], Carlo Carbone[2], and Pietro Gambardella[1,4] — [1]CIN2-ICN Barcelona — [2]CNR Trieste — [3]ESRF Grenoble — [4]ICREA Barcelona

The magnetic properties of transition metal ions embedded in metal-organic complexes have attracted wide interest due to the interplay between spin and orbital phenomena. Recent studies, however, have shown that the deposition of Metal-Phthalocyanine (MePc) molecules on metal substrates may quench their magnetic moment. Here we investigate the magnetic properties of CuPc adlayers on a Ag(100) surface by x-ray magnetic circular dichroism (XMCD). The Cu centers present a robust spin S=1/2 magnetic moment with extraordinary high orbital moment (L) anisotropy. This effect, amounting to a 400% change of L from the in-plane to out-of-plane direction, is an order of magnitude larger compared to metallic layers and is accompanied by an unprecedented large spin-dipole moment T. By means of ligand-field multiplet theory we are able to simulate both the magnetic moment components and XMCD spectra versus applied field, relating these findings to the electronic structure of the adsorbed molecules.