O 32: Surface or interface magnetism

Time: Wednesday 10:30–12:30 Location: SCH A315

O 32.1 Wed 10:30 SCH A315

Surface Plasmon Excitation on Magnetoactive Materials — Luca Sapienza and •Dominic Zerulla — University College Dublin, School of Physics, Dublin 4, Ireland.

The interaction of surface plasmons - fluctuations in the electron density at the interface between media with dielectric constants of opposite sign - with magnetically ordered systems has attracted a lot of interest in the last ten years, as a result of the possibility of enhancing magneto-optical properties, like the Faraday and Kerr effect. More recently, research has been focused on the merging of the areas of spintronics and plasmonics, developing of a new field, called spin-plasmonics.
Here, we will present a systematic study of the excitation of surface plasmons on ferromagnetic materials in multilayered structures composed of thin films of nickel, iron, cobalt, capped by a silver layer [1]. The electromagnetic properties of the systems are theoretically and experimentally investigated as a function of the metal layers' thickness and the critical parameters in this study of the interaction between surface plasmon waves and the magneto-active material are discussed. Finally, an optimized structure for the investigations of spin-plasmonic effects in thin films is proposed.

[1] L. Sapienza, D. Zerulla, "Surface Plasmon Excitation on Magnetoactive Materials", Phys. Rev. B (accepted Nov. 2008)

O 32.2 Wed 10:45 SCH A315

Electric field control of the magnetic anisotropy of ultra-thin Fe films — •Daniel Wortmann, Gustav Bihlmayer, and Stefan Blügel — Institut für Festkörperforschung and Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany

With the advancement of spintronics, magnetoelectric coupling phenomena move into the focus of research. They offer the possibility to manipulate the magnetic state by means of an electric field. In particular, such effects are useful in magnetic multilayers in which an applied bias voltage and its resulting field might assist in switching magnetic layers. While different magnetoelectric effects can be considered we will focus here on a change of the magnetic anisotropy due to an applied electric field.

We present DFT-type *ab initio* calculations performed with the `FLEUR` code (www.flapw.de) utilizing the full-potential linearized augmented planewave method (FLAPW). The magnetic systems we studied are 1-2 monolayers of Fe on a Au(100) substrate. To simulate a tunneljunction setup we compared the effect of an electric field acting on a surface, i.e. a Fe/vacuum interface to a MgO covered system, i.e. a Fe/MgO interface. We observe a significant enhancement of the field-dependence by covering the Fe film with the insulator.

O 32.3 Wed 11:00 SCH A315

Depth-resolved photoemission studies on the system MgO/Fe — •Sven Döring[1,2], Frank Schönbohm[1,2], Ulf Berges[1,2], See-Hun Yang[3], Christian Papp[3,4], Benjamin Balke[3,4], Reinert Schreiber[5], Daniel E. Bürgler[5], Claus M. Schneider[5], Charles S. Fadley[3,4], and Carsten Westphal[1,2] — [1]DELTA, TU Dortmund, Maria-Goeppert-Mayer-Str. 2, 44221 Dortmund, Germany — [2]Experimentelle Physik 1, TU Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany — [3]Materials and Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — [4]University of California, Davis, CA 95616, USA — [5]Jülich Forschungszentrum, IFF-9, 52425 Jülich, Germany

A high depth-resolution in photoemission experiments can be obtained by exciting the photoemission process with nm-scale x-ray standing waves above a multilayer mirror (e.g. Yang et al., J. Appl. Phys. 103, 07C519 (2008)). With this technique, we investigated a model MgO/Fe magnetic tunnel junction, in particular exploring the degree of Fe oxidation at the interface between the two layers, which is thought to critically affect the tunnel magnetoresistance.. With the Fe in a wedge profile, the MgO-Fe interface can be moved through the standing wave field by moving the sample relative to the beam. The experiments were performed at DELTA (Dortmund), the ALS (Berkeley), and BESSY II (Berlin). Such standing wave/wedge scans, as well as rocking curves, allow us to develop a depth-profile of our sample. As one preliminary conclusion, we find no evidence for the presence of iron oxide at the interface.

O 32.4 Wed 11:15 SCH A315

Non-collinear magnetic phases in the electron gas: Results from Hartree-Fock and RDMFT — •Florian Eich[1,2], Stefan Kurth[2,3], César R. Proetto[2,4], Sangeeta Sharma[1,2], and E. K. U. Gross[2] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin — [2]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin — [3]Nano-Bio Spectroscopy Group and European Theoretical Spectroscopy Facility (ETSF), Dpto. de Física de Materiales, Universidad del País Vasco UPV/EHU, Centro Mixto CSIC-UPV/EHU, Av. Tolosa 72, E-20018 San Sebastián, Spain — [4]Centro Atómico Bariloche and Instituto Balseiro, 8400 S. C. de Bariloche, Río Negro, Argentina

In 1962 Overhauser [1] demonstrated that the Homogeneous Electron Gas exhibits an instability w.r.t. a Spin Density Wave (SDW) within the Hartree-Fock approximation. Overhauser showed that it is possible to construct a spin-spiral state that is lower in energy than the collinear paramagnetic state at any density. We investigated the properties of this broken symmetry groundstate using the framework of Reduced Density Matrix Functional Theory (RDMFT). Specifically we determined the dependence of the spin-spiral wavelength on the density. Furthermore it was possible to determine a critical density for which a transition to the ferromagnetic configuration takes place.
[1] A.W. Overhauser, Phys. Rev. 128, 1437 (1962)

O 32.5 Wed 11:30 SCH A315

Single electron capture versus double electron capture by slow He-ions above transition metal surfaces — •Christian Tusche and Jürgen Kirschner — MPI für Mikrostrukturphysik, D-06120 Halle, Germany

We studied the electron-capture by slow Helium ions (kinetic energy $\leq$ 30eV) scattered at epitaxial films of the transition metals Mn, Fe, and Ni, grown on a W(110) substrate. At a distance of 2-5Å above the surface, metastable He^{**} is formed by resonant transfer of electrons from the metal to the 2s or 2p shells of the projectile. The decay of He^{**} proceeds via the emission of a He-KLL Auger electron with an energy of $\approx$ 34.5eV or 36.0eV for a *triplet* or *singlet* term, respectively. In the experiment, either a beam of metastable He^{*+} (2s), or doubly charged He^{++} is used. In the former case, only one electron is transferred to the He ion, while He^{++} captures two electrons.

Based on the assumption of two subsequent, but independent one-electron transitions Unipan et al. [1] related the population of *singlet* and *triplet* terms simply to the spin-polarization of the surface. In contrast, we observe largely different *triplet* contributions using He^{*+} (2s) and He^{++}, that cannot be explained by a two-step process. Instead, we propose the simultaneous capture of two correlated electrons. Moreover, the *triplet* population, using double-capture, is particularly sensitive to minute modifications of the surface electronic structure, e.g., by adsorption of sub-monolayers of C and O.

[1] M. Unipan, A. Robin, R. Morgenstern and R. Hoekstra: Phys. Rev. Lett. **96**, 177601 (2006)

O 32.6 Wed 11:45 SCH A315

Time-Of-Flight and Spin Filtering in Low Energy Electron Microscopy — •Lushchyk P.[1], Hahn M.[1], Schönhense G.[1], Oelsner A.[2], Panzer D.[2], Krasyuk A.[3], and Kirschner J.[3] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz — [2]Surface Concept GmbH, Staudingerweg 7, 55128 Mainz — [3]Max-Planck-Institut für Mikrostrukturphysik, Halle

The spin degree of freedom in microscopy is exploited in SEMPA [1] and SP-LEEM [2] using diffraction of polarised electrons from magnetic surfaces for generating high magnetic contrast. We are developing two alternative approaches by implementing an imaging spin-filter into the column of a low-energy microscope. In the first set-up, spin-polarised electron diffraction from a single crystal surface is used for spin filtering. The method makes use of the Bragg condition for the electron rays in combination with spatial separation of the rays analogous to an optical mirror. An alternative method uses spin dependent transmission through an ultra thin ferromagnetic foil at low electron energies. From spectroscopy experiments it is known that the optimum analysing power of such a transparent foil can be very high due to the differences in inelastic mean free path for low-energy electrons in ferromagnets [3].

Funded by DFG (Scho 341/9)

[1] H.P. Oepen, J. Kirschner, Scanning Microsc. 5 (1991) 1 [2] Th. Duden, E. Bauer, Surf. Rev. Lett. 5 (1998) 1213 [3] G. Schönhense, H. C. Siegmann, Ann. Phys. 2 (1993) 465

O 32.7 Wed 12:00 SCH A315

Spin polarized STM on an artificially engineered atomic structure — •David Serrate[1], Yasuo Yoshida[1], Paolo Ferriani[1], Saw-Wai Hla[1,2], Matthias Menzel[1], Oliver Ferdinand[1], Kirsten von Bergmann[1], Stefan Heinze[1], André Kubetzka[1], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Department of Physics & Astronomy, Ohio University, USA

Manipulation of single atoms using a scanning tunneling microscope (STM) tip offers the possibility to build functional structures with precision down to the atomic scale. On the other hand, atomically resolved magnetic contrast can be achieved by means of spin polarized STM (SP-STM). In this work we demonstrate the combination of both techniques, which constitutes a major breakthrough in the field of low dimensional magnetism. We used an iron coated tungsten tip to precisely position individual magnetic atoms on a magnetic substrate having well defined local magnetization directions. Here, the substrate plays the role of a magnetic template for the adatoms. SP-STM performed with the same tip on the atomically engineered magnetic nanostructure reveals clear spin contrast, which can be explained on the basis of density functional theory calculations. Thus, this work opens up a novel research direction for engineering spin structures at the atomic scale with simultaneous magnetic imaging capability.

O 32.8 Wed 12:15 SCH A315

Correlation between morphology and magnetism of Ni films on adsorbate modified Cu(110) — •Mariella Denk, Richard Denk, Michael Hohage, Lidong Sun, and Peter Zeppenfeld — Institut für Experimentalphysik, Johannes Kepler Universität Linz, A-4040 Linz, Austria

We have investigated the growth and magnetism of thin Ni films evaporated on adsorbate modified Cu(110) in situ and under UHV conditions. In particular, we used Cu(110)-(2×1)O, Cu(110)-c(6×2)O, and Cu(110)-(2×3)N as substrates. In all cases the adsorbates (O, N) were found to float on top of the Ni film, acting as surfactants. Combining complementary methods like STM and Reflectance Difference Spectroscopy (RDS), as well as utilizing the sensitivity of RDS to the polar Magneto-Optic Kerr Effect (RD-MOKE), structural and magnetic properties have been probed simultaneously. For nickel grown on Cu(110)-(2×1)O we find an extremely sharp reversal of the magnetic easy axis from in-plane to out-of plane at 9 ML, while for the growth on Cu(110)-c(6×2)O the transition takes place at slightly higher coverages (10 ML), apparently due to a rougher Ni film. However, for growth on Cu(110)-(2×3)N no switching of the easy axis to out-of plane has been observed, even though the film roughness and morphology is similar as in the Cu(110)-c(6×2)O case. Thus, the termination by O or N of the Ni film is crucial for the magnetic properties. Indeed, oxygen exposure during the growth of Ni on Cu(110)-(2×3)N leads to a partially O-terminated Ni film and to the appearance of out-of plane ferromagnetism.