O 46: Surface magnetism I (jointly with MA)

Time: Wednesday 11:15–13:30 Location: CHE 184

O 46.1 Wed 11:15 CHE 184

Structural and magnetic investigations of Fe_3Si/GaAs(001) — •Sani Noor, M. Samet Özkan, and Ulrich Köhler — Experimentalphysik IV, AG Oberflächen, Ruhr-Universität Bochum

Fe_3Si has got magnetic and electric properties that make it a possible candidate as a spin aligning material in spintronic devices. Thus, it is of great interest to investigate its growth behaviour on semiconductor substrates.

In this contribution we present growth studies of the system Fe_3Si/GaAs(001) as measured by STM. Atomic resolution reveals long range ordering alongside a lattice structure that is to be compared with theory. The influence of varying growth temperatures and post annealing on the surface morphology has been investigated. We find that under the appropriate parameters layer-by-layer growth can be achieved. Magnetic analysis was performed by angular dependent in situ MOKE. While the uniaxial anisotropy remains unaffected by the growth temperature the coercive field scales with it. In order to determine the magnetic moment the samples were measured with SQUID magnetometry. It appears that the magnetic moment shows a dependence on the layer thickness.

O 46.2 Wed 11:30 CHE 184

Scattering behaviour of single non-magnetic and magnetic impurities buried under a Cu(100) surface — •Henning Prüser[1], Martin Wenderoth[1], Piet E. Dargel[2], Alexander Weismann[1], Robert Peters[2], Thomas Pruschke[2], and Rainer G. Ulbrich[1] — [1]IV. Physikalische Institut, Georg-August Universität Göttingen, Germany — [2]Institut für Theoretische Physik, Georg-August Universität Göttingen, Germany

It has been recently shown [1] that the anisotropy of the copper Fermi surface leads to a strongly directional propagation of quasi particles called electron focusing. This effect gives access to individual bulk impurities in a metal that were previously assumed to be "invisible" due to charge screening. Following this idea we have investigated the energy-dependent scattering characteristics for single isolated atoms of Ag, Co and Fe buried under a Cu(100) surface using low temperature scanning tunnelling spectroscopy (STS). For the case of a non-magnetic Ag impurity a Friedel oscillation in the local density of states is observed. For a magnetic Fe or Co impurity the Kondo effect influences strongly the energy-dependent scattering behaviour. We present a theoretical interpretation of the measured signatures using a combined approach of band structure and many-body numerical renormalization group calculations. The obtained results are in excellent agreement with the rich spatially and spectroscopically resolved experimental data. This work was supported by DFG SFB 602 Project A3.

[1] A. Weismann et al., Science 323, 1190 (2009)

O 46.3 Wed 11:45 CHE 184

First-principles study of the magnetic interaction in single atom contacts — •Cesar Lazo, Paolo Ferriani, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, University of Kiel, Germany

The miniaturization of spintronic devices towards the limit of single atoms calls for an understanding of the interaction and electron transport in atomic-scale contacts. Such structures are extreme cases, where the typical dimensions are comparable to the Fermi wavelength and a fully quantum mechanical description is required. Based on density functional theory calculations, we investigate single atom contacts formed by an antiferromagnetic Cr-tip of a scanning tunneling microscope (STM) and a magnetic atom adsorbed on a metallic surface. We analyze the exchange interaction between tip and adatom from the tunneling to the contact regime and explain a spin-valve effect observed with an STM [1]. Furthermore, we characterize the geometric properties of the contact as the tip approaches the sample, and show that the relaxations in the system can be related to the measured spin-polarization [1].

[1] M. Ziegler et al. in preparation

O 46.4 Wed 12:00 CHE 184

Spin-Resolved Investigations of the Exchange Split Gd Surface and Image-Potential State — •Beatrice Andres[1,2], Kristian Döbrich[1], Marko Wietstruk[1], Anke B. Schmidt[3], Markus Donath[3], and Martin Weinelt[1,2] — [1]Max-Born-Institut, 12489 Berlin — [2]Fachbereich Physik, Freie Universität Berlin, 14195 Berlin — [3]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster

The study of image-potential states (IPS) in front of ferromagnetic surfaces provides information about the magnetic properties of surfaces and thin films. Recent investigations on IPS revealed exchange splittings ΔE_{ex} in Fe, which persist even above the Curie temperature T_C [1].
Gd(0001) exhibits a d-derived surface state (SS) with $\Delta E_{ex} > 0$ above T_C [2]. We used the occupied majority spin component of this state to populate the first ($n = 1$) image potential state on a 100-Å-thick Gd film on W(110) with the second harmonic of our Ti:Sa laser ($h\nu = 3.30$ eV). By probing with the fundamental IR pulse ($h\nu = 1.65$ eV), we investigated the binding energy and exchange splitting of the IPS as a function of the temperature.
[1] M. Pickel *et. al.*, *Phys. Rev. Lett.* **104**, 237204 (2010).
[2] M. Getzlaff *et al.*, *J. Magn. Magn. Mater.* **184**, 155 (1998).

O 46.5 Wed 12:15 CHE 184

Magnetic signature of surface defects at nanodiamonds — •Nora Jenny Vollmers, Uwe Gerstmann, and Wolf Gero Schmidt — Theoretische Physik, Universität Paderborn

The n-type doping of diamond has been a long-standing issue, which recently gained attention in the context of nanodiamonds. Attempts of doping with nitrogen failed to result in the Electron paramagnetic Resonance (EPR) fingerprints expected from bulk material. Instead, the nanodiamond signals show a much larger deviation from the free-electron g-value and are believed to be related to intrinsic, carbon inherited defects. However, the absence of the bulk-like EPR spectra does not mean that nitrogen is not incorporated at all. The N atoms could be built in predominantly at or at least close to the surfaces yielding EPR spectra, very different from those measured in the bulk.

In this work, we elucidate the situation by investigating the magnetic signature of paramagnetic defects in the nanodiamonds. We use the gauge-including projector augmented plane wave (GI-PAW) approach [1, 2] to calculate the hyperfine splittings and the elements of the electronic g-tensor. Taking the C(100) surface as a first model system, a possible contribution of nitrogen is discussed by comparing EPR parameters for different N incorporation depths: Incorporated directly at the surface, N gives rise to surface states similar to intrinsic carbon dangling bond-like states. Otherwise N is able to introduce surface conductivity as demonstrated by calculated effective mass tensors.

[1] Ch.J. Pickard, F. Mauri, Phys. Rev. Lett. 88, 086403 (2002).
[2] U. Gerstmann et al., phys. stat. sol. (c) 7, 157 (2010).

O 46.6 Wed 12:30 CHE 184

Realizing Spin Logic Atom by Atom — •Alexander Khajetoorians, Bruno Chilian, Jens Wiebe, and Roland Wiesendanger — Institute of Applied Physics, Hamburg University, Jungiusstrasse 11, 20355 Hamburg, Germany

Scanning tunneling microscopy (STM) has emerged as a leading technique which can address single atom magnetism with high energy and spatial resolution. With the development of sub-Kelvin high-magnetic field STM, two complementary methods, namely spin-polarized scanning tunneling spectroscopy (SP-STS) and inelastic STS (ISTS), can address the fundamental properties of individual magnetic impurities at surfaces [1-2]. We use a map of the distance-dependent RKKY interaction between Fe atoms on Cu(111) obtained by SP-STS to engineer complex magnetic nanostructures with tailored magnetic properties with atomic manipulation. By combining constructed antiferromagnetic structures with spin frustration, we realize an atomic-scale logic device which functions solely on the spin-degrees of freedom of its magnetic constituents.

[1] A. A. Khajetoorians, B. Chilian, J. Wiebe, S. Schuwalow, F. Lechermann, and R. Wiesendanger, Nature 467, 1084 (2010).

[2] A. A. Khajetoorians, S. Lounis, B. Chilian, A. T. Costa, L. Zhou, D. Mills, J. Wiebe, and R. Wiesendanger, arXiv:1010.1284v2 (2010).

O 46.7 Wed 12:45 CHE 184

Magnetic anisotropy of Co and Ni adlayers on diamond and GaAs surfaces: an ab-initio study — •Bernd Stärk, Peter Krüger, and Johannes Pollmann — Westfälische Wilhelms-Universität, Münster, Germany

We present ab-initio investigations of magnetic transition-metal multilayers on semiconductors. In our work, we focus on the description of noncollinear magnetic systems and their magnetic anisotropy. To this end, we employ density functional theory in the framework of both LDA and GGA using a basis set of Gaussian orbitals.

Adsorption of Co/Ni adlayers on C(111)/C(001)-(1x1) surfaces is distinguished by a very small lattice mismatch. For one adlayer we find the metal adatoms to be localized in positions saturating all surface dangling bonds. They form strong covalent bonds with the substrate atoms that markedly reduce the magnetic moment at the interface and can even change the direction of the easy axis of magnetization as compared to the free standing monolayer. Furthermore, we find a strong dependance of anisotropy energies on the number of adlayers.

Secondly, we also discuss Ni on GaAs surfaces. Recent experiments suggest [1] that Ni grows epitaxially in bcc structure on GaAs(001) and that its magnetic properties strongly deviate from the bulk fcc case. We present a thorough investigation of possible atomic structures for this system and their magnetic properties.

[1] C. S. Dian *et al.*, PRL 94, 137210 (2005).

O 46.8 Wed 13:00 CHE 184

A spin polarizing electron mirror for spin-resolved photoelectron microscopy — •Christian Tusche, Martin Ellguth, A. Akin Ünal, Aimo Winkelmann, Alexander Krasyuk, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik Halle, D-06120 Halle, Germany

We report on a novel imaging spin-filter for electrons, that allows the parallel detection of the electron spin-polarization over a two-dimensional field of view. The spin-filter is installed in our momentum microscope, consisting of a photoelectron emission microscope (PEEM) optics and a double hemispherical imaging energy analyzer. After the energy analyzer, a reciprocal image is 90 degrees reflected at a tungsten (100) surface. Spin contrast is obtained due to the spin-dependent reflection probability of low energy electrons, while the angle of incidence is conserved in the outgoing elastic (00) diffraction spot [1]. This geometry transfers the full PEEM image, whereas the spatial information is encoded by small deviations of the angel of incidence.

We demonstrate that the magnetic domain structure of cobalt films grown on Cu(100) can be imaged with a resolution better than 500 nm, limited by the natural domain wall width ($\approx$ 400 nm [2]) of the film. The intensity asymmetry, defined by $A = [M^+ - M^-]/[M^+ + M^-]$, shows sharp maxima and minima as a function of the scattering energy in the range between 15 eV and 90 eV, whereas a maximum scattering asymmetry of up to A=45% is found.

[1] German Patent DE102005045622B4 (2009)
[2] A. Berger and H. P. Oepen, Phys. Rev. B **45**, 12596 (1991)

O 46.9 Wed 13:15 CHE 184

(SP)VLEED: Experimental access to the spin-dependent surface barrier — •Kathrin Wulff, Anke B. Schmidt, and Markus Donath — Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster

We present the first spin-polarized very-low-energy electron-diffraction (SPVLEED) measurements on a ferromagnetic system.

The fine structures, which appear in intensity vs. energy *I(V)* profiles of elastically reflected electrons [1], are sensitive to the shape of the surface-barrier potential. On the vacuum side far from the surface, the potential resembles the well-known Coulomb-like shape, while, on the crystal side, it merges the inner potential. In theoretical calculations the transition region, i.e. the surface barrier, is usually described by a parameterized phenomenological model. Our experiment gives access to exactly this transition region.

On Co/Cu(001) we found a significant spin dependence of the reflected intensities that varies strongly with incidence and azimuth angles. It should be noticed that the spin-dependent reflectivity of very-low-energy electrons from ferromagnetic surfaces has recently been utilized in electron spin polarimeters [2,3].

[1] R.O. Jones, P.J. Jennings, Surf. Sci. Reports **9**, 165 (1988) ; [2] A. Kakizaki *et al.*, Rev. Sci. Instrum. **79** (2008) 123117 ; [3] A. Winkelmann *et al.*, Rev. Sci. Instrum. **79** (2008) 083303