O 21: Clean surfaces: Metals, semiconductors, oxides and insulators II

Time: Monday 17:15–18:30 Location: WIL B122

O 21.1 Mon 17:15 WIL B122

A combined Frequency Modulation Dynamic Force Microscopy (FM-DFM) and Scanning Tunneling Microscopy (STM) Study of a SiO_2/Ru(0001) Model System — •Christin Büchner, Leonid Lichtenstein, Lars Heinke, Markus Heyde, and Hans-Joachim Freund — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Silica based support materials play an important role in catalysis. A stable and well characterized crystalline silica film can act as a model system for bulk silica and help us to understand silica's properties in detail. In order to examine catalytically relevant processes on such model surfaces, a thorough investigation of defect sites of any form is eminent. Recently, a double-layer silica film could be prepared on Ru(0001).[1] Here we used a combined frequency modulation dynamic force microscope (FM-DFM) and scanning tunneling microscope (STM) under low temperature and ultra-high vacuum conditions to unveil the thin film's structural and electronic surface properties. Atomically resolved images of the crystalline silica film grown on Ru(0001) are presented. Structural elements of the pristine film, as well as its defects, are highlighted. Based on atomic resolution FM-DFM and STM images a direct comparison with density functional theory calculation can be made. Theory as well as experiment favor a hexagonal honeycomb structure of the film. Spectroscopy measurements, i.e. scanning tunneling spectroscopy (STS) and Kelvin probe force microscopy (KPFM), provide first insights into electronic properties of the system.
[1] Löffler et al., Phys. Rev. Lett. 105, 146194-1-4 (2010).

O 21.2 Mon 17:30 WIL B122

Imaging domain structures of ferroelectric and multiferroic surfaces by PEEM — •Anke Höfer, Klaus Duncker, Stefan Förster, and Wolf Widdra — Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

$BiFeO_3$ is one of the very rare single-phase magnetoelectric multiferroics and shows ferroelectric and antiferromagnetic behavior at room temperature, whereas $BaTiO_3$ exhibits only a ferroelectric order. The surface domain structure of $BaTiO_3$(001) and $BiFeO_3$(001) has been studied by Laser-excited photoelectron emission microscopy (PEEM) under UHV conditions. The PEEM images of $BaTiO_3$ allow for discrimination of three domain types by their different photoemission yields. In wavelength dependent measurements the ferroelectric a and c domains exhibit approx. 100 meV different photoemission onsets. Based on the markedly high surface sensitivity of PEEM a specific ferroelectric surface domain structure on-top of a paraelectric bulk is observed in a temperature window up to 100 K above the bulk Curie temperature.

For the multiferroic $BiFeO_3$(001) surface we demonstrate imaging of the ferroelectric and the antiferromagnetic domain structure by PEEM using threshold excitation with linearly and circularly polarized laser light. The specific polarization dependencies will be discussed.

O 21.3 Mon 17:45 WIL B122

Spin-orbit effects in two-electron emission from ferromagnets — •Franz Giebels[1,2], Herbert Gollisch[1], and Roland Feder[1,2] — [1]Theoretische Festkörperphysik,Universität Duisburg-Essen, 47048 Duisburg, Germany — [2]Max-Planck Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

The momentum-resolved detection of correlated electron pairs, which are ejected from ferromagnetic surfaces upon impact of spin-polarized low-energy electrons, yields information on exchange and correlation effects and on the spin-resolved electronic surface structure [1]. Furthermore, spin-orbit coupling (SOC) effects have been found experimentally [2]. We present a theoretical formalism for electron-induced electron pair emission from ferromagnetic surfaces, which is based on a Dirac equation with an effective magnetic field. Exchange interaction and SOC are thus incorporated simultaneously. The formalism has been implemented in a computer code. We present typical numerical results, which demonstrate the manifestation of SOC in pair emission energy and angular distributions. Depending on the relative orientations of the primary electron spin polarization, the reaction plane and the magnetization direction of the surface system, SOC effects may dominate over exchange effects or vice versa. In two-dimensional momentum distributions, SOC reduces the rotation symmetry of the exchange-correlation hole, e.g. for cubic (001) surfaces from four-fold to two-fold.
[1] F. Schumann et al., Phys. Rev. Lett. **104**, 087602 (2010)
[2] S. Samarin et al., Phys. Rev. Lett. **97**, 096402 (2006)

O 21.4 Mon 18:00 WIL B122

Photoemission induced gating of topological insulator — •A. A. Kordyuk[1,2], T. K. Kim[1], V. B. Zabolotnyy[1], D. V. Evtushinsky[1], M. Bauch[1], C. Hess[1], B. Büchner[1], H. Berger[3], and S. V. Borisenko[1] — [1]Institute for Solid State Research, IFW-Dresden, P.O.Box 270116, D-01171 Dresden, Germany — [2]Institute of Metal Physics of National Academy of Sciences of Ukraine, 03142 Kyiv, Ukraine — [3]Institute of Physics of Complex Matter, EPFL, 1015 Lausanne, Switzerland

The recently discovered topological insulators exhibit topologically protected metallic surface states which are interesting from the fundamental point of view and could be useful for various applications if an appropriate electronic gating can be realized. Our photoemission study of Cu intercalated Bi_2Se_3 shows that the surface states occupancy in this material can be tuned by changing the photon energy and understood as a photoemission induced gating effect. Our finding provides an effective tool to investigate the new physics coming from the topological surface states and suggests the intercalation as a recipe for synthesis of the material suitable for electronic applications.

O 21.5 Mon 18:15 WIL B122

Anomalous double layer step formation on Si(100) in hydrogen ambient — •Henning Döscher, Peter Kleinschmidt, Anja Dobrich, Sebastian Brückner, Oliver Supplie, Johannes Luczak, and Thomas Hannappel — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin, Germany

Generation of double layer steps on Si(100) is desirable for subsequent anti-phase domain-free heteroepitaxy of III-V semiconductors. In UHV established procedures exist for the formation of double layer steps at the clean Si(100) surface. In the (metal-organic) vapour phase epitaxy environment the situation is more complicated due to the presence of hydrogen in the process ambient. Both theory and experiment of the hydrogenated surfaces suggest that under equilibrium conditions no preference for double layer steps is to be expected. Previously, we have shown that annealing in hydrogen at near atmospheric pressure leads to termination of the surface by monohydride. Here, we show that a process using Si(100) with an intermediate offcut of 2° in <011> can lead to a double layer stepped surface. Our process consists of deoxidation, homoepitaxial growth employing silane, annealing and slow cooling to 500°C in hydrogen ambient. We observe the formation of double layer steps using Fourier-transform infrared spectroscopy, low-energy electron diffraction and scanning tunneling microscopy. In sharp contrast to established UHV results, the double layer steps are of the D_A type, where dimer rows of the reconstructed surface are parallel to the step edges.