O 32: Spin-Orbit Interaction at Surfaces II

Time: Tuesday 11:15–12:45 Location: WIL C307

O 32.1 Tue 11:15 WIL C307

Spin-orbit split occupied and unoccupied surface states of Bi alloys on Cu(111) and Ag(111) — •A. Akin Ünal[1], Christian Tusche[1], Francesco Bisio[2], Aimo Winkelmann[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — [2]CNR-SPIN, Corso Perrone 24, I-16152 Genova, Italy

We investigated the electronic band structure of Bi surface alloys on Cu(111) and Ag(111) surfaces by one- and two-photon photoemission experiments (1PPE and 2PPE) excited by the second and fourth harmonics of a mode-locked Ti:sapphire femtosecond oscillator with photon energies of 3.1 eV and 6.0 eV. Occupied and unoccupied states can be respectively probed by 1PPE and 2PPE, providing comprehensive information on the electronic band structures. The negative electronic dispersions and Rashba-splittings of the partially-filled sp_z and of the unoccupied p_xp_y surface states were measured using our momentum microscope, which directly maps the parallel momentum component k_x, k_y of the photoelectrons as a function of energy without the need for sample or detector rotation. 1PPE experiments show that in the $\sqrt{3}\times\sqrt{3}$-R30° Bi/Cu(111) system, the Fermi level is below the crossing point of the spin-split sp_z bands; however, in the case of Bi/Ag(111), the Fermi level lies above this crossing point. The 2PPE experiments, on the other hand, show the spin-splittings of the unoccupied p_xp_y states of both systems in the momentum space.

O 32.2 Tue 11:30 WIL C307

Spin-orbit interaction in magnetic quantum well states of Ni/W(110) — •Andreas Nuber[1], Hendrik Bentmann[1], and Friedrich Reinert[1,2] — [1]Experimentelle Physik VII, Universität Würzburg, Germany — [2]Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

Nickel is a model system for ferromagnetism with an exchange splitting of the minority and majority bulk band structure of approximately 0.3 eV. Growing thin films of Nickel on a W(110) substrate results in the formation of quantum well states (QWS) within the film. Due to the non-perfect confinement, the wave function of the QWS extend into the first monolayers of the tungsten substrate leading to an interaction with the large potential gradient of the W atoms. We present a high resolution ARUPS study of the electronic structure of thin Nickel films on W(110) which is influenced by the spin-orbit interaction mediated by the substrate and the exchange interaction of Nickel.

O 32.3 Tue 11:45 WIL C307

The Rashba-Bychkov model in a simple *sp*-band tight binding framework — •Christian R. Ast, Isabella Gierz, and Klaus Kern — MPI für Festkörperforschung, Stuttgart

The Rashba-Bychkov model has been remarkably successful in describing the lifted spin-degeneracy of two-dimensional states at surfaces and interfaces. A more detailed description has been given by Petersen and Hedegård with a *p*-band tight-binding model accounting for the atomic spin-orbit coupling as well as an asymmetric orbital overlap resulting from the potential gradient perpendicular to the surface [1]. Here, we present an extension of this model by including other orbitals. In this way, contributions of the potential gradient originating from within an atom as well as from neighboring atoms become evident. The results will be applied to the model system graphene.

[1] L. Petersen and P. Hedegård, Surf. Sci. **459**, 49 (2000)

O 32.4 Tue 12:00 WIL C307

Visualizing spin-dependent scattering in strong spin-orbit systems — •Anna Strozecka[1], Asier Eiguren[2], and Jose Ignacio Pascual[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Dpto. Física de la Materia Condensada, Universidad del País Vasco, Bilbao, Spain

For surfaces which exhibit spin-orbit coupling, electrons originating from spin polarized surface bands are protected against backscattering by time reversal symmetry. Electron interference patterns observed in STM confirm the chiral spin texture of the surface Fermi contours of such materials and reveal the dominant role of spin in the scattering processes. Using a combined experimental and theoretical approach, we distinguish the role of spin in the electron scattering processes on Bi(110). By spectroscopic imaging of the local density of states in STM, we studied the energy dependence of the interference patterns formed around single adsorbates. Simulations based on Green's functions correctly reproduce the interference patterns, unveiling the role of spin in the interference process and allowing identification of the dominant scattering events.

O 32.5 Tue 12:15 WIL C307

Spin-resolved photoemission experiments of Rashba-split quantum-well electron states — •Sebastian Jakobs[1], Andreas Ruffing[1], Sabine Steil[1], Indranil Sarkar[1], Mirko Cinchetti[1], Stefan Mathias[1,2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]JILA and Department of Physics, University of Colorado, Boulder, CO 80309-0440, USA

The Rashba-Bychkov effect in a 2D electron gas, which originates from spin-orbit interaction and an asymmetric confinement of the electron gas, can produce spin-split energy bands in nonmagnetic materials without the need to apply any external magnetic field. The effect has been shown on various surfaces, and the resulting spin-split surface-state bands show a high spin polarization in the in-plane direction and perpendicular to the k-vector of the photoelectrons [1]. Recently, we reported on the observation of such a giant Rashba spin-orbit splitting of quantum-well state bands in the unoccupied electronic structure of a Bi monolayer on Cu(111) [2]. Due to an asymmetry in the alignment of the Bi-atoms in the incommensurate structure an additional out-of-plane spin component is to be expected. In this talk we will present first spin-dependent photoemission experiments on the one monolayer Bi/Cu(111) system, which confirm the expected out-of-plane spin component of the split quantum-well electron bands.

[1] J.H. Dil, J. Phys.: Condens. Matter 21, 403001 (2009)
[2] S. Mathias et al., Phys. Rev. Lett. 104, 066802 (2010)

O 32.6 Tue 12:30 WIL C307

Visualizing Electron Scattering near Step Edges in the Surface States of Bismuth (111) — •Christian Bobisch[1], Maren Cottin[1], Johannes Schaffert[1], Giriraj Jnawali[1], Gustav Bihlmayer[2], and Rolf Möller[1] — [1]Faculty of Physics, Center for Nanointegration Duisburg-Essen, University Duisburg-Essen, Lotharstr.1, 47048 Duisburg, Germany — [2]Institut für Festkörperforschung and Institute for Advanced Simulations, Forschungszentrum Jülich, 52425 Jülich, Germany

Recently, many studies focus on the group V element bismuth due to its rather unique physical properties. A thin and high quality epitaxial Bi(111) film of about 25 bilayers was grown on a Si(111)-7x7 substrate. Such a thin film can serve as a prototype system to study scattering in surface states with strong spin orbit splitting. We use a low temperature scanning tunneling microscope at cryogenic temperatures (80 K) to study the electronic surface structure in the vicinity of surface step edges, thus gaining insight into the electronic structure of the Bi film with high precision and lateral resolution. In dI/dV images of a surface area including surface steps, the scattering of propagating electrons is visualized by a wave like pattern. Moreover, the Fourier transform analysis of these dI/dV maps at various voltages, i.e. various energies, reveals the spectrum of scattering vectors of electrons impinging on the surface steps.