O 99: Electron and spin dynamics II

Time: Friday 11:15–13:00 Location: WIL B321

O 99.1 Fri 11:15 WIL B321

Image-potential states on graphene on Ir(111) — •Daniel Niesner and Thomas Fauster — Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany

Graphene, a single layer of graphitic carbon, can be produced with high quality on different metal substrates by decomposition of hydrocarbons. On the hexagonal Ir(111) surface the growth of graphene is self-limiting to a single layer with pronounced Moiré superstructure.[1]

Image-potential states, which are unoccupied electronic surface states close to the vacuum level, were investigated by time- and angle-resolved two-photon photoelectron spectroscopy. Besides the work function of the material, binding energies and lifetimes of the lowest three image-potential states were determined. The dispersion and intensity distribution of the first two states will be presented.

[1]A. T. N'Diaye et al., Phys. Rev. Lett. **97**, 215501 (2006)

O 99.2 Fri 11:30 WIL B321

Time-resolved 2PPE Study of Image-Potential States on Helium Adlayers on Cu(111)/Ru(001) — •Nico Armbrust[1], Jens Güdde[1], Ulrich Höfer[1], Sarah Kossler[2], and Peter Feulner[2] — [1]Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, D-35032 Marburg — [2]Physik-Department E20, TU München, D-85748 Garching

Image-potential states on thin He films on metal surfaces have attracted interest since their first observation on liquid He in the mid-seventies due to the possibility of preparing a dense two-dimensional electron gas. Because of the difficulties in combining UHV and cryogenic technology with two-photon photoemission spectroscopy (2PPE) image-potential states on well-defined He adlayers on single crystal surfaces have not been investigated systematically up to now. Here we present first results of a time-resolved two-photon photoemission study of the image-potential states on He/Cu(111). We used a specially designed lHe cryostat which made it possible to prepare He adlayers up to a thickness of 2 monolayers. These were deposited on a Cu(111) film which has been grown epitaxially on a Ru(001) substrate. The He adlayers lead to a decoupling of the image-potential states from the metal surface resulting in a reduction of the binding energy of up to 310 meV for the $n = 1$ state and only of about 15 meV for the $n = 2$ state. This goes along with a huge increase of the lifetime from 30 fs up to 350 fs for the $n = 1$ state and from 105 fs to 360 fs for the $n = 2$ state.

O 99.3 Fri 11:45 WIL B321

Spatially and momentum resolved electronic transport trough metal films using the Boltzmann Transport Equation — •Mourad El Kharrazi[1], Orkhan Osmani[1,2], Bärbel Rethfeld[2], and Marika Schleberger[1] — [1]University of Duisburg-Essen, Germany — [2]Technical University of Kaiserslautern, Germany

After the electronic excitation of a thin metal film, by e.g. laser or highly charged ion impact, the electronic system of the metal possesses high kinetic energy. Transport processes dissipate this excitation energy into the material. The hot electrons equilibrate at the same time to a new equilibrium distribution. These mechanisms can be described via a spatially and momentum resolved Boltzmann Transport Equation. We present results on both the transport inducing a momentum-dependent nonequilibrium distribution as well as the collisional processes of hot electrons.

O 99.4 Fri 12:00 WIL B321

Electron dynamics in the Rashba spin-orbit split Bi/Cu(111) quantum-well system — •Andreas Ruffing[1], Sebastian Jakobs[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, University of Colorado and NIST, Colorado 80309 0440, USA

Metallic quantum wells (QW) have been studied extensively in the recent past motivated by their potential to tune condensed matter properties via control of the quantum mechanical boundary conditions in these low-dimensional systems. Additional to the tuneability of QW systems, they show interesting features in the electronic structure, such as avoided crossings, band gaps, spin-orbit splitting and modifications due to interaction with the substrate. All these features influence the decay dynamics of excited carriers. We investigated the quantum-well system of one monolayer Bi/Cu(111), which shows a giant spin-orbit splitting of its unoccupied quantum-well bands [1]. We use time- and angle resolved two-photon photoemission to explore the femtosecond electron dynamics in this peculiar two-dimensional band structure. The band structure dependence of the hot-electron lifetimes is discussed by means of femtosecond lifetime maps $\tau(E, k_{||})$ with specific attention to a spin hot-spot at the Γ-Point of the Bi/Cu(111) quantum-well structure.

[1] S.Mathias et al., Phys. Rev. Lett. 104, 066802 (2010)

O 99.5 Fri 12:15 WIL B321

Two-photon photoemission study of ultrathin NiO(100) films on Ag(001) — •Mario Kiel, Klaus Duncker, Stephan Grosser, and Wolf Widdra — Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

The electron dynamics within ultrathin transition metal oxide NiO films grown on a Ag(001) substrate have been investigated using time-resolved two-photon photoemission (2PPE) in combination with scanning tunneling microscopy and spectroscopy (STM, STS).

For sub-monolayer NiO coverages upward shifts of the well-known Ag(001) image potential states are observed. These are explained by the increase of the electrostatic potential close to the surface due to the local work function difference between Ag(001) and NiO islands.

Using two-color 2PPE an unoccupied Ni 3d state at 3.73 eV above the Fermi energy is identified for the NiO monolayer. This Ni 3d state is also observed as prominent feature in STS spectra for defect-free NiO monolayer islands. Time-resolved data reveal a short lifetime of approx. 35 fs for this state. Additionally a second unoccupied Ni 3d-derived state at 2.4 eV is identified in 2PPE as well as in STS spectra.

O 99.6 Fri 12:30 WIL B321

Phonon-mediated adsorption and desorption of an image bound electron — •Rafael Leslie Heinisch, Franz Xaver Bronold, and Holger Fehske — Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald, Deutschland

We study phonon-mediated physisorption, that is, temporary trapping and desorption, of an electron in polarization-induced external surface states (image states) of a dielectric surface [1,2]. Electron energy relaxation at the surface is enabled by surface vibrations whose energy scale is the Debye energy. Due to the large depth of the surface potential with respect to the Debye energy, multiphonon processes are important. Using a quantum kinetic rate equation for the occupancy of the image states, we calculate desorption times and prompt as well as kinetic sticking coefficients for an electron at a dielectric surface. We show that the classification of the potential depth and bound state level spacing in terms of Debye energies is paramount for a scenario of sticking and desorption and present results for graphite, MgO, CaO, Al_2O_3 and SiO_2.

[1] R. L. Heinisch et al., Phys. Rev. B 81, 155420 (2010)
[2] R. L. Heinisch et al., Phys. Rev. B 82, 125408 (2010)

O 99.7 Fri 12:45 WIL B321

Electron dynamics of atomic gold chains on vicinal Si(111) surfaces — •Kerstin Biedermann and Thomas Fauster — Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen, Germany

Atomic wires of noble metals such as gold serve as a model system for the investigation of one-dimensional electron systems. Recent experiments on Si(557)-Au have provided initial information on the unoccupied part of the electronic band structure [1,2]. We extended our research to Si(111)-(5×2)-Au and Si(553)-Au and investigated the electron dynamics of these systems.

Time-resolved two-photon photoemission experiments were carried out using infrared (IR, $E_{IR} = 1.55$ eV) and ultraviolet (UV, $E_{UV} = 4.65$ eV) femtosecond laser pulses. In normal emission the beams were incident on the sample at a glancing angle of 10° and their electric field vectors could be aligned either perpendicular to (s-pol.) or parallel (p-pol.) to the plane of incidence in order to evaluate the parity of the electronic states.

For all three surfaces we find an even, short-lived ($\tau < 10$ fs) state at about $E = E_{Vac} - 0.6$ eV below the vacuum level, which we assign to the $n = 1$ image-potential resonance, and a long lived feature ($\tau > 600$ fs) within the bulk band gap of silicon. We present here an analysis of our time- and energy-resolved measurements and discuss the similarities and differences between the surfaces investigated.

[1] J. A. Lipton-Duffin et al., Phys. Rev. B **73**, 245418 (2006)
[2] T. K. Rügheimer et al., Phys. Rev. B **75**, 121401(R) (2007)