

O 48: Surface dynamics I

Time: Wednesday 10:30–12:45

Location: H40

O 48.1 Wed 10:30 H40

Probing the Momentum-Dependent Response of the Charge Density Wave Phase in TbTe₃ by Ultrafast Time- and Angle-Resolved Photoemission — ●P.S. KIRCHMANN^{1,2}, F.T. SCHMITT¹, U. BOVENSIEPEN^{2,3}, R.G. MOORE¹, L. RETTIG², M. KRENZ², J.-H. CHU¹, N. RU¹, L. PERFETTI^{2,4}, M. WOLF^{2,5}, I.R. FISHER¹, and Z.-X. SHEN¹ — ¹Department of Applied Physics, Stanford University, Stanford, CA 94305, USA — ²Fachbereich Physik, Freie Universität Berlin, 14195 Berlin, Germany — ³Universität Duisburg-Essen, Institut für Experimentelle Physik, 47048 Duisburg, Germany — ⁴Ecole Polytechnique, 91128 Palaiseau cedex, France — ⁵Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin, Germany

Charge density wave (CDW) systems such as TbTe₃ offer fascinating options for studying the correlation of electrons and the lattice. We investigate the ultrafast response of the charge density wave (CDW) phase in TbTe₃ [1] after femtosecond IR excitation using time- and angle-resolved photoemission [2]. The time-dependent photoemission intensity at the Fermi level yields a characteristic time for the closing of the CDW bandgap. With increasing laser fluence the bandgap closes faster, pointing to an increasing slope of the excited potential energy surface. As function of electron momentum the amplitude of the response increases strongly at the position of the Fermi wave vector k_F . These results vividly demonstrate that the CDW system is most susceptible to electronic excitations near k_F and that these electronic perturbations drive collective excitations of the coupled electron-lattice system. [1] Phys. Rev. B **77** (2008) 235104. [2] Science **321** (2008) 1649.

O 48.2 Wed 10:45 H40

Fluence-dependent two-pulse correlation for electronically induced diffusion of O/Pt(111) — ●KRISTINA KLASS¹, GERSON METTE¹, JENS GÜDDE¹, MICHAEL DÜRR^{1,2}, and ULRICH HÖFER¹ — ¹Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, D-35032 Marburg — ²Fakultät Angewandte Naturwissenschaften, Hochschule Esslingen, D-73728 Esslingen

We present results of a time-domain study of electronically induced diffusion of atomic oxygen on a vicinal Pt(111) surface. At low substrate temperatures, hot electrons are excited by femtosecond laser pulses and result in a hopping of O atoms from the O-saturated steps onto the terraces. Optical second-harmonic generation (SHG) was used to observe this process via monitoring the occupation of the step sites. The strong fluence dependence of the diffusion process was detected via SHG microscopy by analyzing the signal across the laser beam profile. In combination with two-pulse correlation measurements this technique was used to study the dynamics of energy flow from the initial excited substrate electrons to the adsorbate degree of freedom at different laser fluences. The widths of the two-pulse-correlations are in the picosecond range and increase with increasing laser fluence. The results are qualitatively similar to those obtained recently for CO/Pt(111) [1]. They are discussed on the basis of an empirical friction model using an electronic friction coefficient that depends on excitation density.

O 48.3 Wed 11:00 H40

Ultrafast electron transfer across polar molecule-metal interfaces: strong coupling vs. molecular screening — ●JULIA STÄHLER^{1,2}, MICHAEL MEYER¹, UWE BOVENSIEPEN^{1,3}, and MARTIN WOLF^{1,2} — ¹Freie Universität Berlin, FB Physik, Berlin, Germany — ²Fritz-Haber-Institut der MPG, Abt. Phys. Chemie, Berlin, Germany — ³Universität Duisburg-Essen, FB Physik, Duisburg, Germany

Heterogeneous charge transfer plays a crucial role for the development of molecular electronics such as, for example, OLEDs. The screening properties of the involved molecules hereby play an important role as they determine the timescales on which electron transfer (ET) occurs. However, also the substrate's electronic band structure significantly influences the ET dynamics. We use amorphous D₂O and NH₃ layers on Cu(111) and Ru(001) surfaces as model systems for systematic investigation of the ultrafast ET dynamics at polar molecule-metal interfaces by means of time-resolved two-photon photoelectron (2PPE) spectroscopy. With a 1st laser pulse, electrons are excited in the metal and injected into the adsorbate layer where they localize at favorable sites. The subsequent electron (back) transfer to the substrate is monitored with a 2nd, time-delayed laser pulse. The study unveils that

(i) molecular screening is observed for $t > 200$ fs after electron injection, (ii) before, ET is dominated by the strong coupling to the substrate states. Our results strongly suggest that this transition from the *substrate-dominated* to the *barrier-determined* regime of ET is a general characteristic of ET across (polar) molecule-metal interfaces.

O 48.4 Wed 11:15 H40

Neutral hydrogen desorption from graphite induced by ultra short laser pulses — ●ROBERT FRIGGE¹, TIM HÖGER¹, BJÖRN SIEMER¹, HELMUT ZACHARIAS², THOMAS OLSEN², and JAKOB SCHIØTZ¹ — ¹Physikalisches Institut, Universität Münster, Germany — ²CINF, Technical University of Denmark, Denmark

The desorption of hydrogen from HOPG is an important issue in the understanding of molecular hydrogen formation on dust particles upon irradiation. Surface mediated processes lead to H atom desorption. The velocity distribution of atomic hydrogen from HOPG is examined after surface excitation with fs pulses at $\lambda = 400$ nm using a Ti:sapphire laser. Desorbing neutral H atoms are ionized using (2+1) REMPI via the $2s \leftarrow 1s$ transition and are detected with a time-of-flight mass spectrometer. As a result the velocity distribution reveals a structure consisting of different maxima for fast, medium and very slow desorbing hydrogen atoms.

Electron scattering calculations are performed employing a repulsive electronic state and the H-graphite adsorption potentials appropriate for different adsorption sites[1]. Besides populating different vibrationally excited states in multiple scattering events, velocity distributions for desorption out of different adsorption sites are obtained. A good agreement with the experimentally observed velocities is obtained, not only for the fast but also for the very slow atoms. [1]L. Hornekær et al., Phy. Rev. Lett., **96**, 156104 (2006)

O 48.5 Wed 11:30 H40

Momentum dependent electron and hole relaxation dynamics in EuFe₂As₂ — ●L. RETTIG¹, R. CORTES¹, S. THIRUPATHAIAH², U. BOVENSIEPEN^{1,3}, M. WOLF¹, H. A. DUERR², P. GEGENWART⁴, T. WOLF⁵, and J. FINK^{2,6} — ¹Freie Universität Berlin, D-14195 Berlin — ²Helmholtz-Zentrum Berlin, D-12489 Berlin — ³Universität Duisburg-Essen, D-47048 Duisburg — ⁴Georg-August-Universität Göttingen, D-37077 Göttingen — ⁵Karlsruhe Institute of Technology, D-76021 Karlsruhe — ⁶Leibniz-Institute for Solid State and Materials Research Dresden, D-01171 Dresden

The influence of the electronic bandstructure on the fundamental relaxation processes of excited carriers leading to intra- and interband scattering is of fundamental interest in solid state physics. Here, we report on fs time- and angle-resolved photoemission spectroscopy (trARPES) on the parent compound EuFe₂As₂ of the new class of FeAs based high-T_c superconductors. Using intense fs laser pulses ($h\nu = 1.5$ eV), part of the electronic population is excited to states above the Fermi level. The transient evolution of both occupied and unoccupied states is probed by energy- and angle-resolved photoelectron spectroscopy using a time-delayed ultraviolet pulse ($h\nu = 6.0$ eV). Upon excitation, occupied states around the hole-pocket at the Γ -point of the Brillouin zone become partially depopulated by excited holes, whereas electrons are filling the empty states within the hole-pocket. The timescales of electron and hole dynamics within this band differ drastically and cannot be explained solely by intraband e-h pair generation, but an additional interband excitation channel has to be considered.

O 48.6 Wed 11:45 H40

Relaxation dynamics and bulk-to-surface-recombination of hot electrons on Si(001) studied by two-photon photoemission — ●CHRISTIAN EICKHOFF^{1,2} and MARTIN WEINELT^{1,2} — ¹Max-Born-Institut, Max-Born-Straße 2a, 12489 Berlin, Germany — ²Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin, Germany

We have studied the relaxation of hot carriers excited to the conduction band minimum (CBM) on the Si(001) surface. Two-photon photoemission combined with an electron analyzer equipped with a 2D-CCD-imaging detector allows us to follow the relaxation dynamics of photoexcited carriers in energy and momentum space simultaneously on a femtosecond timescale. With a pump fluence of $570 \mu\text{J}/\text{cm}^2$ an electron density of $\approx 10^{18} \text{ cm}^{-3}$ is created 1 eV above the CBM,

leading to an ultrafast cooling of initially excited electrons within the laser pulse width of 70 fs. After 350 fs the hot carriers can be described by a Fermi-distribution with a temperature of several thousand Kelvin. This temperature initially decreases on a fast time scale of 1 ps to 350 K, the same time scale on which the observed intensity from the normally unoccupied surface state D_{down} shows a strong increase. On a second time scale the remaining occupation in the CBM decreases within several hundred picoseconds. We conclude that electron-electron-scattering, which becomes important in semiconductors for excited carrier densities $> 10^{17} \text{ cm}^{-3}$, is the main mechanism behind efficient bulk-to-surface-recombination in the first picosecond after excitation.

O 48.7 Wed 12:00 H40

Ultrafast electron dynamics at alkali-ice interfaces probed with two-photon photoemission — •MICHAEL MEYER¹, MATHIEU BERTIN², UWE BOVENSIEPEN³, and MARTIN WOLF¹ — ¹Freie Universität Berlin, FB Physik, 14195 Berlin, Germany — ²LPMAA, Université Pierre et Marie Curie, 75252 Paris cedex 05, France — ³Fakultät für Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

An excess charge in a polar environment, i.e. an electron or an ion, is known to form a charge-solvent complex. This process involves a re-orientation of the molecules surrounding the charge, resulting in the screening of the extra charge and in the increase of its binding energy. Following earlier work, which investigated the dynamics of such solvated electrons in amorphous $\text{D}_2\text{O}/\text{Cu}(111)$ by time-resolved two-photon photoemission, we analyze here the influence of coadsorbed sodium ions. In amorphous ice multilayers these electrons are located in the bulk of the ice film. After adsorption of sub-monolayer coverages of sodium ions a new species of solvated electrons is observed. By titration experiments using Xe overlayers we can demonstrate that the binding site of these electrons is located at the ice/vacuum-interface. Depending on the sodium coverage the lifetime of the excited electrons in this state is up to ten picoseconds, which is more than one order of magnitude longer compared to solvated electrons in amorphous water ice on $\text{Cu}(111)$. The energetic stabilization rate of around 800 meV/ps is almost three times higher than in the case without sodium. The observed state can be attributed to excess electrons located at the alkali ions residing at the ice/vacuum-interface.

O 48.8 Wed 12:15 H40

Two-dimensional Fano resonances on Si(100) — •MARTIN TEICHMANN¹, CHRISTIAN EICKHOFF^{1,2}, JENS KOPPRASCH^{1,2}, CORNELIUS GAHL¹, and MARTIN WEINELT^{1,2} — ¹Max-Born-Institut, Max-Born-Straße 2a, 12489 Berlin — ²Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin

Fano resonances have enabled the understanding of many systems, from atomic to nuclear physics, and in the solid state. We present a two-dimensional extension of Fano's theory for the description of a transition between two discrete states both degenerate with a continuum. As a model system, we have studied the surface- and image potential states on $\text{Si}(100)$ using two-photon photoemission. These states are degenerate with the bulk continuum. Tuning the photon energy reveals Fano line shapes of the intensity. This allows us to deduce couplings between surface and bulk states, and to estimate the lifetime of single hole excitations in an inhomogeneously broadened system.

O 48.9 Wed 12:30 H40

Electronic structure and charge carriers dynamics in 6T absorbed on Au(111). — •ERWAN VARENE, ISABEL MARTIN, MARTIN WOLF, and PETRA TEGEDER — Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195

Two-photon photoemission (2PPE) spectroscopy is employed to gain insight into the electronic structure as well as the charge carriers dynamics at the sexithiophene (6T)/ $\text{Au}(111)$ interface. This oligothiophene was chosen because it serves as a model system for the more structurally disordered polythiophene. These materials are used as electron donors in organic photovoltaic cells and organic field effect transistors. We observed the formation of an interface dipole of -0.8 eV and we found the highest occupied molecular orbital (HOMO) to be located 1.5 eV below the Fermi level (EF). In addition, we resolved two unoccupied states at 1.2 eV and 3 eV with respect to EF. The state 1.2 eV exhibiting a long lifetime of 500 fs can be assigned to an exciton. The state at 3 eV originates from the LUMO+1, possessing a lifetime of about 150 fs.