

O 27: Time-Resolved Spectroscopy II

Time: Tuesday 11:15–12:45

Location: MA 043

O 27.1 Tue 11:15 MA 043

Unoccupied band-structure and hot electron lifetimes in Pb and Bi quantum-wells — ANDREAS RUFFING¹, ●STEFAN MATHIAS¹, MARTIN WIESENMAYER², LUIS MIAJA-AVILA³, FREDERIK DEICKE¹, HENRY KAPTEYN³, MARGARET MURNANE³, and MICHAEL BAUER² — ¹Department of Physics, TU Kaiserslautern, 67663 Kaiserslautern — ²Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — ³JILA, University of Colorado, Colorado 80309-0440, USA

The two-dimensional electronic structure of metallic quantum wells (QW) enable a unique access to peculiarities of solid state band structures by means of momentum resolved photoelectron spectroscopy, such as avoided crossings, band gaps or modifications due to interactions at interfaces. With respect to ultrafast dynamical processes in metals these features are highly interesting as they enable for instance insights into the relevance of band-structure details for the decay of hot electrons. Momentum and time-resolved two-photon photoemission (2PPE) performed with a two-dimensional electron analyzer for parallel energy (E) and momentum ($k_{||}$) detection provide the required sensitivity for such experiments. In this contribution we will present and discuss first results obtained for ultrathin Pb and Bi quantum wells grown on a Cu(111) substrate. The 2PPE experiments enable us to directly map the unoccupied band structure of these systems and the according momentum resolved hot electron lifetime $\tau(E, k_{||})$.

O 27.2 Tue 11:30 MA 043

Photoelectron microscopy of the Mott-Hubbard transition at inhomogeneously Rb adsorbed 1T-TaS₂ surfaces — ●DIRK RAHN¹, HANS STARNBERG², MARTIN MARCZYNSKI-BÜHLOW¹, TIM RIEDEL¹, JENS BUCK¹, KAI ROSSNAGEL¹, and LUTZ KIPP¹ — ¹Institut für Experimentelle und Angewandte Physik, Universität Kiel, D-24098 Kiel, Germany — ²Department of Physics, Göteborg University and Chalmers University of Technology, SE-41296 Göteborg, Sweden

Layered 1T-TaS₂ is of particular interest because it shows a rich phase diagram including various charge-density-wave phases and a first-order metal-insulator transition at about 180K which is widely understood as a Mott-Hubbard-type localization. Using angle-resolved photoemission, it has been shown that a similar metal-insulator transition at the surface of 1T-TaS₂ can be induced already at room temperature by simple adsorption of Rb [1]. To further investigate this emerging transition we have tried to prepare sharp Rb domains at the surface of 1T-TaS₂. Photoelectron microscopy measurements at beamline BL 31 at MAX-lab (Lund) and photoelectron spectroscopy measurements at beamline BW 3 at HASYLAB (Hamburg) show that it is indeed possible to prepare such a sharp Rb domain and that the Mott-Hubbard transition is taking place in the Rb adsorbed region. Photoelectron microscopy images of the inhomogeneously Rb adsorbed surface will be presented as well as photoelectron spectra at sites with different alkali metal concentrations. This work is supported by the DFG Forschergruppe FOR 353 and the European Community - Research Infrastructure Action. [1] Rossnagel et. al. Phys. Rev. Lett. 95, 126403 (2005).

O 27.3 Tue 11:45 MA 043

Spectroscopy of TaS₂ through the metal-insulator transition — ●MARTIN BEYE, ALEXANDER FÖHLISCH, URS HASSLINGER, ANNETTE PIETZSCH, and WILFRIED WURTH — Institut für Experimentalphysik, Universität Hamburg, Deutschland

Soft X-ray spectroscopies allow the analysis of the electronic structure of matter. They are specific to different elements, to their chemical surroundings and to individual orbitals, resolving their polarization. In combination with the newly available pulsed soft X-ray sources, they constitute an ideal tool to locally probe ultra-fast electron dynamics of phase transitions.

The layered material 1T-TaS₂ for example is at room temperature in a Mott insulating phase and exhibits a transition to a metallic state at liquid nitrogen temperatures, connected with the evolution of a charge density wave and a slight shift in atomic positions. This is well established around the Ta-atoms but should show effects on the electronic structure at S-centers as well. At the synchrotron sources MAX-lab and BESSY, we have studied the occupied and unoccupied electronic states. We observe large differences at both atomic centers depending on sample temperature and on polarization.

In a next step, we will drive the phase transition through excitation with a short-pulsed optical laser and study the electron dynamics on a femtosecond timescale at the free electron laser in Hamburg (FLASH).

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O 27.4 Tue 12:00 MA 043

Ultrafast laser-induced phase transitions in group-V elements — ●NILS HUNTEMANN, EEUWE S. ZIJLSTRA, and MARTIN E. GARCIA — Theoretische Physik, Fachbereich Naturwissenschaften, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

A number of pressure-induced phase transitions exist in Arsenic, Antimony, and Bismuth [U. Häussermann et al., J. Am. Chem. Soc. **124**, 15359 (2002)]. These transitions occur in thermodynamical equilibrium. In the last years different nonthermal, ultrafast structural changes have been induced in solids by means of femtosecond laser pulses [See, for example, A. Cavalleri et al., Phys. Rev. Lett. **87**, 237401 (2001)]. These structural transitions take place under extreme nonequilibrium conditions, primarily because laser light interacts very strongly with electrons but not with ions, and secondarily because the electrons thermalize relatively slowly with the ions (typically on a timescale of roughly 10 ps). As a consequence, laser-driven phase transitions are induced while the electrons are very hot, but the ions are still cold.

Based on first-principles electronic structure calculations we explored the possibility of inducing nonthermal structural changes in the above-mentioned group-V elements by ultrashort laser pulses. For this purpose, we determined the potential energy surface (electronic free energy) as a function of the lattice parameters and atomic coordinates for different electronic temperatures, which simulates the ultrafast laser heating of the electrons.

O 27.5 Tue 12:15 MA 043

Kinetic Approach for Laser-Induced Heating of Metals — ●BANAZ OMAR and BAERBEL RETHFELD — Technical University of Kaiserslautern, Department of Physics, Erwin Schroedinger Str. 46, D-67663 Kaiserslautern, Germany.

Non-equilibrium distribution functions of electron gas and phonon gas are calculated for metals irradiated with an ultrashort intense laser pulse. The excitation during femtosecond irradiation and the subsequent thermalization of the free electrons, as well as the dynamics of phonons can be described by a kinetic equation. The microscopic collision processes, such as absorption by inverse Bremsstrahlung, electron-electron, and electron-phonon interaction are considered with complete Boltzmann collision integrals. In contrast to aluminum, with a free-electron like conduction band considered in [1], the d-band in gold lies within the conduction band at about 2.5 eV below the Fermi surface of free electrons in s-band. Therefore, secondary electrons may be excited strongly, originating also from the d-band. We apply our kinetic approach to the case of gold by taking the electron density of states into account, and compare with the case of excitation of aluminum.

[1] B. Rethfeld, A. Kaiser, M. Vicanek, and G. Simon, Phys. Rev. B **65**, 214303 (2002)

O 27.6 Tue 12:30 MA 043

Electron Transfer & Solvation Dynamics at the NH₃/Cu(111) Interface: Determination of Tunneling Barriers — ●JULIA STÄHLER, MICHAEL MEYER, UWE BOVENSIEPEN, DANIELA O. KUSMIEREK, and MARTIN WOLF — Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin

Understanding the fundamental processes of heterogeneous electron transfer (ET) is highly important for a variety of different fields, as e.g. the development of nanoscale molecular electronic devices or photovoltaic cells. Here, we investigate ET and solvation dynamics at the interface of amorphous NH₃ and Cu(111) using femtosecond time-resolved two-photon photoelectron spectroscopy. After photoexcitation with UV light, metal electrons are injected into the adsorbate layer. They localize at favorable sites and are stabilized by reorientations of the surrounding solvent molecules. Concurrently, they decay back to the metal substrate. Two different regimes are observed for both, electron solvation and electron back transfer: Initially, electron

decay and stabilization occur on fs-timescales. The dynamics slow down abruptly after 250 fs leading to electron transfer and solvation on ps-timescales. The lifetime of this second species of solvated electrons depends exponentially on the ammonia layer thickness, showing

that ET is mediated by distance-dependent tunneling through an interfacial barrier. The acquired data allows for an estimate of the temporal evolution of this transient potential barrier, yielding profound insight into the ET mechanisms at molecule-metal interfaces.