O 55: Time-resolved spectroscopies II

Time: Thursday 15:00–16:15 Location: SCH A315

O 55.1 Thu 15:00 SCH A315

Quantum-beat spectroscopy of image-potential resonances — •Manuel Marks, Christian Schwalb, Kai Schubert, and Ulrich Höfer — Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität Marburg, D-35032 Marburg

Previous 2PPE studies of image-potential states on metal surfaces have largely concentrated on states that are located in a gap of the projected bulk band. In these cases, the states decay by inelastic electron-hole-pair excitation. In many situations of more practical interest, however, the resonant charge transfer at metal interfaces is more important. In this contribution we report the first results of a systematic 2PPE investigation of the image-potential states of Ag(111) where the states ($n \geq 2$) are degenerate with the upper *sp*-band of the metal. Although one might expect a rapid delocalization of electrons excited to these image-potential resonances, a whole series could be observed by coherent excitation of resonances up to quantum number $n = 7$, just like in the well-studied case of the gap states of Cu(100). The binding energies E_n deduced from quantum-beat spectroscopy fit well to a Rydberg series with a quantum defect $a = 0.062$. The inelastic lifetimes of the resonances show good agreement with the n^3-scaling law. Surprisingly, the absolute values of the experimental lifetimes are longer than expected theoretically. A major difference between the Cu(100) image-potential states and the Ag(111) image-potential resonances is a considerably shorter dephasing time of the latter.

O 55.2 Thu 15:15 SCH A315

Decoupling of image-potential states by Ne adlayers — •Nico Armbrust[1], Jens Güdde[1], Ulrich Höfer[1], and Peter Feulner[2] — [1]Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität Marburg, D-35032 Marburg — [2]Physik-Department E20, TU München, D-85748 Garching, Germany

The influence of neon adlayers on the image-potential states of Cu(100) has been investigated by time-resolved two-photon photoemission (2PPE). Ne represents a particularly interesting case for studies of the decoupling of image-potential states because its large negative electron affinity of -1.3 eV is expected to result in a large tunnelling barrier even for very thin Ne adlayers. We find that the adsorption of one monolayer of Ne reduces the binding energies of the first two image-potential states by about 30% to $E_1 = 438$ meV and $E_2 = 139$ meV and that the inelastic lifetime of the $n = 1$ state increases from 40 fs to 300 fs. We compare these results with model calculations using a one-dimensional potential that has been developed for adlayers of the heavier rare-gases [1]. We further report on the observation of laser-induced desorption of the Ne films which is surprisingly efficient not only for the UV pump pulses ($\hbar\omega_{\mathrm{UV}} = 4.66$ eV), but also for the near-infrared probe pulses ($\hbar\omega_{\mathrm{IR}} = 1.53$ eV).

[1] W. Berthold *et al.*, Appl. Phys. A **78**, 131 (2004)

O 55.3 Thu 15:30 SCH A315

The role of exchange scattering in the spin-dependent lifetime of hot electrons — •Andreas Goris[1,2], Ilja Panzer[1,2], Kristian Döbrich[1], Martin Pickel[1], Anke B. Schmidt[3], Markus Donath[3], and Martin Weinelt[1,2] — [1]Max-Born-Institut, 12489 Berlin — [2]Freie Universität Berlin, 14195 Berlin — [3]Physikalisches Institut, Universität Münster, 48149 Münster

We have identified a Δ_1 surface resonance of minority character on cobalt thin films on Cu(001) at 0.45 eV below the Fermi level in spin-resolved photoemission and two-photon photoemission (2PPE) [1]. With a laser pulse ($h\nu = 1.5$ eV) we excite electrons above the Fermi level and create photoholes in the surface resonance. A second UV laser pulse is used to probe lifetimes and spin-polarization of the excited electrons. While the hot electron lifetime shows only weak spin dependence ($\tau_\uparrow = 30$ fs; $\tau_\downarrow = 22$ fs at $E - E_F = 0.25$ eV), we find a long-living tail with predominantly majority character for energies up to 0.45 eV above E_F. By quenching the minority surface resonance with oxygen adsorption, the long-living tail of majority electrons vanishes. This strongly suggests that exchange scattering dominates hot electron decay and leads to the discrepancy between measured and calculated hot electron lifetimes [2,3]: the minority photohole is filled by a minority electron and in exchange a majority electron is excited above E_F, thereby adapting $\tau_\uparrow$ and $\tau_\downarrow$.

[1] A. B. Schmidt et. al., J. Phys. D **41** No 16, 164003 (2008)
[2] Aeschlimann et al., Phys. Rev. Lett. **79**, 5158 (1997)
[3] Zhukov et al., Phys. Rev. Lett. **93**, 096401 (2004)

O 55.4 Thu 15:45 SCH A315

Ultrafast dynamics of occupied quantum well states in Pb/Si(111) — •Laurenz Rettig, Patrick S. Kirchmann, Martin Wolf, and Uwe Bovensiepen — Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin

We investigated the ultrafast response of occupied quantum well states (QWS) in the two-dimensional model system Pb/Si(111) to an intense optical excitation using time-resolved photoemission spectroscopy (tr-PES). Employing pump photon energies of 1.5 eV and absorbed fluences up to 200 μJ/cm^2 a significant part of the valence electrons can be excited. The effect on the QWS is probed with 6.0 eV photon energy. We find a pronounced shift of up to 40 meV of the binding energy of the highest occupied QWS to higher binding energies, i.e. an energetic stabilization. A detailed analysis reveals that this shift is established within the laser pulse duration of $\sim$ 80 fs where most of the excess energy resides in the electronic system. Therefore, this gain in binding energy can be attributed to an electronic effect. The shift can be explained by a transient reduction of the electronic screening of the ion core potentials due to the excitation of electrons into unoccupied parts of the discrete QWS band structure. This can lead to a spatial redistribution of the electron density within the metal film, hence reducing the electron density at the core sites. Furthermore, a careful analysis of the transient binding energy reveals a small (2 meV) periodic modulation of the binding energy at a frequency of 2.18(5) THz which we attribute to a coherent longitudinal high energy phonon excitation within the lead film.

O 55.5 Thu 16:00 SCH A315

Unoccupied band-structure and hot electron lifetimes in Pb quantum-wells — •Andreas Ruffing[1], Stefan Mathias[1], Frederik Deicke[1], Martin Wiesenmayer[2], Michael Bauer[2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67633 Kaiserslautern — [2]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24908 Kiel, Germany

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, these systems show interesting features in the electronic structure, such as avoided crossings, band gaps or modifications due to interaction with the substrate. All these features dominantly influence the decay dynamics of excited carriers. Our goal is to gain further knowledge in femtosecond hot electron dynamics by investigating these electronic features with time-resolved two-photon photoemission (2PPE) and a two-dimensional analyzer for parallel energy (E) and momentum ($k_\parallel$) detection. A prominent example of these systems are thin Pb films, which we investigated on a Cu(111) substrate. We will show the unoccupied band structure and discuss the according electron dynamics by means of angular resolved hot electron lifetime maps τ(E,$k_\parallel$).