O 63: Poster Wednesday: Ultrafast Processes

Time: Wednesday 17:45–20:00 Location: Poster B1

O 63.1 Wed 17:45 Poster B1

Electron dynamics in MoS_2 after resonant optical excitation probed with different light polarizations — •Lasse Münster, Robert Wallauer, Johannes Reimann, Jens Güdde, and Ulrich Höfer — Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, 35032 Marburg

We will report on the application of time- and angle-resolved two photon photoemission (2PPE) with a high harmonic probe for the investigation of electron dynamics of MoS_2 in momentum space. For this purpose, we combined a high-repetition rate high-harmonic source with tunable femtosecond pump pulses and a 3D (k_x, k_y, E) electrostatic electron spectrometer [1].

We used this setup to study the electron dynamics in the conduction band of MoS_2 after resonant optical excitation at the $\overline{K}$-point with different polarizations of pump- and probe pulses. In addition to the excitation into the conduction band, we observe non-resonant 2PPE from the valence band which can be suppressed by using cross-polarized pump and probe pulses. Within our time-resolution of better than 50 fs, we observe an instantaneous occupation of the conduction band at $\overline{K}$ followed by an ultrafast transfer to the conduction band minimum at $\overline{\Sigma}$.

[1] R. Wallauer et al., Appl. Phys. Lett. 109, 162102(2016).

O 63.2 Wed 17:45 Poster B1

Quenching of charge density wave states in ultrafast transmission electron microscopy — •Till Domröse, Thomas Danz, and Claus Ropers — 4th Physical Institute - Solids and Nanostructures, University of Göttingen, Germany

Ultrafast transmission electron microscopy (UTEM) allows for investigation of nanoscale dynamics in a laser-pump/electron probe scheme [1]. Employing photoemission from a Schottky emitter, the Göttingen UTEM provides spatial resolution down to the subnanometer regime with down to 200fs temporal resolution [2].

Here, we present a time-resolved investigation of charge density wave (CDW) state quenching in UTEM. The diffraction pattern of 1T-TaS_2 in its nearly-commensurate (NC) phase gives insights into structural dynamics triggered upon optical excitation by analyzing diffraction intensities associated with the periodic lattice distortion (PLD) coupled to the CDW. The temporal evolution of the CDW amplitude and the transient lattice fluctuations are followed with femtosecond resolution over a range of excitation fluences. Following an initial quench of the CDW/PLD amplitude in the NC phase, we observe a partial recovery within few picoseconds and the excitation of a broad phonon population.

[1] A. H. Zewail, Science 328, 187 (2010)
[2] A. Feist et al., Ultramicroscopy 176, 63 (2017)

O 63.3 Wed 17:45 Poster B1

Energy-resolved measurement and simulation of hot electron transport in Au/Fe/MgO(001) — •Jan Beckord[1], Yasin Beyazit[1], John Thomas[1], Ping Zhou[1], Detlef Diesing[2], Uwe Bovensiepen[1], and Manuel Ligges[1] — [1]Faculty of Physics, University of Duisburg-Essen, 47048 Duisburg, Germany — [2]Faculty of Chemistry, University of Duisburg-Essen, 45141 Essen, Germany

We have established a new time-resolved, two-photon photoemission (tr-2PPE) technique, where the sample is pumped from the back side through a transparent substrate and subsequently probed from the front side. We apply this technique to Au/Fe/MgO(001) samples with various gold thicknesses and obtain energy-resolved transport velocities from the temporal shifts of the tr-2PPE signal. To understand the influence of the hot electron lifetimes in Au and Fe and other experimental parameters on these time shifts, we simulate the ballistic transport equation in this particular system both analytically and numerically. The simulation is then compared to our experimental results to extract the energy-dependent ballistic velocities. Our obtained values are consistent with previous, not energy-resolved measurements and comparable to theoretical values predicted from band-structure calculations. This study was funded by the DFG through SFB1242.

O 63.4 Wed 17:45 Poster B1

Ultrafast miniaturised pulsed electron gun for time-resolved LEED — •Dennis Epp, Gero Storeck, Max Lukas Kroll, Murat Sivis, and Claus Ropers — IV. Physical Institute, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Solid state surface systems display complex structural and electronic phases, with properties that may drastically differ from the bulk [1]. The coupling between electronic, lattice and spin degrees of freedom can be studied by ultrafast techniques. The structural dynamics associated with transitions between different phases can be studied by the recently developed method of Ultrafast Low-Energy Electron Diffraction (ULEED) [2, 3]. In this method, a miniaturized laser-driven photoelectron source generates ultrashort low-energy electron pulses to probe pump-induced changes to the surface structure in a stroboscopic manner. In recent works, we employed millimetre- and a micrometre-sized photoelectron guns [2, 3]. The reduced outer diameter of both electron sources allows for a small working distance from the sample, minimizing dispersive electron pulse broadening and reducing shadowing on the detector in backscattering. Temporal resolutions down to 16 ps (millimetre-gun) and 1ps (micrometre-gun) are demonstrated. This contribution will describe the fabrication of the electron beam systems, measured beam properties and first applications. Further strategies to facilitate ULEED with sub-picosecond temporal resolution will be discussed. [1] J. M. Kosterlitz. & D. J. Thouless, J. Phys. C 6, 1181*1203 (1973). [2] G. Storeck et al., Structural Dynamics 4, 044024 (2017). [3] S. Vogelgesang, et al., Nature Physics 14,184-190 (2018).

O 63.5 Wed 17:45 Poster B1

Towards time resolved photoemission spectroscopy using a circularly polarized fs-XUV light source — •Pascale Klaeger[1], Sebastian Emmerich[1], Jonas Hoefer[1], Sebastian Hedwig[1], Johannes Stöckl[1], Benito Arnoldi[1], Ofer Kfir[2], Claus Ropers[2], Benjamin Stadtmüller[1], and Martin Aeschlimann[1] — [1]University of Kaiserslautern and research center OPTIMAS, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern, Germany — [2]Georg-August-Universität Göttingen, IV. Physikalisches Institut, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

The combination of photoelectron spectroscopy with XUV- or soft x-ray radiation with circular polarization offers the intriguing opportunity to determine not only the band structure of solids but also to gain insight into the orbital character and the symmetry of the electronic states in these systems. Such radiation was so far mainly available at large scale facilities such as synchrotron light sources. Recent progress in high harmonic generation has demonstrated a novel way to create circularly polarized fs-XUV light on a laboratory scale[1,2]. Here, we show the implementation of the so called MAZEL-TOV device[2] into our HHG beamline and discuss our first ARPES data results obtained with circularly polarized fs-XUV radiation for ferromagnetic surfaces.

[1]O. Kfir et al., Nat. Phot. 9, 99 (2015) [2]O. Kfir et al., Appl. Phys. Lett. 108, 211106 (2016)

O 63.6 Wed 17:45 Poster B1

Oscillating kinetic energy in time-resolved photoemission — •Xinwei Zheng[1], Kamil Bobowski[1], Dominic Lawrenz[1], Robert Carley[2], Beatrice Andres[1], Cephise Cacho[3], Richard Chapman[3], Emma Springate[3], Serguei Molodtsov[2], and Martin Weinelt[1] — [1]Freie Universität Berlin, Fachbereich Physik, Arnimalle 14, 14195 Berlin, Germany — [2]European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld, Germany — [3]Rutherford Appleton Laboratory, Didcot, OX11 0QX, UK

We measured ultrafast time-resolved photoemission spectra on Gd (0001) and W (110) with an IR pump, XUV probe set up at the Artemis laser facility. We observed an oscillating kinetic energy of the photoemitted electrons before time zero. Such oscillations have been observed on the surface state of Gd by Bovensiepen *et al.* [1]. They described the oscillations with a ponderomotive acceleration of the emitted photoelectrons in a transient grating formed by the interference between the incident and reflected parts of the pump pulse. We performed a further investigation on these oscillations by varying the wavelengths of the pump pulse and found that the amplitude and the phase of the oscillations are pump wavelength-dependent. They show different behavior than predicted by the ponderomotive acceleration model. By comparing the amplitude of the oscillations on different bands, we discovered that the oscillating kinetic energy depends on the initial state of photoemission.

[1] Bovensiepen *et al.*, Phys. Rev. B, **79**, 045415 (2009)

O 63.7 Wed 17:45 Poster B1

Surface motion of femtosecond-laser excited silicon films — Tobias Zier[1], •Marie Kempkes[1], Sabrina Schuster[1], Lukas Nöding[1], J. Gaudin[2], P. Martinez[2], V. Blanchet[2], D. Descamps[2], S. Petit[2], A. Lévy[3], and Martin E. Garcia[1] — [1]Theoretische Physik, Universität Kassel, Kassel, Germany — [2]CEntre Lasers Intenses et Applications, Talence, France — [3]Institut des Nanosciences de Paris, France

Surfaces are active regions that exhibit various effects, like, structural reconstructions, already in the thermodynamic ground state. The underlying reason for most of these effects is the broken symmetry at the surface, which modifies the interatomic bonding of surface atoms. After an intense femtosecond-laser pulse the interatomic bonding characteristic of the whole irradiated area is changed due to the induced non-equilibrium conditions, which are characterized by an extremely hot electronic system and nearly unaffected room temperature atoms. Therefore, the bonding of surface atoms is modified twice after a femtosecond-laser excitation, which makes a prediction for the surface behavior non-trivial. We examined the surface response to a femtosecond-laser irradiation by performing ab initio MD simulations of a thin silicon film using our code CHIVES (Code for Highly excIted Valence Electron Systems). Our results can directly be compared to recent time-resolved optical measurements, thus allowing us to unravel the surface response to femtosecond-laser excitation on an atomistic level.

O 63.8 Wed 17:45 Poster B1

Electron-Phonon coupling in non-equilibrium: tr-RHEED on few monolayer Pb/Si(111) films — •Tobias Witte, Bernd Hafke, Christian Brand, and Michael Horn-von Hoegen — Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

The recent advances in temporal resolution of electron diffraction experiments raised a multitude of questions regarding non-equilibrium dynamics of optically excited systems. Here, the response of the phonon system of few monolayer (ML) thin Pb/Si(111) films upon fs-IR laser excitation is investigated. This system is known for exhibiting different quantum well states for even or odd layers which should influence the electron phonon interaction. Employing time-resolved reflection high-energy electron diffraction the mean squared displacement of the surface atoms is analyzed for different Pb film thicknesses θ_{Pb}. The excitation time constant is found to be almost independent of the layer thickness for coverages of 3 ML $\leq \theta_{\mathrm{Pb}} \leq$ 15 ML. The average value of $\tau_{\mathrm{exc}} = 3.2 \pm 0.4$ ps is significantly slower than expected from a two temperature model ($\tau_{\mathrm{TTM}} < 1$ ps). This discrepency is discussed with respect to the non-thermal lattice model[1].

[1] L. Waldecker et al. - Phys. Rev. X 6, 021003 (2016)