O 45: Poster Tuesday: Ultrafast Processes

Time: Tuesday 18:00–20:00 Location: Poster D

O 45.1 Tue 18:00 Poster D

Four-dimensional XUV time- and angle-resolved photoemission spectroscopy of solids at 500 kHz — Michele Puppin[1,2], Christopher W. Nicholson[1,3], •Samuel Beaulieu[1], Shuo Dong[1], Tommaso Pincelli[1], Patrick Xian[1], Maciej Dendzik[1], Yoav W. Windsor[1], Yunpei Deng[1,4], Claude Monney[1,3], Martin Wolf[1], Laurenz Rettig[1], and Ralph Ernstorfer[1] — [1]1Department of Physical Chemistry, Fritz Haber Institute of the Max Planck Society, Faradayweg 4-6, 14195 Berlin — [2]2Laboratory of Ultrafast Spectroscopy, ISIC, and Lausanne Centre for Ultrafast Science (LACUS), Ecole Polytechnique Federale de Lausanne, CH-1015 Lausanne, Switzerland — [3]4Department of Physics, University of Fribourg, Chemin du Musee 3, 1700 Fribourg, Switzerland — [4]3Paul Scherrer Institute, Swiss FEL, 5232 Villigen PSI, Switzerland

We report on four-dimensional time- and angle-resolved photoelectron spectroscopy (trARPES) employing a 500 kHz extreme-ultraviolet (XUV) light source operating at 21.7 eV probe photon energy [1]. This beamline is coupled to a state-of-the-art time-of-flight momentum microscope (METIS 1000, SPECS GmbH) that allows us to measure the out-of-equilibrium multidimensional electronic band structure of solids (including excited states) in the entire Brillouin zone and with a temporal system response function below 40 fs. Exemplary data on inorganic and organic semiconductors will be presented. [1] Puppin et al., arXiv:1811.06939v1 [physics.ins-det] (2018).

O 45.2 Tue 18:00 Poster D

Multidimensional photoemission spectroscopy data: A framework for distributed and volumetric processing — Rui P. Xian[1], Yves Acremann[2], Steinn Y. Agustsson[3], Maciej Dendzik[1], Davide Curcio[4], Dmytro Kutnyakhov[5], Ralph Ernstorfer[1], and •Laurenz Rettig[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Department of Physics, ETH, Zurich, Switzerland — [3]Department of Physics, University of Mainz, Mainz, Germany — [4]Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark — [5]DESY Photon Science, Hamburg, Germany

Recent developments of photoelectron spectrometers based on time-of-flight techniques using multi-dimensional delay-line detectors such as k-TOFs and momentum microscopes are fueling the emerging field of multidimensional photoemission spectroscopy (MPES). It enables a rapid volumetric mapping of the electronic band structure of materials and naturally incorporates further dimensions such as k_z dispersion, spin or pump-probe time. A significant challenge for the data handling are the high throughput data streams of individual detected electrons with multi-dimensional coordinates, and the vast amount of events needed to fill a typical dataset, which reach into the order of hundreds of millions to tens of billions and requires histogramming, corrections and calibrations to convert into a structured format. We have developed a distributed open-source pipeline to process these data streams for use at large facilities and in tabletop experiments. Event-wise operation allows reliable experimental diagnosis and artifact correction.

O 45.3 Tue 18:00 Poster D

Development of a sub 50 fs mid-infrared laser source using the principle of OPCPA — •Manuel Bridger, Oscar Naranjo, Alexander Tarasevitch, and Uwe Bovensiepen — Universität Duisburg-Essen, Fakultät für Physik, 47057 Duisburg, Germany

For many different experiments to measure the lattice modes or molecular vibrations, it is essential to have an ultrashort laser pulse with a wavelength which is in resonance with such processes, namely in the mid infrared (MIR) range. Additionally it has been shown that the cutoff frequency of high harmonics can be increased into the keV X-ray range using longer wavelengths, which will be our central application for the MIR light [1].

We will present the development of a high peak power two step Optical Parametric Chirped Pulse Amplifier (OPCPA). With this procedure, it is possible to switch the wavelength from the visible range towards the MIR by simultaneously increasing the pulse energy by several orders of magnitude.

We start out with a Ti:sapphire oscillator yielding an octave-spanning spectrum around 800 nm, which is first stretched from 6 fs to 6 ps. Within two subsequent steps consisting of amplification using an OPA stage and wavelength switching within a DFG stage, we reach 3200 nm central wavelength with a bandwidth supporting sub 50 fs and a pulse energy of >500 μJ. This work is funded by the DFG through SFB 1242, TP A05.

[1] T. Popmintchev et al., Science 336, 1287-1291 (2012).

O 45.4 Tue 18:00 Poster D

Analysis of the Excited State Potential Energy Surface of an Ultrafast Charge-Density-Wave-to-Metal Transition — •J. Maklar[1], W. Windsor[1], C. Nicholson[1], V. Esposito[2], P. Walmsley[3], M. Puppin[1], E. Bothschafter[2], M. Porer[2], J. Rittmann[2], D. Leuenberger[4], M. Kubli[5], M. Savoini[5], E. Abreu[5], S. Johnson[5], I. Fisher[3], P. Beaud[2], G. Ingold[2], U. Staub[2], R. Ernstorfer[1], M. Wolf[1], and L. Rettig[1] — [1]Fritz-Haber-Institiut der Max-Planck-Gesellschaft, Berlin, Deutschland — [2]SLS, Paul Scherrer Institut, Villigen, Schweiz — [3]GLAM, Department of Applied Physics, Stanford, California, USA — [4]Department of Physics, Univ. Zürich, Schweiz — [5]Inst. für Quantenelektronik, ETH Zürich, Schweiz

Charge-density-waves (CDWs) exhibit a fascinating broken-symmetry ground state due to their intertwining with high-Tc superconductivity, their competition with Mott physics, and their interaction with magnetism. In this study we investigate the electronic and structural dynamics of the prototypical 2D CDW compound TbTe3 using XUV time-resolved ARPES and time-resolved X-ray diffraction. We observe a CDW-to-metal transition concomitant with a strongly fluence-dependent coherent oscillatory behavior of the electronic band gap and a simultaneous suppression of the periodic lattice distortion. Based on a Ginzburg-Landau-type approach we discuss how to extract the excited state energy potential of the order parameter and how to access the coupling strengths between different degrees of freedom on a quantitative level.

O 45.5 Tue 18:00 Poster D

High harmonic generation up to the keV regime and further applications of mid-infrared radiation — •Oscar Andres Naranjo Montoya, Manuel Bridger, Alexander Tarasevitch, and Uwe Bovensiepen — Universität Duisburg-Essen, Fakultät für Physik, 47057 Duisburg, Germany

Pump-probe experiments with optical excitation and absorption spectroscopy in the soft X-ray range on a femtosecond timescale are useful to analyze electronic and magnetic properties of complex material systems and their temporal evolution. Tabletop generation of soft x-rays pulses has become available using high harmonic generation driven by mid-infrared (MIR) femtosecond pulses in noble gases[1].

We developed a two-step Optical Parametric Chirped Pulse Amplifier that delivers sub 50 fs pulses at a wavelength of 3200 nm and energy >500 μJ as a pump for a tabletop soft x-ray source. That opens a door to perform a wide variety of soft x-ray experiments. Moreover, this MIR source also allows us to observe Floquet-Bloch states on the surfaces of topological insulators by femtosecond photoelectron spectroscopy[2]. We present the achieved spatial, spectral and temporal pulse characteristics of the MIR source as well as the estimate soft x-ray flux with some of the applications to be developed.

This work is funded by the DFG through SFB 1242, TP A05.

[1] T. Popmintchev et al., Science **336**, 1287 (2012).
[2] F. Mahmood et al., Nature Phys. **12**, 306 (2016)

O 45.6 Tue 18:00 Poster D

Development of time-resolved photoemission electron microscopy of magnetization dynamics triggered by back-side illumination — •Maximilian Paleschke, Cheng-Tien Chiang, and Wolf Widdra — Institute of Phyiscs, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany

Over the last decades, both ultrafast microscopy and spintronics have progressed in a remarkable manner. Experimental and theoretical methods have been developed in order to understand and control the spin transport and magnetization dynamics approaching the spatial-temporal limit of available techniques [1]. Supported by the newly founded CRC/TRR 227 Ultrafast Spin Dynamics we set up an experiment for spin and magnetization dynamics of magnetic thin films on nanometer-femtosecond scales. Our approach combines state-of-the-

art time-resolved photoemission electron microscopy (PEEM) with a back-side pumping geometry. With this setup, we image magnetic domains using magnetic dichroism in photoemission [2] and record nm-fs movies of domain switching and domain wall motion triggered by fs spin and optical excitations. In this poster, we will present our experimental setup including quantitative estimations of the excitation density required to trigger ultrafast magnetization dynamics, the accessible temporal resolution, as well as the size of the magnetic linear and circular dichroic effects in PEEM.

[1] A. Kirilyuk et al., Rev. Mod. Phys. 82, 2731 (2010)
[2] C. M. Schneider, G. Schönhense, Rep. Prog. Phys. 65, 1785 (2002); W. Kuch, C. M. Schneider, ibid. 64, 147 (2001)

O 45.7 Tue 18:00 Poster D

Band Occupation and Optical Response of Gold far from Equilibrium — •Pascal D. Ndione[1], Sebastian T. Weber[1], Dirk O. Gericke[2], and Baerbel Rethfeld[1] — [1]Department of Physics and OPTIMAS Research Center, TU Kaiserslautern, Germany — [2]Centre for Fusion, Space and Astrophysics, Department of Physics, University of Warwick, UK

Short laser pulses drive materials into a nonequilibrium state. Then due to diverse scattering processes, a new thermodynamic equilibrium is reached. It is important to understand the transient changes of the optical properties which strongly depend on the nonequilibrium electrons dynamics within the bands.
This contribution investigates the band occupation and the optical properties in gold upon excitation with a short laser pulse. We propose two different models depending on the photon energy of the applied excitation. With optical pulses, only *d* and *sp*-band electrons can be excited and electrons might be promoted into states above Fermi energy. The subsequent dynamics are calculated in a two-band model. On the other hand, X-ray light allows accessing deeper bands like the *f*-shell. In that case, more kinetic processes are at play and more bands are needed. Our model with three active bands allows tracing the occupation numbers for VUV excitation. With the bands' occupation, we are able to calculate the transient optical properties and make a comparison to experimental data.

O 45.8 Tue 18:00 Poster D

Picosecond acoustic waves in laser-excited metal-semiconductor heterostructures studied by ultrafast X-ray diffraction — •Fabian Brinks[1], Mohammadmahdi Afshari[1], Philipp Krumey[1], Andrey Akimov[2], Dmitri Yakovlev[3], Manfred Bayer[3], and Klaus Sokolowski-Tinten[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen, University of Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany — [2]School of Physics and Astronomy, University of Nottingham, NG7 2RD, UK — [3]Faculty of Physics, Technical University Dortmund, 44221 Dortmund, Germany

Absorption of ultrashort optical pulses in solids leads to a quasi-instantaneous increase of stress/pressure, which is subsequently released by acoustic strain waves traveling through the sample. We investigate the excitation and transient evolution of such coherent acoustic phonons in metal-semiconductor heterostructures composed of thin metal films (Ti, Cr, Al, Pt, Au, Pd) deposited on 100-oriented GaAs substrates by time-resolved X-ray diffraction using ultrashort X-ray pulses at 4.5 keV from a fs laser-plasma X-ray source. By probing the GaAs (400) Bragg reflection in an optical pump - X-ray probe scheme we are able to monitor the strain waves. To reveal the underlying physical processes we follow a combined approach. Direct reconstruction of the strain profile together with simulation of the elastic wave equation followed by dynamical diffraction calculations give a complementary view on the material-dependent evolution of stress/strain upon ultrafast excitation.

O 45.9 Tue 18:00 Poster D

Suspended 2D-materials as targets for ps-ion source — Tobias Foller, Alexander Breuers, •Leonard Christen, Matthias Herder, Anke Hierzenberger, Andreas Wucher, and Marika Schleberger — Faculty of Physics, University of Duisburg-Essen, Germany

For a high yield in transmission experiments and experiments involving broad probing beams large area ultrathin targets are required. CVD-grown 2D materials are a suitable starting material for this purpose allowing possible applications [1] and experimental approaches [2,3]. Therefore, we have inherited [4] and adapted a new technique to fabricate large area suspended 2D-membranes. We start off with CVD-grown 2D material. Protected by a thin poly(methyl methacrylate) (PMMA) film the heterostructure is then transferred to a perforated substrate. Using the solvent replacement technique [4] PMMA is gently removed.

The duration of a secondary electron pulse is a direct image of the parent picosecond ion pulse. For our ion source creating picosecond pulses it is thus important to know the secondary electron emission and radiation hardness of the targets under Ar+ ion-irradiation. We have developed an experimental setup to investigate these characteristics.

[1] Cohen-Tanugi et al., Nano Lett., 7 (2012) pp 3602-3608 [2] Kotakoski et al., Nat. Commun. 5 (2014) 3991 [3] Gruber et al, Nat. Commun. 7 (2016) 13948 [4] Chen et al., Nanoscale 8 (2016) pp 3555-3564