Contribution ID: **100** Type: **Contributed poster**

Highly efficient end-station for space-, time- and spin-resolved photoemission spectroscopy at free electron lasers and high harmonic generation sources.

Monday, 25 June 2018 18:45 (15 minutes)

Photoemission spectroscopy (PES) is a powerful technique, which allows to investigate the electronic properties of solid systems and molecules. If used in combination with high repetition rate free electron lasers (FEL) in the XUV and soft X-ray regime such as FLASH, DESY, Hamburg or with table-top laser systems based on the high harmonic generation (HHG), it offers unique possibilities for the time-resolved PES. The possibility to use both X-ray and laser pulses with time duration of few tens of femtoseconds will allow to access ultrafast electronic phenomena and chemical reactions. The photo-emitted electrons will carry all the information regarding the electronic states of the system in the photo-generated non-equilibrium state. To fully exploit this information, it is necessary to use very efficient detection schemes for the photoelectrons. The combination of a time-of-flight (ToF) momentum microscope with the FEL or HHG as probe photon source is an ideal combination for time- and angle-resolved PES and time-resolved x-ray photoelectron diffraction to study ultrafast electron- and lattice dynamics. The momentum microscope allows simultaneous detection of the entire band structure with unprecedented efficiency in the full surface Brillouin zone with up to 8 $Å^{-1}$ diameter and several eV binding energy range, resolving about 2.5×10^5 voxels, or the angular pattern of core level photoelectrons, respectively, for each time step in a pump-probe experiment. Adding an imaging spin detector extends the capability to detect the spin-polarized band structure of the material, resolving more than 10^4 voxels [1,2].

First test results with this set-up have been achieved using the combination of the table-top laser source from KMLabs - Wyvern 1000, capable to deliver pulses of 50 fs at 790 nm (1.54 eV) with a repetition rate of 3 kHz, with a maximal energy per pulse of 3.2 mJ, providing us with EUV radiation up to 45 eV as a probe and optical photons in a range from 790 to 400 nm as a pump pulse.

Recently, a highly efficient end-station for space-, time- and spin-resolved photoemission spectroscopy and time-resolved x-ray photoelectron diffraction was commissioned at the PG2 beam-line at FLASH, DESY, Hamburg. During pump-probe beam-times, we investigated ultrafast electron thermalization dynamics at the surface of a Cu(100) single crystal, time-resolved photoelectron diffraction of a photoexcited graphene layer on SiC, as well as excited state dynamics in the layered semiconductors WSe_2. First results will be presented.

References:

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Session Classification: Poster session