High-Energy Time-of-Flight Momentum Microscope Development

Olena Tkach[1, 2, a)], Katerina Medjanik[1], Olena Fedchenko[1], Sergey Babenkov[1], Hans-Joachim Elmers[1] and Gerd Schönhense[1]

[1]*Institute of Physics, Johannes Gutenberg University, Staudingerweg 7, 55128 Mainz, Germany*
[2]*Sumy State University, Sumy, Ukraine*

[a)] *Corresponding author: tkachole@uni-mainz.de*

Abstract. Photoelectron momentum microscopy (MM) is a modern research method for determining the electronic structure of solids using photoelectron energy, momentum and spin analysis. In the language of electron microscopy, this information can be retrieved from the ‘reciprocal image’, being nothing else than the lateral momentum distribution. MM constitutes an alternative route to angle-resolved photoelectron spectroscopy (ARPES). Time-of-flight (ToF) recording allows us to capture the energy states simultaneously in an interval of several eV. A delay-line detector (DLD) is used for time resolved momentum-space and real-space (= Gaussian) imaging as well as for spatio-temporal beam diagnostics.

The new generation of ToF microscopes comprises 3 zoom-lens groups arrays of 16 field and contrast apertures and auxiliary grids for adjustment (piezomotor driven), Gauss- and k-stigmator octupoles. A *dodecapole bandpass filter* can act as dispersive spectrometer, slightly deflecting the electrons depending on their energy. Selectable entrance and exit apertures define a bandpass of some 10 to 100 eV and thus effectively suppresses background electrons with undesired energies. The instrument enables energies from threshold up to >7 keV and k-fields-of-view between < 4 and ~ 16 $Å^{-1}$ diameter. Lenses with low spherical aberrations yield high resolution in real-space imaging, important e. g. for in-*operando* studies. The first prototypes are operated at the hard- and soft-X-ray beamlines P22 and P04 at the Synchrotron-radiation source PETRA-III (DESY, Hamburg). We show details of the instrument and report on the first experiments. These microscopes will be used for the study of new interesting samples, for example, with topological states in which quantum effects are manifested. A stronghold of ToF-MM is fs time resolved ARPES at existing and upcoming free-electron laser sources (FLASH, EuXFEL and LCLS-II in Stanford).