MI 3: X-ray Imaging, Holography, Ptychography and Tomography

Time: Wednesday 10:00–12:30 Location: H5

Invited Talk MI 3.1 Wed 10:00 H5

Laboratory-based X-ray microscopy - Technique and applications — •Ehrenfried Zschech, Jürgen Gluch, Sven Niese, Kristina Kutukova, and Qiong Li — Fraunhofer IKTS Dresden, Germany

High-resolution nondestructive characterization of materials and structures, including kinetic processes in materials, is a highly ranked request from basic research (e. g. in materials science and nanotechnology). Due to the particular properties of X-rays, i. e. high penetration of matter and good material contrast in absorption, high resolution X-ray imaging is a versatile tool for nondestructive 3D bulk analysis of materials and for the investigation of complex 3D structures. Novel focusing lenses, so-called multilayer Laue lenses, have the potential to bring hard X-ray microscopy (high photon energy) at high efficiencies to resolutions down to the 10 nm range and below.

Examples for materials development supported by high-resolution X-ray imaging and analysis will be shown, including studies of kinetic processes in materials: Physical failure analysis in 3D-stacked microchips, kinetic reactions for energy storage and conversion processes, crack initiation and propagation in microchips and composites. Eventually, the application to biological objects (cells, pollen grains) will be demonstrated.

MI 3.2 Wed 10:45 H5

Scanning X-Ray Microscopy of Superconductor/Ferromagnet Bilayers — •Claudia Stahl[1], Stephen Ruoss[1], Markus Weigand[1], Patrick Zahn[1,2], Jonas Bayer[1,2], Gisela Schütz[1], and Joachim Albrecht[2] — [1]Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany — [2]Research Institute for Innovative Surfaces, FINO, Aalen University, Beethovenstr. 1, 73430 Aalen, Germany

The magnetic flux distribution arising from a high-T_c superconductor is detected and visualized with high spatial resolution using scanning x-ray microscopy (SXM). Therefore, we introduce a sensor layer, namely, an amorphous, soft-magnetic CoFeB cover layer [1]. The magnetic stray fields of the supercurrents lead to a local reorientation of the magnetic moments in the ferromagnet, which is visualized using the large x-ray magnetic circular dichroism (XMCD) effect of the Co and Fe L3-edge.

We show that the XMCD contrast in the sensor layer corresponds to the in-plane magnetic flux distribution of the superconductor [2] and can hence be used to image magnetic structures in superconductors with high spatial resolution [3,4]. Using the total electron yield (TEY) mode the surface structure and the magnetic domains can be imaged simultaneously and can be correlated.

The measurements are carried out at our scanning x-ray microscope MAXYMUS at Bessy II, Berlin with the new low temperature setup.

[1] C. Stahl et al., EPL 106, 27002 (2014). [2] C. Stahl et al., PRB 90, 104515 (2014). [3] S. Ruoß et al., APL 106, 022601 (2015). [4] C. Stahl et al., Journ. of Appl. Phy. 117, 17D109 (2015).

MI 3.3 Wed 11:00 H5

Efficiency simulation and measurements for MZP hard X-ray nanofocusing and imaging — •Jakob Soltau[1], Christian Eberl[2], Tim Salditt[1], Hans-Ulrich Krebs[2], and Markus Osterhoff[1] — [1]Röntgenphysik, Uni-Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen — [2]Materialphysik, Uni-Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

Latest developments in fabrication and inspection technologies have enabled the manufacturing of multilayer zone plates (MZP) with high aspect ratio using pulsed laser deposition [1]. This allows sub-5 nm focusing of hard X-rays in two dimensions and enabling photonic imaging on a nanometer scale. To improve the efficiency of zone plates, we investigated the propagation of the electromagnetic wave field inside and behind the MZP with two different simulation methods. The results are compared with the latest measurements of a 2D-MZP with an outermost zone width of only 5 nm used at the synchrotron source at DESY. The simulation methods we used are: a multi slice propagation according to Huygens, which can handle almost any geometry with only few artefacts and a finite difference simulation which has already stated its capabilities in the waveguide development [2]. The central challenge in the development of hard X-ray nanofocusing MZPs is the fulfilling of the Bragg condition across the zone plate. To achieve this, the zones are tilted. The tilting was a central point in our investigations. It was also studied with the MZP used in our latest experiments carried out at DESY. [1] Eberl, C. et al. Appl. Surf. Sci. 307 (2014) [2] Salditt, T. et al. Phys. Rev. Lett. 115, 203902 (2015)

MI 3.4 Wed 11:15 H5

Multi plane probe retrieval in X-ray nearfield imaging — •Johannes Hagemann and Tim Salditt — Institut für Röntgenphysik, GAU Göttingen, Deutschland

The probe, i.e. the impinging X-ray beam on the sample, is the main actor in X-ray imaging experiments when it comes to image quality. We characterized the probe of the GINIX-Setup at P10(DESY) using a multiple detection plane scheme. With that we can determine beam parameters as for example the size of the focus. We could also directly study the influence of different slit settings on the focus. We can compare the results with another approach called longitudinal nearfield ptychography.

Coffee break (15 min)

MI 3.5 Wed 11:45 H5

Holography-guided ptychography with soft X-rays — •Piet Hessing[1], Bastian Pfau[3], Erik Guehrs[2], Michael Schneider[2], Laura Shemilt[2], Jan Geilhufe[1], and Stefan Eisebitt[1] — [1]Max-Born-Institut, Berlin, Germany — [2]TU Berlin, Berlin, Germany — [3]Lund University, Lund, Sweden

We present a novel combination of two coherent imaging methods, namely holography [1,2] and ptychography [3,4] for imaging nanoscale objects using soft X-rays. Ptychography as a scanning imaging method relies on the exact knowledge (or post-experimental retrieval) of the position of the X-ray illumination on the sample during scanning. Our method combination allows to directly encode the scan positions in the diffraction pattern without the need of accurate position encoders. We demonstrate that holographically encoded positions significantly reduce the experimental and numerical requirements. Our ptychographic reconstructions cover a large field of view with diffraction-limited resolution and high sensitivity in the reconstructed phase shift and absorption of the objects.

[1] S. Eisebitt et al., Nature 432, 885 (2004). [2] B. Pfau and S. Eisebitt, X-ray holography, in: Synchrotron Light Sources and Free-Electron lasers (Springer, 2015). [3] K. Giewekemeyer et al., Opt. Express 19, 1037 (2011). [4] M. Rose et al., J. Synchrotron Rad. 22, 819 (2015).

MI 3.6 Wed 12:00 H5

Polarization contrast of nanoscale waveguides studied by coherent diffractive imaging with high-harmonic source — •Sergey Zayko, Murat Sivis, Sascha Schäfer, and Claus Ropers — 4th Physical Institute - Solids and Nanostructures, University of Göttingen, 37077 Göttingen

Recently proposed high harmonic generation (HHG) schemes offer novel means of control over the polarization state of the emitted radiation, enabling ultrafast table-top implementations of polarization-dependent spectroscopy, such as circular dichroism [1-4]. Here, we present a novel approach to analyze and control the polarization state in the case of extreme ultraviolet radiation via nanoscale waveguides. Using coherent diffractive imaging (CDI), we experimentally study the propagation of high harmonics through nanoscale slab waveguides with optically dense cladding materials and find a strong dependence of the waveguide transmission on the incident light polarization [5]. Employing such waveguides, we demonstrate a novel type of high harmonic polarizer and design a scheme to analyze the polarization state of extreme ultraviolet radiation by means of single image acquisition. Our results on polarization sensitive CDI highlight the potential of HHG sources for ultrafast magnetic imaging.

[1] O. Kfir *et al.*, Nature Photonics 9, 99-105 (2015).
[2] G. Lambert *et al.*, Nature Communications 6, 6167 (2015).
[3] A. Ferré *et al.*, Nature Photonics 9, 93-98 (2015).
[4] D. Hickstein *et al.*,, Nature Photonics 9, 743-750 (2015).
[5] S. Zayko *et al.*, Optics Express 23, 19911-19921 (2015).

MI 3.7 Wed 12:15 H5

Phase-Contrast Tomography with Anisotropic X-Ray Sources — •Malte Vassholz and Tim Salditt — Institute for X-Ray Physics, University of Göttingen, Göttingen, Germany

Nanoscale x-ray tomography is an important method for analysing hard and soft matter. However, high-resolution tomography requires high brilliance x-ray probes with small source sizes in both lateral dimensions and is therefore carried out at synchrotrons. The minimum focal spot size at laboratory x-ray sources is highly limited by insufficient photon flux, whereas anisotropic one-dimensional focusing provides significantly more flux. The central challenge is to get isotropic resolution from anisotropic x-ray probes. Towards the goal of nanoscale resolution at laboratory x-ray sources we have designed a new tomographical data-acquisition scheme with two-dimensional angular sampling and advanced reconstruction methods based on the three-dimensional Radon transform, compatible with anisotropic x-ray probes. Furthermore, we have tested the applicability of propagation-based phase contrast with the novel tomography setup.