MI 6: X-ray Imaging, Holography and Tomography

Chair: Christian Schroer (TU Dresden)

Time: Wednesday 11:00–12:00 Location: MER 02

MI 6.1 Wed 11:00 MER 02

Phase retrieval in near-field X-ray holography based on separation of object and probe — •Anna-Lena Robisch, Matthias Bartels, and Tim Salditt — Institut für Röntgenphysik, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

X-ray full-field holography offers quantitative amplitude and phase contrast on the nm-scale. However the image quality suffers form imperfections and aberrations in the illuminating beam.

The general way of reducing such unwanted features is to divide the data by the intensity profile of the illumination before performing phase reconstruction which allows to get the real space image of the sample back. This procedure is mathematically not correct; as the division of the complex illumination in amplitude and phase should be performed in real space where the exit wave right behind the sample can be modeled as the product of the sample's transmission function and the incoming beam. One possibility of reconstructing object and probe in the described way is via ptychography[1].

Here we present an algorithm that can be interpreted as a generalization/extension to ptychography using defocus scanning instead of lateral scanning in one fixed plane. Similar to ptychography simultaneous reconstruction of object and probe is possible [2]. Besides the algorithmic concept and simulations first experimental results using data recorded at the nano-scale imaging beamline DESY/PETRAIII/P10 are shown.

[1] P. Thibault et al., ULTRAMICROSCOPY 109, 338-343 (2009)

[2] A-L. Robisch, T. Salditt, OPT EXPRESS 21(20), (2013)

MI 6.2 Wed 11:15 MER 02

High resolution coherent diffractive imaging with a table-top high harmonic source — •Sergey Zayko[1], Eike Mönnich[1], Murat Sivis[1], Tobias Mey[3], Dong-Du Mai[2], Klaus Mann[3], Tim Salditt[2], and Claus Ropers[1] — [1]1IV. Institute of Physics, University of Göttingen, Germany — [2]Institute for X-Ray Physics, University of Göttingen, Germany. — [3]Laser Laboratorium Göttingen, Germany

High harmonic up-conversion of femtosecond laser pulses allows for the generation of coherent extreme ultraviolet radiation from table-top devices. Here, we present a study of coherent diffractive imaging (CDI) using high harmonic generation at a wavelength of 34.7 nm using amplified 800 nm femtosecond laser pulses. The setup employs a toroidal grating monochromator in order to carry out diffraction-limited CDI at a reduced spectral bandwidth. Diffraction images for several lithographically prepared objects were recorded, and successful object reconstructions were obtained by means of iterative phase retrieval algorithms. Resolutions of 38 nm and 34 nm are achieved for a single exposure of 5 s and accumulating multiple exposures, respectively, corresponding to the maximum achievable resolution given by the numerical aperture of the detection setup. Reconstructions for objects up to about 10 micrometres diameter were performed, presently limited by the transverse coherence length of the incident wavefront, which was independently characterized. A further increase of the photon flux and a reduction of the exposure times will be reached by utilizing 400 nm pump pulses, and the spatial resolution will be improved by the use of shorter harmonic wavelengths.

MI 6.3 Wed 11:30 MER 02

Multi-layer Fresnel zone plates towards high resolution soft and hard x-ray microscopy — •Umut Tunca Sanli[1], Kahraman Keskinbora[1], Corinne Grévent[1], Marcel Mayer[1], Adriana V. Szeghalmi[2], Keith Gregorczyk[3], Anna-Lena Robisch[5], Tim Salditt[5], Mato Knez[3,4], and Gisela Schütz[1] — [1]MPI for Intelligent Systems — [2]Friedrich-Schiller-University Jena — [3]CIC nanoGUNE Consolider — [4]IKERBASQUE Basque Foundation for Science — [5]Institut für Röntgenphysik, Universität Göttingen

We fabricate full-material multi-layer Fresnel zone plates (ML-FZPs) by depositing alternating layers of high and low absorbing materials on glass fibers via Atomic Layer Deposition (ALD) followed by a slicing process with a Focused Ion Beam. Depending on their thicknesses the FZPs may be optimized to focus photons in a wide range from soft x-rays to gamma rays. We recently resolved 21 nm structures at 1 keV by direct imaging experiments. For hard x-rays, at 7.9 keV, Fourier analysis of the diffraction patterns gives clues about sub 30 nm resolution. The key to improve the resolution is to increase the Diffraction Efficiency (DE) in order to compensate for the efficiency losses associated with thinner zones. Our newest Al2O3-HfO2 FZPs are theoretically twice as efficient as our previous Al2O3-Ta2O5 FZPs at 1 keV and for dr = 11 nm. According to the coupled wave theory, the DE can be improved by 5 times by using commercially available materials for the ALD, such as Ir-Al2O3. It is expected, that the number of materials available with the ALD will increase allowing further improvement of the FZP performance.

MI 6.4 Wed 11:45 MER 02

High Throughput Fabrication of Fresnel Zone Plates *via* Ion Beam Lithography — •Kahraman Keskinbora, Corinne Grévent, Umut Tunca Sanli, Ulrike Eigenthaler, and Gisela Schütz — Max Planck Institute for Intelligent Systems, 70569, Stuttgart, Germany

Fabrication of high resolution Fresnel Zone Plates (FZPs) by means of e-beam Lithography (EBL) have contributed to the establishment of the X-ray microscopy. However, EBL is an intricate and costly technique. Here, alternatively, we demonstrate the rapid fabrication of FZPs *via* direct write ion beam lithography (IBL) with resolutions approaching those of commercially available EBL-FZPs. Fabrication of 50 μm wide FZP with 50 and 30 nm outermost zone widths were completed in less than 13 and 9 minutes, respectively. Utilizing these IBL-FZBs as the focusing optics in a soft X-ray microscope, it was possible to clearly resolve features of 28 down to 21 nm size with respective cut-off half-pitch resolutions of 24.5 and 21 nm. We believe this rapid fabrication technique will have positive impact on the development of laboratory based soft X-ray microscopy and in applications where large arrays of FZPs are required, such as zone plate array lithography or disposable FZPs for FEL applications.