Multilayer Bragg-Fresnel optics for nano-focusing of coherent femtosecond soft X-ray pulses in Coherent Diffractive Imaging experiments

Christian Späth, Michael Hofstetter, Ulf Kleineberg (ulf.kleineberg@physik.uni-muenchen.de)
Ludwig Maximilians University Munich, Faculty of Physics, D-85748 Garching, Germany

M. Dierolf, P. Thibault, F. Pfeiffer,
Department of Physics, Technical University of Physics, 85748 Garching/ Munich, Germany

Coherent Diffractive Imaging in the (soft) X-ray regime is an emerging new lens-less X-ray microscopy technique with the future potential of molecular or even atomic resolution, because it is ultimately limited by the wavelength of the illuminating radiation and not by the imaging quality of the x-ray lens. However, this technique depends on the availability of coherent x-ray sources, while *coherent femtosecond short x-ray pulses* bear the capability of single shot imaging of single molecules or cells as well as stroboscopic snapshots of structural dynamics in macromolecules

While coherent femtosecond hard X-ray pulses are expected to become available from X-ray FELs in the near future, laboratory based soft x-ray sources of high spatial coherence and femtosecond pulse duration, but much smaller flux, are already available today, e.g. from table top soft X-ray lasers or High Harmonic Generation sources. Using these coherent low power soft x-ray sources for CDI calls for the development of dedicated nano-focusing optics to increase the illumination intensity.

In this paper we describe the development fabrication and testing of a reflective multilayer Bragg Fresnel phase zone plate for focusing XUV radiation at 13 nm wavelength from a High Harmonic Generation source. This optical device serves for spectral filtering as well as sub-micron focusing of the HH spectrum in a single element for reduced losses. Large zone plate structures (conventional, spiral) matching the HH beam size are recorded by e-beam lithography in ultrathin HSQ e-beam resist and over-coated with a reflective Mo/Si multilayer by Ion Beam Deposition. By accurately matching the groove depth of the diffractive structure to odd multiples of the quarter Bragg wavelength, the total diffraction efficiency can be improved by a factor of 4 theoretically compared to amplitude structures.

Finally, a setup of a ptychographic CDI soft X-ray microscope with a High Harmonic Generation source and a multilayer Bragg Fresnel zone plate, where the sample is scanned through the focused soft X-ray beam and the diffraction patterns are recorded by a gated, integrating 2D soft X-ray detector, is described.