Imaging with Nanometer Resolution from 8 to 100 keV using Multilayer Zone Plates (MZP)

Jakob Soltau[(1)], Hans-Ulrich Krebs[(2)] , Tim Salditt[(1)] and Markus Osterhoff[(1)]

(1) Institute for X-ray Physics, University of Goettingen, Friedrich-Hund Platz 1, 37077 Goettingen,
(2) Institute for Material Physics, University of Goettingen, Friedrich-Hund Platz 1, 37077 Goettingen,

jakob.soltau@uni-goettingen.de

Latest developments in the fabrication of multilayer zone plates (MZP) using the pulsed laser deposition process (see Fig. 1(a)) have enabled to decrease the resolution defining smallest zone widths down to 5 nm (see Fig. 1(b)) [1], the optical thickness, important for efficiency, was enlarged up to 30 µm. This promises imaging with nanometer resolution with MZPs in an X-ray energy range from 8 keV up to 100 keV.

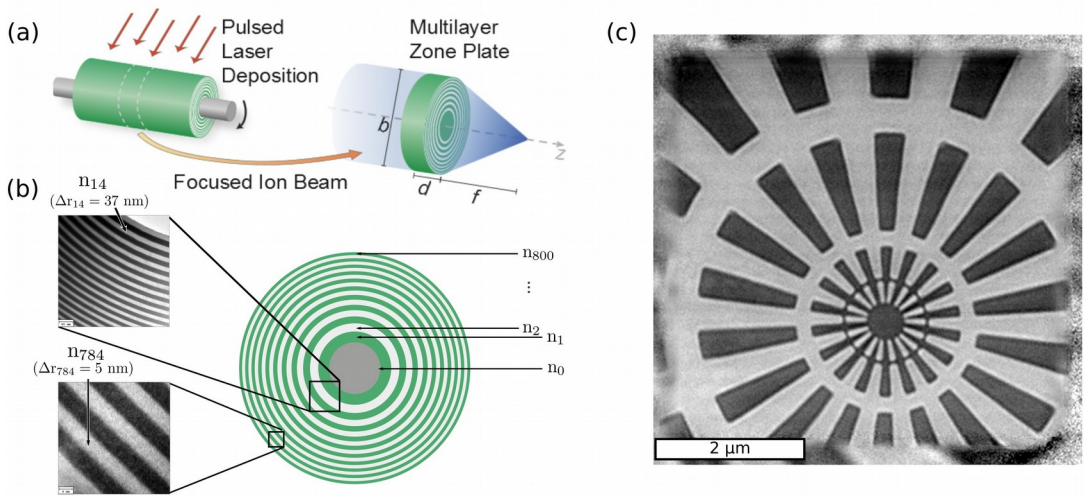

Figure 1: (a) Sketch of the pulsed laser deposition (PLD) process to fabricate the MZPs. (b) Illustration of an MZP together with electron microscope images of the individual zones at different radii with zone widths down to 5 nm. (c) Scanning X-ray microscope image of a Siemens star with smallest feature size of 50 nm. Taken with the new high-resolution setup at the P10/Petra III/DESY using an MZP at 13.8 keV.

In recent experiments at Petra III endstation P10, the MZPs have been used in a scanning microscopy setup at 13.8 keV. It has been possible to resolve a Siemens star test pattern with smallest feature sizes of 50 nm (see Fig. 1(c)). The high precision has been enabled by a new vibration reduced high-resolution setup with sub-nm motor positioning capabilities.

A first proof-of-concept experiment at the ESRF endstation ID31, has extended the limit of imaging with MZPs to photon energies of 100 keV. To demonstrate the feasibility of non-invasive imaging, micrometer sized silver droplets (nanocrystallites), located below a 1.5 µm layer of ZrO_2, were used as sample. The high penetration depth of the 100 keV X-rays and the nanometer-sized focal spot of the MZP enabled the determination of size, shape and position of single silver droplet grains by measuring their Bragg-reflection in a scanning experiment.

[1] Christian Eberl et al. “Fabrication of laser deposited high-quality multilayer zone plates for hard X-ray nanofocusing”. In: Applied surface science 307 (2014), S. 638–644.