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Zone-plate based soft x-ray microscopy with sub-10 nm resolution

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Soft x-ray scanning transmission microspectroscopy (STXM) using Fresnel zone plates (FZPs) as focusing elements has developed into a routine technique for the investigation of semi-transparent thin film specimens. The x-ray absorption contrast is utilized as elemental or chemical fingerprint in multinary component specimens. Routine operation of STXMs uses spatial resolution of around 30 nm determined by the outermost zone width of the FZP. An elegant method to fabricate high-resolution FZPs has been introduced by doubling the line density obtained from the lithography step utilizing atomic layer deposition (ALD). We have recently prepared FZPs with line structures to about 7 nm thus pushing the resolution limits into the sub-10 nm regime. We performed the experiments at the SLS PolLux-STXM and the HERMES beamline at SOLEIL to evaluate the influences of energy resolution, coherence length and FZP parameters on the achievable resolution. In order to obtain ultimate resolution, interferometric positional feedback is required. We will report on the resolution tests of specific test samples but also on technologically relevant specimens where the improvement in lateral resolution becomes inevitable. Determination of the spatial resolution was conducted using a two-dimensional Fourier shell correlation of two independent data sets. This yielded a frequency cut-off at 0.15 nm^{-1} in Fourier space, or 6.8 nm (7.1 nm) in real space considering the half-bit (one bit) criterion. The project is funded by the BMBF (project 05K16WED) and within the EU-H2020 Research and Innovation Programme, No. 654360 NFFA-Europe and under the Marie Skłodowska-Curie grant agreement No. 701647.

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