XRnanotech – Recent Developments In Nanostructured X-ray And EUV Optics

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Abstract: Recent developments have brought significant improvements in X-ray and EUV optics and optical structures. We will discuss how this can improve current setups and measurements with added functionalities and efficiency. © 2022 The Author(s)

At XRnanotech, a spin-off from the Paul Scherrer Institut (PSI) in Switzerland, we develop X-ray optics to enable experiments at many large-scale research facilities. Our goal is to push the limits of diffractive and refractive X-ray optics by continuously improving the resolution and efficiency enabling new applications in microscopy to make the invisible visible. In X-ray microscopy, Fresnel zone plates (FZPs) are used as high-resolution lenses. Their resolution depends mainly on the size of their smallest outermost zones and many years of development were required in order to push this value into ever-smaller regimes. Here, the fabrication process known as atomic layer deposition (ALD) assisted line-doubling has proved extremely successful in improving the resolution. While conventional FZP fabrication techniques can hardly yield line widths below 20 nm, the line-doubling approach broke the 10 nm barrier recently. [1] We will show some of the recent developments in terms of high efficiency blazed, hybrid, high-resolution zone doubled [2] and advanced customized geometry Fresnel zone plates for special applications. This includes the possibility of using zone plates for multibeam applications. [3] This can be useful to probe a sample with an FEL and at the same time obtain a beam for reference purposes. Especially with the fluctuating SASE emission of modern FELs, this proves to be a valuable tool. It is also possible to improve upon ptychography reconstructions by modifying the wavefront of existing focusing optics. Here a periodic or pseudo random modification of the phase is added for a focusing optic. [4] This can be achieved either by modifying the focusing optics directly or adding an additional optical element.

New procedures recently allowed using 3D-printing methods also in the field of X-ray optical applications. For X-ray energies of several keV a sufficient transmission and refractive properties is achieved together with a low surface roughness. Through its versatility, 3D printing allows manufacturing various types of geometries, X-ray optics and samples alike. This can be used to create refractive lenses with resolutions in the range of down to approximately 100 nm. [5] Furthermore, the flexibility of this approach allows aiming for unprecedented application using refractive elements. Phase plates can be used to correct for phase errors in existing compound refractive lenses (CRLs) and achieve diffraction limited beam with significantly reduced out of focus intensity [6]. Vortex beams with an azimuthal phase ramp can be generated; other tailored beam modifications are also accessible with this approach and combinations of optical properties in one optical element is possible. [7] Further applications of this technique 3D resolution targets e.g. for an X-ray tomography setup and a combination of refractive and diffractive elements also has successfully shown achromatic focusing of hard X-rays. [8]

References


