HIGH RESOLUTION ZONE-DOUBLED FRESNEL ZONE PLATES FOR THE MULTI-keV REGIME

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X-ray microscopy based on Fresnel zone plates is a powerful technique for sub-100 nm resolution imaging of biological and inorganic materials. Here, we report on the modeling, fabrication and characterization of zone-doubled Fresnel zone plates for the multi-keV regime (4—12 keV). We demonstrate unprecedented spatial resolution by resolving 15 nm lines and spaces in scanning transmission X-ray microscopy, and focusing diffraction efficiencies of 7.5 % at 6.2 keV photon energy. These developments represent a significant step towards 10 nm spatial resolution for hard X-ray energies of up to 12 keV. In addition to conventional characterization techniques, we have used ptychographic scanning coherent diffractive imaging to obtain a 3D reconstruction of the hard X-ray beam focus of a high resolution Fresnel zone plate with an outermost zone width of 20 nm, with high spatial resolution and dynamic range.

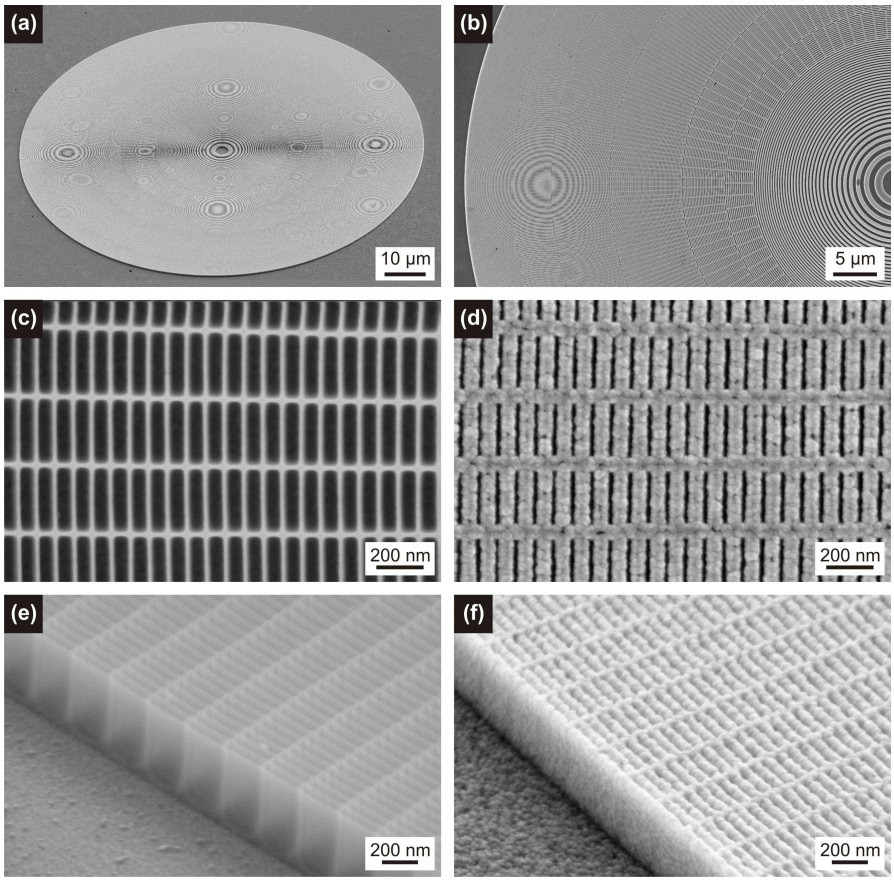

Figure.
Scanning electron micrographs of a zone-doubled FZP made of HSQ resist and iridium (100 µm diameter, outermost zone width of $w = \Delta r = 20$ nm and height of $h \sim 550$ nm). (a) and (b) show overviews of the diffractive X-ray lens. (c) High magnification top view of the outermost region consisting of 20 nm-wide lines made of HSQ resist in 80 nm-period before the iridium coating. (d) High magnification top view of the zone-doubled structure after the iridium coating by atomic layer deposition. Tilted views of the edge of the zone-doubled FZP (e) before and (f) after the iridium deposition (tilt angle of 50º). The final structure contains an effective iridium grating made of 20 nm lines and spaces with an aspect ratio of $h/w > 27.5$.