Fresnel Zone Plates for Hard X-ray Nanofocusing

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The focusing of hard X-rays (hν >8 keV) is important prerequisite for many techniques such as micro-fluorescence, microimaging, and microdiffraction. At present, the best resolution for x-ray focusing is obtained by using Fresnel Zone Plates (FZPs). In the soft x-ray range FZPs can reach a resolution down to below 20 nm [1], and sub-100 nm values are routinely achieved. The efficient focusing of hard X-rays is more difficult, since in order to obtain acceptable diffraction efficiencies, the zone plate structures should be made from heavy materials, but even then the required height of the structures needs to be a micron or more. This means that the aspect ratios of the structures of FZPs have to be very high, when both high resolution and efficiency are needed [2]. This is the reason why the high resolution potential of FZPs could not be exploited in the hard X-ray regime.

We developed a method which allows us to produce gold structures with aspect ratios up to 10. FZPs with an outermost zone width of 100 nm and diameters ranging from 20 μm to 200 μm were fabricated and tested in MicroXAS beam line of Swiss Light Source. FZP of 30 μm diameter (see Fig. 1) was used in nanofocusing experiments. In order to match transverse coherence length of the incident illumination we used 20 μm aperture in front of the FZP, which means that only zones down to 150 nm were illuminated. A spot size below 250 nm and diffraction efficiency of 8.4 % were measured at X-ray energy of 8 keV and focal distance of 19.4 mm.

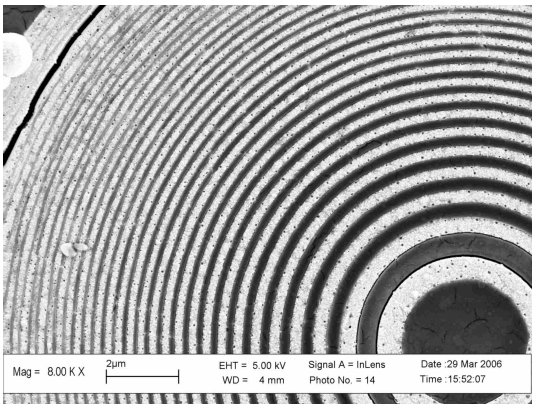

Fig.1. SEM-image of 30 μm diameter FZP with outermost linewidth of 100 nm.

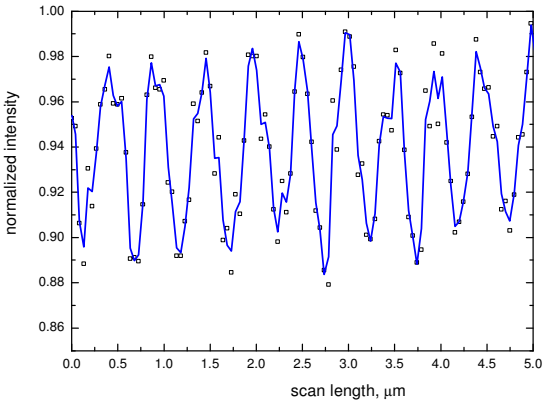

Fig.2. Scan across a grating with 250nm lines and spaces in the focal plane of FZP.

1. W. Chao, B.D. Harteneck, J.A. Liddle, E.H. Anderson and D.T. Attwood, Nature **435**, 1210 (2005).
2. B. Nöhammer, C. David, M. Burghammer, and C. Riekel, Appl. Phys. Lett. **86**, 163104 (2005).