Focusing performances of Transmission Phase Fresnel Zone Plates

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The high spatial resolution capability and the high efficiency of the Fresnel zone plates (FZP) explain why they are choosen in many applications for focusing x-ray radiation (1). An amplitude FZP consist of concentric annuli alternately transparent and opaque. J. Kirz (1) has shown that a maximum theoretical focusing efficiency of approximately 10% can be obtained, due to the total x-ray absorption within the opaque zones. To improve this efficiency (40%) and to reduce the influence of the different diffraction orders, he has also shown that it is possible to use a FZP in which the opaque zones are only slightly absorbing; the phase of the transmitted radiation through these zones can then be adjusted to contribute to the focusing. It is currently known as a Phase Zone Plate (PZP). We present an experimental and theoretical study concerning a gold PZP, made by lithography technique (2), which is used to focus x-rays in the 1-4 keV range.

The performances of our PZP were at first evaluated on the SB3 beamline of the SUPER-ACO Synchrotron source (LURE/Orsay), equipped with a double crystal monochromator and a theta-2theta goniometer (3). Efficiency measurements at the zeroth and the first order diffraction orders have been realized between 1400 eV and 3200 eV, and a focusing efficiency as high as 23 % has been obtained at 1900 eV photon energy, which is in real good agreement with our calculation based on the thickness indicated by Heidenhain (0.5 nm). At this photon energy, the ratio between the zeroth and the first orders efficiencies is very low (28%). Energy distribution of the synchrotron beam is given: a spatial resolution better than a few microns has been obtained.

We, in a second time, obtained images of grids illuminated by a classical x-ray tube. An intense radiation line is selected by a multilayer mirror with a very narrow bandwidth (E/DE = 100). In this way, the chromatic aberration, which has a noticeable effect on the spatial resolution, is suppressed. We very soon expect to get at the first order focus the 0.4 um spatial resolution, which corresponds to the width of the PZP outmost ring.

1. J. Kirz, Phase zone plates for X-rays and the extreme UV, JOSA, Volume 64, Number 3, (1974).

2. HEIDENHAIN BELGIEN Bellekouter, 30, B-1790 Affligem.

3. M. Idir, Etude experimentale et theorique d'optiques focalisantes de type Bragg-Fresnel graves sur des multicouches adaptes aux domaines X et X-UV, Thesis, Universite Pierre et Marie Curie (Paris VI) (1994).