Formation of X-Ray Microbeam Using Ta Phase Zone Plate and Its Application to Scanning X-Ray Microscope

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A phase zone plate made of tantalum [1] for focusing hard x-rays has been designed and fabricated. It is designed to optically match to the undulator radiation of BL24XU. The thickness of tantalum zones is 2.4 μm, with which the theoretically calculated diffraction efficiency is higher than 20 % in the photon energy range from 8 keV to 15 keV. As the radius of the innermost zone is 5.0 μm, the focal length is 202 mm at the photon energy of 10 keV. The diameter is 100 μm. The zone plate has also an apodization mask of 5 μm-thick electroplated gold with a diameter of 45 μm. Condition for the coherent illumination is satisfied in the photon energy lower than 10 keV. As the outermost zone width is 0.25 μm, the spatial resolution is expected to be 0.3 μm.

The focused beam size has been measured by using a knife-edge profile method. A slit was scanned either vertical or horizontal direction with a 50-nm pitch by using a piezo-driven flexure hinge stage. The spot size was evaluated to be 0.89 μm in vertical and 0.97 μm in horizontal. Although the values did not reach the diffraction limit size of 0.3 μm, the sub-μm microbeam has been achieved.

The diffraction efficiency has also been measured around the photon energy of 10 keV. The maximum efficiency was 20.7 % at 9.8 keV. The efficiency higher than 16 % was achieved from 9.5 keV to 11 keV. Since these values are much higher than the theoretical diffraction efficiency of the amplitude zone plate of 10 %, it was confirmed that the zone plate fabricated worked really as a phase zone plate.

The phase zone plate has been used as an x-ray-focusing lens in a scanning x-ray microscope. Figures below are x-ray micrographs of a copper #2000 mesh. The mesh pitch is 12.7 μm. The photon energy was tuned to 10 keV. Fig.1 is a transmission image and Fig.2 is a fluorescence image. The images clearly demonstrate the high feasibility of the scanning x-ray microscope system developed at BL24XU.

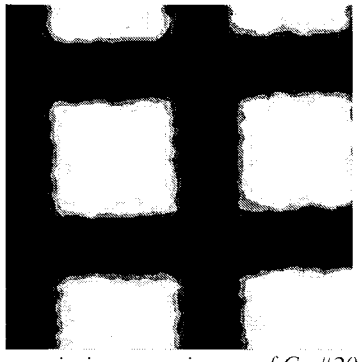

Fig.1. Transmission x-ray image of Cu #2000 mesh.

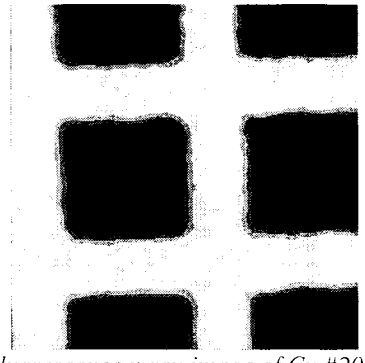

Fig.2. Fluorescence x-ray image of Cu #2000 mesh.

References

1) A. Ozawa, T. Tamamura, T. Ishii, H. Yoshihara and Y. Kagoshima, Microelectronic Engineering **35**(1997)pp.525-529.