Hard X-ray Micro-Interferometer for High-Spatial-Resolution Phase Measurement

Takahisa Koyama, Akihiko Saikubo, Kenichi Shimose, Kenji Hahashi, Aiko Nakagawa, Hidekazu Takano, Yoshiyuki Tsusaka and Yasushi Kagoshima

Graduate School of Material Science, University of Hyogo, 3-2-1 Kouto, Kamigori, Ako, Hyogo 678-1297, Japan

Owing to the highly brilliant undulators in SPring-8, a large spatially coherent region is available even in the hard X-ray region, and therefore many kinds of coherent optics have been developed. We proposed and constructed a novel hard X-ray micro-interferometer using an imaging microscope for high-spatial-resolution phase measurement at Hyogo-BL of SPring-8 [1]. We report about the latest results of this work.

The optical system is shown in Fig. 1(a). This hard X-ray micro-interferometer is formed as a wavefront-division-type, therefore both object and reference waves are necessary. Two zone plates (ZP-A and ZP-B) are arranged closely in the same plane perpendicular to the beam axis. If the two zone plates are illuminated coherently, the corresponding two secondary point sources are produced in their back focal positions. Two spherical waves diverging from these two point sources overlap each other and interference fringes are formed at an image plane. In order to prevent the –1st order diffracted waves from being mixed on the interference region, ZP-A was designed to have a half-moon shape. We call this optical element consisting of two zone plates “twin zone plate”. The circumstantial parameters are shown in Fig. 1(b). Photon energy was tuned to 9 keV. An X-ray zooming tube was employed to observe interference patterns. To convert the interference pattern into the quantitative phase map, the fringe scanning method was applied. A 125-μm-thick kapton film was used as a rotatable phase plate.

Quantitative phase map of polystyrene microparticles with a diameter of 7 μm was imaged clearly. Spatial resolution of the phase map was 160 nm, estimated by edge response of phase retrieved image of a copper #2000 mesh. Furthermore, by putting a sample on a high-precision rotating stage, tomographic image was also obtained. Spatial resolution of the reconstructed image was achieved to be 250 nm, which was estimated by edge response of tomographic slice of a grass capillary. From these results, we have succeeded in high-spatial-resolution phase measurement using the X-ray micro-interferometer.

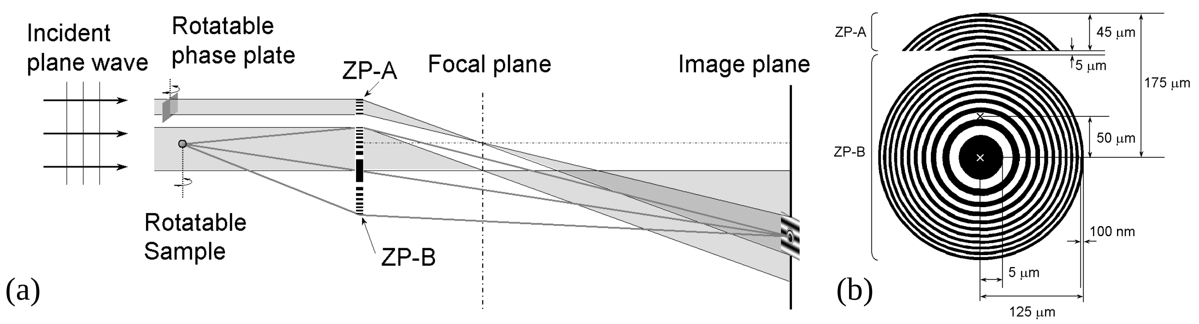

Fig. 1. (a) Schematic drawing of the hard X-ray interferometer. (b) Design of the “twin zone plate” made of tantalum, fabricated by NTT Advanced Technology Corporation.

Reference
[1] T. Koyama *et al.*: Jpn. J. Appl. Phys. **43** (2004) L421.