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Differential phase microscope and micro-tomography with a Foucault knife-edge scanning filter

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1 Introduction

In x-ray region, phase-contrast is much higher than absorption contrast. X-ray phase tomography is very attractive for the 3D observation of weakly absorbing material. In order to realize phase tomography, quantitative phase measurement is required. It was difficult by a conventional method like a Zernike phase-contrast microscope [1]. Nagayama showed that a quantitative differential phase image was obtained in electron microscopy by introducing a scanning knife-edge filter at a back focal plane of an objective lens [2]. We applied this method to an x-ray microscope with a zone plate [3]. In this report, x-ray differential phase imaging and phase tomography at 5.4 keV by using the synchronous operation between the scanning the knife-edge and the image accumulation are described.

2 Experiment

A Schematic of the differential phase microscope is shown in Fig. 1. An objective zone plate (NTT Advanced Technology Inc.) had the outermost zone width of 50 nm and the diameter of 330 μm. Monochromatic parallel x-rays of 5.4 keV were incident onto a specimen and the transmitted x-rays were focused on a CCD camera. The distance between the specimen and the CCD camera was 3.6 m and the magnification ratio was about 50. A gold wire of 250 μm in diameter was set as a knife-edge at the back focal plane of the zone plate. A differential phase image was calculated by $(I_R\text{-}I_L)/(I_R+I_L)$, where I_R and I_L were the images obtained by using the right- and left-scanning filter. A CT image was reconstructed from 360 projection images of different angles of view over the range of 360 degrees.

3 Results and Discussion

Polystyrene beads (diameter: 2.8 μm) in a glass capillary was observed. Figure 2 shows the bright field images. Figure 3 shows the Zernike phase-contrast images. The optical system was shown elsewhere [1]. Figure 4 shows the differential phase image and the reconstructed section phase image. The phase-contrast images in Fig. 3 have good contrast compared with the bright field images in Fig. 2. However, the glass capillary could not reconstruct in the CT image of Fig. 3. By using the differential phase microscope, the CT image could be successfully reconstructed as shown in Fig. 4(b).

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References

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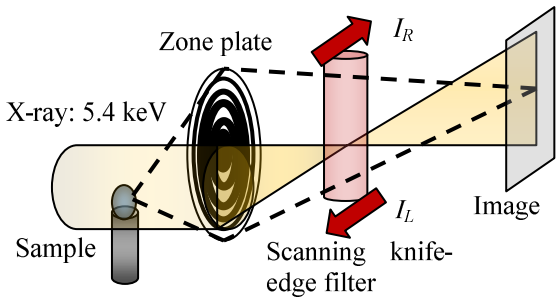

Fig. 1: Schematic of the differential phase microscope.

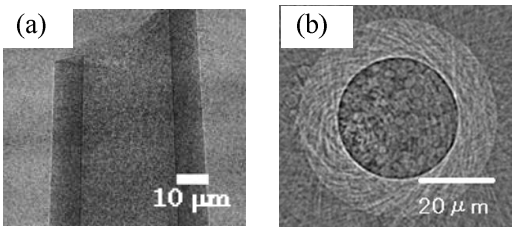

Fig. 2: (a) Bright field image and (b) the CT section image of polystyrene beads in a glass capillary.

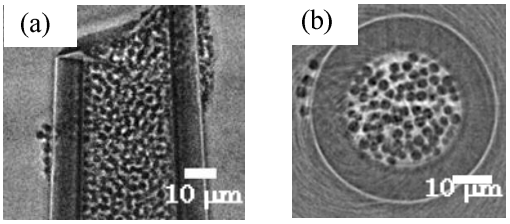

Fig. 3: (a) Phase-contrast image and (b) the CT section image of polystyrene beads in a glass capillary.

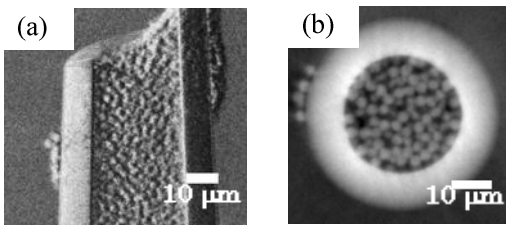

Fig. 4: (a) Differential phase image and (b) the CT section image of polystyrene beads in a glass capillary.