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Quantitative phase tomography by using an X-ray microscope with a Foucault knife-edge scanning filter

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1 Introduction

X-ray phase tomography is very attractive for the observation of weakly absorbing material, such as biological samples. In order to realize phase tomography, quantitative phase measurement is required. A quantitative differential phase image could be obtained by introducing a scanning knife-edge filter at a back focal plane of an objective zone plate of an x-ray microscope [1]. In this report, the quantitative accuracy of the phase tomography was evaluated.

2 Experiment

A Schematic of the optical system 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 $2\pi S(I_R-I_L)/(I_R+I_L)$, where I_R and I_L were the images obtained by using the right- and left-scanning filter, and S was the spatial frequency corresponding to the half of the scanning width (10 μm in this experiment). A CT image was reconstructed from 360 projection images of different angles of view over the range of 360 degrees. Exposure time of each projection was 4 s × 2.

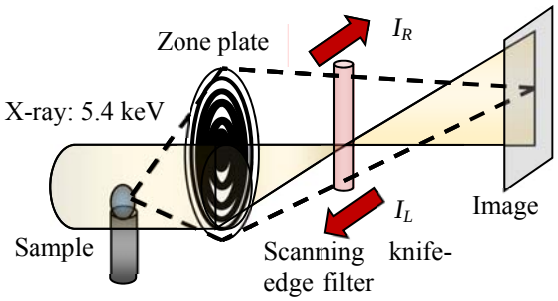

Fig. 1: Differential phase microscope.

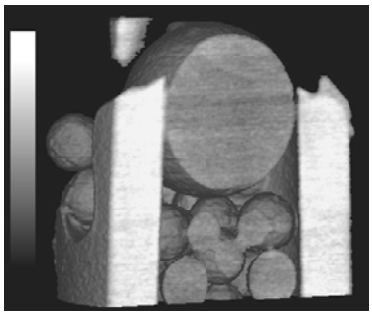

Fig. 2: 3D rendering image of polystyrene beads (30 μm and 10 μm) in a glass capillary.

3 Results and Discussion

Figure 2 shows a 3D rendering image of polystyrene beads of 30 μm and 10 μm in diameter. Figure 3(a) is the section image and Fig. 3(b) is the phase profile along the white line in Fig. 3(a). The average value of the reconstructed δ of the refractive index $n = 1-\delta+i\beta$ was 7.4×10^{-6}, which was 11 % lower than the calculated one from Henke's table [2]. The standard deviation of δ was 5.4 %. These results show the quantitative phase reconstruction is possible by this x-ray microscope.

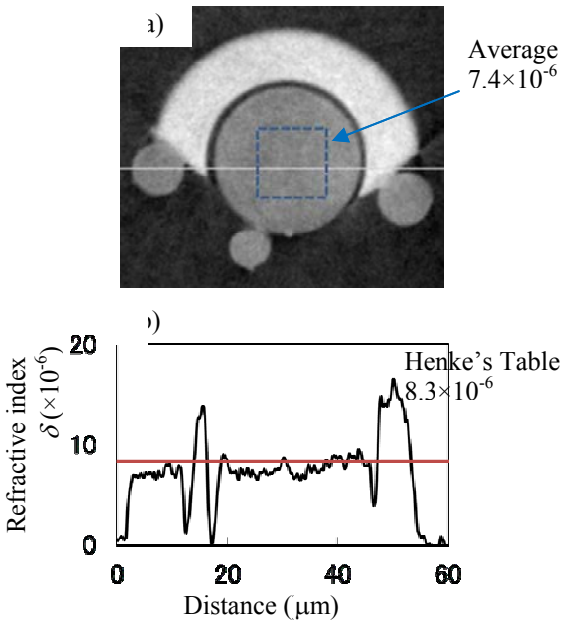

Fig. 3: (a) Section image of polystyrene beads (30 μm and 10 μm) in a glass capillary and (b) the phase profile along the white line in (a).

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References

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[2] http://henke.lbl.gov/optical_constants/