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X-ray Differential Phase Imaging Using Foucault knife-edge and Diffuser Plate

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1 Introduction

We have been developing an x-ray differential phase-contrast microscope. By combining a zone plate x-ray microscope and a scanning knife-edge filter at the back focal plane of the zone plate, a differential phase-contrast image can be obtained by two images recorded successively with opposite scanning directions of the knife-edge [1-3]. However, this method needs to scan the knife-edge accurately within a range of 1 μm during exposure. Therefore, we examined whether the same result as edge scanning could be obtained by shaking the illumination x-rays with a diffuser.

2 Optical system with a diffuser

Figure 1 shows the optical system of the microscope. A rotating abrasive paper with grading of #1200 SiC was used as a diffuser. Figure 2(a) shows the focused x-ray spot at the back focal plane of the zone plate without the diffuser at 5.4 keV. With the diffuser, the spot size increased as shown in Fig. 2(b). Figure 2(c) shows the calculated transmission intensity profiles when an edge is scanned at the plane. Using the diffuser, the slope width was increased from 2.9 μm to 8.5 μm. Thus, using this diffuser, the same effect as scanning the edge with a width of ± 4 μm can be expected.

3 Phase tomography

Phase tomography performance was evaluated using polystyrene spheres and a meteorite (Ghubara) sample at 7.0 keV as shown in Fig. 3. The reconstructed index of refraction δ of polystyrene is 3.33×10^{-6}, which is smaller than the value in Henke's Table[4] 4.85×10^{-6}. This is because the scan range corresponding to the diffuser is small [1]. By using a diffuser having a wider divergence angle, it seems that the phase measurement accuracy can be improved.

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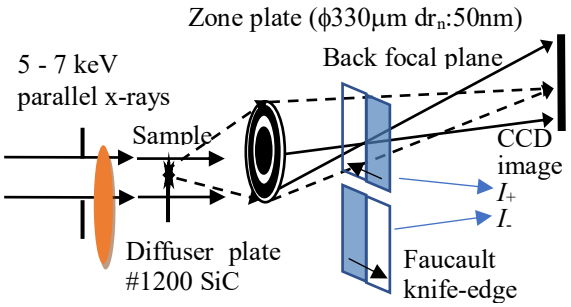

Fig. 1: Optical system of microscope. A differential phase image is calculated by $(I_+ - I_-)/(I_+ + I_-)$.

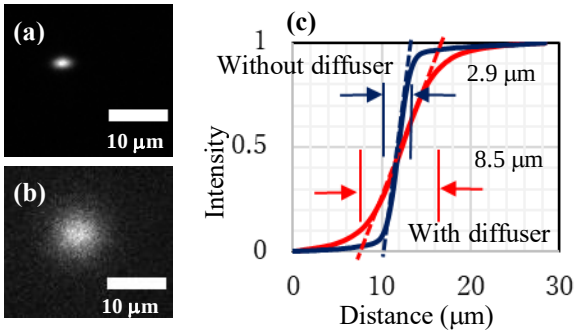

Fig. 2: (a) and (b) are the focused x-ray images at the back focal plane of the zone plate without a sample at 5.4 keV. (a): without the diffuser. (b): with the diffuser. (c) is the transmission intensity profiles calculated by (a) and (b) when an edge is scanned.

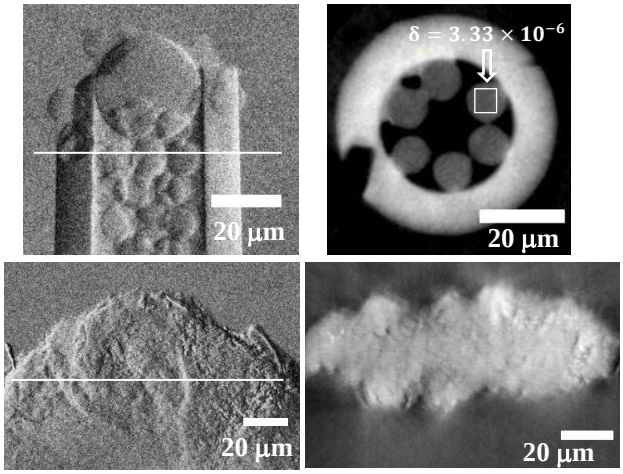

Fig. 3: Phase tomography at 7.0 keV. (a) A differential phase image of polystyrene beads in a glass capillary and (b) the section image along the white line in (a). (c) A differential phase image of a piece of Ghubara L5 chondrite meteorite and (d) the section image along the white line in (c).

References

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