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Development of Soft X-ray Spectro-Microscope with Wolter mirror

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1 Introduction

A Wolter mirror is an optical element that uses total external reflection and has no chromatic aberration. In a Wolter mirror imaging system, the magnification does not change even if the soft X-ray energy is changed, so it is possible to easily compare changes in the image when the energy is changed. Therefore, it is an optimum optical element for a full-field spectroscopic microscope. Since a Wolter mirror has a ring aperture, it is necessary to adjust the NA so that the illumination light enters the mirror ring. In this study, a plane mirror was used to illuminate a sample at the angle of the average NA. The imaging performance was evaluated in a wide energy range from 100 eV to 900 eV.

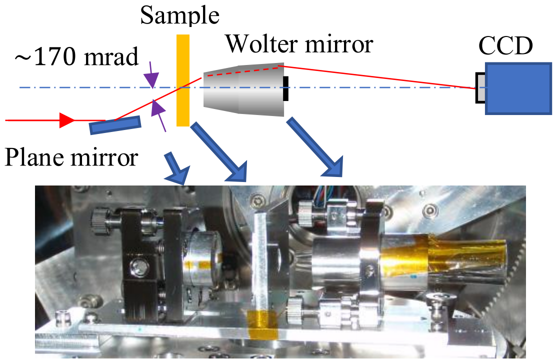

Fig. 1: Optical system of microscope with a Wolter mirror objective.

2 Experiment

Figure 1 shows the optical system. The Wolter mirror has a magnification ratio of 32, an average grazing-incidence angle of about 40 mrad, and the surface material of Pyrex glass [1]. A sample was illuminated with a quartz plane mirror. As a test sample, diamond powder (size: 4-8 μm, Nilaco) placed on a carbon foil (Quantifoil R1.2/1.3, 1.2 μm diameter holes spaced at 2.5 μm intervals, Elsevier Science) was used. The optical system was mounted on the sample stage of the reflectometer system[2] installed on the beam line. The observation was performed at a magnification of 19, which was two-third of the specification, due to the restriction of the beam line length. Therefore, the image was slightly distorted. The soft x-ray images were recorded with a cooled CCD camera (Hamamatsu Photonics, C4742, pixel size: 13 μm).

3 Results and Discussion

Figure 2 shows the observed soft X-ray images. Figure 2(a) is the image at 280 eV and Fig. 2(b) is the image at 290 eV. Figure 2(b) has good contrast since 290 eV is the higher energy side of the absorption edge of carbon. Figure 2(c) is the image at 800 eV. At 800 eV, the exposure time was doubled due to the decrease in the mirror reflectance, but it did not affect the image contrast. Figure 2(d) is a part of Fig 2(c). The holes of 1.2 μm in the carbon film could be observed.

Since these images do not change the observation location, it is possible to easily analyze the change in absorption with respect to the change in energy of soft X-rays. Therefore, it is considered to be very useful for XAFS measurement of microscopic area.

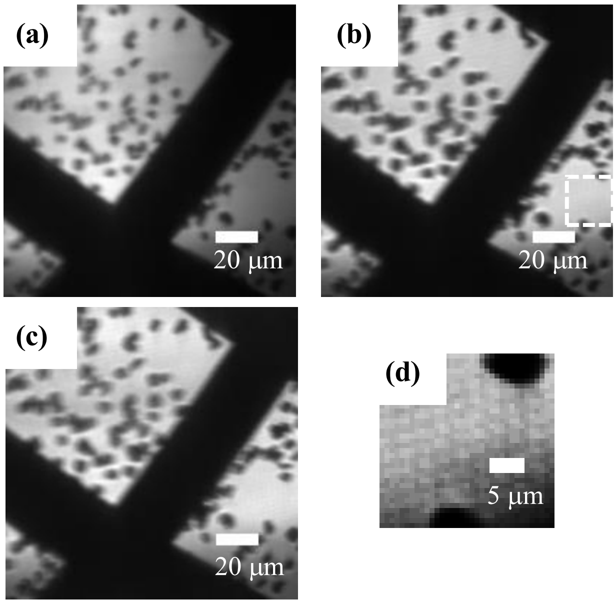

Fig. 2: Soft x-ray images of diamond powder (4 – 8 μm) at (a) 280 eV, (b) 290 eV, and (c) 800 eV. (d) is the area of white dash line in (b) with enhanced contrast. The holes of 1.2μm diameter and 2.5 μm pitch of the carbon foil can be observed. The exposure time of (a) and (b) was 5 s ×10 accumulation. That of (c) was 10 s×10 accumulation.

References

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