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We have been developing a projection microscopy system using synchrotron radiation, where an intense X-ray point source is produced by a Fresnel zoneplate[1]. The resolution was improved and estimated to be around 0.2 μm. However, the test pattern for this estimation was found to be inappropriate for precise determination, because a periodical pattern having many lines could produce pseudo-line images probably due to the overlapped Fresnel fringes. In the present study, we re-examined the spatial resolution using a new test pattern with much fewer lines of a defined width. Furthermore the obtained images were subjected to image processing including iteration procedure for reconstruction of a real image from an image accompanying Fresnel fringes[2]. These trials confirmed that the spatial resolution is better than 0.25 μm at the present status.

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Monochromatic soft X-rays of 1.5 nm wavelength were obtained at the beamline 11A. A typical optical layout of the projection microscopy was illustrated in Fig. 1. A pinhole behind the zone plate was installed to remove the higher order diffracted light, and a pre-pinhole before the zone plate, which was placed at the focal point of the focusing toroidal mirror installed at the downstream of the monochromator, was used for improving spatial coherence of incident light to the zone plate.

Spatial resolution was evaluated using a test pattern with grooves of defined widths (Silson Ltd, England).

Reconstruction procedure of an image with Fresnel fringes is basically identical to that used for the in-line holography. The procedure was previously developed for the reconstruction of images of specimens having a totally dark surrounding restriction area[2]. We used the method with some modification.

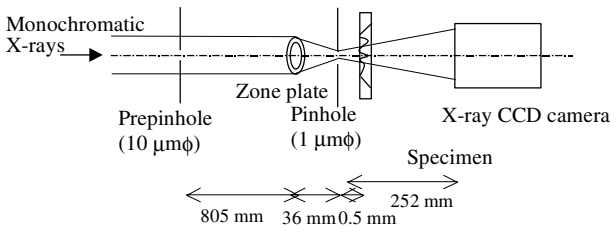

Fig. 1. Layout of projection X-ray microscope.

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Figure 2 shows an X-ray image of the test pattern taken under the condition of 1 μm pinhole with 10 μm pre-pinhole. The test pattern has four sets of vertical and horizontal lines with 0.5, 0.25, 0.1 and 0.05 μm. The image was blurred with Fresnel fringes, showing no apparent pattern structure except the 0.5 μm section.

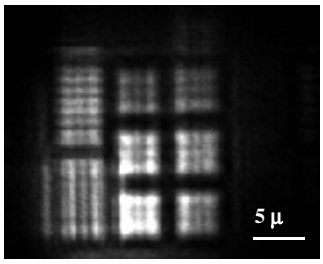

Fig. 2.
X-ray image of a test pattern with lines and spaces of defined widths taken at 1.5 nm.

However, after image processing the 0.25 m section was clearly resolved, indicating that the iteration method is effective. These results demonstrated that the resolution of the present projection microscope achieved at least 0.25 μm with the aid of image processing.

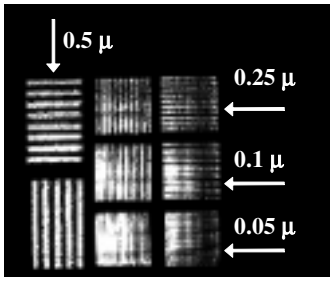

Fig. 3.
Reconstructed image of a test pattern.

[1] K. Shinohara et al., In "X-RAY MICROSCOPY", (edited by W. Meyer-Ilse et al.), pp. 346-349, New York: American Institute of Physics, (2000).
[2] K. Shinohara et al., J. Synch. Radiat., 3, 35-40 (1996).

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