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Improvement of computer reconstruction of images obtained with soft X-ray projection microscope

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Introduction

In our continuing effort to improve spatial resolution of projection microscope using focused beam by a Fresnel zone plate, computer reconstruction procedure for projection images blurred with Fresnel diffraction has been improved. In the previous reconstruction method, specimens were required to be surrounded with totally dark area (called "field stop") that offers a restriction condition in the iteration process in the computer reconstruction [1]. However, setting specimen in the stop becomes a great limitation in preparing particularly biological specimens. In the present study, reconstruction procedure without such restriction was developed.

Materials and Methods

Monochromatic soft X-rays of 1.5 nm wavelength were obtained at the beamline 11A. A typical optical layout of the projection microscope 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 was placed at the focal point of the focusing toroidal mirror installed at the downstream of the monochromator. In the present observation of 1000-mesh grid specimen, 1 μmϕ pinhole was chosen and a pre-pinhole was not used. The distance between the specimen and the pinhole was set at 1.5 mm.

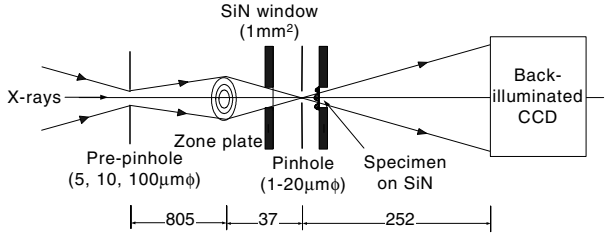

Fig. 1. Optical layout of projection microscope.

Results and Discussion

The reconstruction procedure is briefly described as follows: 1) a projection image blurred with diffraction has only intensity (or amplitiude) distribution. But the phase distribution is necessary for the reconstruction. The spherical wave-front from the pinhole is assumed as an initial phase distribution. 2) The first reconstrcuted object is obtained by inverse Fresnel transform to this complex distribution. 3) By applying restriction condition that limits maximum illumination intensity (amplitude), the reconstructed object is modified. 3) The modified object is blurred with Fresnel transform. 4) The phase distribution derived from the resulting image is added to the amplitude information in the original projection image. 5) The next reconstruction is carried out by the second inverse Fresnel transform. The above procedure is repeated until the reconstructed object is not changed (iteration process). Figure 2 shows a projection X-ray image of 1000-mesh grid (panel (a)) taken at the maginfication of 168, the first reconstructed object after inverse Fresnel transform (panel (b)), and the reconstructed object after 100 times iteration process (panel (c)). Apparently the object was improved by the iteration process resulting in decreasing Fresnel fringes. Applicaiton to cell images is in progress.

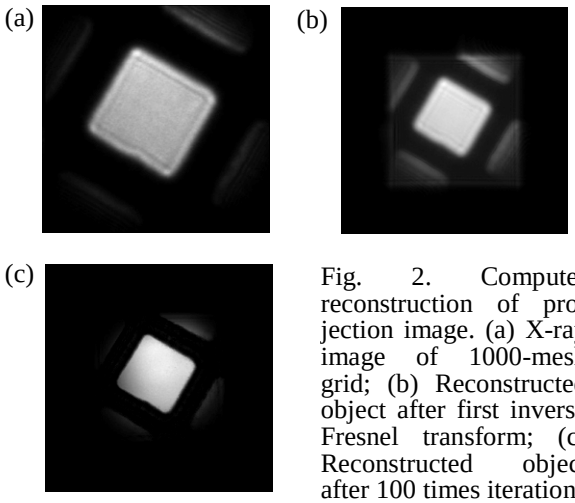

Fig. 2. Computer reconstruction of projection image. (a) X-ray image of 1000-mesh grid; (b) Reconstructed object after first inverse Fresnel transform; (c) Reconstructed object after 100 times iteration.

References

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