CT reconstruction by diffraction correction in soft X-ray projection microscopy

Tatsuo Shiina[1], Kensuke Hotta[1], Yosuke Tsuge[1], Toshio Honda[1], Hideyuki Yoshimura[2], Yasuhito Kinjo[3] and Atsushi Ito[4]

[1]*Faculty of Engineering, Chiba Univ., Inage-ku, Chiba-shi, Chiba, 263-8522, Japan*
[2]*School of science and Technology, Meiji Univ., Kawasaki-shi, Kanagawa, 214-8571, Japan*
[3]*Tokyo Metropolitan Industrial Technol. Res. Inst., Setagaya-ku, Tokyo 158-0081, Japan*
[4]*School of Engineering, Tokai Univ., Hiratsuka-shi, Kanagawa, 259-1292, Japan*

A computer tomographic microscopy (CT microscopy) has been studied by installing a rotary stage into a soft X-ray projection microscope at KEK-PF in Tsukuba. The aim is CT observation of a living tissue. Projection microscopy should eliminate fringes caused by the Fresnel's diffraction in contrast with imaging microscope[1]. In this trial, the microscopy was evaluated from the viewpoint of the correction of the fringes on a projection image and the comparison between the resolution on the reconstructed CT image and that determined by the microscope's magnification and CCD pixel size. The experiment was accomplished at the beam line 11A or 12A at KEK-PF. The system is illustrated in Fig.1. The soft X-rays of wavelength 15 and 25 angstrom were used as a light source to utilize the penetration and absorption characteristics in the water-window region for a living tissue. The projection image was obtained at the fixed magnification of 50 by a back-illuminated X-ray CCD camera with the pixel pitch of 24.8μm. The diffraction fringes were observed on the projection image when the post-pinhole's aperture was smaller than 5μm$^{\phi}$ as shown in Fig.2. The image of the absorption coefficient just behind the specimen was calculated by the iteration process[2], which repeated the calculation between Fresnel and inverse Fresnel transformations under some restricted conditions such as illumination intensity. The projection images were obtained at the interval of 1 or 5 degrees in all directions. Each image was integrated its intensity for a few minutes to improve the signal-to-noise ratio. It took 3-4 hours to obtain a set of projection images. Figure 3 shows the reconstructed CT image. The sample was a taper glass capillary of the diameter of 5μm at the cusp. The figure is a cross- sectional image at the position of 30μm below the cusp. The outside diameter and its thickness were calculated as 8μm and 1μm, respectively. The pipe structure was clearly reconstructed with the resolution of 0.5μm, while the blur and the distortion due to the eccentricity of the rotary stage should be considered.

For the future study, precise control of the sample stage is essential to realize the high-magnified and high-resolutive CT measurement.

[1]D. Weiβ, et al., Ultramicroscopy, 84, 185(2000)
[2]J. R. Fienup, Applied Optics, 21(15), 2758(1982)

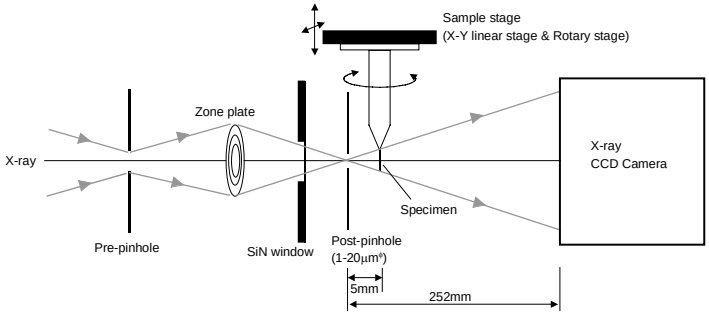

Fig. 1 Projection microscope with rotary stage.

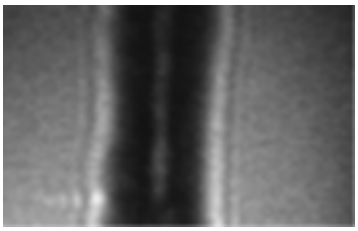

Fig. 2 Fringes of Fresnel's Diffraction on a projection image (Glass capillary of 10μm$^{\phi}$).

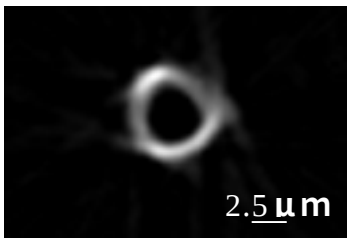

Fig. 3 Reconstructed CT image of the glass capillary.