Biological Science

11A, 12A/2003G326

Installation of rotary stage into soft X-ray projection microscope and evaluation of reconstructed CT image

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Introduction

A rotary stage was installed into our soft X-ray projection microscope to obtain a CT image. CT reconstruction was accomplished with the aid of the iteration process to eliminate diffraction fringes from projection images. To evaluate the resolution of the CT reconstructed image, glass capillaries of 5-10 μmϕ were used. Human HeLa cells on a Mylar film were also observed to obtain a CT image under limited angle condition.

Installation of rotary stage

The precedent projection microscope[1] was improved by adding a motor-driven rotary stage. The specimen was rotated at a perpendicular axis to the X-ray path, and its projection images were obtained in all direction at the interval of 1-5 degrees (See Fig.1). A hands-on XY linear stage adjusts the specimen within CCD's field of view (FOV) during the rotation. The distance between the rotation axis and the post-pinhole was 5 mm, and the magnification was x50. The CCD's FOV becomes 244 μm just behind the specimen. The resolution was about 0.5 μm. The specimen was bonded on the tip of the rod on the rotary stage with epoxy resin. The eccentricity should be low not to miss the specimen from the CCD's FOV.

Results and Discussion

The experiment was accomplished at the beam line 11A and 12A. The monochromatic soft X-rays of 1.5 and 2.5 nm were used to utilize the penetration and absorption characteristics in the water-window region for living tissue. The diffraction fringes were observed on the projection image when the post-pinhole's aperture was smaller than 5 μmϕ as shown in Fig. 2(a). The image of the absorption coefficient just behind the specimen was corrected by the iteration process. Figure 2(b) shows an example of reconstructed CT images. The specimen was a taper glass capillary of the diameter of 5 μm at the cusp. The figure is a cross-sectional image at the position of 30 μm below the cusp. The outside diameter and its thickness were calculated as 8 μm and 1 μm, respectively. The pipe structure was clearly reconstructed with the resolution of 0.5 μm, while the blur and the distortion due to the eccentricity of the rotary stage should be considered.

We have tried CT observation of human HeLa cells on a Mylar film. Projection images of different view angles are shown in Fig.2(c) and (d). The specimen's film was fixed on a frame of 3-5 mm width. It could not rotate in all direction on account of interrupting X-ray light by the frame. Limited angle condition lowered the resolution of CT reconstructed image.

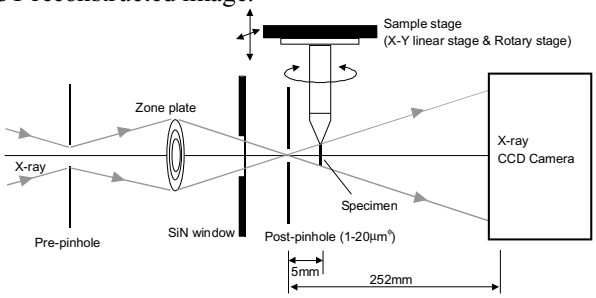
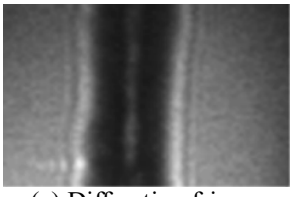
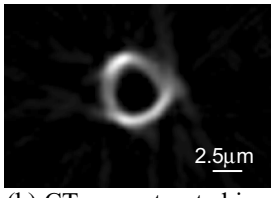


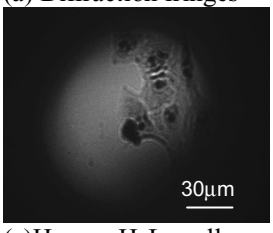
Fig.1 Projection CT microscope.



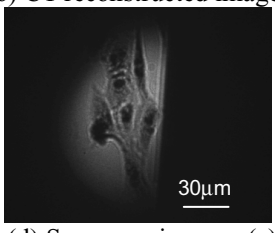
(a) Diffraction fringes



(b) CT reconstructed image



(c)Human HeLa cells



(d) Same specimen as (c)

Fig.2 Projection images of (a) glass capillary of 10 μmϕ and (c), (d) Human HeLa cells at different angles (interval: 15 degs.), and (b) CT reconstructed image of glass capillary section of 5 μmϕ[cusp]. All the data were obtained at the beam line 11A.

References

[1] A. Ito et al., PF Activity Rep. 2003, 21, 210 (2003)

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