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Phase tomography using diffraction-enhanced imaging

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Introduction

Hard X-ray phase tomography is an attractive tool for observing weakly absorbing materials. It reveals a three-dimensional map of the refractive index difference between a sample and its surrounding material. Several methods of phase tomography have been reported and high sensitivities of such methods have been demonstrated so far [1,2]. Recently, we have studied another phase tomography method [3] using diffraction-enhanced imaging (DEI) [4]. We report the observation of biological tissues with this method and discuss its feasibility.

Phase tomography using DEI

DEI is a phase-sensitive imaging method comprising relatively simple optics. An image contrast is generated using a perfect silicon crystal called *analyzer*. The X-ray going through a sample is refracted and a propagation direction deviates slightly from that of the incident X-ray. When the analyzer is placed behind the sample, it only diffracts the beam propagating in a determined direction, so that an image contrast is created.

DEI also enables a quantitative measurement of the deflection-angle distribution, which is corresponding to a differential phase map, by means of changing the analyzer angle and measuring an analyzer-angle dependence of the X-ray intensity. A phase map can be obtained by an integration of the deflection-angle distribution, so that phase tomography is attainable.

Experiment

Experiments were performed at beamline BL-14B with 0.07-nm X-rays. The experimental setup is shown in Fig.1. Each image was recorded by an X-ray sensing pickup tube, whose pixel size was tuned to be 8.3 μm × 6.9 μm, with a 0.67-second exposure. The samples we prepared were a tail and a xiphoid process of a nude mouse. They were placed in a cell filled with formalin. Tomographic scans were performed by rotating the samples in a 0.72-degree step. At each step, twenty one images were recorded as the analyzer was rotated in a 2.4-μrad step. From these images, a deflection-angle distribution was calculated and then integrated to obtain a phase map.

Results and Discussion

Tomographic reconstruction was performed with normal CBP algorithm and reconstructed sectional images are shown in Fig. 2. Structures are cleary revealed by our phase tomography method for the samples consisting of not only soft tissues but also cartilages and bones which have large refractive index differences from formalin. The feasibility of our phase tomography method is well demonstrated for this kind of samples.

References

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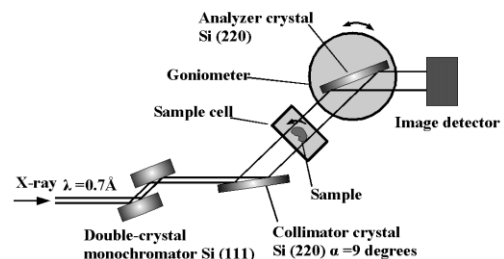[4] T. J. Davis *et al*., Nature **373**, 595 (1995).

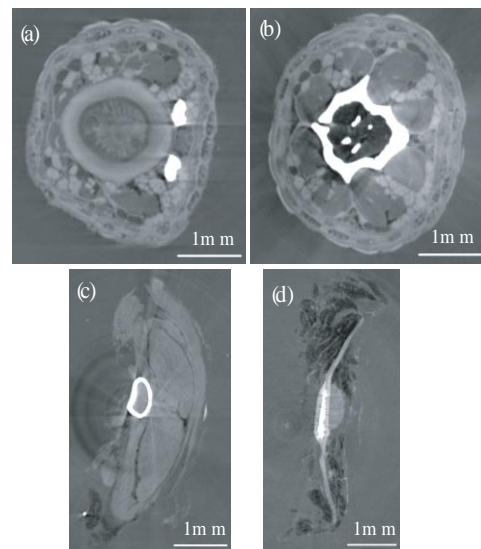Fig.1 Experimental setup of the phase tomography using DEI.

Fig.2 Reconstructed sectional images of a tail ((a) & (b)) and a xiphoid process ((c) & (d)) of a nude mouse.

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