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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 (typically water or air).

The phase tomography was first developed by Momose, introducing the technique of phase-shifting interferometry into the field of X-ray interferometry. Later, the phase tomography was also performed with the propagation-based phase imaging [2].

In this report, we propose another type of the phase tomography which uses the diffraction-enhanced imaging (DEI) [3]. DEI is one of the methods used to observe weakly absorbing materials. It creates an image contrast using an analyzer crystal from the X-ray deflection caused by a sample. In our phase tomography method, the distribution of the deflection angle is measured by rocking the analyzer crystal and the measurement is repeated rotating the sample. A three-dimensional map of the refractive index is reconstructed through a variation of the convolution back-projection algorithm, which is used in the beam-deflection optical tomography [4] in the visible light energy region.

Experiment

The experimental setup is shown in Fig.1. X-rays were monochromatized to 0.092 nm by a double-crystal monochromator and reflected by a collimator crystal. A channel-cut crystal whose surface was inclined by 12 degrees from the Si 220 plane was used as an analyzer. Each image was recorded by an X-ray sensing pickup tube, whose pixel size was tuned to be 8.3 µm x 6.7 µm, with a 0.67-second exposure.

A tomographic scan was performed by rotating the sample in a 0.72-degree step. At each step, eleven images were recorded as the analyzer was rotated in a 2.4-µrad step. From these images, the deflection angle distribution was calculated. The sample consisted of four tubes made of polyvinyl chloride. One tube was filled with water and three tubes were empty.

Results and Discussion

Figure 2 shows a reconstructed sectional image. Though it has ring artifacts which are caused by the surface roughness of the analyzer crystal, the structures of the sample are almost resolved by this method. The refractive index difference between the water and the polyvinyl chloride, which is calculated to be 1.7 x 10^{-7}, could be resolved.

In our method, highly brilliant or highly spatial coherent beam is not necessary and the size of the viewing field can be enlarged easily. These aspects would be advantageous to medical and industrial applications.

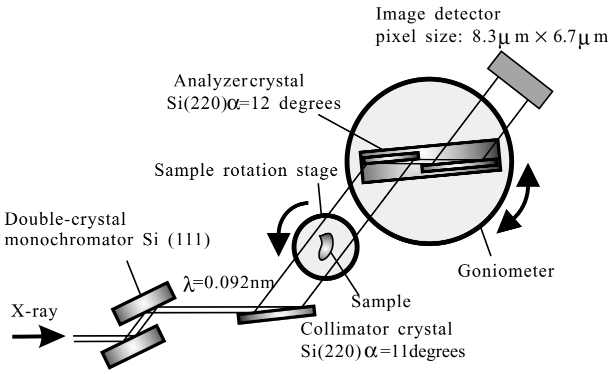

Fig.1 Experimental setup of the phase tomography using DEI.

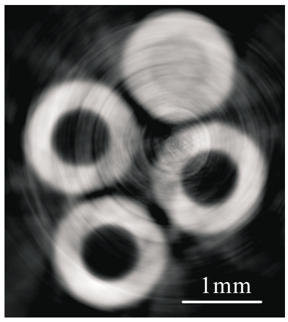

Fig.2 Reconstructed sectional image obtained by the phase tomography using DEI.

References

[1] A. Momose, Nucl. Instrum. & Methods A **352**, 622 (1995).
[2] P. Cloetens *et al.*, Appl. Phys. Lett. **75**, 2912 (1999).
[3] T. J. Davis *et al.*, Nature **373**, 595 (1995).
[4] G. W. Faris and R. L. Byer, Appl. Opt. **27**, 5202 (1988).

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