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Decoherence in X-ray Talbot interferometry and its application to tomography

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Introduction

X-ray Talbot(-Lau) interferometry has been studied as a novel phase imaging method[1,2]. Recently the use of another information derived from X-ray Talbot(-Lau) interferometry has been proposed, which relies on the decrease in the visibility of moiré fringe caused by a sample[3]. Currently the mechanism is considered to be related with the small angle scattering from the sample, with which the spatial coherence of X-rays is degraded. Normally the structural size related with the phenomenon of the small angle scattering is smaller than the spatial resolution of our imaging system. Therefore, the visibility reduction is attractive as the third information source, in addition to differential phase information and absorption information, which were obtained in X-ray Talbot(-Lau) interferometry. However, the contrast mechanism has not been clarified, and we aimed at investigating the relation between the image of visibility reduction (visibility map) and some relevant experimental parameters. Although the mechanism has not been elucidated yet, we have found empirically a linear relation between the logarithm of the visibility reduction and the sample thickness. This implies that tomographic image reconstruction is possible using the conventional algorithm. An experiment for demonstrating this novel tomography was performed with a sample of polymer foams.

Experimental

We carried out an experiment with 0.07 nm X-rays at BL14C1 using an X-ray Talbot interferometer consisting of 5.3-µm-pitch phase and amplitude gratings. A CCD-based X-ray image detector, whose effective pixel size was 18 µm, was used behind the amplitude grating. Visibility maps were calculated using the data obtained with the fringe-scanning method, which was performed for X-ray phase imaging. The fringe scan was attained by displacing one of the gratings in its diffraction vector (1/5 of the grating pitch per step).

A sample was made by combining a rolled paper and sponges of melamine and polyvinyl alcohol (PVA). The sample was rotated in front of the phase grating with an angular step of 0.45°. A visibility map was measured at every angular position, and resultant tomogram is shown in Fig. 1. Every component of the sample and their structure were successfully revealed in a sectional image.

Discussion

The relation between the visibility map V and sample thickness T, $V = \exp(-\alpha T)$, was the basis of the tomographic reconstruction, and the resultant image maps α, which must involve structural information. Although small angle scattering at the sample is considered to the visibility reduction, the relation between α and the theory of X-ray small angle scattering is still unknown. In order to extract structural information from the presented image, the elucidation of the relation is crucial. Also, the universality of the V-T relation should be checked for other samples.

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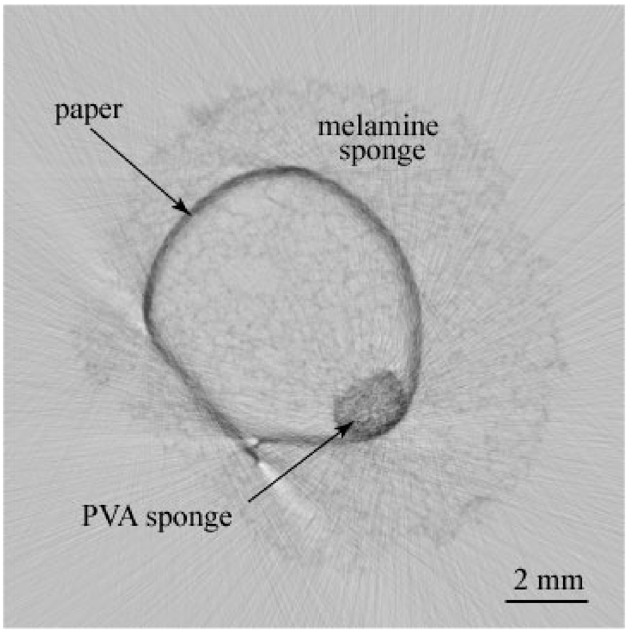

Fig. 1 Tomogram generated from visibility maps.

References

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