Tomographic analysis of unresolvable microstructure using visibility contrast in X-ray Talbot interferometry

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Recently X-ray Talbot and Talbot-Lau interferometries have attracted increasing attention because they work with polychromatic and cone beam from a compact laboratory source [1]. In the X-ray Talbot (-Lau) interferometry, we can retrieve two quantitative images, i.e., absorption and differential-phase images, from a series of experimentally obtained moiré images. Pfeiffer *et al.* has proposed another approach to form image contrast, where relative decrease in the visibility of the moiré image is quantified by defining normalized visibility [2]. They reported that the visibility contrast is formed through the mechanism of small angle X-ray scattering from microstructures with a scale much smaller than the spatial resolution of the imaging system. However, no general formulation of the phenomenon, which is essential for quantitative structure analysis, was provided.

We had shown that the visibility contrast can be generally formulated by autocorrelation function describing spatial fluctuation of wavefront due to the unresolvable microstructures [3,4]. Because our formulation had opened a quantitative way to analyze the microstructures, tomographic reconstruction was also realized. Figure 1 (a) shows a tomogram obtained from visibility contrast images at a Talbot order of 0.5. From such tomograms obtained at different Talbot orders, we can retrieve structural information on the microstructure at a point in a sample as shown in Fig. 1 (b). From least-squares fittings to the experimental data of Fig. 1 (b), we successfully revealed the structural parameters around two points A and B (in CR rubber and melamine sponge) in Fig. 1 (a). Thus, our method provides a powerful way to quantitatively investigate three-dimensional distribution of unresolvable microstructures in a sample.

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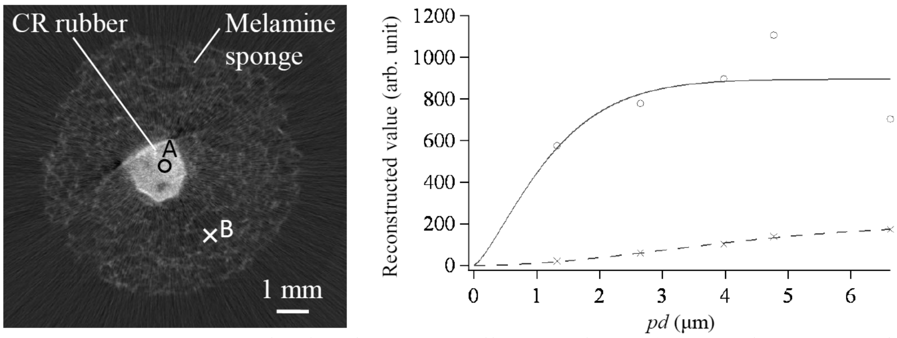

Fig. 1: (a) A tomogram obtained at a Talbot order of 0.5. (b) Dependencies of reconstructed value on *pd* (*p*: Talbot order; *d*: pitch of the gratings) around two points shown in (a) (open circles and crosses: experimentally obtained data around A and B; solid and broken lines: best-fit curves to the data).

[1] A. Momose *et al.*, *Biomedical Mathematics: Promising Directions in Imaging, Therapy Planning and Inverse Problems*, edited by Y. Censor, M. Jiang, and G. Wang (Medical Physics Publishing, 2008, Madison, Wisconsin, USA).
[2] F. Pfeiffer *et al.*, *Nat. Mat.* **7** (2008) 134.
[3] W. Yashiro *et al.*, *Opt. Exp.* **18** (2010) 16890-16901.
[4] W. Yashiro et al., *Phys. Rev.* B 84 (2011) 094106.