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Observation of gas diffusion layer of fuel cells by X-ray interferometric laminography

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1 Introduction

X-ray interferometric imaging, which detects phase shifts by X-ray interferometer, is a powerful tool for biomedical and material imaging. The phase shift cross-section of light elements in a hard X-ray region is about 1000 times bigger than the absorption cross-section; therefore, this imaging technique enables us to perform fine two- and three-dimensional observations of samples mainly composed of light elements without any supplemental methods. Many detailed observations of biological soft tissues such as kidney, liver, brain, organic material, and clathrate hydrates were performed using an imaging system fitted with a two-crystal X-ray interferometer [1]. For wider application of this imaging technique, we developed X-ray interferometric laminography making it possible to observe thin and flat objects nondestructively and applied it to the observation of a thin gas diffusion layer of fuel cells.

2 Experiment

Figure 1 shows the schematic view of our experimental set-up of interferometric laminography. The incident X-ray beam was divided, refracted, and recombined in turn by the 4-crystal wafers of the interferometer. Two generated interference beams were detected by two CCD-based X-ray imagers for the measurements and the feedback control of the interferometer.

The sample was placed in one interference path and rotated around an axis inclined by 45 degrees with respect to the path in the horizontal plane. At each rotational angle, phase map, which depicts spatial distribution of phase shift caused by the samples, was obtained by fringe scanning methods with three steps.

The three-dimensional image was reconstructed by algebraic reconstruction technique (ART), which is based on an iterative calculation of three-dimensional projection and back projection. To shorten the calculation time, a general purpose graphic processer unit (GPGPU) was used.

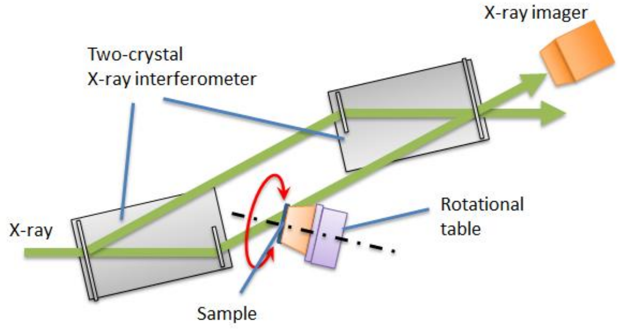

Fig. 1: Schematic view of X-ray interferometric laminography.

3 Results and Discussion

Figure 2 shows three-dimensional and sectional images of the layer. The interference images were obtained using a 35-keV X-ray with 5-s exposure. The sample was rotated through 360 degrees in 0.72 degree steps. Many fibers composing the layer were visualized clearly, and image quality was good enough to perform quantitative estimation of the length and the overlap structure of fibers. The spatial resolutions estimated from the slope of the line profile near the fiber were 30 μm and 50 μm in the horizontal and vertical directions, respectively. The density resolution calculated from the standard deviation of phase fluctuations was 3 mg/cm^3.

This result indicates that X-ray interferometric laminography is a powerful tool for the observation of thin and flat samples consisting of light elements.

References

[1] A. Yoneyama *et al*., Nucl. Instr. and Meth. A 523, 217 (2004).

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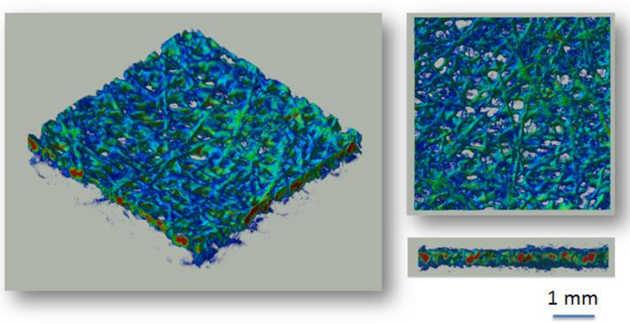

Fig. 2: Three-dimensional and sectional images of gas diffusion layer.