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Development of X-ray Depolarizer

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Introduction

Polarization property of synchrotron radiation has been utilized widely owing to the recent development of X-ray polarizer and phase retarder. However, it can be a nuisance too in some cases. In general, most of samples of interest are more or less sensitive to X-ray polarization, and hence, it is necessary to characterize the polarization state of X-ray beam incident to a sample even when the polarization property is not utilized in the experiments.

But, it is not easy to characterize the polarization states of X-rays. Therefore, it would be useful if unpolarized X-rays could be obtained in stead of not-well-defined polarized X-rays for experiments in which the use of polarized X-rays is not intended and/or complicates the data analysis. As an example, MAD method which is widely used in protein structure analysis assumes no polarization dependence of anomalous scattering factors, and the accuracy of the data analysis would be improved if unpolarized X-rays would be available.

Here, we propose an idea to generate unpolarized X-rays from polarized synchrotron X-ray radiation by using a transmission-type X-ray phase retarder as a depolarizer. An X-ray phase retarder is an optical component to utilize double refraction which takes place in the vicinity of Bragg condition in a perfect crystal. The phase shift is approximately proportional to the inverse of deviation angle from Bragg condition. If the crystal is set just at Bragg condition, it should yield the random phase shift of the X-ray beam on average, resulting in generating pseudo unpolarized states of X-rays. The performance of the depolarizer will be reported.

Experimental & Results

The phase retarder used as a depolarizer was a (100)-oriented diamond (300 & 800 μm thickness) crystal giving a 111 reflection in an asymmetric Laue geometry. The energy of the incident X-ray was set at the cobalt K absorption edge (7709 eV). The energy spread was about 1 eV, and the horizontal beam divergence was 20 arcsec.

The phase retarder used as a depolarizer was evaluated by using an X-ray ellipsometer, which consisted of the analyser and the quarter plate. Fig.1(a) shows that the output beam is highly depolarized. The degrees of polarization (Pl) were 0.043 and 0.042, for 300 and 800 μm thick depolarizers, respectively. It means that the dependence of a depolarizer's performance on thickness is negligible unlike a phase retarder. The losses of the X-ray intensity with 300 and 800 μm thick depolarizers were 50% and 85%, respectively.

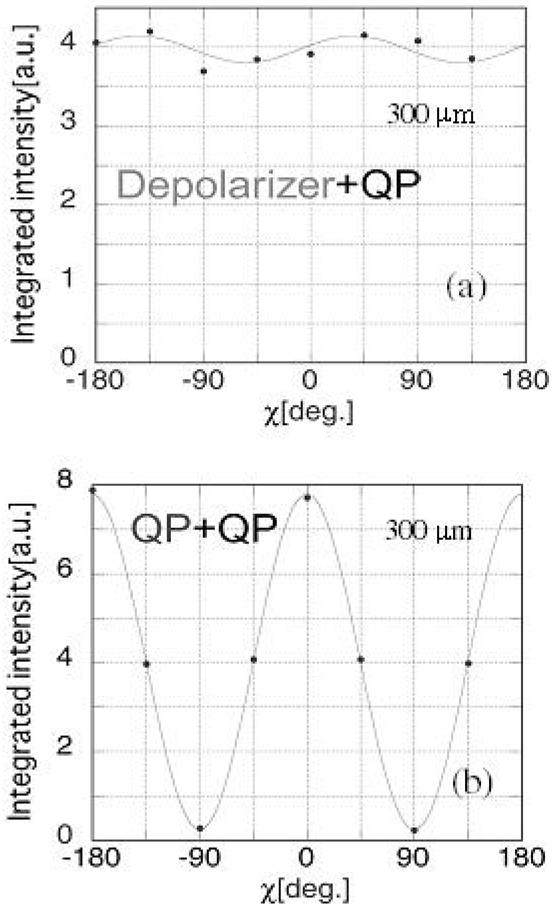

Figure 1 Evaluation by an X-ray ellipsometer

For comparison, the phase retarder was evaluated also when it was used as a quarter plate (QP) and it was confirmed that a high-degree (0.94 and 0.98, for 300 and 800 μm thick QPs, respectively) of vertical polarized X-rays were generated (Fig.1(b)).

These experiments have shown that the X-ray phase retarder works reasonably as an X-ray depolarizer.

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