Characterization of an x-ray diamond phase plate by a polarization analyzer using multiple diffraction

Keiichi Hirano¹,* , Yuto Ito², Yuya Shinohara² and Yoshiyuki Amemiya²

¹Photon Factory, Tsukuba 305-0801, Japan
²Graduate School of Frontier Sciences, University of Tokyo, Chiba 277-8561 Japan

1 Introduction
X-ray phase plate plays an important role, for example, in x-ray magnetic circular dichroism (XMCD), x-ray anisotropic-tensor scattering (ATS), and x-ray magnetic diffraction studies. For the characterization of x-ray phase plates we have introduced a polarization analyzer based on multiple Bragg diffraction (MBD) instead of the conventional linear polarization analyzer based on 45° Bragg diffraction [1].

2 Experiment
The experiment was carried out at the vertical-wiggler beamline BL-14B. Figure 1 shows a schematic of the experimental setup. The x-ray wavelength was tuned to 0.1239 nm by a pair of Si(111) crystals. Higher harmonics in the incident beam were first removed by a Si(220) crystal, and then x-rays linearly polarized in the vertical plane were directed onto a phase plate, for which a 2-mm-thick (001)-oriented diamond crystal slab was used. The (111) plane of the diamond crystal was tilted by 45° with respect to the horizontal plane in order to coherently excite both the σ- and π-components with equal amplitude. The polarization of the transmitted beam was controlled through the offset angle, Δθ, from the 111 Laue-case diffraction condition.

We initially used a Si(620) crystal as the linear analyzer (θB = 46.22°) because this is the simplest way for adjusting Δθ. From the reflected intensity profile, we estimated that right-handed circular polarization (RHC) is produced at around Δθ = 0.014° and left-handed circular polarization (LHC) at around Δθ = −0.03°. The degree of circular polarization was −0.70 at Δθ = −0.03° and +0.95 at Δθ = 0.014°.

We then replaced the linear analyzer with a GaAs (222) crystal in order to perform a complete determination of the polarization at Δθ = −0.03°, 0.014°, and 0.25°. The measured Stokes parameters (S1, S2, and S3) are also shown.

To summarize, we have used the linear analyzer based on the 45° Bragg diffraction and the MBD analyzer for the alignment and characterization of the x-ray phase plate. By using the Si(620) linear analyzer, we could adjust the offset angle, Δθ, of the diamond phase plate to produce elliptically polarized x-rays. A complete successful determination of the polarization by a Renninger scan of the GaAs(222) analyzer revealed that the degree of circular polarization was −0.70 at Δθ = −0.03° and +0.95 at Δθ = 0.014°.

3 Results and Discussion
The Stokes parameters were determined for each Δθ from the experimental data. Figure 2 shows the polarization ellipses for Δθ = −0.03°, 0.014°, and 0.25°. The polarization was close to LHC at Δθ = −0.03°, RHC at Δθ = 0.014°, and vertical polarization at Δθ = 0.25°. The degree of circular polarization was −0.70 at Δθ = −0.03° and +0.95 at Δθ = 0.014°.

![Fig. 1: The experimental setup for the polarization analysis.](image)

![Fig. 2: The polarization ellipse obtained at (a) Δθ = −0.03°, (b) Δθ = 0.014°, and (c) Δθ = 0.25°. The measured Stokes parameters (S1, S2 and S3) are also shown.](image)

Reference
[1] K. Hirano et al.: *keiichi.hirano@kek.jp*