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

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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 base 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, $\Delta\theta$, from the 111 Laue-case diffraction condition.

We initially used a Si(620) crystal as the linear analyzer (θ_B = 46.22°) because this is the simplest way for adjusting $\Delta\theta$. From the reflected intensity profile, we estimated that right-handed circular polarization (RHC) is produced at around $\Delta\theta$ = 0.014° and left-handed circular polarization (LHC) at around $\Delta\theta$ = −0.03°.

We then replaced the linear analyzer with a GaAs (222) crystal in order to perform a complete determination of the polarization at $\Delta\theta$ = −0.03°, 0.014°, and 0.25°. The glancing angle of the analyzer crystal, θ, was adjusted to excite the main reflection, ***H*** = (222), and the azimuth angle, ϕ, was rotated to excite the detoured reflections ***L*** = (11-3), (-1-1-5), and (-5-1-1) while maintaining the main reflection. At each ϕ, the intensity integrated over θ was measured with an x-ray photodiode detector

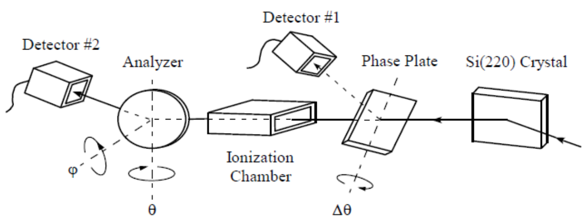

Fig. 1: The experimental setup for the polarization analysis.

3 Results and Discussion

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

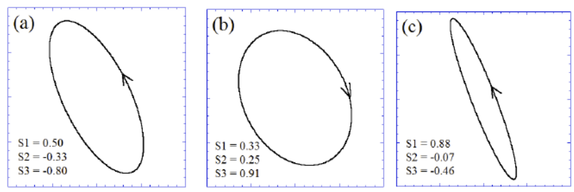

Fig. 2: The polarization ellipse obtained at (a) $\Delta\theta$ = −0.03°, (b) $\Delta\theta$ = 0.014°, and (c) $\Delta\theta$ = 0.25°. The measured Stokes parameters (S1, S2 and S3) are also shown.

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, $\Delta\theta$, 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 $\Delta\theta$ = −0.03° and +0.95 at $\Delta\theta$ = 0.014°.

Reference

[1] K. Hirano et al.:

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