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Development of x-ray polarization analyzer using multiple diffraction

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1 Introduction

The analysis of the x-ray polarization 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. To date, x-ray polarization analyses have been carried out mainly by an x-ray linear analyzer, the Bragg angle of which is close to 45°. Although this method is convenient, there are several disadvantages: the available wavelength is limited by the condition that the Bragg angle must be close to 45°, and the method is not sensitive to either the difference between the circularly polarized and unpolarized components, or the helicity of the x-rays. One way to overcome these disadvantages is to employ an x-ray analyzer that makes use of multiple Bragg diffraction (MBD) in a nearly perfect crystal [1]. Although this method is useful, the available signal is usually weak. To exploit the advantages of these two methods, we have combined the linear analyzer with the MBD-based analyzer [2].

2 Experiment

The experiment was carried out at the vertical-wiggler beamline BL-14B. The x-ray wavelength was tuned to 0.1239 nm by a pair of Si(111) crystals. Figure 1 shows a schematic of the experimental setup. 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 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 $\Delta\theta$. We could estimate 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°.

As the MBD-based analyzer, a GaAs(222) wafer was used for the complete determination of the polarization at $\Delta\theta$ = −0.03°, 0.014°, and 0.25°. The glancing angle of the GaAs 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 = $(11\bar{3})$, $(\bar{1}\,\bar{1}\,5)$, and $(\bar{5}\,\bar{1}\,\bar{1})$ while maintaining the main reflection. At each ϕ, the intensity integrated over θ was measured with an x-ray photodiode detector. The Stokes parameters were determined for each $\Delta\theta$ from the experimental data.

3 Results

Figure 4 shows the polarization ellipses with the Stokes parameters for $\Delta\theta$ = 0.014°. The polarization was close to RHC. The degree of circular polarization was estimetaed to be 0.95.

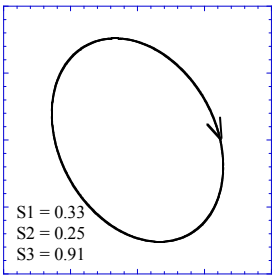

Fig. 2: The polarization ellipse at $\Delta\theta$ = 0.014°.

References

[1] Q. Shen and K. D. Finkelstein, *Phys. Rev. B* **45**, 5075 (1992).
[2] K. Hirano *et al.*, *J. Phys.: Conf. Ser.* **425**, 052030 (2013).

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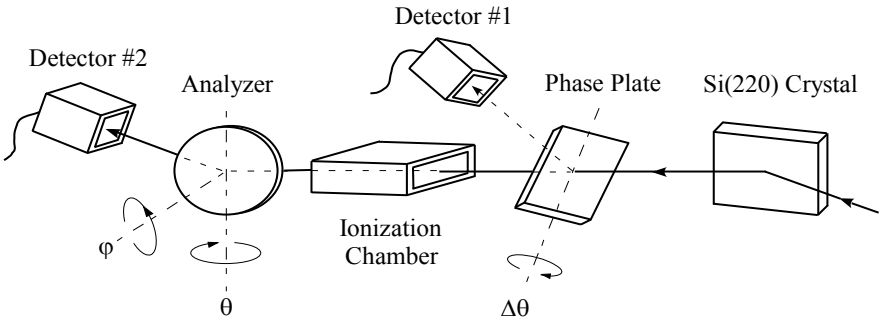

Fig. 1: The experimental setup for the polarization analysis.