Instrumentation and Technique

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Performance study of the multilayer polarizers for soft X-ray region

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Introduction

In the resonant X-ray scattering measurement, polarization dependence of the incident light and the scattered light give important information in dividing the scattering intensities into charge, magnetic, and orbital-ordering scatterings. In soft X-ray region, polarization of the incident SR light can be controlled by the undulator. For the scattered light, however, it is required to prepare multilayer polarizer, adjusted for the aimed energy region owing to the strong self-absorption effect.[1]

We are constructing a new UHV diffractometer for resonant soft X-ray scattering measurement and planning to set a polarization analyzer for the scattered light. For this polarization analyzer we have prepared two multilayer polarizers for Co $L_{2,3}$ and Mn $L_{2,3}$ edges. Before construction, we studied the performance of these polarizers. In order to earn enough statistics to separate scattering intensities into σ and π polarizations, we need the reflectivity of the polarizers at least 0.01. In addition to this, we need to set FWHM of the reflection peak larger than several eV to measure energy scans of scattering intensities at the aimed absorption edge with smooth lineshape.

Experiment and Results

Experimental

Two polarizers are fabricated by NTT-ATN. They are the multilayers of W and B_4C, with 400 pairs. Periodic length d was designed for the aimed absorption edge; Polarizer #1 for Mn $L_{2,3}$ edge is 1.36 ± 0.05 nm, corresponding to 643 eV and Polarizer #2 for Co $L_{2,3}$ edge is 1.13 ± 0.05 nm, corresponding to 773 eV. Roughness of the multilayers are limited within 0.4 nm to keep the reflectivity larger than 0.01. We have checked the exact performance of them for practical use by the reflectometer equipped at BL-11D for the measurements of reflectivities of gratings and optical mirrors.

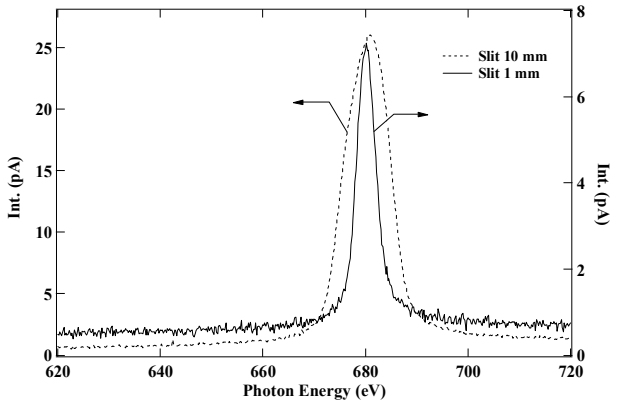

Fig. 1: Energy scan of the reflection of the polarizer #1. Incident angle and scattering angle are set at 45° and 90°, respectively.

Results

Energy scans of the reflection of the polarizers #1 and #2 were measured with incident and scattered angles set Brewster's angles. Optimized photon energy of #1 was estimated as 680 ± 5 eV as shown in Fig.1 As for #2, we didn't measure the optimized photon energy directly since BL-11D produces photon energy below 800 eV. We estimated the periodic length of #2 as 1.078 nm from the value of scattering angle for the strongest reflectivity at 800 eV, which indicates that the optimized photon energy of #2 is 813 eV. FWHMs of the energy scan were estimated as 11eV and 4.8 eV with slit-width of the detector 10 mm and 1 mm, respectively.

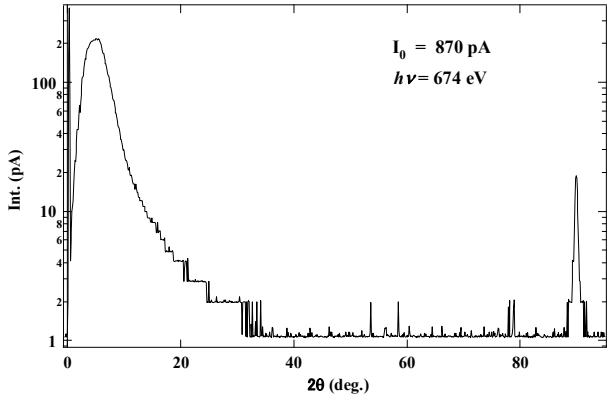

Fig. 2: Reflection intensity of the polarizer #1. Photon energy is set at 674 eV and intensity of the direct beam is 870 pA.

Reflectivities of #1 and #2 were measured at $h\nu$ of 674 eV and 800 eV, respectively. Figure 2 shows the θ-2θ scans of reflection intensity of the polarizer #1. Reflection intensity at 2θ of 90° degrees is in the several percent of the total reflection at 2θ of ~ 3°. Reflectivities were estimated at 0.02 ± 0.005 for #1 and 0.015 ± 0.005 for #2, which are stronger than 0.01. These estimated values fulfill the expected conditions for constructing the soft X-ray polarization analyzer.

References

[1] U. Staub *et al*., J. Synchrotron Rad. **15**, 469 (2008).

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