Polarizance Evaluation of Multilayer Analyzer

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Introduction

Polarizance or polarizing power of a multilayer as a polarization analyzer is important factor in an analysis of the reflectivity curve obtained by the rotation analyzer method. If polarizance is apart from unity, the contrast factor obtained from the reflectivity curve directly is far from the degree of linear polarization. The other factor of inaccuracy of the rotation analyzer method is the unpolarized and higher order component in light. It is difficult to estimate exactly the later factor. In this article, the polarizance is evaluated under the assumption that the degree of linear polarization of light source equals to unity and unpolarized and higher order component can be neglected.

Theory

The theoretical reflectivity curve obtained by the rotation analyzer method is given as follows [1]:

$$I(\theta) = \frac{(1+h)}{2}[1 + P\frac{1-h}{1+h}\cos 2\theta]$$

Here, θ is the azimuth angle, P is the degree of linear polarization of light source, $h \equiv R_p / R_s$ (R_p, R_s: reflectivity of the multilayer in p, s geometry, respectively) is the reciprocal of the polarizing power. The contrast factor *P'* is defined and obtained from the curve as follows:

$$P' \equiv \frac{I(\theta)_{\max} - I(\theta)_{\min}}{I(\theta)_{\max} + I(\theta)_{\min}} = P\frac{1-h}{1+h}$$

$P_z \equiv \frac{1-h}{1+h}$ is the polarizance of the multilayer. In the case of $P = 1$, the contrast factor equals to the polarizance, i.e. $P' = P_z$.

Experiment and Results

Monochromatic light is obtained by four segments of horizontal polarized Figure-8 undulator with proper phase shifters and VLS-PGM [2]. The multilayer analyzer used in the present measurement is designed to obtain the maximum reflectivity at glancing angle of 45 degrees for photon energy of 300 eV [3]. Glancing angles vary with the photon energies, which are 253, 300, 339, 405 eV for the present measurements. Fitting is performed with data analysis and graphing soft ware Origin8.0.

Figure 1 shows the measured reflectivity of the multilayer analyzers with white squares and fitting results with red lines. The measured curves are normalized by maximum plus minimum (I_{max}+I_{min}) of each curves. The glancing angle (θ_M) are 56.3, 44.9, 38.2 and 31.4 degrees for photon energies of 253, 300, 339 and 403 eV, respectively. The polarizance (reciprocal of polarizing power) 0.180(0.123), 0.993(0.003), 0.855(0.078), 0.489(0.343) are obtained under the assumption of P=1.

Figure 2 shows the measured (black squares) and calculated (red circles) reciprocal of polarizing power and their difference (green triangles). The calculation is performed with using a software “Multilayer Reflectivity” [4].

Discussion

The degree of linear polarization of the photon energy apart from optimized photon energy (=300eV in the present case) can be evaluated with calibration using polarizance or polarizing power which depend on photon energy. Measured contrast factor P' is converted to true degree of linear polarization P by the formula $P = P' / P_Z$. For 300 eV, the contrast factor P' can be equal to the degree of linear polarization with accuracy of 1%. The values of polarizance of the multilayer analyzer may be calculated, however, the difference is not small to be neglected in some photon energies. So it is necessary for exact measurements of a degree of linear polarization to evaluate the polarizance beforehand.

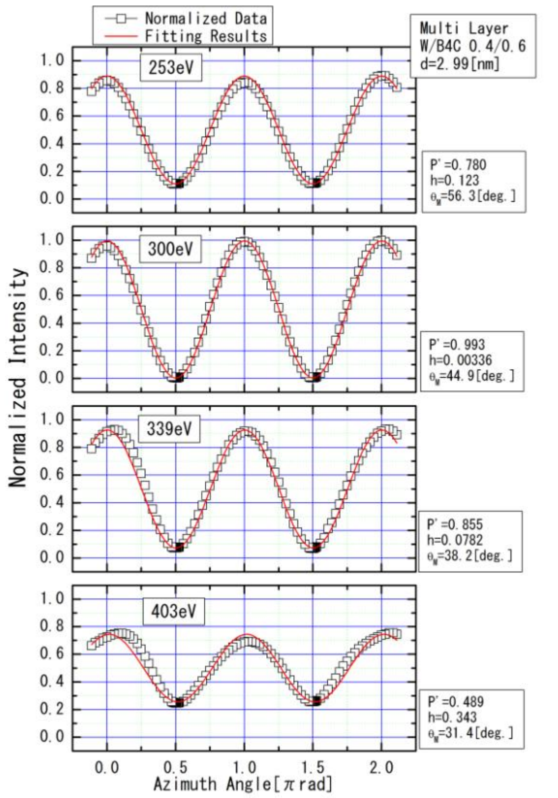

Figure 1
Reflectivity curves of multilayer analyzer (white squares) and fitting curves (red lines)

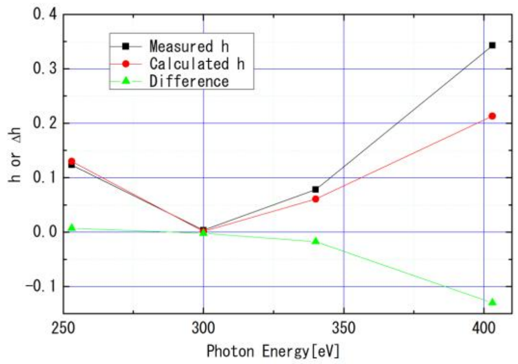

Figure 2
Measured (black squares) and calculated (red circles) reciprocal of polarizing power of multilayer analyzer with their difference (green triangles).

References

[1] H. -Ch. Mertins et al., Phys. Rev. B, 61(2000) R874.
[2] Activity Report of Synchrotron Radiation Laboratory 2009.
[3] Activity Report of Synchrotron Radiation Laboratory 2010.
[4] http://henke.lbl.gov/optical_constants/multi2.html