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XMLD study at the L_2 edge of Gd in transmission method with the universal X-ray ellipsometer

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Introduction

X-ray magnetic linear dichroism (XMLD) is the absorption difference for linearly polarized light (parallel or perpendicular to the magnetization), while X-ray magnetic circular dichroism (XMCD) is absorption difference for circularly polarized light (right-handed or left handed). XMCD is known to be odd for magnetization **M,** i.e., it reverses its sign when **M** is reversed, therefore XMCD cannot be applied to anti-ferromagnetic materials. On the other hand, XMLD does not change its sign when **M** is reversed, so it can be applied to not only ferromagnetic but also anti-ferromagnetic materials.

The research on XMCD has been actively performed because of its particular aspects (e.g., element selective, capable of separating orbital and spin magnetic moment), and XMCD has become a useful tool for investigating magnetic feature of materials. However, few XMLD studies have been reported as yet [1], especially XMLD spectra in transmission method[2,3]. One of the reasons might be that XMLD signal is expected to be much smaller compared to XMCD signal[1].

In our experiment, we attempted to detect XMLD spectra at the L_2 edge of Gadolinium (7930 eV). Gd is lanthanoid, of which 4f shell is filled with 7 electrons. It forms a hcp crystal structure, and is a simple ferromagnet below the critical temperature T_c=297 K. XMLD spectrum can be detected by measuring the so-called Voigt rotation of polarization, originating from the asymmetry of absorption. We can also measure XMCD spectrum from the so-called Faraday rotation, originating from magnetic circular birefringence (MCB), which is connected to MCD by K-K relation. Here, we focused attention on the relation between XMCD and XMLD spectra. It is predicted that in the particular situation XMLD spectra are proportional to the energy derivative of XMCD spectra[1].

Experimental

The experiment was performed at BL-8C, with the X-ray ellipsometer. The sample was Gd polycrystal sheet, thickness of which was estimated to be about 4 μm. It was chilled to 4 °C, and its magnetization axis was controlled by permanent magnet. At first the magnetization was saturated along the direction expected to give the targeted signal, then along the direction expected to reverse the sign. The difference of two signals was extracted by removing other factors, such as rotation originating from NLD and NCD.

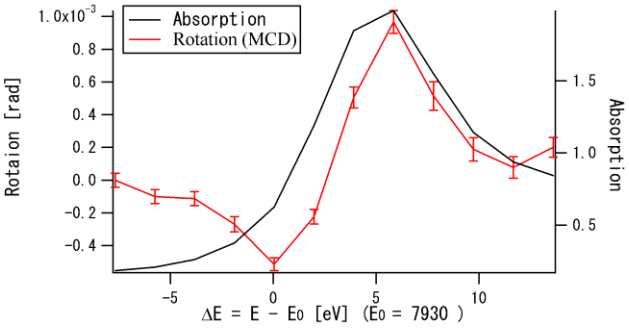

Fig. 1 XMCD spectrum obtained as Faraday rotation

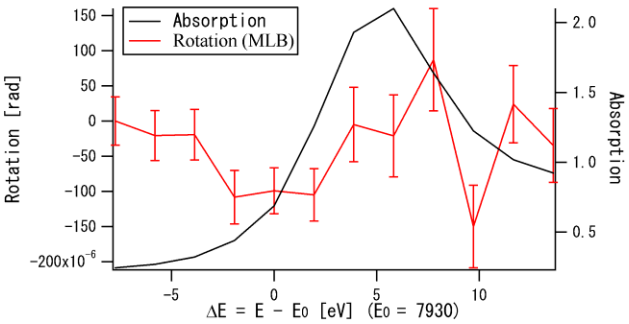

Fig. 2 XMLD spectrum obtained as Voigt rotation

Results and Discussion

Figures 1 & 2 show XMCD and XMLD spectra, respectively, which were obtained as the rotation of X-ray polarization. The maximum rotations of XMCD and XMLD were about 1 mrad, 0.1 mrad, respectively. We compared XMLD and XMCD spectra which were transformed from the above spectra. As was theoretically predicted, the similarity was found between XMLD spectrum and the energy derivative of XMCD spectrum.

In order to make quantitative discussion, it is necessary to improve the accuracy of the experiment by increasing data point and/or measuring time.

References

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