MAGNETO-OPTICAL SPECTROSCOPY BY POLARIZATION MODULATION METHOD USING A MULTICHANNEL SPECTROMETER

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1. Introduction

Magneto-optical (MO) spectroscopy is an indispensable evaluation method for MO materials. In recent years, the use of multi-channel spectrometer has made it possible to significantly reduce the measurement time [1,2]. There are several conventional methods such as spinning analyzer method [3], Faraday cell method [4], and polarization modulation method [5] for quantitative measurement of the MO effect. However, there was a common problem that measurement time is long, typically it takes 1 - 2 h, because monochromatic light was measured in order. Here, we propose an MO spectrum measuring apparatus using polarization modulation method [6] with a multi-channel spectrometer, in which the Faraday rotation and ellipticity can be obtained simultaneously from the three spectra of linear polarization, left and right circular polarization.

2. Experiment

Figure 1 shows a schematic diagram of an MO spectrometer that we proposed in this research. A halogen lamp (Olympus model TH4-100) was used as a light source, and a multi-channel spectrometer (Ocean Optics model USB2000+VIS-NIR, with a 2048-element linear silicon CCD array detector) was used as a detector. In addition, for MO measurement, collimate lens (L1, L2, L3), pinhole, polarizer (Pol.), quarter-wave plate (Q.W.), perforated electromagnet (E.M.), and analyzer (Ana.) were used. Three light intensity spectra were measured with the optical axes of the quarter-wave plate at -45, 0 and 45°, with applied magnetic field. Faraday rotation (θ_F) and ellipticity (η_F) can be calculated using the following equations [5],

$$\theta_F \approx \frac{1}{2}\left\{\frac{2I_{0^\circ}-(I_{45^\circ}+I_{-45^\circ})}{(I_{45^\circ}+I_{-45^\circ})}\right\}, \qquad (1)$$

$$\eta_F = -\frac{(I_{45^\circ}-I_{-45^\circ})}{2(I_{45^\circ}+I_{-45^\circ})}, \qquad (2)$$

where, I_{-45°, I_{0° and I_{45° are light intensities when the optical axis of the quarter-wave plate is -45, 0 and 45°, respectively. Each optical spectrum was measured 100 times and an average was taken to reduce the noise. In addition, the average value measured for the positive and negative magnetic fields with ± 2.5 kOe was taken in order to adjust zero point for both Faraday rotation and ellipticity.

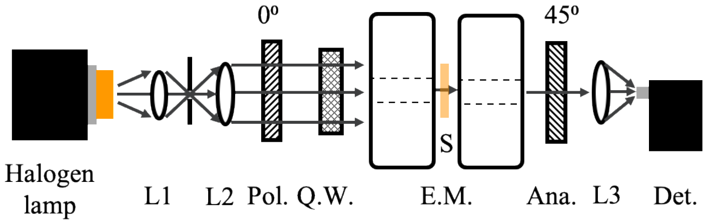

Fig.1 Magneto-optical multi-channel spectrometer using polarization modulation method

3. Result and discussion

Figure 2 shows Faraday rotation and ellipticity spectra of a $Nd_{0.5}Bi_{2.5}Fe_5O_{12}$ (Bi:NIG) film with a thickness of 200 nm prepared by metal-organic decomposition (MOD) method on a GGG (111) substrate. The Bi:NIG film used for the measurement should have a large peak of the Faraday rotation around 400 nm, but the rotation angle was measured to be small due to the large optical absorption of the film. On the other hand, Faraday rotation angle had a maximum, θ_F = -4.75° at a wavelength λ = 525 nm, and ellipticity has a peak, η_F = 6.65° at 495 nm, which agreed with the typical MO response of Bi: NIG [7,8]. The resolution of Faraday rotation was about 0.01° in the wavelength range of 500 to 600 nm in this measurement. The measurement time of these spectra was expected to be shorter than 2 minutes, which was significantly short as compared with conventional methods.

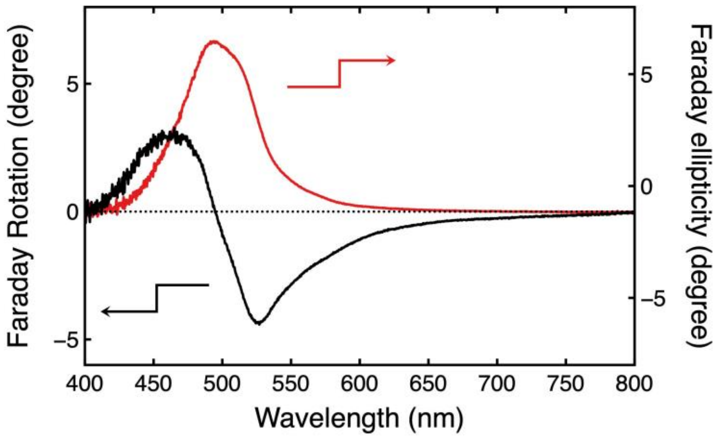

Fig.2 Faraday rotation and ellipticity spectra of Bi:NIG thin film on GGG substrate.

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