High Frequency MO Imaging of Bismuth-substituted Europium Iron Garnet

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$Nd_{0.5}Bi_{2.5}Fe_5O_{12}$ thin films have been successfully developed and used for magneto-optical (MO) imaging at frequencies up to 6 GHz[1]. However, to achieve visualization of near magnetic fields at higher frequencies, the MO properties of these garnet thin films need significant enhancement. In our recent studies, we were able to obtain magnetization and angular momentum compensation composition for highly Bi-substituted Europium Iron Garnet, $Eu_{0.5}Bi_{2.5}Fe_{5-x}Ga_xO_{12}$ (Eu,Ga:BIG), at room temperature[2]. Therefore, in this study, we are measuring MO signals at high frequency using Eu,Ga:BIG garnet thin films in order to evaluate the improvement in the high frequency region.

$Eu_{0.5}Bi_{2.5}Fe_{5-x}Ga_xO_{12}$ (x=0, 0.5, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 2) thin films were prepared using metal-organic decomposition (MOD) method where high-purity chemical solutions, BiFeEu (2.5/5/0.5) and BiFeEuGa (2.5/3/0.5/2) prepared by Kojundo Chemical Lab., were mixed to achieve desired Ga content. The films went through multiple repetitions of coating, drying and pre-annealing before obtaining an approximate thickness of 150 nm. Utilizing a micro strip line (MSL) configuration as shown in Figure 1, detailed measurements of the Faraday rotation angle across a frequency range of 0.05 to 10 GHz have been conducted. The experimental setup incorporated Eu,Ga:BIG garnet films placed on the MSL, where an applied alternating current (AC) magnetic field and femtosecond laser alignment facilitated the imaging process.

Figure 2 shows the frequency dependence of the faraday rotation angle for the Eu:BIG thin films. It has been observed that with the increasing amount of Ga substitution, the peak position of the Faraday rotation shifts to a higher frequency region in the gigahertz range. Furthermore, magnetic field distribution has also been studied. Further details will be presented on the day of meeting.

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1) T. Ishibashi, *J. Magn. Soc. Jpn*. **44**, 108 (2020)
2) W. Asano et al., *J. Magn. Soc. Jpn.* (2024) (*Accepted*)

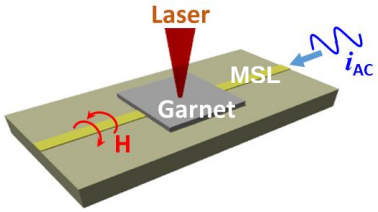

Fig.1 High frequency measurement of $Eu_{0.5}Bi_{2.5}Fe_{5-x}Ga_xO_{12}$ thin films.

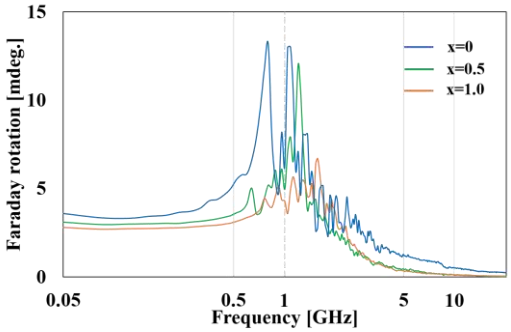

Fig.2 Frequency response of $Eu_{0.5}Bi_{2.5}Fe_{5-x}Ga_xO_{12}$ thin films.