Fabrication of Ga doped Gadolinium Iron Garnet Thin Films by Metal Organic Decomposition and their Magneto-optic Characterizations

Tokyo Univ. of Agri. & Tech, ○Jo Sato, Danish Abdul Wahid, Takaya Hattori and Hiromasa Shimizu

Email: h-shmz@cc.tuat.ac.jp

[Introduction]

Magnetic garnet such as $Gd_3Fe_5O_{12}$ shows large magneto optic effect and has been applied to optical isolators owing to large Faraday rotation in visible to near infrared light. Metal organic decomposition (MOD) is a method to prepare magnetic garnet films by spin coating of liquid containing Bi, Gd and Fe carboxylates followed by annealing. It is a simple fabrication method, and guarantees high uniformity in chemical composition and purity combined with chemical stability [1]. One of the advantages of MOD method is that composition of the magnetic garnet can be easily controlled by mixing the solutions before spin coating. In this study, we fabricated Ga doped $Gd_3Fe_5O_{12}$ thin films by MOD method and characterized the magneto-optic effect with temperature dependence in order to investigate the influence of the number of valence electrons in Fe ions on magnetic anisotropy. It is possible to observe the change of the magnetic anisotropy due to the change of the valence electron number of Fe ions by comparing with Si doped $Gd_3Fe_5O_{12}$ thin films.

[Experiment]

We prepared Ga-doped Gadolinium Iron garnet on GGG (1 1 1) substrate by MOD method. We used FeGd-05(5/3) and Ga-03 made by KOJUNDO CHEMICAL LABORATORY as MOD solutions, and mixed them with composition ratio of $Gd_3Fe_{5-x}Ga_xO_{12}$ (x = 0, 0.5, 1.0, 1.5). We repeated spin coating and pre-annealing (550 °C: 10 min) 6 times, then we performed the final-annealing (800 °C: 2hour) and crystallized them. The film thickness is about 240 nm. And, we measured the lattice constant by X Ray Diffraction (XRD) and Faraday rotation by polarization modulation technique. We measured the Faraday rotation spectra at magnetic field of 12 kG and magnetic field dependences at a wavelength of 600 nm. During the measurements, we cooled or heated the samples to evaluate the temperature dependence with the range from 0 to 200 °C.

[Experimental results]

The lattice constant of $Gd_3Fe_{5-x}Ga_xO_{12}$ linearly decreased with increasing x to 1 from XRD measurements, showing that doped Ga substituted Fe. Fig.1 (a) shows the magnetic field dependences of Faraday rotation for $Gd_3Fe_5O_{12}$ with temperature of 0 - 200 °C, showing that the compensation temperature is between 5 and 10 °C for x = 0. Fig. 1(b) shows the temperature dependences of Faraday rotation for $Gd_3Fe_{5-x}Ga_xO_{12}$ (x = 0, 0.5, 1.0, 1.5). The compensation temperature is higher (100~150℃) for x = 0.5. This is because the magnetic moments of Fe ions are reduced by Ga doping, thus the compensation temperature became higher for higher x. The Curie temperature for x = 0, 0.5 was higher than 200 °C. We confirmed that Ga doped $Gd_3Fe_5O_{12}$ thin films were successfully fabricated by MOD method and the Curie temperature and compensation temperature were controlled by Ga doping.

[1] T. Ishibashi, T. Kosaka and T.Nomura: "Magneto-optical Properties of Bi-substituted Yttrium Iron Garnet Films by Metal-organic Decomposition Method" J. Phys., Conf. Series **200** (2010) 112002.

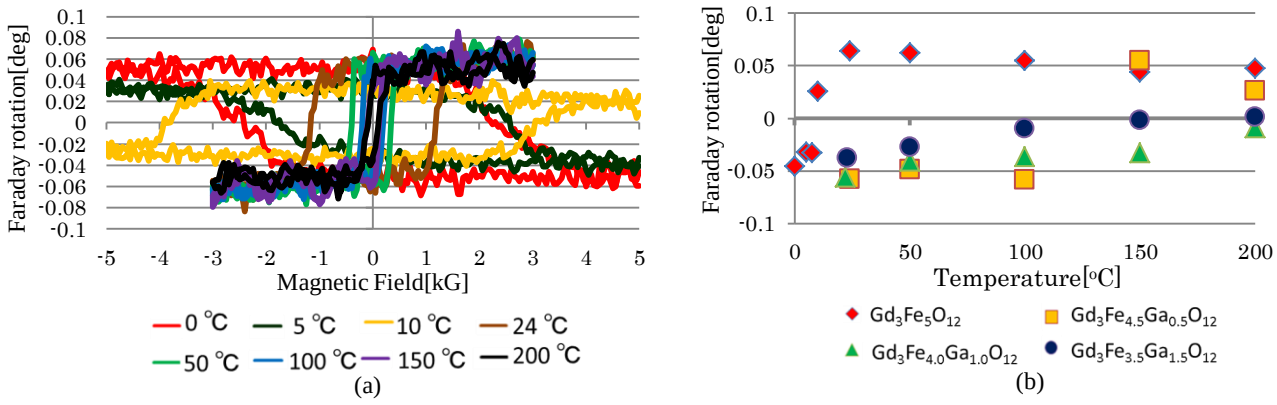

Fig.1 (a) Magnetic field dependence of Faraday rotation for $Gd_3Fe_5O_{12}$. (b) Temperature dependence of Faraday rotation for $Gd_3Fe_{5-x}Ga_xO_{12}$.

© 2015年 応用物理学会