Faraday Rotation Spectra of Bi-substituted YIG Thin Films with thinner YIG buffer layer on Glass Substrates by Metal Organic Decomposition Method

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Yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) shows large Faraday rotation (FR) and high optical transmittance in visible to near-infrared region. It is widely known that FR is enhanced by substituting bismuth for yttrium ($Bi_xY_{3-x}Fe_5O_{12}$, Bi:YIG) [1]. We have fabricated $Bi_xY_{3-x}Fe_5O_{12}$ and $Bi_xGd_{3-x}Fe_5O_{12}$ thin films on glass substrates by metal organic decomposition (MOD) method [2, 3]. MOD is one of the methods for depositing oxide thin films on substrates by spin coating of the organic solution containing the oxides and annealing for decomposition and crystallization. It is possible to prepare magnetic garnet thin films on the specific area in a substrate with different levels, such as optical waveguides. However, lattice constant and thermal expansion coefficient are quite different between magnetic garnet and glass substrate, making it difficult to prepare thin films on glass substrates. Also, since it is difficult to prepare Bi:YIG main layer on glass substrates with higher Bi substitution *x* for larger FR, insertion of the YIG / GdIG buffer layer is useful to obtain high-quality Bi:YIG main layer. So far, we obtained FR of 6×10^4 deg./cm at a wavelength of 600 nm in 205 nm-thick $Bi_2Y_1Fe_5O_{12}$ with 305 nm-thick YIG buffer layer on glass substrate, where solution for YIG was spin-coated with 2000 rpm and 6 times, and annealed at 750 °C [2]. In order to apply for optical waveguide devices, it is necessary to prepare Bi:YIG thin film with YIG buffer layer whose thickness is as thin as possible, thus leading to smaller loss and preparation on waveguides. Here, we report the FR with thinner YIG buffer layer in visible to near-infrared region.

We prepared 200 nm-thick $Bi_2Y_1Fe_5O_{12}$ thin films with the YIG buffer layer where solution of YIG were spin-coated with 4000 rpm to make thinner layer. Also we changed the spin-coating times to 2 and 4. Drying, pre-annealing, and final annealing conditions are the same as those of our previous study [2]. When the spin-coating time is 2, the YIG buffer layer thickness is approximately 110nm. Fig. 1 shows the magnetic field dependence of FR at a wavelength of 600 nm. Fig. 2 shows the Faraday rotation spectra in the wavelength range from 550 to 1550 nm with a magnetic field of 12 kG. FR of the films is 4.5×10^4 deg./cm at a wavelength of 600 nm, which is 75 % of our previous samples [2] and 60 % of the single crystalline Bi:YIG thin film prepared on SGGG substrate. FR is 0.01 deg. at a wavelength of 1550 nm (5×10^2 deg./cm). These results show that Bi:YIG with thinner YIG buffer layer crystallize and show FR even at optical communication wavelength of 1550 nm, enabling magnetic garnet films having high crystalline quality on glass substrates with thinner YIG buffer for waveguide optical isolators.

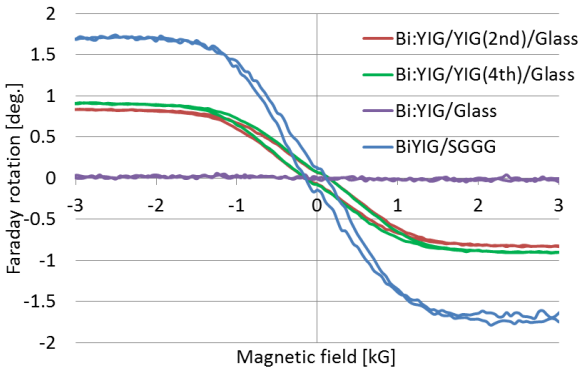

Fig.1 Magnetic field dependence of Faraday rotation of the samples at 600nm (@RT)

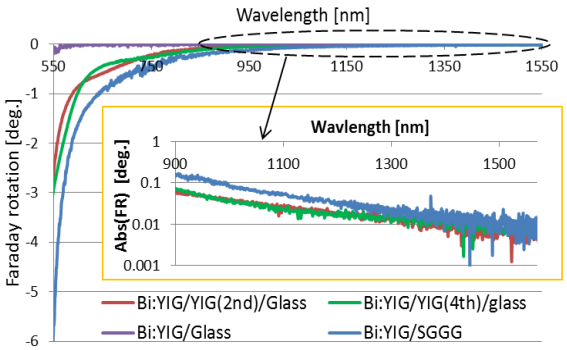

Fig.2 Faraday rotation spectra of the samples under magnetic field of 12kG.

[1] M. Gomi et al, Jpn. J. Appl. Phys. **27**, 1536 (1988). [2] M. Hosoda et al, Extended abstracts 2016, SSDM conference, PS12-12.

[3] D. A. Wahid et al., ELEX **13** 20161011 (2016).