Preparation and Characterization of Bi substituted gadolinium iron garnet $(Bi_xGd_{3-x})Fe_5O_{12}$ films with x = 1 to 2.5 by Enhanced Metal Organic Decomposition method

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Bi-substituted rare-earth iron garnets have a considerable interest owing to their large magneto optic effect. Bismuth substituted gadolinium iron garnet ($Bi_xGd_{3-x}Fe_5O_{12}$) is a ferromagnetic material and shows perpendicular magnetic anisotropy, which is one of the most desirable materials for magneto optical devices owing to its high optical transmittance and extremely high magneto optical activity in the visible and near infrared regions[1)] , Faraday rotation can be controlled by Bi substitution of Gd. Therefore, it is very important to control the amount of Bi substitution in order to control and increase Faraday rotation. There are several methods to prepare the bismuth substituted rare-earth iron garnet thin films such as a laser ablation[2)], RF magnetron sputtering[3)], etc. Among them, MOD is a promising method to prepare magnetic garnet film, because it is a simple fabrication method which is composed of spin coating of the MOD solution and annealing, and guarantees high uniformity in chemical composition and purity combined with chemical stability[4)]. However, when we choose one MOD solution in order to prepare $Bi_xGd_{3-x}Fe_5O_{12}$ thin films, the Bi content x of $Bi_xGd_{3-x}Fe_5O_{12}$ is fixed. On the other hand, there is another kind of MOD method, which is called enhanced metal organic decomposition (EMOD) method. When we consider the fabrication of $(Bi_xGd_{3-x})Fe_5O_{12}$ in a variety of different Gd / Bi content this method is important, Because the solutions of Fe_2O_3, Bi_2O_3, and Gd_2O_3 can be mixed and combined Gd / Bi content in EMOD method. The EMOD solution can be mixed and prepared in any proportion of Gd / Bi thereby offering a greater degree of freedom and more precise control of composition in order to fabricate $Bi_xGd_{3-x}Fe_5O_{12}$ thin films.

We fabricated the $Bi_xGd_{3-x}Fe_5O_{12}$ with x = 1, 2 and 2.5 at different annealing temperatures of 620°C, 650°C and 700°C on glass substrates by enhanced metal organic decomposition (EMOD) method. X-ray diffraction (XRD), optical transmittance / reflectivity, and Faraday rotation were measured for characterizations in order to examine their dependence on annealing temperatures and different amount of Bismuth substitution (x). Figures 1(a)-(d) show with increasing Bi content x from 1 to 2, the Faraday rotation increased from 1.2 to 5.8 deg./μm at the wavelength of 530 nm. Faraday rotation of $Bi_{2.5}Gd_{0.5}Fe_5O_{12}$ thin films prepared directly on glass substrates were smaller (0.35 deg./μm) than that with x = 2. When $Bi_{2.5}Gd_{0.5}Fe_5O_{12}$ thin films were prepared with annealing temperature of 650°C with $Gd_3Fe_5O_{12}$ buffer layer on glass substrates, the films showed Faraday rotation, which is comparable with that of $Bi_{2.5}Gd_{0.5}Fe_5O_{12}$ thin films prepared on (111) SGGG substrates. Our experimental results show that $Bi_xGd_{3-x}Fe_5O_{12}$ thin films can be prepared on glass substrates with controlled Bi content, and Faraday rotation as high as that prepared on SGGG substrate can be obtained by EMOD method.

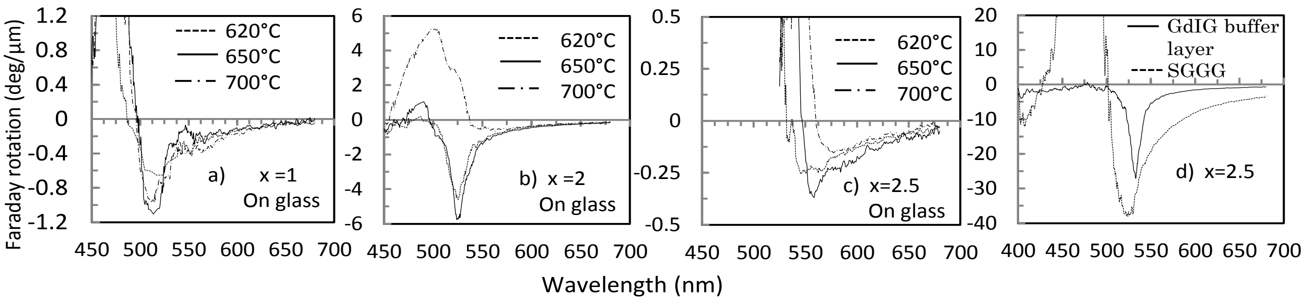

Fig 1 Faraday rotation spectra of Bi:GdIG samples with different annealing temperatures, and different Bi contain (a) x = 1, (b) x = 2 (c) x = 2.5 on glass substrate and (d) x = 2.5 on GdIG buffer on glass substrate and SGGG sustrate

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