MAGNETIC AND MAGNETO-OPTICAL PROPERTIES OF Al SUBSTITUTED Bi-RIG PARTICLES DISPERSED IN A PLASTIC BINDER

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ABSTRACT

Nano-size $R_2BiAl_xFe_{5-x}O_{12}$ (R: Dy, Gd, Tb) particles were prepared with a coprecipitation and annealing method. The coating films of the particles were prepared with a coating technique. The magnetic and magneto-optical properties of the particles and films were investigated. The coercive force H_C of the particles and films was increased and saturation magnetization M_S dropped with the Al content x. The H_C of the coating films was about 200 Oe at the compositions of dispersed particles for which the M_S was almost zero. These results suggest that the increase was made with magnetic compensation. The $BiTb_2Al_{0.6}Fe_{4.4}O_{12}$ coating film shows Faraday rotation spectra. The figure of merit of the film is about 0.5 at 520 nm. The coating $BiTb_2Al_{0.6}Fe_{4.4}O_{12}$ film is one of the candidate materials for a new economical magneto-optical storage medium.

INTRODUCTION

We have been studying the preparation process and applications of coating magneto-optical films [1][2]. Nano size particles of Bi-YIG have been dispersed in plastic binders on base films. The increase in the coercive force of the particles has been one of the major tasks in order to apply the films to recording media. The fine particles of garnet, however, require more effort to increase the coercive force than the thin films because of their low internal stresses [3][4].

Some high coercive force films have been prepared by dry processes [5][6] with a substrate temperature of more than about 500°C. Inexpensive plastic sheets can not be used as substrates. We can solve this thermal problem by employing the coating technique in film preparation processes.

In this paper, the magnetic and magneto-optical properties of Bi-RAlIG ($R_2BiAl_xFe_{5-x}O_{12}$ (R: Dy, Gd, Tb ; $0.0 \le x \le 1.5$)) particles and its coating films were investigated to develop high coercive force films.

EXPERIMENT

Preparation of the Bi-RIG particles

Bi-RAlIG particles were prepared by co-precipitation and annealing processes [7]. Fig.1 shows the preparation process of the particles. Aqueous solutions of nitrates of Bi, Dy, Gd, Tb, Al and Fe were mixed in order for the ratio of the cations to correspond to the composition of $R_2BiAl_xFe_{5-x}O_{12}$ (R: Dy, Gd, Tb ; $0.0 \le x \le 1.5$). The solution was mixed with a NaOH solution with stirring at room temperature. After the coprecipitation reaction, the pH of the solution was 12 ~ 13. The obtained slurry was washed, filtered and dried at 300°C for 1.5h. Then the coprecipitate was heated in air at 700°C for 4h. The crystal phases of

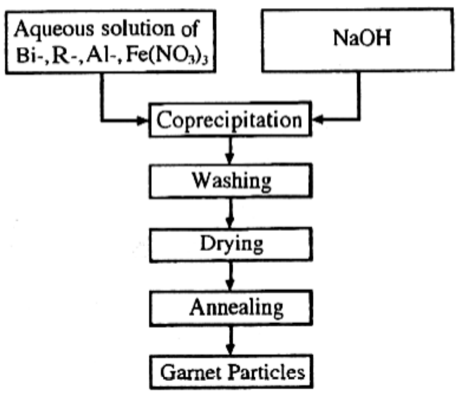

Fig.1 The preparing process of the particles.

the particles were examined by x-ray diffraction analysis.

Preparation of the coating films

The particles were mixed with an epoxy binder (Epo-tek 396 ; Epoxytechnology), dissolved in a cyclohexanone and milled with a planetary milling machine (Pulverisette 7 ; Fritsch) for 30h. They were then coated by a spin coater on Corning 7059 glass. The thickness of the films was about 2μm. It was controlled by the viscosity of the ink and the rotation speed of the spin coater. The films were dried at 80°C for 1h in an oven. The volume content of the particles in the coating films was about 0.2.

The magnetic properties of the films were measured with a vibrating sample magnetometer (VSM) Faraday rotation θ_F was measured by the polarization modulation method. The absorption coefficient α was measured with a spectrophotometer.

RESULTS

Magnetic properties of the particles

Figure 2 shows the relations between the lattice constants of the Bi-RAlIG particles and Al contents of the coprecipitates. The relations show straight lines to Al content of the coprecipitates. The slopes of the relations are the same. These results suggest that the Al substitutions to the garnet crystal are proportional to x in these regions.

Figure 3 and 4 show the saturation magnetization M_S and coercive force H_C of the Bi-RAlIG particles. The M_S of the particles decreased with x. The M_S was less than 1 emu/g at the compositions of 0.8 < x < 1.0 (R:Dy), 0.6 < x < 0.8 (R:Tb) and 0.4 < x < 0.6 (R:Gd). The Bi-RAlIG

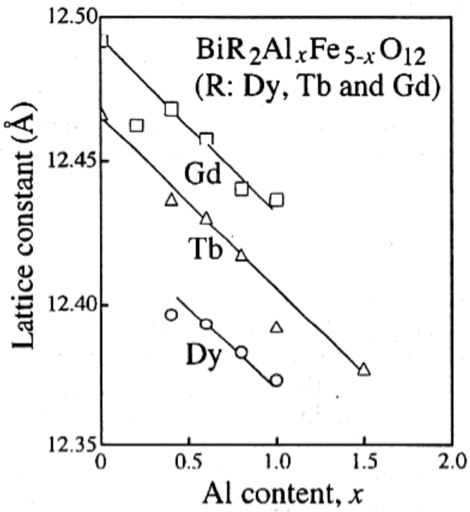

Fig.2 The relation between the lattice constant and the composition on the particles.

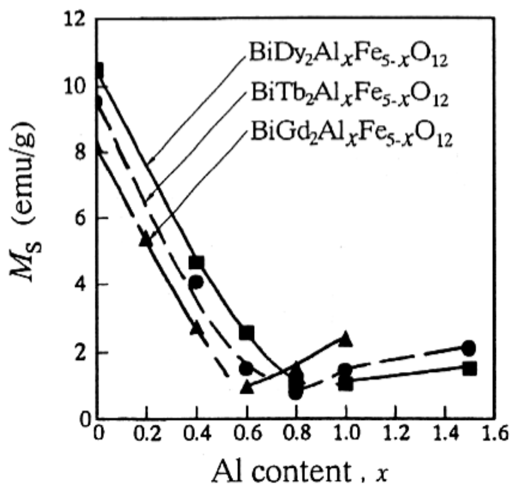

Fig.3 The relation between the M_S and Al content x of the Bi-RAlIG particles.

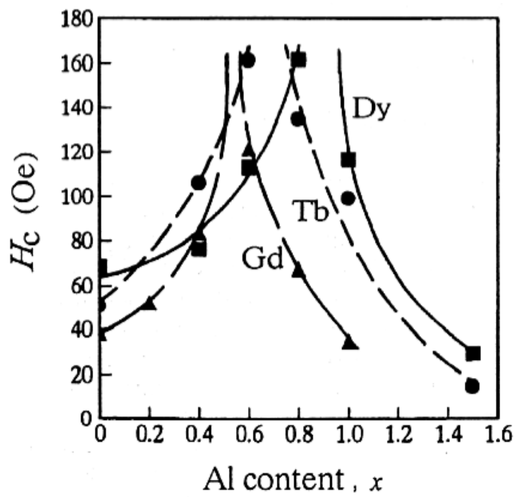

Fig.4 The relation between the H_C and Al content x of the Bi-RAlIG particles.

particles have magnetic compensation at these compositions x. The H_C of the particles was increased at those compositions. The H_C for the composition of $BiDy_2Al_{0.8}Fe_{4.2}O_{12}$ and $BiTb_2Al_{0.6}Fe_{4.4}O_{12}$ is about 160 Oe. Those values are about 5 times larger than that of the Bi-YIG particles[1].

Magnetic properties of the coating films

Figures 5, 6 and 7 show the *M-H* loops of the Bi-RAlIG coating films. The Figures (a) show the *M-H* loops of the Bi-RIG coating films which have no Al substitution. The H_C of the Bi-RIG coating films is about 30 ~ 50 Oe which is the same value as that of the particles. The Figures (b) show the *M-H* loops of the Bi-RAlIG which have $x = 0.8$ (R:Dy), 0.6 (R:Tb) and 0.6 (R:Gd). The H_C of the Bi-RAlIG coating films have about 200 Oe.

As indicated in these figures, we measured the difference between the in-plane M_S and perpendicular M_S. The reason is not clear but we measured the difference in all measurements. We presume that the difference belongs to the films which are dispersed materials.

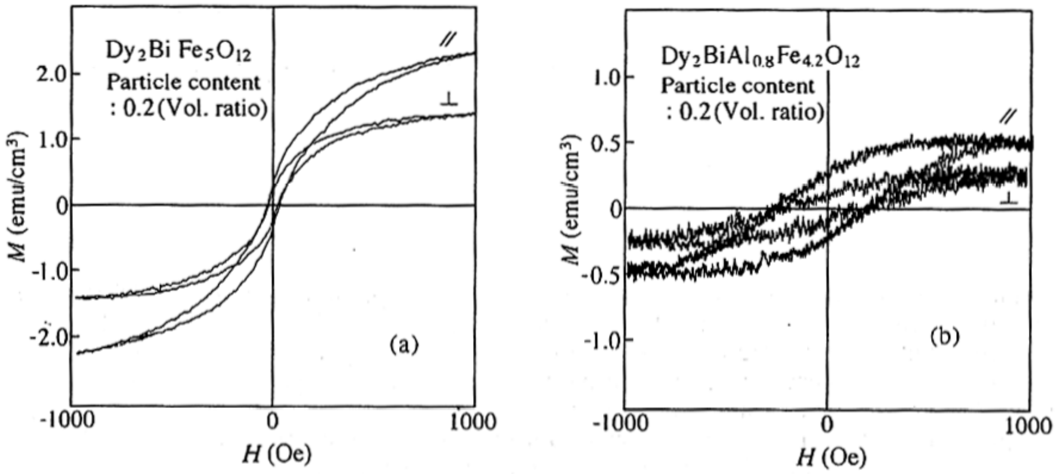

Fig. 5 The *M-H* loops of the Bi-DyAlIG coating films.

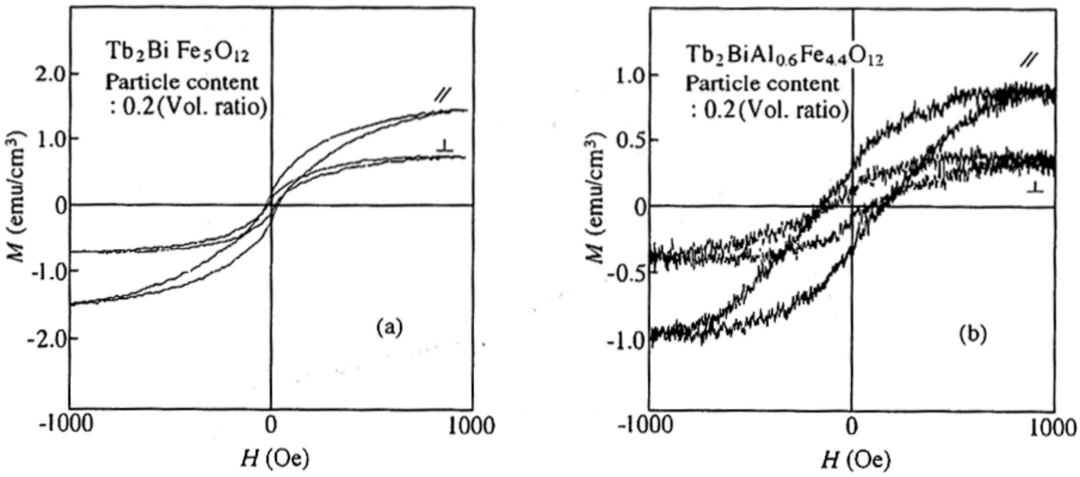

Fig. 6 The *M-H* loops of the Bi-TbAlIG coating films.

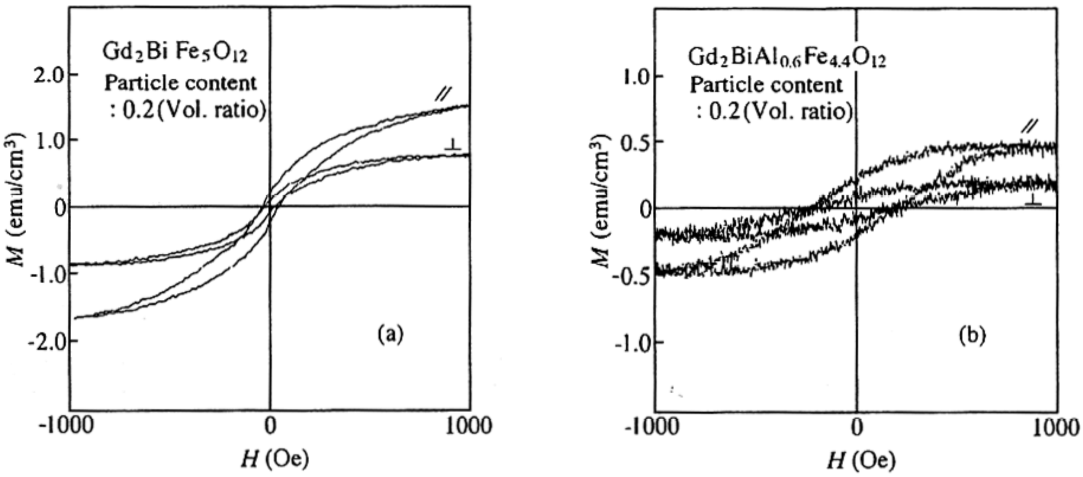

Fig. 7 The *M-H* loops of the Bi-GdAlIG coating films.

Magneto-optical properties of the coating films

Figure 8 shows the Faraday rotation spectra and absorption spectra of the Bi-RIG coating films. In the figures, we show the figure of merit θ_F/α of the films at 520 nm. The figures of merit are about 0.5 ~ 1 (degree). We can expect that the figures of merit will be 2~3 times larger than those of these films, because the volume ratios of the particles in the films are only about 0.2. However, increasing the volume ratio is not difficult.

Figure 9 shows the Faraday rotation spectrum and absorption spectrum of the $BiTb_2Al_{0.6}Fe_{4.4}O_{12}$ coating film. Although the film has Faraday rotation, it has small M_S. The figure of merit θ_F/α of the film at 520 nm is about 0.5. These results indicate that the coating films have the potential to develop into a new economical magneto-optical recording medium.

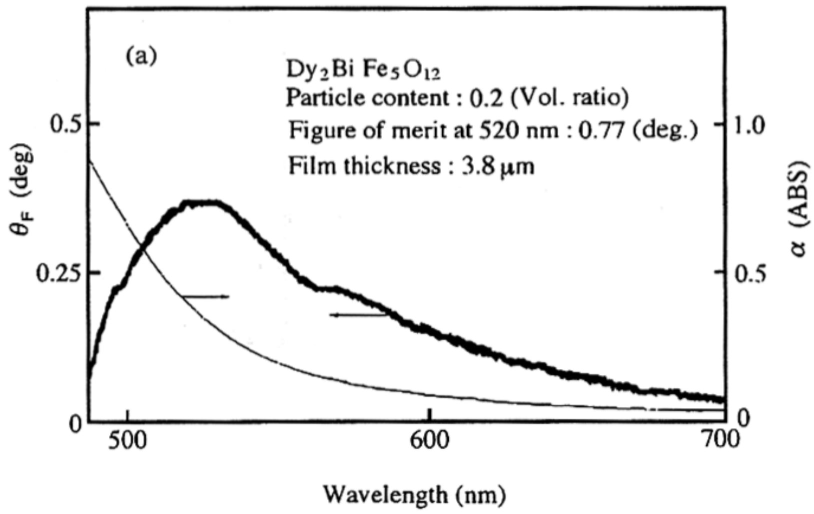

Fig.8(a) Faraday rotation spectrum and absorption spectrum of the Bi-DyIG coating film.

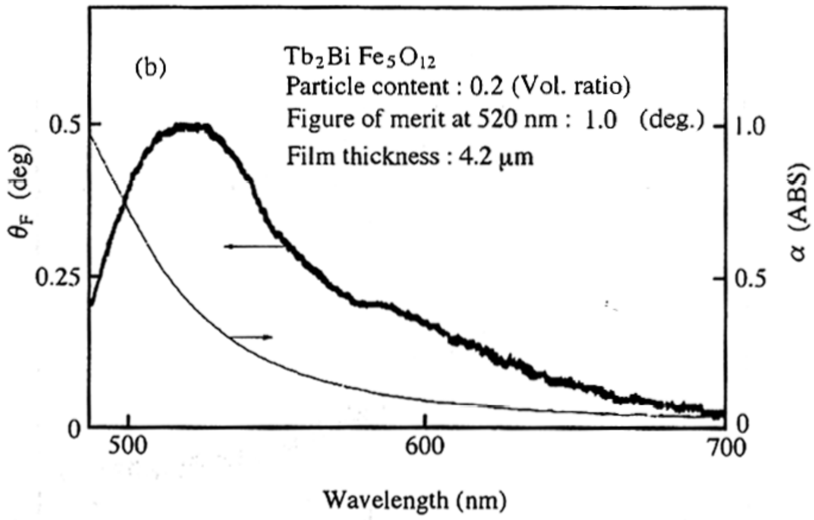

Fig.8(b) Faraday rotation spectrum and absorption spectrum of the Bi-TbIG coating film.

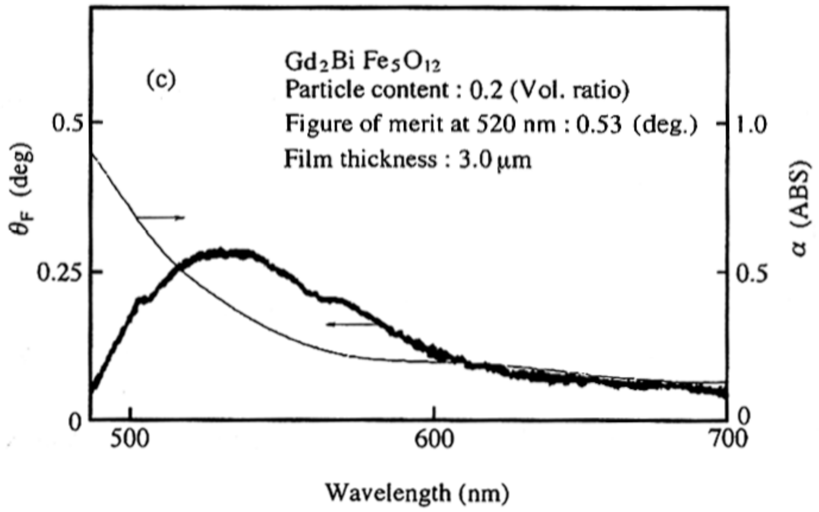

Fig.8(c) Faraday rotation spectrum and absorption spectrum of the Bi-GdIG coating film.

IV. CONCLUSIONS

Nano-size Bi-RAlIG particles were synthesized by coprecipitation and annealing processes. Thin films of the particles were prepared by coating methods with the ink made by a milling process. The magnetic and magneto-optical properties of the particles and films were measured.
The H_C of the Bi-RAlIG particles increased with decreasing M_S of the particles. The H_C of the particles were about 160 Oe when the M_S were almost zero.
The Faraday rotation θ_F of the Bi-RIG and Bi-RAlIG (R = Dy, Tb and Gd) films were measured. The figure of merit θ_F/α of the $BiTb_2Al_{0.6}Fe_{4.4}O_{12}$ coating film is about 0.5 at 520 nm. These results show that the coating $BiTb_2Al_{0.6}Fe_{4.4}O_{12}$ film is one of the candidate materials for a new, economical magneto-optical storage medium.

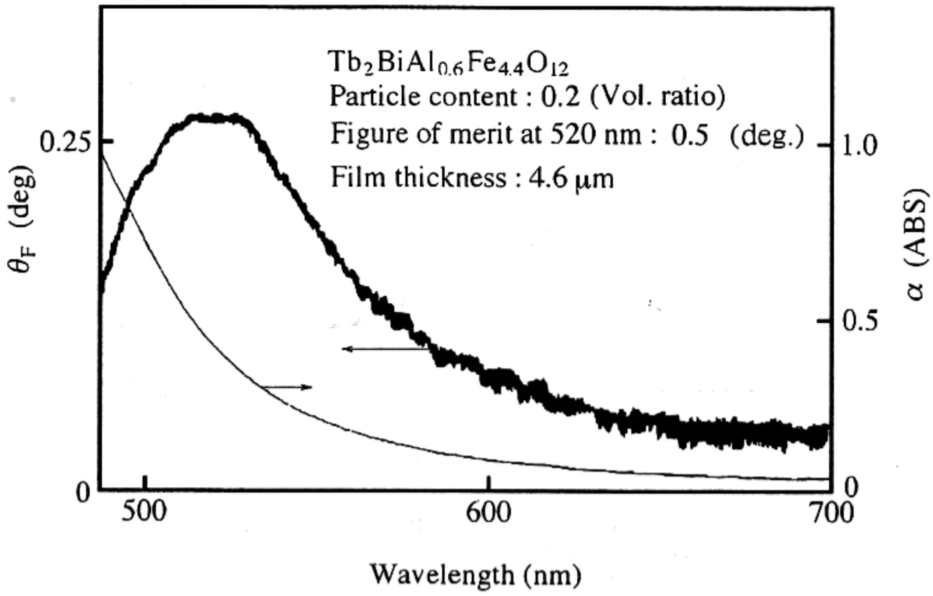

Fig.9 Faraday rotation spectrum and absorption spectrum of the $Tb_2BiAl_{0.6}Fe_{4.4}O_{12}$ coating film.

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