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Magneto-optical properties of barium ferrite sputtered films

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Abstract. Barium ferrite thin films with perpendicular anisotropy were grown on (111) oriented GGG substrate by rf diode sputtering method. Their magnetic properties were measured. Faraday rotation was measured in the wavelength range 460–800 nm for such sputtered thin films. These films were found quite suitable for magneto-optical recording applications.

Keywords. Magneto-optical rotation; Faraday rotation; barium ferrite; rf sputtering; X-ray diffraction; vibrating sample magnetometer.

1. Introduction

Today, engineers and scientists involved in designing and developing recording systems must choose between advancing old technologies and developing new technology to achieve higher recording densities. During the first twenty years of history magnetic recording relied heavily on particulate iron-oxide media and bulk ferrite materials and recording heads. Today there is serious contention between proponents of particulate, metallic thin films and sputtered oxide-recording media. Nevertheless new recording technologies such as optical recording are making inroads into the market place. These technologies which use focussed laser beams to access bits can today be made with much narrower trackwidths than the conventional magnetic recording and bit densities of the order of $10^8/cm^2$ have been demonstrated. Using magneto-optic media such optical recording technology (Gomi *et al* 1988; Kucera *et al* 1989) could be made erasable and have all the features of present-day magnetic recording as well as the high bit densities of optical recording.

Barium ferrite thin films have a large magneto-optic rotation (Corradi *et al* 1989; Kaneko *et al* 1987) and are expected to be used as the next generation magneto-optical (MO) disk materials. It is a hexagonal ferrite with magneto-plumbite structure and the films from this material are expected to be better perpendicular magnetic films because of their large crystalline anisotropy. Such oxide materials exhibit high corrosion resistance to attain high reliability.

In this study, we have successfully grown barium ferrite thin films by rf sputtering. Faraday rotation and magnetic properties of barium ferrite thin films have been measured. Such films exhibit strong magneto-optical effect in the short wavelength region. The value of Faraday rotation measured for some of the films was $0{\cdot}72 \times 10^4$ deg/cm at 530 nm.

2. Experimental

Barium ferrite thin films were prepared by rf diode sputtering in pure argon gas. The substrate used for the film growth was (111)-oriented $Gd_3Ga_5O_{12}$ (GGG) single

Table 1. Sputtering conditions for barium ferrite thin film.

Base pressure	5×10^{-7} torr
Discharge current	270 mA
Argon gas pressure	50 m torr
Deposition rate	210 Å/min
Substrate temperature	590°C
Substrate	GGG (111)

Table 2. Composition, thickness, Faraday rotation and magnetic properties of a typical sample BaF-46.

Composition	$Ba_{0.92}Fe_{12}O_{19}$
Thickness	0·6 μm
Faraday rotation	0.72×10^4 deg/cm
M_s (perpendicular to film plane)	362 emu/cm³
H_c (perpendicular to film plane)	1400 Oe

crystal (25 × 20 mm in size) which were heated up to 580°C during sputtering. Ceramic targets were used with the stoichiometric barium ferrite compositions of $BaFe_{12}O_{19}$ and $Ba_{1.14}Fe_{12}O_{19}$ (barium overdosed). Table 1 shows typical sputtering conditions. The chemical composition of the films was analysed by an induction coupled plasma (ICP) method. Magnetic properties such as coercive force (H_c) and saturation magnetization (M_s) of the films in perpendicular direction were measured by vibrating sample magnetometer. Table 2 represents the composition, thickness, Faraday rotation and magnetic properties of a typical sample out of the many samples prepared. Faraday rotation of the films was measured at room temperature by polarization modulation method using a monochromator.

3. Results and discussion

X-ray diffraction analysis (figure 1) showed that the films were polycrystalline with magnetoplumbite type barium ferrite structure exhibiting a preferred orientation along C-axis with the presence of (006), (008), (200) and (220) lines. Most of the films showed saturation magnetization values in perpendicular direction to the plane of the film which was close to the value of bulk barium ferrite material as shown in figure 2. Saturation magnetization value 362 emu/cc in thin film was obtained from overdosed barium target, as barium ferrite film grown by this target gave stoichiometry close to $BaFe_{12}O_{19}$ composition (table 2).

To confirm the magneto-optical behaviour of the thin films Faraday rotation spectra of different barium ferrite films were measured. The peak value of Faraday rotation in $Ba_{0.92}Fe_{12}O_{19}$ thin film was as large as 0.72×10^4 deg/cm at 530 nm wavelength.

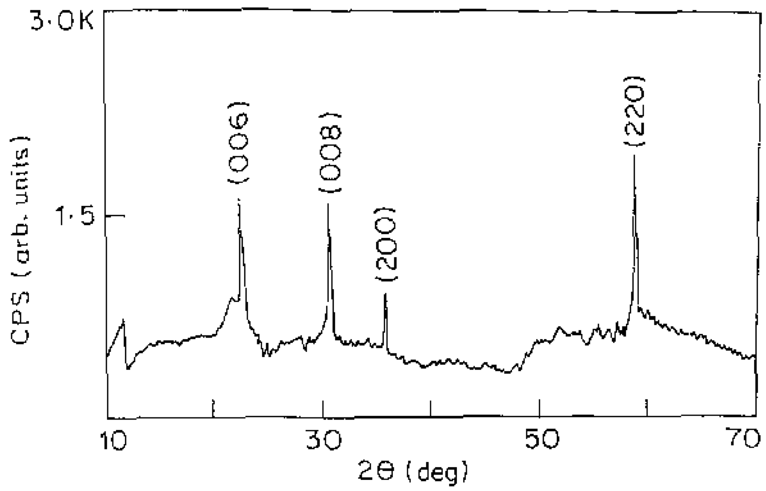

Figure 1. X-ray diffraction pattern of $Ba_{0.92}Fe_{12}O_{19}$ film.

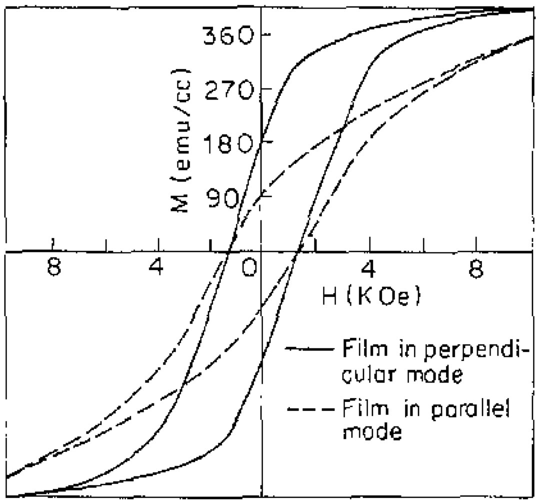

Figure 2. B–H loop in perpendicular and parallel mode for the $Ba_{0.92}Fe_{12}O_{19}$ film.

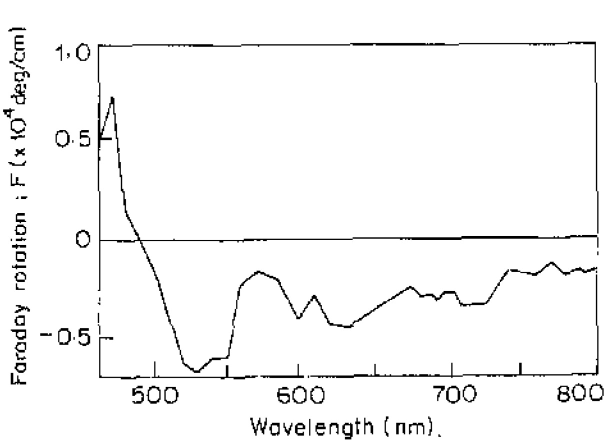

Figure 3. Faraday rotation of the barium ferrite thin film in the wavelength range 460–800 nm.

4. Conclusions

Good quality barium ferrite thin films showing magnetization in perpendicular direction to the plane of the films were grown. These films which were magneto-optically active were useful for magneto-optical recording.

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