Journal of Magnetism and Magnetic Materials 35 (1983) 181–182
North-Holland Publishing Company

MAGNETO-OPTICAL SPECTRA OF RF-SPUTTERED AMORPHOUS Gd–Co AND Gd–Fe FILMS

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Spectra of polar magneto-optical effects of Gd–Co and Gd–Fe have been studied; Kerr rotation increases gradually from the visible to the near ir region with a hump around 1 eV and Kerr ellipticity changes sign at a certain photon energy, which depends on sputtering conditions.

Recently, amorphous rare earth-transition metal alloy films have attracted growing interest as thermomagnetic recording media [1,2]. In such a system the magneto-optical Kerr effect is employed for a readout of recorded signals.

In order to establish the most efficient wavelength for the readout, we measured the Kerr rotation ϕ_K and Kerr ellipticity η_K on Gd–Co and Gd–Fe films.

Amorphous Gd–Co and Gd–Fe films were prepared on glass substrate (50 mm × 50 mm) by means of the rf-sputtering technique. Details of sputtering conditions have been published elsewhere [3].

Spectra of ϕ_K and η_K were measured by means of the polarization modulation technique [4]. The magnetic field up to 1.5 kOe was applied perpendicular to the surface of the film. All measurements were carried out through the substrate glass, to get the same condition as used in our magneto-optical recording system [1]. To avoid the Faraday rotation due to the substrate material, spectra were measured at the remanence magnetization.

Near normal incidence reflectivity spectrum of Gd–Co film was measured through the substrate glass by using an apparatus previously described [5].

In fig. 1 are shown typical spectra of ϕ_K, η_K and the reflectivity R of a Gd–Co film prepared with the bias voltage of −100 V during sputtering. Kerr rotation increases slightly from the visible to the near infrared showing a hump around 1 eV, followed by a sudden decrease below 1 eV. The curve for the visible region is consistent with the data published by other authors [6,7]. The peak value of ϕ_K was about 24 min.

The resultant spectral response, which is the product of the reflectivity, R, the Kerr rotation, ϕ_K, and the photoresponse of an Si photodetector, S, has a maximum at about 0.9 μm. This shows that the near infrared semiconductor laser is favorable for the magneto-optical readout.

The spectrum of η_K of Gd–Co shows a characteristic

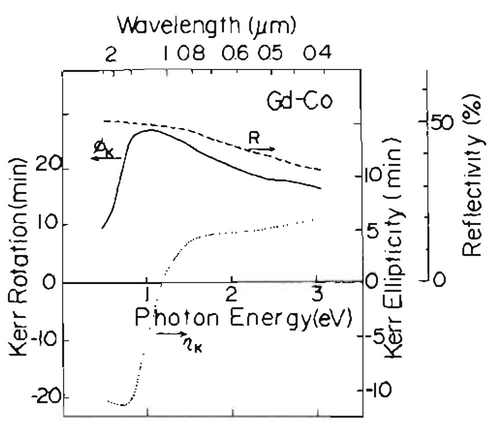

Fig. 1. Kerr rotation ϕ_K, Kerr ellipticity η_K, and reflectivity R of Gd–Co film measured through substrate glass. Solid curve: ϕ_K, dotted curve: η_K, and dashed curve: R.

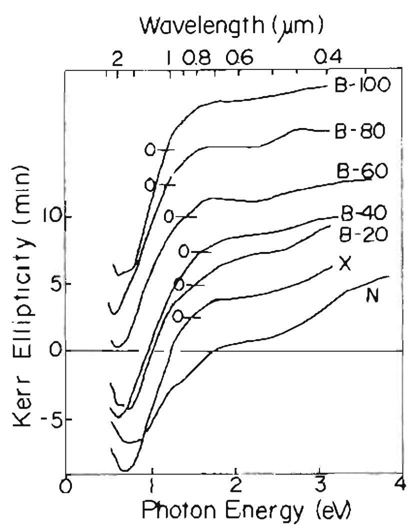

Fig. 2. Kerr ellipticity spectra of amorphous Gd–Co films prepared under various sputtering conditions. About symbols, N, B, and X, see the text. Zero-level of each curve is shifted by arbitrary amount for the sake of clarity.

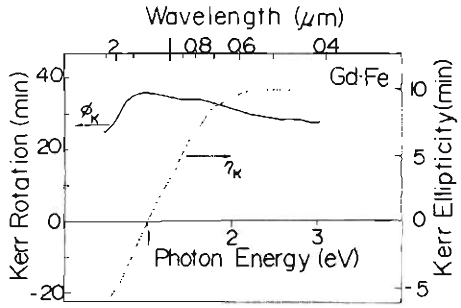

Fig. 3. Kerr rotation spectrum and Kerr ellipticity spectrum of a Gd–Fe film. Solid curve: ϕ_K and dotted curve: η_K.

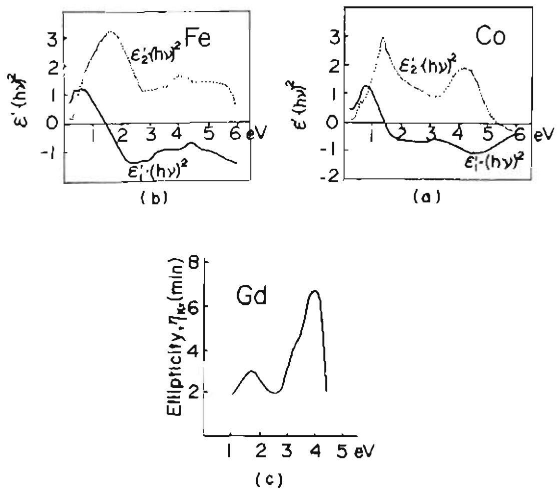

Fig. 4. Magneto-optical spectra of (a) Co; (b) Fe; (after Krinchik and Artemjev [8]), and (c) Gd; (after Erskine and Stern [9]).

zero-crossing behavior at a certain photon energy E_0 between 1 and 2 eV. Fig. 2 illustrates how the sputtering condition affects the Kerr ellipticity spectrum of the Gd–Co film. In this figure N denotes the non-biased film, B the biased film with the number behind B representing the applied bias voltage, and X the film prepared with the bias voltage of -100 V and with oxygen at 2×10^{-6} Torr introduced during sputtering. With low bias voltage E_0 has a value higher than 1.5 eV, which differs from sample to sample. On the other hand, when the bias voltage exceeds a certain critical value (~ 60 V) E_0 takes a value around 1.2 eV and becomes less sample-dependent. The value of E_0 for the film X was very close to that of B-20. From this experiment we tentatively conclude that the magneto-optical spectrum inherent to Gd–Co is not the one measured on the non-biased film but the one on the biased film. The former suffers an influence of oxidization. The role of the applied dc-field may be to get rid of the native oxygen by the re-sputtering process as has been pointed out in the previous paper [3].

In fig. 3 typical spectra of ϕ_K and η_K of a Gd–Fe film are shown. Kerr rotation of the Gd–Fe film gradually increases from the visible toward the near infrared showing a hump around 0.9 eV, which is followed by an abrupt decrease below 0.8 eV. The peak value of ϕ_K is about 35 min, which is nearly 40% larger than the value observed in Gd–Co film. Kerr ellipticitiy η_K of Gd–Fe has a larger value above 1 eV than that of Gd–Co. Kerr rotation of Gd–Fe decreases as the film becomes oxidized. In such a case a value of η_K becomes comparable or even greater than that of ϕ_K. It is found that insertion of a quarter-wave plate can improve the output SNR in this case, since the maximum improvement is given by $(\phi_K^2 + \eta_K^2)^{1/2}/\phi_K$ if the insertion loss is neglected.

Finally, we give a brief comment on the origin of the magneto-optical effect of Gd–Co and Gd–Fe films. In fig. 4 are reproduced the magneto-optical spectra of Fe and Co published by Krinchik and Artemjev [8], and Gd published by Erskine and Stern [9]. In this figure ϵ_1' and ϵ_2' stand for real and imaginary parts of the off-diagonal element of the dielectric tensor. It can be assumed that ϵ_1' corresponds to η_K and ϵ_2' to ϕ_K. By comparing this figure with figs. 1 and 3, we can see the close resemblance of line shapes between the curves of Gd–transition metal film and those of the corresponding transition metal. The Kerr ellipticity of Gd does not change its sign between 1 eV and 5 eV. This spectrum differs from that of the characteristic behaviour of those of Gd–Co and Gd–Fe. We therefore conclude that the magneto-optical effect of amorphous Gd–transition metal films in the visible and near infrared region essentially derives from the magneto-optical polarizability of the transition metal atom.

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