MAGNETO-OPTICAL CHARACTERISTICS OF Tb-Fe-Co LAYERS COVERED WITH PERPENDICULAR MAGNETIC Co-Cr LAYERS

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Abstract – The bilayers composed of Tb-Fe-Co and Co-Cr alloy layers have been prepared by using a facing targets sputtering apparatus. The specimen films revealed apparent magnetic coupling between ferrimagnetic Tb-Fe-Co and ferromagnetic Co-Cr layers. The bilayers revealed Kerr rotation angle as large as 0.6 deg. at the wavelength of 633 nm.

KEYWORDS: Tb-Fe-Co thin film, Co-Cr thin film, facing targets sputtering, magneto-optical recording, perpendicular magnetic recording

EXPERIMENT

INTRODUCTION

Nowadays, many researchers and engineers have been engaged with investigation of the interaction between magnetic multilayers. It is very important to clear these phenomena for developing and designing artificial materials with useful new characteristics. In this study, Tb-Fe-Co and Co-Cr bilayers have been prepared sequentially in order to investigate the interfacial effect between the layers. Ferrimagnetic amorphous Tb-Fe-Co and ferromagnetic crystalline Co-Cr layers were famous about the usage of magneto-optical and perpendicular magnetic recording media with high perpendicular magnetic anisotropy energy [1]. Some interesting results would be introduced in this paper.

The Tb-Fe-Co/Co-Cr bilayered films were sequentially deposited on plasma-free glass slide substrates by using a facing targets sputtering apparatus [2,3]. The compositions of the films were fixed about $\text{Tb}_{20}(\text{Fe}_{90}\text{Co}_{10})_{80}$ and $\text{Co}_{82}\text{Cr}_{18}$. Each layer was deposited at the argon pressure P_{Ar} of 0.5 mTorr and the deposition rate R_d of 100 nm/min. The thickness t_{MO} of magneto-optical Tb-Fe-Co layers was changed in the range between 5 to 300 nm and the thickness $t_{\text{Co-Cr}}$ of the perpendicular magnetic recording Co-Cr layers was fixed at 100 nm.

The Internal stress of specimen films was measured by bending beam method reviewed by Blackburn and Campbell [4]. The magnetic and magneto-optical characteristics have been investigated by using a vibrating sample magnetometer (VSM), a torque magnetometer and Kerr loop tracer.

RESULT AND DISCUSSION

Figure 1 shows the compressive internal stress $|\sigma_i|$ of Tb-Fe-Co/Co-Cr bilayers dependent on t_{MO} with t_{Co-Cr} of 100 nm. The compressive stress reduced with increasing t_{MO} .

Fig. 1. compressive internal stress $|\sigma_i|$ of Tb-Fe-Co/Co-Cr bilayers dependent on t_{MO}

Fig. 2. Distance of (001) plane d_{001} of crystalline Co-Cr layer dependent on t_{MO}

The x-ray diffraction pattern of specimen bilayers revealed a (001) peak of hexagonal Co-Cr layers. Figure 2 and 3 show the distance of (001) plane d_{001} and the crystal size $\langle D \rangle_{001}$ of Co-Cr crystalline dependent on t_{MO} . The d_{001} of bilayers increased to the value of 2.038 Å from 2.033 Å of Co-Cr single layer. The $\langle D \rangle_{001}$ decreased from 330 Å to 220 Å. The crystal size of Co-Cr single layer was restricted by bilayer. And the degree of crystal orientation $\Delta\theta_{50}$, which was estimated by the full width of half maximum of the (001) rocking curve, increased from 8 deg. to 10 deg., as illustrated in Fig. 4.

Figure 5 shows the magnetization curves of (a) Tb-Fe-Co single layer with t_{MO} of 30 nm, (b) Co-Cr single layer with t_{Co-Cr} of 100 nm and (c) Tb-Fe-Co/Co-Cr bilayer with t_{MO} and t_{Co-Cr} of 30 and 100 nm, respectively, where ($\perp$) and solid line represent the hysteresis loops observed for fields applied in the direction perpendicular to the layer plane, on the other hand ($\parallel$) and dashed line represent the in-plane loop.

Fig. 3. Crystal size $\langle D \rangle_{001}$ of crystalline Co-Cr layer dependent on t_{MO}

Fig. 4. Degree of crystal orientation $\Delta\theta_{50}$ of Co-Cr layer dependent on t_{MO}

Fig. 5. M-H curves of (a) Tb-Fe-Co (b) Co-Cr single layers and (c) Tb-Fe-Co/Co-Cr bilayer

The specimen bilayers showed a sharp rectangular perpendicular hysteresis loop with the coercivity H_c almost same as that of the Tb-Fe-Co single layer, where the side of the loop was slightly sloped, but the in-plane hysteresis loop exhibited larger H_c than those of Tb-Fe-Co and Co-Cr layers.

Figure 6 shows the t_{MO} dependence of θ_K for Tb-Fe-Co/Co-Cr and the Kerr hysteresis loops observed from the substrate side at the wavelength λ of 633 nm. θ_K of these bilayer took maximum of 0.6 deg. at t_{MO} of about 30 nm. The Kerr hysteresis loops of bilayers with semihard magnetic Co-Cr overlayers with t_{MO} more than 25 nm revealed rectangular loop shape. The loop shape became similar to that of Co-Cr layers with decrease of t_{MO} .

Figure 7 shows the reflectivity R of Tb-Fe-Co/Co-Cr bilayers observed from the substrate side at λ of 633 nm. Higher R of Co-Cr single layer decreased with increasing t_{MO} from 60 to

Fig. 6. t_{MO} dependence of Kerr rotation θ_K of Tb-Fe-Co/Co-Cr bilayers

Fig. 7. t_{MO} dependence of reflectivity R of Tb-Fe-Co/Co-Cr bilayers

the minimum value of 37 % at t_{MO} of about 30 nm, and it increased with increasing t_{MO} and converged about 49 %, which is the R of single Tb-Fe-Co layer.

CONCLUSIONS

Tb-Fe-Co/Co-Cr bilayers composed of amorphous Tb-Fe-Co and crystalline Co-Cr

layers have been prepared by using a facing targets sputtering apparatus. Results are as follows;

- (1) The specimen bilayers shows large Kerr rotation angle of 0.6 deg. at t_{MO} of about 30 nm.
- (2) The bilayers revealed poor degree of crystal orientation $\Delta\theta_{50}$ of about 10 deg.
- (3) The normal magnetization curve seems a simple superposition of each M-H curves, but the change of shape and H_c of the in-plane M-H curve implies a kind of magnetic interaction between Tb-Fe-Co and Co-Cr layers.

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