EFFECT OF PARAMAGNETIC CO₆₇Cr₃₃ INTERMEDIATE LAYER ON LONGITUDINAL RECORDING MEDIA WITH FERROMAGNETIC CO₈₃Cr₁₇/Cr BILAYERED FILM

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Abstract—In order to clarify the magnetic properties of the initial growth region of Co₈₃Cr₁₇ layers deposited on Cr underlayers, very thin paramagnetic Co₆₇Cr₃₃ intermediate layers, which possess the almost same crystallographic characteristics as Co₈₃Cr₁₇ layer, were deposited as the intermediate layer between Co₈₃Cr₁₇ and Cr layers. The paramagnetic Co₆₇Cr₃₃ intermediate layers were effective to control the magnetic characteristics in the initial growth region of the Co₈₃Cr₁₇ layer deposited on the 2000 Å-thick Cr underlayer. The trilayered films with 50 Å-thick Co₆₇Cr₃₃ intermediate layer revealed higher Hc// and small SFD.

Key words: longitudinal recording media, initial growth region, Co₆₇Cr₃₃ intermediate layer, in-plane coercivity, switching field distribution

1. INTRODUCTION

Co-Cr/Cr bilayered films are commonly used for longitudinal magnetic recording media. It is well known that (110) oriented Cr underlayer tends to orient the c-axis of Co-based alloy crystallites to in-plane direction, due to the effect of hetero-epitaxial growth [1]. In order to achieve higher linear density for longitudinal recording media, it is required to increase in-plane coercivity and to decrease the thickness of the recording layer [2]. However, it has been found that the in-plane coercivity Hc// of the bilayered films decreased with decrease of the ferromagnetic layer thickness. This fact indicates that there is an apparent distribution of the magnetic characteristics through thickness direction in ferromagnetic Co-Cr layers. In order to increase Hc//, the influence of the initial growth region, which seems to play an important role of revealing such a distribution, should be clarified in more detail. Then, it is required to clarify the dependence of intrinsic magnetic properties in the very thin initial growth region of Co-Cr layer deposited on Cr underlayer on the distance from the interface between Co-Cr and Cr layers. It is useful to deposit paramagnetic Co₆₇Cr₃₃ layer with the hcp lattice, which is the same as that of ferromagnetic Co₈₃Cr₁₇ layers, between Cr underlayer and Co₈₃Cr₁₇ ferromagnetic layers in order to clarify such a distribution of magnetic properties. Since Co₆₇Cr₃₃ layers possess the almost same crystallographic characteristic as ferromagnetic Co₈₃Cr₁₇ layers and reveal paramagnetic properties at room temperature, these layers were used as the intermediate layers to eliminate the ferromagnetic behavior in the initial growth region as described above. On the other hand, for Co-Cr-Pt recording media, it has been found that a thin Co-Cr-Ta layer between a Co-Cr-Pt recording layer and a Cr underlayer improved the in-plane magnetic properties of Co-Cr-Pt layer [3]. For Co-Cr-Ta recording layer, it was reported that paramagnetic Co-Cr intermediate layer is effective to improve the lattice matching between Cr underlayer and Co-Cr-Ta recording layer [4]. This kind of intermediate layers have a high potential to improve the magnetic characteristics of recording layers. In this study, very thin paramagnetic Co₆₇Cr₃₃ layers were deposited as the intermediate layer between Co₈₃Cr₁₇ and Cr layers. The magnetic and crystallographic characteristics of these films were investigated in detail.

II. EXPERIMENT

All specimen films were deposited on the substrates of silicon (100) wafer at room temperature using the facing targets sputtering (FTS) apparatus. This apparatus can deposit very smooth and dense thin layers on plasma-free substrates at high mobility of adatoms without undesirable damage to the depositing films caused by the bombardment of high energy particles [5]. The Ar gas pressure PAr was fixed at 0.6 mTorr. Deposition rates of Co₈₃Cr₁₇, Co₆₇Cr₃₃ and Cr layers were 230, 310 and 280 Å/min, respectively.
Fig. 1 shows a schematic illustration of Co₈₃Cr₁₇/Co₆₇Cr₃₃/Cr trilayered film. The thickness of recording layer δCo₈₃Cr₁₇ and that of intermediate layer δCo₆₇Cr₃₃ were varied in the range from 50 to 1000 Å and from 0 to 1000 Å, respectively.

The crystallographic characteristics were determined by Cu-Kα X-ray diffractometry (XRD). The magnetic properties which include the switching field distribution (SFD) were measured by using a vibrating sample magnetometer (VSM).

III. RESULTS AND DISCUSSION

Fig. 2 shows the XRD diagrams of Co₈₃Cr₁₇/Co₆₇Cr₃₃/Cr trilayered films and Co₈₃Cr₁₇/Cr(2000 Å) bilayered films. The low diffraction peaks corresponding to hcp-Co(101) were identified for all films. It was recognized that the c-axis of Co₆₇Cr₃₃ crystallites in the intermediate layer were aligned in almost same direction as the c-axis of Co₈₃Cr₁₇ crystallites in recording layer when they were reposited on Cr underlayers. However, observations of M-H hysteresis loops of 50 Å-thick Co₈₃Cr₁₇ layers deposited on Co₆₇Cr₃₃ intermediate layer with different thickness imply that the perpendicular magnetic anisotropy appears in the film with thick Co₆₇Cr₃₃ intermediate layers. These results insists on that the Co-Cr layer, which is located far from the interface between Co-Cr and Cr layers, has crystallites with c-axis orientation perpendicularly to the film plane.

Fig. 3 shows the change of Hₜ of (a) Co₈₃Cr₁₇/Cr bilayers and (c) Co₈₃Cr₁₇/Co₆₇Cr₃₃(50 Å)/Cr trilayers as a function of the thickness of recording layer δCo₈₃Cr₁₇. The Hₜ values of (b) Co-Ni/Cr(2500 Å) bilayers for a function of Co-Ni layer thickness were also plotted as a reference.

Hₜ of each bilayered films were extremely dependent on the thickness of the recording layer. Especially, Hₜ of Co₈₃Cr₁₇/Cr bilayers drastically decreased with decrease of δCo₈₃Cr₁₇. The trilayered films with δCo₆₇Cr₃₃ of 50 Å exhibited higher Hₜ than the bilayered films at every δCo₈₃Cr₁₇ and Hₜ reduced gradually with increase of δCo₈₃Cr₁₇. It is recognized that the distribution of Hₜ through thickness direction in ferromagnetic layers was suppressed owing to use of the Co₆₇Cr₃₃ intermediate layer. The Co₆₇Cr₃₃ intermediate layer seems to be useful to increase Hₜ of the Co₈₃Cr₁₇ recording layer. In addition, the δCo₆₇Cr₃₃ dependences of Hₜ and SFD were also investigated.
Fig. 4. \( \delta \)Co67Cr33 dependences of \( H_{dl} \).

Fig. 4 shows the \( \delta \)Co67Cr33 dependences of \( H_{dl} \) of the trilayered films as illustrated schematically in the inset. \( H_{dl} \) of the 300 Å-thick Co83Cr17 layer increased drastically with increase of \( \delta \)Co67Cr33 up to 50 Å, while it was almost constant above 50 Å. On the other hand, \( H_{dl} \) of the 50 Å-thick Co83Cr17 layer deposited on Co67Cr33 intermediate layer with \( \delta \)Co67Cr33 below 50 Å also increased drastically with increase of \( \delta \)Co67Cr33, while it decreased with further increase of \( \delta \)Co67Cr33 above 50 Å. Then, maximum \( H_{dl} \) of both trilayered films were obtained at \( \delta \)Co67Cr33 of 50 Å. Assuming that elimination of the ferromagnetic behavior in only the initial growth region resulted in increase of \( H_{dl} \), the estimated thickness of initial growth region of Co83Cr17 layer should be less than 50 Å. These results explain well why trilayered films with \( \delta \)Co67Cr33 of 50 Å exhibited higher \( H_{dl} \) than the bilayered ones, as previously shown in Fig. 3.

Fig. 5 shows the change of the switching field distribution (SFD) of the trilayered films with 50 and 300 Å-thick Co83Cr17 layers as a function of \( \delta \)Co67Cr33. The trilayered film with the 300 Å-thick Co83Cr17 layer revealed sharp SFD for larger \( \delta \)Co67Cr33 than 50 Å. This reduction of SFD indicates that the uniform magnetization reversal mechanism existed in the Co83Cr17 layers deposited on the Co67Cr33 intermediate layers.

Comparing these \( \delta \)Co67Cr33 dependences of SFD for \( \delta \)Co67Cr33 between 50 and 300 Å-thick, it was found that the SFD of 50 Å-thick Co83Cr17 layer was more strongly dependent on \( \delta \)Co67Cr33. It seems that trilayered films with thinner Co83Cr17 layer revealed thickness dependence of magnetic characteristics in Co-Cr layer in more detail.

IV. CONCLUSION

In this study, very thin intermediate layers of paramagnetic Co67Cr33, which possess the almost same crystallographic characteristics as the recording layers of ferromagnetic Co83Cr17, were deposited between Co83Cr17 layer and Cr underlayer. The trilayered films with 50 Å-thick Co67Cr33 intermediate layer exhibited higher \( H_{dl} \) and smaller SFD. The Co67Cr33 intermediate layer may be effective to increase \( H_{dl} \) of the Co83Cr17 recording layers by suppressing the formation of the initial growth region with the undesired magnetic properties.

REFERENCES

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