THE EFFECT OF ADDITIONAL ELEMENTS IN Cr UNDERLAYER OF Co-Cr-Ta/Cr BILAYERED FILMS AT VARIOUS SUBSTRATE TEMPERATURE

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Abstract --- In this study, the dependence of crystal structure on substrate temperature T_s and the effect of additional elements such as Ta, Ge, Si and Co in the Cr underlayer of CoCrTa/Cr-M bilayered films have been investigated. Specimen films were prepared at the Argon gas pressure P_{Ar} as low as 0.1 to 2 mTorr by using Facing Targets Sputtering(FTS) apparatus. The amount of additional elements in Cr underlayer were controlled by constructing the composited targets. Cr-Ta and Cr-Ge films exhibited orientation of bcc(110) phase of Cr($Cr_{bcc(110)}$ phase) only, however Cr-Co and Cr-Si films showed both $Cr_{bcc(110)}$ and $Cr_{bcc(200)}$ phase. CoCrTa/Cr-Ta films had almost constant coercivity H_c of 500 Oe and H_c of CoCrTa/Cr-Co films increased with increase of T_s and reached about 1000 Oe at T_s of 300 °C.

INTRODUCTION

CoCr alloy are very famous for perpendicular magnetic recording media, it can also be applied for longitudinal media with Cr underlayer[1]. As the in-plane coercivity of CoCr/Cr films are lower than that of required value for longitudinal media additional third elements in CoCr layer was investigated[2],[3]. It has been proposed that CoNiCr or CoPtCr alloy on Cr or CrV underlayer have relatively high coercivity.

In this study, the dependence of crystal orientation on additional element in Cr underlayer of CoCrTa/Cr-M(M: Ta, Ge, Si, Co) bilayered film and measurement of H_c of these films were investigated.

EXPERIMENTAL PROCEDURE

Specimen films were prepared by using FTS apparatus for bilayered films as shown in Figure 1. The discharge plasma can be confined between two facing targets by magnetic field which applied

perpendicularly to the target and the substrate holder is placed outside the plasma, therefore the growing films are not exposed to the plasma and sputtered particles are deposited at low working gas

Fig.1 A sketch of Facing Targets Sputtering apparatus for doublelayered film.

pressure with high energy for crystalline. By using this system, dense, columnless and high crystallinity films with very flat surface can be prepared. The applied magnetic field were about 230 gauss at the middle point of facing targets and then the distance between the targets were 170 mm.

The composition of underlayer were controlled by adjusting the number and size of addition element chips inserted into grooves of Cr target plane. Specimen films were deposited on 7059 glass slide substrate after the chamber was evacuated below 5×10^{-7} Torr. The substrate temperature T_s were changed in the range of 20 to 300 °C and input power were about 500 W. The CoCrTa magnetic layer thickness was fixed at 500 Å and Cr-M underlayer thickness were ranged 500 to 1500 Å. The crystal structure and magnetic properties of films were checked by a x-ray diffractometer with Cu-K α radiation and a vibrating sample magnetometer, respectively.

RESULT AND DISCUSSION

Crystal Orientation of CoCrTa/Cr bilayer

Figure 2(a),(b) and (c) show the x-ray diffraction diagrams for various T_s of Cr film 1000 Å thick, Co₈₅Cr₁₃Ta₂ film 1000 Å thick and the bilayered film composed of 500 Å thick each layer, respectively.

In Figure 2(a), Cr_{bcc}(110) phase shifted to Cr_{bcc}(200) phase which is more stable energetically at T_s of above 200 °C. The intensity of Co_{hcp}(002) phase of CoCrTa films were decreased drastically at T_s of above 200 °C (Figure 2(b)). The crystallinity of Co-alloy film seems to be deteriorated thermally in these temperature region. In the case of the bilayered film of these layers, as shown Figure 2(c), although the intensity were different from single layer, the same orientations of each layer were observed at T_s of below 200 °C. However, the orientation of Co_{hcp}(110) phase was observed at T_s above 200 °C and this orientation seems to increase with increase of Cr_{bcc}(200) phase orientation. It suggests that the growth of Co_{hcp}(110)

Fig.2 X-ray diffraction diagram of various thin films for various substrate temperature T_s . (a)Cr (b)CoCrTa (c)CoCrTa/Cr

phase strongly depend on the growth of $\text{Cr}_{\text{bcc}}(200)$ one and it is necessary for preparing CoCrTa films which oriented in-plane to prepare Cr underlayers with well-oriented $\text{bcc}(200)$ phase.

Cr-M underlayer

From above results, the control of the orientation of Cr underlayer was tried by addition of Ta, Ge and Si into the underlayer. X-ray diffraction diagrams of

Cr-Ta and Cr-Ge films for various T_s were shown in Figure 3(a) and (b). The orientation of $\text{Cr}_{\text{bcc}}(200)$ phase was not observed for both (a) and (b), which is necessary for longitudinal orientation of CoCrTa layer. It seems to be due to a lattice distortion by Ta and Ge addition.

Figure 3(c) and (d) show X-ray spectra of Cr-Si and Cr-Co films for various T_s . The $\text{bcc}(200)$ phase of Cr appeared above 200°C , however $\text{bcc}(110)$ phase was observed, too.

Fig.3 X-ray diffraction diagram of various thin films for various substrate temperature T_s .
(a) CrTa (b) CrGe (c) CrSi (d) CrCo

Figure 4 shows lattice space of $\text{Cr}_{\text{bcc}}(110)$ phase for Cr-Ta, Cr-Ge and Cr-Si films as a function of T_s . The lattice spacing of Co-Ge and Cr-Si films took almost same value, however, that of Cr-Ta films decreased with increase of T_s . It seems to be because Ta which has relatively large atomic radius could get enough energy for diffusing into Cr matrix by thermal energy.

Magnetic properties

Figure 5 shows in-plane coercivity H_c of CoCrTa/Cr, CoCrTa/Cr-Ta and CoCrTa/Cr-Co films as a function of T_s . Although H_c increased with increase of T_s for three kind of films, H_c of CoCrTa/Cr-Ta were kept about 500 Oe. The maximum value of H_c was obtained with CoCrTa/Cr film deposited at low P_{Ar} of 0.1 mTorr. These increase of H_c seems to be origin from the orientation change of CoCrTa due to that of underlayer. Although there was no improvement of H_c using by additional element into the Cr underlayer, it was possible to control the H_c .

Fig.4 The change of lattice spacing of $\text{Cr}_{\text{bcc}}(110)$ phase on substrate temperature T_s .

Fig.5 The coercivity of CoCrTa/Cr, CoCrTa/Cr-Ta and CoCrTa/CrCo films deposited on glass substrate as a function of substrate temperature T_s .

CONCLUSION

It is necessary for in-plane orientation of CoCrTa film to deposit on Cr underlayer which oriented $\text{bcc}(200)$ phase. And the $\text{hcp}(002)$ phase of CoCrTa layer changed to $\text{hcp}(110)$ orientation in proportion to $\text{bcc}(110)$ orientation of Cr underlayer shifted to $\text{bcc}(200)$ one by increasing of the substrate temperature. The coercivity of CoCrTa magnetic layer also depended on underlayer orientation and these orientation seems to be possible to control by substituting Cr underlayer with additional elements.

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