Co-Cr-(Ta)박막의 자기특성
The magnetic characteristics of Co-Cr-(Ta) films

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- ***Abstract***- The effects of $Co_{67}Cr_{33}$ underlayer on the crystallographec and magnetic characteristics of the Co-Cr-Ta layer deposited on the underlayer was investigated. The diffraction intensity $I_{p(002)}$ of Co-Cr-Ta layers on the $Co_{67}Cr_{33}$ layer was stronger than that of single layer and Co-Cr-Ta/Ti double layer. Therefore, the crystallinity of Co-Cr-Ta layer was improved by the $Co_{67}Cr_{33}$ underlayers rather than Ti ones. However, the coercivity $H_{c\perp}$ of Co-Cr-Ta layers deposited on $Co_{67}Cr_{33}$ underlayer was as low as 250 Oe even at substrate temperature of 220℃. This $H_{c\perp}$ decrease seems to be attributed to the effect of the $Co_{67}Cr_{33}$ underlayer as well as interval time between deposition of the underlayer and the Co-Cr-Ta layer.

I. INTRODUCTION

The good crystallinity and appropriate coercivity of Co-Cr films are the essential factors to attain high density perpendicular magnetic recording. In general, those of the Co-Cr films have been improved by using underlayers such as Ti, Ge, etc.[1] Moreover, the (111) plane orientation of fcc erystallites in the Ni-Fe back-layer have been improved using the paramagnetic $Co_{67}Cr_{33}$ underlayer proposed in previous work.[2] These results suggest that the $Co_{67}Cr_{33}$ underlayer can improve the crystallinity of Co-Cr recording layer. In this study, the effects of the paramagnetic $Co_{67}Cr_{33}$ underlayer on the crystallographic and magnetic characteristics of Co-Cr-Ta layers were investigated.

II. EXPERIMENTS

The $Co_{80}Cr_{17}Ta_3$ single layer, $Co_{80}Cr_{17}Ta_3$/Ti and $Co_{80}Cr_{17}Ta_3$/$Co_{67}Cr_{33}$ bi-layers structure were deposited on slide glass substrates using Facing Targets Sputtering(FTS) apparatus. The Ar gas pressure P_{Ar} during deposition of the Co-Cr-Ta layers was fixed at 0.3 mTorr. P_{Ar} during deposition of paramagnetic $Co_{67}Cr_{33}$ and Ti underlayers were also fixed at 0.3 mTorr. The thicknesses of Co-Cr-Ta layers and underlayers were 200nm and 20nm, respectively. The substrate temperature T_s during deposition of the Co-Cr-Ta layers were varied in the range from Room Temperature(R.T.) to 270℃. The substrate temperature during deposition of the $Co_{67}Cr_{33}$ layer T_{us} were R.T. or 220℃ Ti underlayer were deposited at T_{us} of 220℃. In addition to these films, the 200nm-thick Co-Cr-Ta layer was deposited which includes 20nm-thick initial growth layer prepared in mixture gas of N_2 and Ar at T_s of 220℃. Here, this initial growth layer was defined as Co-Cr-Ta:N layer. The total pressure P_{N2} + P_{Ar} and N_2 partial pressure P_{N2} were 1 mTorr and 0.1 mTorr, respectively. The Co-Cr-Ta layer was deposited at P_{Ar} of 1 mTorr and T_s of 220℃. The crystallographic characteristics were evaluated by X-ray diffractometry(XRD). The magnetic characteristics were determined using Vibrating Sample Magnetometer(VSM) and Kerr hysteresis tracer.

III. RESULTS AND DISCUSSION

Fig.1 shows the substrate temperature T_s dependences of X-ray diffraction intensity $I_{p(002)}$ of Co (002) plane on substrate temperature T_s for Co-Cr-Ta single layers, Co-Cr-Ta/Ti and Co-Cr-Ta/$Co_{67}Cr_{33}$ double layer, respectively. $I_{p(002)}$ of the Co-Cr-Ta layer deposited on the $Co_{67}Cr_{33}$ underlayer at T_{us} of R.T. was stronger than those of the Co-Cr-Ta single layer and the Co-Cr-Ta/Ti double layer at any T_s. The crystallinity of the Co-Cr-Ta layer was improved, since the Co-Cr-Ta layer grew homo-epitaxially on the $Co_{67}Cr_{33}$ layers and possesed thinner initial growth layer, which exhibited worse c-axis orientation and lower perpendicular coercivity.[3] On the other hand, $I_{p(002)}$ of Co-Cr-Ta layers on the Ti underlayers was slightly stronger than that of single layer deposited at T_s between 180 and 220℃.

The effect of the $Co_{67}Cr_{33}$ underlayer on the magnetic characteristics was investigated. Fig.2 shows the T_s dependences of $H_{c\perp}$ of single layers and double layers.$H_{c\perp}$ of the single layers, increased with increase of T_s in the range above 150℃ and took a high value of about 1500 Oe at T_s of 220℃. $H_{c\perp}$ of the Co-Cr-Ta/Ti double layer also increased with increase of T_s in the range above T_s 180℃. It seems that the change of the threshold value of coercivity is attributed to the interval time between the deposition of Co-Cr-Ta and Ti layer. The impurity, such as O_2, N_2 and H_2O, seems to be adhered to the surface of the Ti underlayer during this interval. So, the impurity seems to diffuse in the thickness direction during deposition of the Co-Cr-Ta layer. It seems that these layers should be deposited without interval.

On the other hands, $H_{c\perp}$ of the Co-Cr-Ta/$Co_{67}Cr_{33}$ double layer remained at low value about 250 Oe even at T_s of 220℃ as shown in Fig.2. This valus of $H_{c\perp}$ was much lower than that of the Co-Cr-Ta single layer 1500 Oe. Furthermore, the M-$H_{c\perp}$ hysteresis loops with a sharp shoulder was observed even at T_s of 220℃ as shown in Fig.3. These results suggested that the compositional separation into Co-rich and Cr-rich regions was not caused. The drastic decrease of $H_{c\perp}$ seems to be attributed to the effect of $Co_{67}Cr_{33}$ underlayer in addition to interval time effect between deposition of the underlayer and the Co-Cr-Ta layer. then, the Co-Cr-Ta:N layer was deposited on the $Co_{67}Cr_{33}$ underlayer in order to clarify the effect of $Co_{67}Cr_{33}$ layer on the Co-Cr-Ta layer. Table 1 lists the relationships between coercivities and configurations of the specimens, deposited under various sputtering condition. $H_{c\perp}$ of the Co-Cr-Ta/$Co_{67}Cr_{33}$ double layer was lower than that of the layer without $Co_{67}Cr_{33}$ underlayer regardless of the existence of Co-Cr-Ta:N layer. It should be noted that $H_{c\perp}$ changed from 250 Oe to 600 Oe by insertion of the Co-Cr-Ta:N layer on the $Co_{67}Cr_{33}$ underlayers. The addition of N_2 to initial growth layer seems to suppress the effect of $Co_{67}Cr_{33}$ underlayer. This result implies that the $Co_{67}Cr_{33}$ underlayer has the effect to suppress the increase of the perpendicular coercivity $H_{c\perp}$.

Ⅳ. CONCLUSION

The effect of paramagnetic $Co_{67}Cr_{33}$ underlayer on the crystallographic and magnetic characteristics of Co-Cr-Ta layer was investigated. It was found that the crystallinity of the Co-Cr-Ta layer was improved by using $Co_{67}Cr_{33}$ underlayer. However, the coercivity remained low value of 250 Oe even at substrate temperature T_s as high as 220℃. The decrease of coercivity seems to be attributed to the effect of the $Co_{67}Cr_{33}$ underlayer as well as interval time between deposition of the underlayer and the Co-Cr-Ta layer.

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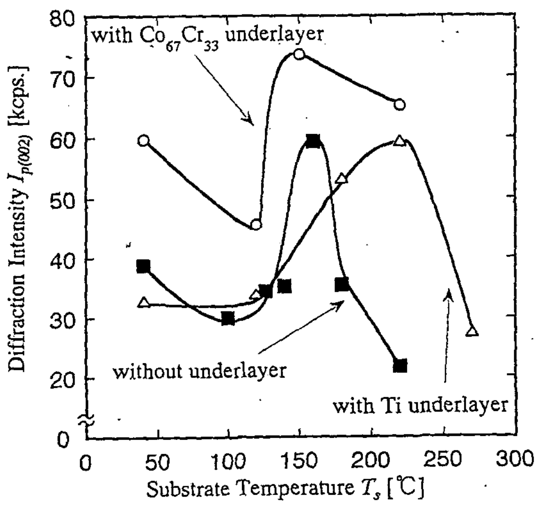

Fig.1 T_s dependences of X-ray diffraction intensity $I_{p(002)}$ of single layer and double layers.

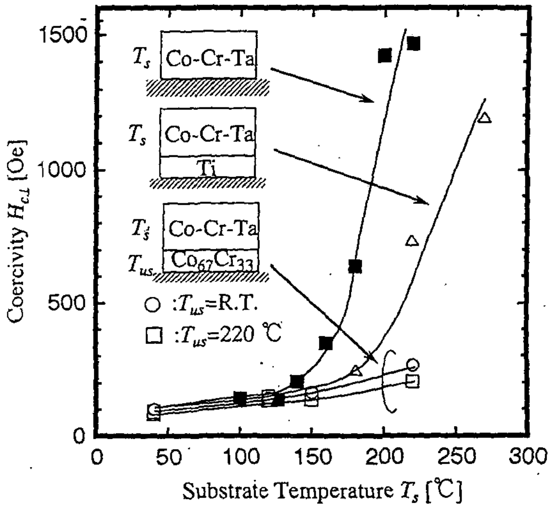

Fig.2 T_s dependences of perpendicular coercivity $H_{c\perp}$ in single layer and double layers.

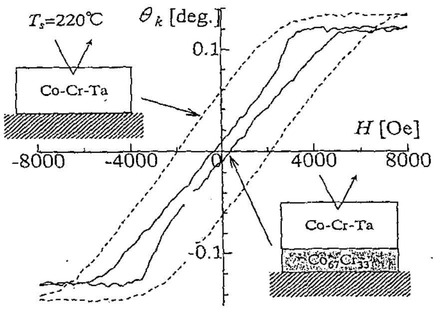

Fig.3 Kerr hysteresis loops in the Co-Cr-Ta single layer and the Co-Cr-Ta/$Co_{67}Cr_{33}$ double layers

Table 1 Relationships between coercivity and configuration of specimens deposited under various condition.

	without $Co_{67}Cr_{33}$ underlayer T_s=220℃	with $Co_{67}Cr_{33}$ underlayer T_s=220℃ T_{us}=R.T.
No N_2 addition	Co-Cr-Ta $H_{c\perp}$=1500 Oe	Co-Cr-Ta / $Co_{67}Cr_{33}$ $H_{c\perp}$=250 Oe
N_2 addition to initial growth layer	Co-Cr-Ta $H_{c\perp}$=1070 Oe	Co-Cr-Ta / $Co_{67}Cr_{33}$ $H_{c\perp}$=600 Oe