대향타겟식 스퍼터로 제작된 Co-Cr 박막의 자기적 특성

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The Magnetic Characteristics of Co-Cr Thin Films Deposited by Facing Targets Sputtering

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Abstract - The distribution of coercivity in the thickness direction were investigated by using Kerr hysteresis loop tracer for the Co-Cr films deposited by Facing Targets Sputtering apparatus. It $H_{c\perp}(S)$-$H_{c\perp}(I)$ correlated strongly with ΔH_c, which represents the degree of distribution of coercivity. Furthermore, the Cr content was varied in order to improve the coercivity of intial growth layer $H_{c\perp}(I)$ took a maximum value of 750 Oe and the distribution of coercivity became sharper at the Cr content of 25 at.%.

1. INTRODUCTION

The Co-Cr films are one of the most suitable candidates for perpendicular magnetic media. the control of the magnetic characteristics, such as distribution of coercivity and anisotropy field in Co-Cr film, is considered to be important to attain ultra high density recording for perpendicular magnetic recording media.[1] But the distribution of coercivity are not uniform in the direction of thickness because of the existence of initial growth layer.[2,3] The Co-Cr films deposited by Facing Targets Sputtering(FTS) method possesses intial growth layer thinner than conventional method such as RF, magnetron and so on.[4] In this study, the Cr contents were varied to obtain the better uniformity of distribution of coercivity.

2. EXPERIMENTS

The Co-Cr films were deposited on the glass side substrates by using Facing Targets Sputtering apparatus. The Cr content C_{Cr} were ranged rom 15 to 28 at.%. The substrate temperature T_s was varied in the range from room temperature(R.T.) to 240℃. The film thickness δ and Ar gas pressure P_{Ar} were fixed at 200 nm and 1 mTorr, respectively. Crystallographic characteristics were evaluated by X-ray diffractometry(XRD). The magnetic characteristics were evaluated by Vibrating Sample Magnetometer(VSM). The coercivites of surface and initial growth layers were evaluated for Kerr hysteresis loops observed from both sides from surface nd substrate, respectively of the whole film was obtained from M-$H_\perp$ hysteresis loop measured by VSM. The coercivities of surface layer, initial growth layer and whole film were defined as $H_{c\perp}(S)$, $H_{c\perp}(I)$ and $H_{c\perp}(W)$, respectively.

3. RESULTS AND DISCUSSION

Fig. 1 shows the T_s dependences of perpendicular coercivity of surface layer, intial growth layer and whole film in the $Co_{83}Cr_{17}$ films, respectively. $H_{c\perp}(S)$ and $H_{c\perp}(W)$ increased with increase of T_s in the range above 150℃, although $H_{c\perp}(I)$ remained at low value of about 200 Oe even at high T_s. This result indicates that Co-Cr films reveal segregation except intial growth layer.[5] $H_{c\perp}(W)$ were slightly lower than $H_{c\perp}(S)$ because $H_{c\perp}(I)$ were low.

The distribution of coercivity seems to exist in the direction of thickness. Fig. 2 shows the relationship between ΔH_c and the difference in coercivity $H_{c\perp}(S)$-$H_{c\perp}(I)$, were ΔH_c represents the degree of distribution of coercivity and anisotropy field in the film determined from M-$H_\perp$ major and minor loops measured by Vibrating Sample Magnetometer(VSM).[1] It was clarified that the difference in coercivity $H_{c\perp}$

(S)-$H_{c\perp}(I)$ of $Co_{83}Cr_{17}$ films deposited at various T_s were strongly dependent on ΔH_c. Furthermore, the lower value of full width at half maximum of rocking curves of Co(002) plane $\Delta\theta_{50}$ gives the smaller value of $H_{c\perp}(S)$-$H_{c\perp}(I)$ as shown in Fig 3. Therefore, the value of $H_{c\perp}(S)$-$H_{c\perp}(I)$, should be minimized not only by making distribution of coercivity sharp but also by improving crystallinity.

To obtain the smaller value of $H_{c\perp}(S)$-$H_{c\perp}(I)$, lower $H_{c\perp}(S)$ or higher $H_{c\perp}(I)$ are required. Higher $H_{c\perp}(I)$ is preferable to lower $H_{c\perp}(S)$, because low $H_{c\perp}(S)$ corresponds to low $H_{c\perp}(W)$. The effective way to obtain higher $H_{c\perp}(I)$ was the addition of Cr and Ta as shown in Fig. 4. Fig. 4. shows the T_s dependences of coercivity of initial growth layer $H_{c\perp}(I)$ in the $Co_{83}Cr_{17}$ films and $Co_{80}Cr_{17}Ta_3$ films. $H_{c\perp}(I)$ was increased with increase of T_s in the range above 150℃ and took a value of about 400 Oe at T_s of 200℃ for the $Co_{80}Cr_{17}Ta_3$ films, while $H_{c\perp}(I)$ remained at low value of about 200 Oe for the $Co_{83}Cr_{17}$ films. It seems that the addition of Cr and Ta into the Co-Cr films cause the increase of $H_{c\perp}(I)$ and makes distribution of coercivity shaper.

Fig. 5 shows the dependence of perpendicular coercivities $H_{c\perp}$ at T_s of 200℃ on the Cr content Cr in the Co-Cr films. $H_{c\perp}(S)$ and $H_{c\perp}(W)$ took maximum value of about 3 kOe and 1.8 kOe, respectively, at C_{Cr} of 21 at.%. However, $H_{c\perp}(I)$ took the maximum value of about 0.75 kOe at C_{Cr} of 25 at.%. Fig. 6 shows the C_{Cr} dependences of $H_{c\perp}(S)$-$H_{c\perp}(I)$ and $\Delta\theta_{50}$ decreased with the increase of Cr content. $H_{c\perp}(S)$-$H_{c\perp}(I)$ of Co-Cr film at higher C_{Cr} was smaller than that at lower C_{Cr} and lower C_{Cr} in the range of 15-17 at.%, the model proposed by Maeda ets. al. can be applied to except the phenomenon.[5] It was pointed out by Kadokura et. al. that compositional separation patterns was observed even for initial growth layer at C_{Cr} of 20 at.%.[6] This compositional separation at the initial growing stage to be one of the reasons why $H_{c\perp}(I)$ increase and $H_{c\perp}(S)$-$H_{c\perp}(I)$ decrease.

4. CONCLUSION

The distribution of coercivity in the thickness direction as investigated by using Kerr hysteresis loop tracer for the Co-Cr films deposited by Facing Targets Sputtering apparatus. It was found that $H_{c\perp}(S)$-$H_{c\perp}(I)$ correlated strongly with $\Delta H_c \cdot H_{c\perp}(I)$ took the maximum value of 750 Oe and the distribution of coercivity became shaper at the Cr content of 25 at.%. Therefore, the Co-Cr film with higher Cr content is more suitable for perpendicular recording media on view point of distribution of coercivity.

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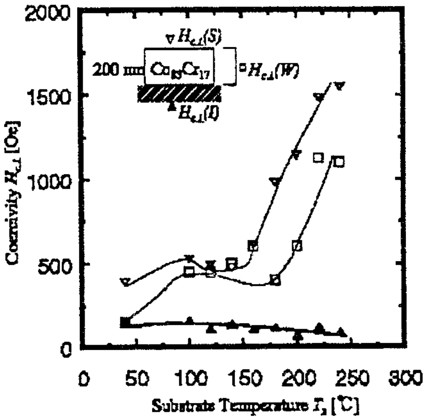

Fig.1 T_s dependences of perpendicular coercivities $H_{c\perp}(W)$, $H_{c\perp}(S)$ and $H_{c\perp}(I)$ in the $Co_{83}Cr_{17}$ films.

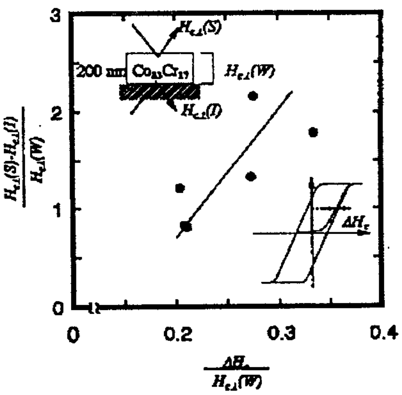

Fig. 2 The differences in the coercivity $H_{c\perp}(S)$-$H_{c\perp}(I)$ as a function of ΔH_c. The horizontal and vertical axis are normalized by $H_{c\perp}(W)$

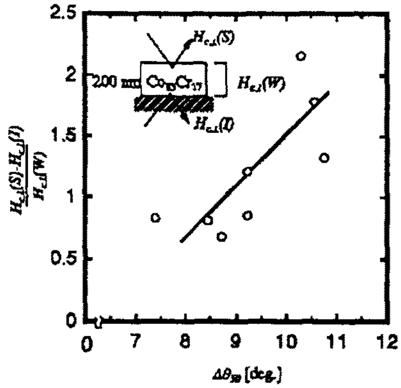

Fig. 3 Relation between $\Delta\theta_{50}$ and $H_{c\perp}(S)$-$H_{c\perp}(I)$.

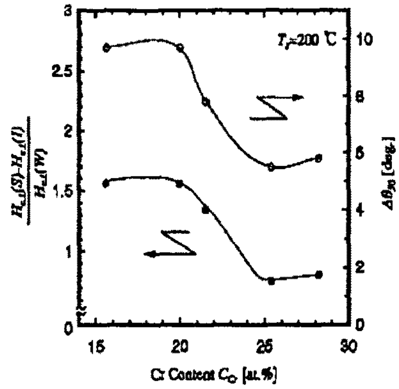

Fig. 6 C_{Cr} dependences of perpendicular coercivity $H_{c\perp}(S)$-$H_{c\perp}(I)$ and $\Delta\theta_{50}$ in the Co-Cr films deposited at T_s of 200℃.

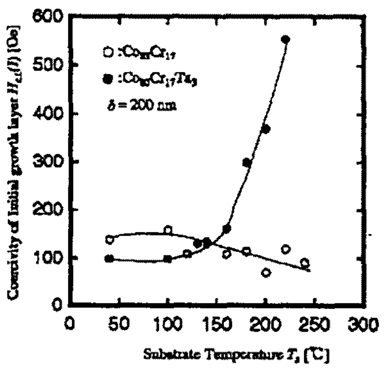

Fig. 4 Ts dependences of perpendicular coercivity of initial growth layer $H_{c\perp}(I)$.

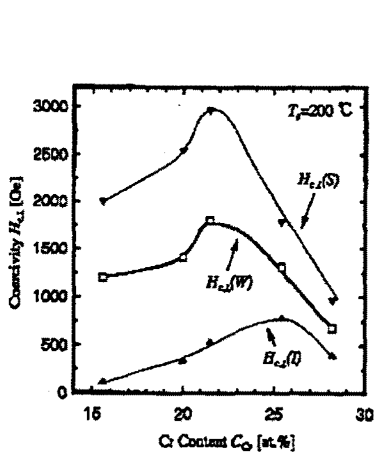

Fig. 5 C_{Cr} dependences of perpendicular coercivity $H_{c\perp}$ in the Co-Cr films deposited at T_s of 200℃.