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# IMPROVEMENT OF DISTRIBUTION OF COERCIVITY IN CO-CR FILMS DEPOSSSITED 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 was found that the difference between the coercivities of surface layer and initial growth layer $H_{c\perp}(S)$-$H_{c\perp}(I)$ correlated strongly with $\triangle H_c$ shich represents the degree of distribution of coercivity. Furthermore, the Cr content was varied in order to improve the coercivity of imitial growth layer $H_{c\perp}(I)$ and distribution of coercivity. $H_{c\perp}(I)$ took a maximum value of 750 Oe and the distribution of coercivity became sharper at the Cr content of 25at. %.

## INTRODUCTION

The Co-Cr films are one of the most suitable candidates for perpendicular magnetic recording media. The control of the magnetic characterictics, 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 initial 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.

## EXPERIMENTS

The Co-Cr films were deposited on the glass slide substrates by using Facing Targets Sputtering apparatus. The Cr content Ccr were ranged from 15 to 28at.%. The substrate temperature $T_s$ was varied in the range fro room temperature(R.T.) to 240℃. The film thickness $\delta$ 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 coercivities of surface and inital growth layers were evaluated for Kerr hysteresis loops observed from both sides from surface and substrate, respectively. The coercivity of te whole film was obtained from M-H⊥ hysteresis loop measured by VSM. The coercivities of surface layer, initial growth layer and whole film were defined as $H_c$⊥(S), $H_c$⊥(I) and $H_c$⊥(W), respectively.

## RESULTS AND DISCUSSION

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

The distribution of coercivity seems to exist in the direction of thickness. Fig. 2 shows the relationship between △$H_c$ and the difference in coercivity $H_c$⊥(S)-$H_c$⊥(I), where △$H_c$ represents the degree of distribution of coercivity and anisotropy field in the film determined from M-H⊥ major and minor loops measured by Vibrating Sample Magnetometer(VSM).[1] It was clarified that the difference in coercivity $H_c$⊥(S)-$H_c$⊥(I) of $Co_{83}Cr_{17}$ films deposited at various Ts were strongly dependent on △$H_c$, Furthermore, the lower value of full width at half maximum of rocking curves of Co(002) plane △$\theta_{50}$ gives the smaller value of $H_c$⊥(S)-$H_c$⊥(I) as shown in Fig.3. Therefore, the value of $H_c$⊥(S) - $H_c$⊥(I) should be minimized not only by making distribution of coercivity sharp but also by improving crystallinity.

To obtain the smaller value of $H_c$⊥(S)-$H_c$⊥(I), low $H_c$⊥(S) or higher $H_c$⊥(I) are repuired. Higher $H_c$⊥(I) is preferable to lower $H_c$⊥(S), because low $H_c$⊥(S) corresponds to low $H_c$⊥(W). The effective way to obtain higher $H_c$⊥(I) was the addition of Cr and Ta shown in Fig. 4. Fig. 5 shows the $T_s$ dependences of coercivity of initial growth layer $H_c$⊥(I) in

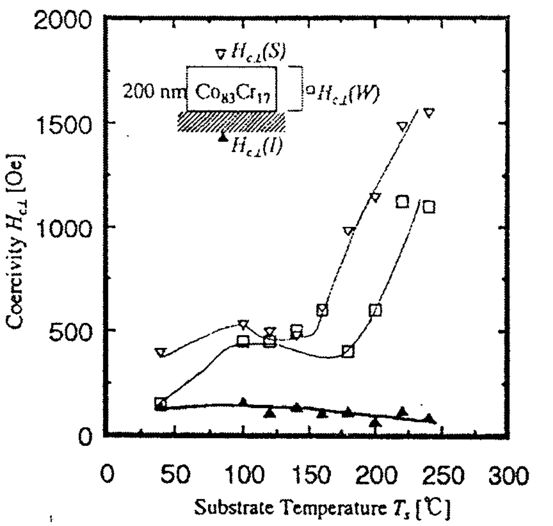



Fig. 1 $T_s$ dependences of perpendicular coercivities $H_c$⊥(W), $H_c$⊥(S) and $H_c$⊥(I), in the $Co_{83}Cr_{17}$ films.

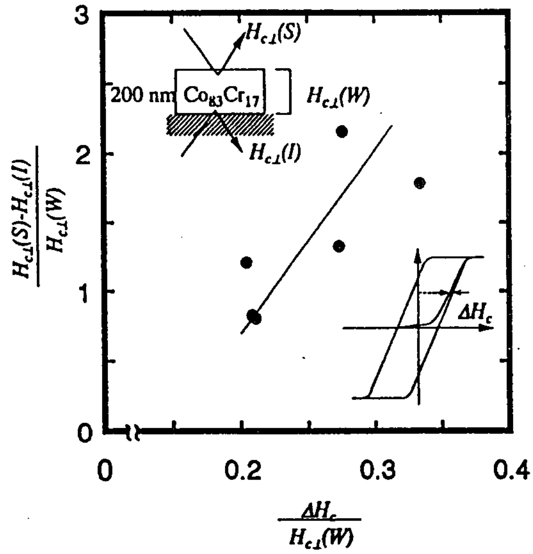



Fig. 2 The difference in the coercivity $H_c$⊥(S)-$H_c$⊥(I) as a function of $\Delta H_c$. The horizontal and verical axis are normalized by $H_c$⊥(W)

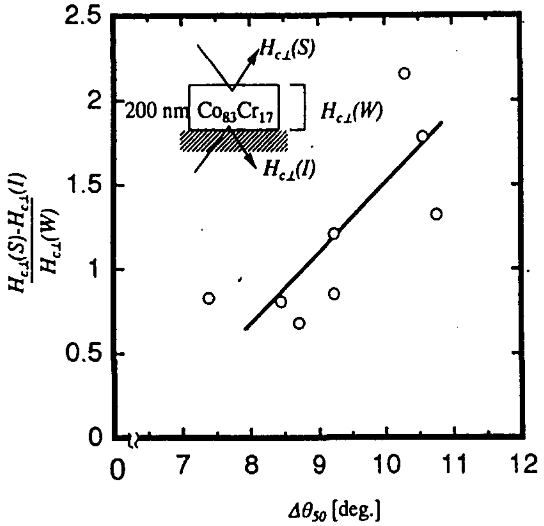



Fig. 3 Relationship between $\Delta\theta_{50}$ and $H_c\perp(S)-H_c\perp(I)$

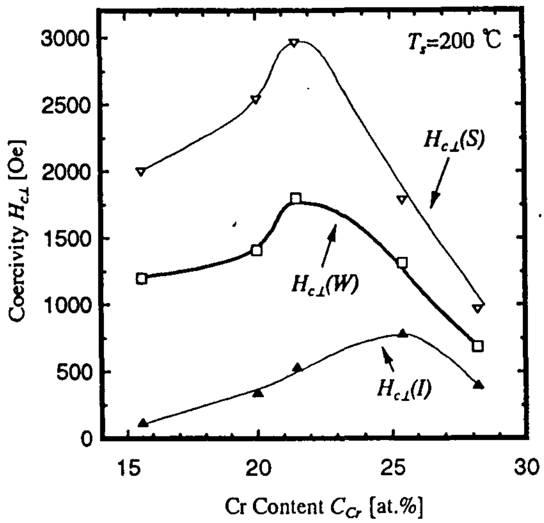



Fig. 5 $C_{Cr}$ dependences of perpendicular coercivity $H_c\perp$ in the Co-Cr films deposited at $T_s$ of 200℃

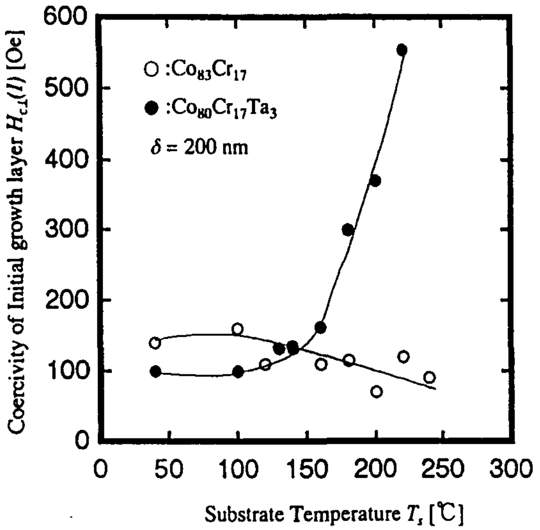



Fig. 4 $T_s$ dependences of perpendicular coercivity of initial growth layer $H_c\perp(I)$

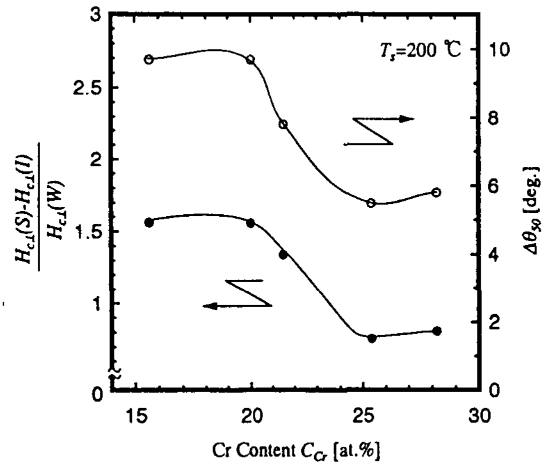
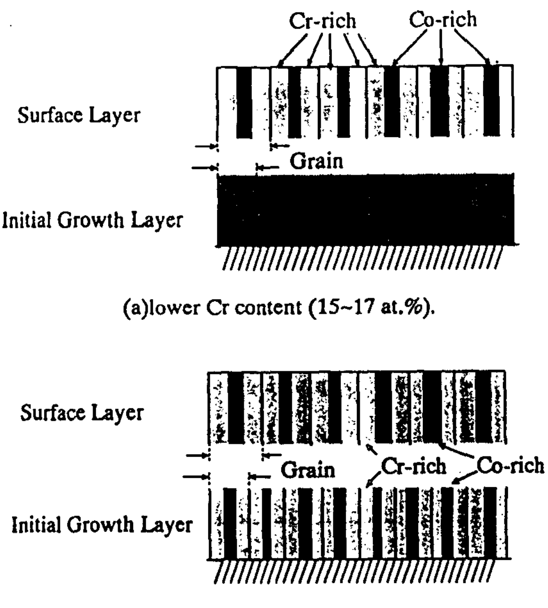



Fig. 6 $C_{Cr}$ dependences of $H_c\perp(S)-H_c\perp(I)$ and $\Delta\theta_{50}$ in the Co-Cr films deposited at $T_s$ of 200℃

the $Co_{83}Cr_{17}$ films and $Co_{83}Cr_{17}$ films. It seems that the addition of Cr and Ta into the Co-Cr films causes the increase of $H_c\perp(I)$ and makes distribution of coercivity sharper.

Fig. 5 shows the dependences of perpendicular coercivities $H_c\perp$ at $T_s$ of 200℃ on the Cr content $C_{cr}$ in the Co-Cr films. $H_c\perp(S)$ and $H_c\perp(W)$ took maximum values of about 3 kOe and 1.8 kOe, respectively, at $C_{cr}$ of 21at.%. However, $H_c\perp(I)$ took the maximum value of about 0.75 kOe at $C_{cr}$ of 25at.%. Fig.6 shows the $C_{cr}$ dependences of $H_c\perp(S)-H_c\perp(I)$ and $\Delta\theta_{50}$ at $T_s$ of 200℃ for the Co-Cr films. $H_c\perp(S)-H_c\perp(I)$ and $\Delta\theta_{50}$ decreased with the increase of Cr content. Since the addition of Cr into the Co-Cr films improved c-axis orientation as well as distribution of coercivity, $H_{c}\perp(S)$-$H_{c}\perp(I)$ of Co-Cr film at higher $C_{cr}$ was smaller than that at lower Ccr. at lower Ccr in the range of 15~17at.%, the model proposed by Maeda et.al. can be applied to explain the phenomenon.[5] the separation into Co-rich and Cr-rich regions seems to be caused in the films except initial growth layer as shown in Fig.7(a). On the other hand, the the initial growth layer as well as the surface layer at higher $C_{cr}$ in the range of 25~28at.% is easy to separate into Co-rich and Cr-rich regions as shown if Fig.7(b). It was pointed out by Kadokura et.al. that compositional separation patterns was observed even for initial growth layer at $C_{cr}$ fo 20at.%.[6] This compositional separation at the initial growing stage seems to be one of the reasons why $H_{c}\perp(I)$ increases and $H_{c}\perp(S)$-$H_{c}\perp(I)$decreases.



(a)lower Cr content (15~17 at.%).

(b) higher Cr content (25~28 at.%).

Fig. 7 Schematic illustration of compositional separation of Co-Cr films

## 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 $\Delta H_{c}$. $H_{c}\perp(I)$ took the maximum value of 750 Oe and the distribution of coercivity became sharper at the Cr content of 25at.%. Therefore, the Co-Cr film with higher Cr content is more suitable for perpendiculat recording media on view point of the distribution of coercivity.

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