Texture of Cr Interlayer in Double CoCrTa Thin Films and Effects of Interlayer on the Magnetic Properties

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Abstract--Multilayer magnetic recording thin film media have attracted much attention because of their high signal to noise ratios. In this work, we investigated the crystallographic texture of the interlayer and the effects of the interlayer on the magnetic properties. We found that: 1) When deposited at room temperature, the Cr interlayer has {110} texture, the same as the texture of the Cr underlayer. 2) When deposited at elevated temperatures, the Cr interlayer may have a different texture than that of the underlayer. 3) The Cr interlayer (only 25 Å thick) can either increase Hc or reduce S*, depending on thickness of the CoCrTa layer. 4) The substrate temperature affects Hc and S* dramatically.

I. Introduction

Multilayer magnetic recording films, which have thin non magnetic isolation layers, are reported to have both low noise and high signal to noise ratios (SNR).[1,2,3] A large amount of work has been done to investigate the effect of the interlayer from the point of view of magnetic interaction. It has been suggested that the low noise was due to:
1) the decoupling of the exchange interaction between magnetic layers by the isolation layer[1,2,3]
2) the less tightly packed grain structure of the initial growth layer of the magnetic film[2]
3) the magnetostatic interaction between the magnetic layers[1]

All of these explanations are phenomenological in nature. Each magnetic layer was assumed to be identical. In this work, we investigate the texture of the Cr interlayer in double CoCrTa thin films and the effect of the interlayer on the magnetic properties of the double CoCrTa thin films.

It is well known that Cr thin films deposited on either glass or NiP/Al substrates have either a {110} or {002} crystallographic texture and that Co-based alloys deposited on such Cr underlayers usually have the $\{10\bar{1}1\}$ or $\{11\bar{2}0\}$ textures respectively.[4,5,6] However, the texture of Cr that develops when it is deposited onto $\{10\bar{1}1\}$ or $\{11\bar{2}0\}$ textured Co-based alloys has not been investigated. The texture developed in Cr deposited onto Co based alloys is important in understanding the development of the crystallographic texture in multilayer thin film media. Here, we report our investigation on the texture of Cr layers deposited on $\{10\bar{1}1\}$ and on $\{11\bar{2}0\}$ textured CoCrTa thin films.

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II. Experimental Procedures

The thin films were deposited onto glass substrates by rf diode sputtering in a LH Z400 system using a Co-14.6 at%Cr-2.6 at% Ta alloy target and a Cr target. The deposition system base pressure was 7×10^{-7} Torr and the Argon sputtering pressure was 10 mTorr. The rf forward power density was 2.2 Watts per cm^2 for both the Cr and CoCrTa layers. No substrate bias was used. Before sputtering, the substrate temperature was either room temperature or 260°C. The crystallographic texture was studied by x-ray diffraction. Hysteresis loops were measured using vibrating sample magnetometer.

III. Results and Discussion

A. Texture of Cr Interlayer in Double CoCrTa Thin Films

Multilayer films were constructed as shown in Figure 1. For the samples used to study the texture of the Cr interlayers as deposited on the first CoCrTa layer, the second layer of CoCrTa was not deposited. Also, the Cr interlayers were made thicker (200Å) than normal (around 40Å) to improve the x-ray diffraction signal to background noise. The samples had the following thicknesses:

Table1

	Cr UL (Å)	CoCrTa (Å)	Cr IL (Å)	T (C°)
A	500	330	None	RT
B	500	330	200	RT
C	500	330	None	260
D	500	330	200	260

UL--underlaye·, IL--interlayer, T--temperature, RT--room temperature

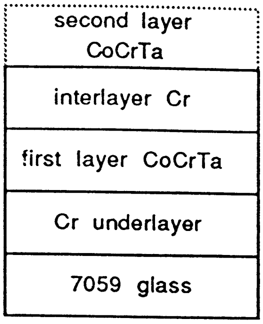

FIG.1 The film structure

It may be expected that the Cr interlayer should have the same orientation relationship (OR) with the CoCrTa layer as the CoCrTa layer has with the Cr underlayer. This is true for the samples prepared at room temperature. The x-ray spectra A and B in Figure 2 show only $\{110\}_{Cr}$ and $\{10\bar{1}1\}_{Co}$ peaks, hence, samples A and B have similar crystallographic textures. The Cr underlayer has the {110} texture and the OR between the CoCrTa and the Cr underlayer is $\{10\bar{1}1\}_{Co}//\{110\}_{Cr}$.[5] Hence, the OR between the Cr interlayer and CoCrTa film is $\{110\}_{Cr}//\{10\bar{1}1\}_{Co}$. The Cr interlayer has the same texture as the Cr underlayer. Thus, if CoCrTa were sputtered onto the Cr interlayer, it should have the same texture as the first CoCrTa layer.

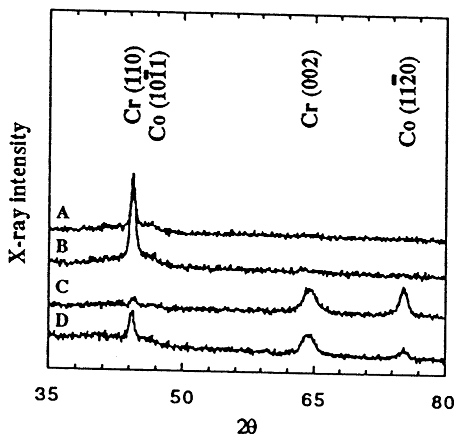

FIG.2 X-ray diffraction spectra

However, for the thin films deposited at high temperature, the situation is not that clear. In the samples deposited at 260°C, we found that the Cr interlayer texture was not the same as the Cr underlayer texture. Spectrum C in Figure 2, obtained from sample C, shows only the $\{002\}_{Cr}$ peak, whereas spectrum D, taken from sample D, shows both the $\{110\}_{Cr}$ and $\{200\}_{Cr}$ peaks. The $\{110\}_{Cr}$ peak must come from the interlayer Cr. This means that the texture of Cr interlayer is not a pure {200} texture but is mixed with the {110} texture. This was not observed[7] for Cr interlayers grown on CoNiCr alloys. Investigation by atomic resolution electron microscopy of cross section specimens is currently being pursued.

B. Magnetic properties

To understand the effect of the Cr interlayer on the magnetic properties, single and double layer CoCrTa films with different thicknesses were deposited. The coercivity, Hc and coercivity squareness, S* were measured. Table 2 shows the results for films which were deposited on glass substrates, preheated to 260 °C. The Cr underlayers were 2000 Å for all samples. The thickness of the Cr interlayer of the double layer CoCrTa films was 25 Å.

Table 2

sample 260 °C		thickness of CoCrTa (Å)	Hc (Oc)	S*
single layer	A	180	1600	0.71
	B	330	1612	0.78
	C	660	1290	0.77
double layer	D	2X180	1642	0.71
	E	2X330	1512	0.78

It can be seen that the coercivity is very high for sample A, which is only 180 Å thick. As has been reported, the coercivity decreases as the CoCrTa film thickness increased over 200 Å.[8] This has been explained to be either due to a stronger interaction between more tightly coupled grains, or because the crystallographic texture begin to changes to the {0001} fiberous texture when the thickness increased.[8] We did not find that the coercivity squareness, S*, increased as the thickness increased from 330 Å to 660 Å. Hence, the coercivity decrease may not be due to the tighter coupling. The coercivity squareness, S*, does increase as the thickness increases from 180 Å to 330 Å. This is due to the initially isolated grains becoming connected to each other as the thickness increases.

Comparing sample D and B, we see that sample D has a smaller coercivity squareness S*. Hence, the grains in sample D may be more separated, so the multilayer, in this case, is expected to improve the SNR.[9]

Comparing the double layer CoCrTa film, sample E, with single layer, sample C, the coercivity is larger for the double layer. This can be understood by considering the textures of the CoCrTa layers. The double CoCrTa layers have $\{11\bar{2}0\}$ or mixed $\{11\bar{2}0\}$ and $\{10\bar{1}1\}$ textures, with the magnetic easy axis either lying in or close to the film plane. The 660Å single CoCrTa layer has mainly the $\{11\bar{2}0\}$ with some {0001} texture (see for example reference [8]). The {0001} grains, with the magnetic easy axis perpendicular to film plane, may lead to the lowering of the in plane coercivity. For the double CoCrTa layers, the Cr interlayer prevents the growth of the {0001} texture, helping to increase the coercivity.

The substrate temperature also affects the coercivity of the doublelayer CoCrTa thin film significantly. Table 3 shows the results for films deposited at room temperature.

Table 3

R.T.	thickness (Å)	Hc (Oc)	S*
G	330	1197	0.75
H	2X180	757	0.72

Comparing the films with the same construction and same thickness deposited at 260 °C and room temperature respectively, the films deposited at higher temperature always have higher coercivity. It was suggested that this could be because of faults or segregation caused by heated substrate.[10] However, other microstructure characteristics, for example, grain size, could effect the coercivity also. Further investigation is required.

IV. Conclusions

1) When deposited at room temperature, the Cr interlayer has the same texture as the Cr underlayer. However, when deposited at elevated temperatures, the texture of the Cr interlayer appears to be a mixed.

2) The use of the Cr interlayer was found to have two effects: Two thinner films can replace one thicker film and hence prevent the coercivity degradation. The interlayer also seems to promote the isolation of grains which reduces the coercivity squareness. Both may help to improve SNR.

3) The substrate temperature affects Hc and S* significantly.

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