MAGNETIC AND RECORDING CHARACTERISTICS OF CoCr FILMS WITH NiFe AND Ti UNDERLAYERS

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Abstract — — — The influence of the Ti underlayer on the structure and magnetic properties of CoCr and CoCr/NiFe films has been studied. The recording characteristics of double layer CoCr/NiFe perpendicular magnetic recording media with Ti film under the NiFe film or inserted between CoCr film and NiFe film was measured and discussed. Although the coercivity and effective magnetic anisotropy field of media increase with increasing the thickness of CoCr film t_{CoCr} , but the output voltage and D_{50} of media became smaller.

INTRODUCTION

It was shown that magnetic properties of CoCr thin films depend strongly on its crystallographic structure[1], and several underlayers have been proposed in order to improve the magnetic and recording characteristics of CoCr films[2]. This paper reported a dependence of magnetic properties and $\Delta\theta_{50}$ of the CoCr film on the substrate temperature and its thickness. The areal homogeneity of a coercivity for RF magnetron sputtered CoCr film was determined. an influence of the Ti underlayer on the structure and magnetic properties of single CoCr film and an effect of the Ti underlayer on recording performance of double layer CoCr/NiFe media with Ti film under the NiFe film or inserted between CoCr film and NiFe film were measured and discussed. It was found that the output voltage and D_{50} strongly depend on the thickness of CoCr film.

EXPERIMENTAL

CoCr, NiFe and Ti films were prepared

by RF magnetron sputtering, using a sputtering system of model SPF—312. The compositions of the 6 inch targets use were Co80% Cr20% and Ni 79.7% Fe 16.3%Mo3%, respectively. The substrates were glass slides and 50 μm thick polyimide films which was degassed at 250°C before deposition. Table 1 gives the sputtering conditions for magnetic layers and Ti layer.

The crystallographic structure was investigated by X—ray diffraction. The degree of c—axis orientation of the hcp CoCr films was evaluated from the halfvalue width $\Delta\theta_{50}$ of the (00.2) plane rocking curve. The film thickness was determined by multiple beam interferometry.

The saturation magnetization M_s , coercivity H_c and magnetic anisotropy field H_K were measured using a highly sensitive vibrating sample magnetometer model VSM—5S—15 with a maximum applied field of 16 KOe. The magnetic properties measured with the magnetic field applied in the sample plane are denoted by the suffix $\parallel$, and those measured with magnetic field applied normal to the plane by the suffix $\perp$. The perpendicular

magnetic anisotropy field $H_{K\perp}$ was determined from an in—plane hysteresis loop.

Table 1 Sputtering conditions for CoCr, NiFe and Ti films

Background pressure		$\leq 1 \times 10^{-7}$ torr
Target—Substrate distance		60mm
Substrate rotation		10RPM
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Sputtering pressure	CoCr	1×10^{-3} torr
	NiFe	6×10^{-3} torr
	Ti	1×10^{-3} torr
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Power density	CoCr	5.5W/cm ²
	NiFe	8.5W/cm ²
	Ti	4.4W/cm ²
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Temperature of substrates	CoCr	180°C~200°C
	NiFe	20°C
	Ti	100°C
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Deposition rate	CoCr	130Å/min
	NiFe	200Å/min
	Ti	44Å/min

The read—write characteristics of a 3.5 inch diameter flexible disk were measured by using a flexible disk test unit. The parameters of the SPT head[4] are as follows: thickness and saturation flux density of the main pole: $T_m = 0.3\mu\text{m}$, $B_s = 12.5\text{KG}$; track width $W = 100\mu\text{m}$; Number of turns $N = 50$ and inductance $L = 4.0\mu\text{H}$.

RESULTS AND DISCUSSIONS

Magnetic Properties of the CoCr Films

The magnetic properties of CoCr films depend on the sputtering condition. The temperature of substrate T_{sub} and film thickness t_{CoCr} have great influence on film's characteristics. The Table 2 gives the influence of T_{sub} on properties of CoCr films. We can see that the M_s and $H_{C\perp}$ increase with an increase of T_{sub} .

Table 2 The dependence of properties of CoCr films on T_{sub}

T_{sub} (°C)	$\Delta\theta_{50}$ (deg.)	M_s (G)		H_c (Oe)		t_{CoCr} (Å)
		$\perp$	$\parallel$	$\perp$	$\parallel$	
20	10	440	400	250	175	1320
100	12	410	410	250	250	1430
150	13	430	430	400	195	1450
200	13	450	450	500	180	1460
250	—	580	580	500	184	1040

In the Table 3 was summarized the thickness dependence of characteristics of CoCr films. With an increase of t_{CoCr} the $H_{C\perp}$, M_r/M_s and $H_{K\perp}$ of films increase, while its H_r/M_s and $\Delta\theta_{50}$ decrease.

Table 3 The dependence of properties of CoCr films on t_{CoCr}

t_{CoCr} (Å)	H_c (Oe)		M_r/M_s (%)		$H_{K\perp}$ (Oe)	$\Delta\theta_{50}$ (deg.)
	$\perp$	$\parallel$	$\perp$	$\parallel$		
520	400	210	7.5	59	600	16.8
2000	520	200	13	30	1400	9.2
3100	740	220	15	24	2800	8.0
5900	740	220	14	17	3800	7.0

The areal homogeneity of the deposited medium is an important issue. The magnetic properties need to be fairly constant in the area for testing. In the Table 4 was summarized the distribution of the H_c and $H_{K\perp}$ of

Table 4 The distribution of H_c and $H_{K\perp}$ for sputtered CoCr film

Distance from the center of medium R (mm)	H_c (Oe)		$H_{K\perp}$ (KOe)
	$\perp$	$\parallel$	
0	700	300	4.8
10	700	300	3.6
20	710	250	3.9
30	700	210	3.8
40	650	200	2.9
50	600	200	2.4
70	400	200	2.0
90	320	200	1.7

CoCr film along the radius direction. So, it is possible to cut out a 3.5 inch diameter flexible disk sample from the central area of deposited medium.

Read—Write Characteristics of Media

The magnetic properties and $\Delta\theta_{50}$ of CoCr film with and without Ti underlayers are given in the Table 5. The coercivity $H_{C\perp}$ and effective magnetic anisotropy field $H_{K\perp}$

Table 5 Characteristics of CoCr films

sample	$\Delta\theta_{50}$ (deg.)	H_c (Oe)		$H_{K\perp}$ (Oe)	M_s (G)
		$\perp$	$\parallel$		
A	12	500	210	1800	475
B	10	560	250	2400	465

A=CoCr (1960Å) /Sub. B=CoCr (1960Å) /Ti (300Å) /Sub.

are all increased by the existence of a Ti underlayer. The $\Delta\theta_{50}$ of the sample B is smaller than that of the sample A. No diffraction peaks were observed other than the one for the hcp CoCr (00. 2) plane in the sample B. To clarify the cause which leads to the improvement of characteristics for CoCr film with Ti underlayer, the film thickness dependence of the structure of Ti films were examined. The X—ray diffraction patterns (Fig. 1) show that the structure of Ti films with

Fig.1 X-ray diffraction patterns of Ti films with different thickness t_{Ti}

different thickness was amorphous. Our experiments indicate that the CoCr/NiFe double layer media with Ti underlayers have improved high recording characteristics as shown in Table 6. It was found that the CoCr/NiFe double layer medium with inserted Ti layer have more smooth surface and better envelope curves of flexible disk sample (Fig. 3), but the inserted Ti layer between the CoCr film and NiFe film decreases the re-

Fig.3 Reproduced Signal envelope at 20KFRPI (Full horizontal Scan Corresponds to one revolution of the disk. Y, 0.1V/div)

Table 6 Read—write characteristics of 3.5 inch diameter flexible disks

Number of Samples	Structure of media thickness of layers (μm)	E_p (mv) (25KBPI)	D_{50} (KBPI) ($T_n=0.3\mu m$)
1	CoCr/NiFe/Ti/sub 0.10/0.50/0.04	255	88
2	CoCr/NiFe/Ti/sub 0.15/0.50/0.04	200	64
3	CoCr/NiFe/Ti/sub 0.20/0.50/0.04	240	54
4	CoCr/Ti/NiFe/sub 0.10/0.01/0.50	175	54
5	CoCr/Ti/NiFe/sub 0.15/0.01/0.50	200	32
6	CoCr/NiFe/sub 0.20/0.50	220	45

Fig. 2 Recording and reproduced characteristics of media A (CoCr/NiFe/Ti/sub) and B (CoCr/Ti/NiFe/sub)

produced voltage at low density and D_{50} (Fig. 2). It is necessary to further investigation to clarify the effect of inserted Ti underlayer[3]. Fig. 4 shows the density response curves for CoCr/NiFe double layer media with different thickness of CoCr films t_{CoCr} . Although with an increase of t_{CoCr} the magnetic properties and the degree of c-axis orientation of CoCr films were improved [Table 3], but the output voltage and D_{50} became smaller.

Fig. 4 Density response curves for Co-Cr films of different thickness

CONCLUSIONS

As a final conclusion, we may state that the structure of sputtered Ti films was of amorphous. The Ti underlayer improve the magnetic and recording characteristics of the single CoCr film and CoCr/NiFe double layer media. The CoCr/NiFe media with inserted Ti layer have more smooth surface and better envelope curve of 3.5 inch diameter flexible samples, but their reproduced voltage and D_{50} were decreased. Although with increasing the t_{CoCr} the $H_{C\perp}$ and $H_{K\perp}$ of double layer media increase, but their output voltage and D_{50} became smaller. It means that in this case the medium thickness loss is dominant factor.

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