THE PROPERTIES OF CoCr AND CoCr/FeNi FILMS

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Abstracts—The properties of CoCr and CoCr/FeNi films, produced by means of the targets facing type of sputtering method (the instrument was made in China), were investigated using VSM, X-ray diffraction and other magnetic measurements. The experimental results showed that the properties of the films were affected by formation parameters of the argon pressure, bias voltage, sputtering power and substrate temperature. The better Gaxis orientation films were obtained when the substrate temperature was adequate and the depositing atomic beams was with adequate energy and low density. Under these formation conditions, the adatoms would have enough time and suitable energy to make an ample diffusion. The CoCr/FeNi flexible disks were also produced.

INTRODUCTION

CoCr thin films, one of the most promising media for perpendicular magnetic recording system, have been extensively investigated [1,2,3]. The films were generally prepared by sputtering or vacuum evaporation methods. The targets facing type of sputtering method (TFTS) was capable of depositing ferromagnetic thin films. Recent studies showed that the preferable thickness of recording layer should be in the range of 1000-2000Å[3]. Such a trend of decrease in thickness is very convenient for the tape application of the novel perpendicular system since the CoCr alloy layer must be thin enough to keep the suitable flexibilities as the recording disks. Therefore, very thin CoCr films with better C-axis orientation is indispensable to the perpendicular magnetic recording.

Meanwhile, the C-axis orientation of the hcp crystalline in the sputtered CoCr films is quite sensitive to formation parameters. Among various factors, argon pressure, Par, the substrate temperature, Ts, and bias voltage, Vb, have been considered to be the dominant factors for obtaining the well C-axis oriented CoCr films.

In this study, the effects of argon pressure, substrate temperature and bias voltage on the crystalline orientation and magnetic properties of the films were investigated, and the films were prepared by using the unique capabilities of plasma-free TFTS system with low argon pressures. The properties of the CoCr/FeNi double layers film were also investigated.

EXPERIMENTS

Specimens were deposited on glass substrates and polyester substrates by sputtering Co79Cr21 and Fe50Ni50 alloy targets respectively in TFTS system.
Films of 1000-2000Å thick were prepared under the various conditions such as argon pressure, substrate temperature and bias voltage. The dispersion of the C-axis orientation of the crystalline α050 in the film was evaluated using the X-ray dieractometry by measuring the half width value of the rocking curve of hcp(002) peak. Magnetic properties were measured by VSM and torque methods.

RESULTS AND DISCUSSIONS

We investigated the relationship between the argon pressure, Par, and the width of semi-altitude of the rocking curve of X-ray diffraction spectrum from hcp(002) plane, and the magnetic perpendicular anisotropy constant Ku as shown on Fig. 1. Figure 1 showed that the values of θ50 were increased from 4.0° to 22.0°, and the values of Ku were decreased from 7.0×10⁵ erg/cc to 3.8×10⁵ erg/cc, with the increase of argon pressure, Par, from 2.0×10⁻⁸ torr to 12.0×10⁻⁸ torr. The Figure 2 showed the variation of θ50 and perpendicular coercivity Hc with the bias voltage Vb. When the bias voltage changes from -200.0V to 0.0V, the value of θ50 decreased at first and then increased, meanwhile, the value of Hc was up to 440 Oe, the minimum value of θ50, 4.0°, was obtained at -75.0V biasing voltage. From Fig 3 and 4, we could find that the value of θ50 increased while the sputtering power Ps increased, but the value of θ50 decreased at first and then increased. Simultaneously, the substrate temperature, Ts, rose, maturely the minimum value of θ50, 4.0°, is also established at Ts=443K.
Fig. 3. The substrate temperature $T_s$ v.s. the C-axis dispersion $\theta_{50}$.

From the results mentioned above, we believed that formation parameters, such as $P_s$, $P_{Ar}$, $V_b$ and $T_s$, affect on the properties, especially the C-axis orientation of the films very much. The better C-axis orientation film was obtained under the conditions that the substrate temperature was adequate and depositing beams were with adequate energy and at low density state. In this case adatoms could diffuse adequately.

In order to obtain the CoCr/FeNi flexible disk with good quality, we investigated the perpendicular properties of CoCr/FeNi film when we added a FeNi layer of $5.0 \times 10^{-7}$ m thick. The value of $\theta_{50}$ would increased from 4.0° to 6.8°. We believed that the crystalline of FeNi film (in plane) affects the C-axis orientation of the CoCr film. And the $\theta_{50}$ would be improved while a 100Å thick layer of Ti was added between FeNi and CoCr. Some magnetic properties of CoCr/FeNi film were listed below:

- $M_s = 160$ emu/cc
- $H_{cA} = 205$ Oe
- $H_{cA} = 162$ Oe
- $K_A = 1.0 \times 10^5$ erg/cc
- $H_K = 3.6 \times 10^3$ Oe

The results mentioned above were the same as the CoCr/FeNi flexible disk.

In general, we have obtained some experimental results as shown below:

1. The value of $\theta_{50}$ increased from 4.0° to 21.0° with the $P_{Ar}$ decreased from $2.0 \times 10^{-3}$ torr to $2.0 \times 10^{-3}$ torr, the other formation parameters kept constant.
2. The coercivity $H_c$ decreased with the decrease of bias voltage from $0.0\text{V}$ to $-200.0\text{V}$, otherwise, the value of $\Delta \theta_{50}$ decreased at first and then increased. The minimum value is $4^\circ$, at $-75.0\text{V}$.

3. When the substrate temperature $T_s$ change from $273K$ to $543K$, the value of $\Delta \theta_{50}$ decreased and then increased. The minimum value is obtained ($4.0^\circ$) at $443K$ $T_s$.

From these results we got an idea that the perfect C-axis films grew when the substrate temperature was adequate and the depositing atom beams were with adequate energy and at low density states. Under these formation conditions, the adatoms would have enough time and suitable energy to make an ample diffusion.

REFERENCES