

Properties of obliquely sputtered Co on different underlayers on polymer substrate

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Abstract

Co films have been obliquely sputtered on different underlayers (Cr and Cu) onto polymer substrate. The thickness of Co and the underlayer were kept at 20 nm and 180 nm, respectively. Microstructural and magnetic properties of these films have been analysed. In all films, the in plane anisotropy is confined in the direction perpendicular to the incident plane (transverse direction). However, the different microstructure of underlayers strongly affected properties of the magnetic layer. The H_c in the transverse direction are 180 and 80 kA/m for Cr and Cu, respectively.

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1. Introduction

Oblique evaporation of Co and Co alloys onto polymer substrate has been used to obtain high-density magnetic recording tape [1]. Recently, sputtering has been utilized to obtain columnar structure on polymer substrate as in ME tape [2]. However, only moderate coercivity is obtained. In previous work, we observe a rapid increase of anisotropy with the introduction of Cr underlayer [3]. The bilayer Co/Cr on polymer also presents a promising type of tape with bi-directional recording behavior [3]. In this paper, the effect of different underlayers are investigated by analysing their microstructural and magnetic properties. The films were deposited by DC magnetron sputtering onto a solid drum covered with PET film 10 μ m thick. Prior to each deposition the vacuum chamber was evacuated down to a base pressure (10^{-7} mb). The underlayers and Co were sputtered with the same incident angle ($70 \pm 5^\circ$ from the film normal) at room temperature and a fixed Ar pressure of 4×10^{-3} mb. Hysteresis loops were measured in the film plane along the longitudinal and transverse

directions (parallel and perpendicular to incident plane, respectively).

2. Results and discussion

The $\theta/2\theta$ scan of Co on different underlayers is depicted in Fig. 1. With Cr underlayer, two peaks positioned at 41.4° and 47° are characteristic of (10.0) and (10.1) planes of HCP Co, respectively. These two planes are known to grow epitaxially on Cr (1 1 0) [4].

With Cu underlayer, the relative intensities of these two peaks are reduced. However, a strong peak of (1 1 1) FCC plane at 44.3° is found. Thus the film with Cu underlayer consist of FCC and HCP phases of Co. It is suggested the FCC structure of Co is favorable in the case of Cu underlayer.

Microstructure of the films has been analysed by AFM. It is shown that the topography of the Cr layer and the Cu layer themselves are significantly different. In the case of Cr underlayer, the grains are well arranged and elongated in the transverse direction (Fig. 2a). In contradiction, the grains of Cu layer are more rounded and the elongation is not evidenced as in the case of Cr layer (Fig. 2b). Moreover, the grain size of Cr (50 nm) is smaller than that of Cu (100 nm). The elongated shape of

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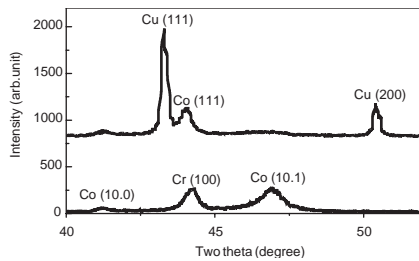


Fig. 1. $\theta/2\theta$ scan of Co on Cu underlayer (upper curve) and Cr underlayer (lower curve).

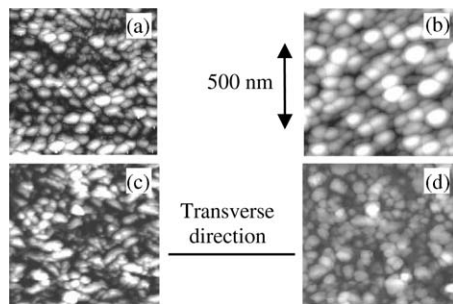


Fig. 2. AFM images of Cr underlayer (a), Cu underlayer (b), Co on Cr underlayer (c) and Co on Cu underlayer (d).

the grains following the transverse direction in oblique deposition can be explained by steering [5], which consists of a non-uniform distribution of the flux of the arriving atoms due to protrusions on the surface. Thus the steering effect is more pronounced in the case of Cr.

The difference in morphology of the underlayers results in different structures of 20 nm Co upper layers. Co grains, which grow on Cr underlayer, are elongated in the transverse direction (Fig. 2c) whereas rounded shape grains are obtained when Co grows on Cu underlayer (Fig. 2d). It can be explained by the epitaxial relationship of Co and Cr which allows a gain to grain growth.

As the consequence of different microstructures, magnetic properties of the films show a distinguished behavior. Hysteresis loops measurements indicate an anisotropy in the transverse direction in both types of films (Fig. 3). In the case of Cr underlayer, large coercivity in the transverse direction of 180 kA/m is achieved. In the film with Cu underlayer, only coercivity of 80 kA/m is obtained. It can be explained as follows:

- Film with Cr underlayer consist of mainly HCP Co whereas film with Cu underlayer consist of HCP and FCC Co. Crystalline anisotropy of HCP Co is much higher than that of FCC Co leads to a higher anisotropy as well as coercivity in the film with Cr underlayer.

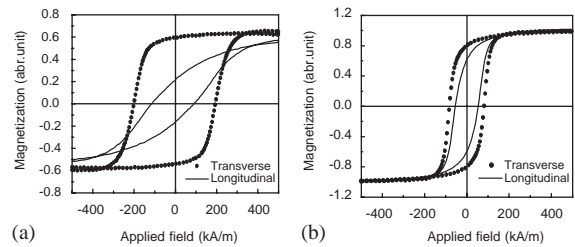


Fig. 3. Hysteresis loop of Co film on Cr underlayer (a) and Cu underlayer (b).

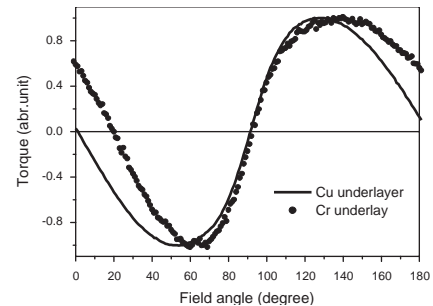


Fig. 4. Torque measurement at 1350 kA/m.

- Co grains have an elongated shape following the transverse direction when grow on Cr underlayer. This results in an additional shape anisotropy in this direction.

The easy axis orientation of the film is also strongly affected by the underlayers. Fig. 4 shows that in the film with Cr underlayer the easy axis is tilted 20° from the film plane while that of the film with Cu underlayer is almost in the film plane. It can be explained by the fact that in the film with Cr underlayer, the Co (10.1) plane gives rise to a c -axis orientation tilting 28° out of the film plane.

In conclusion, by changing underlayer, the crystallographic structure and the morphology of the Co layer are modified. It gives rise to a dramatically change of the magnetic properties.

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