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Textured growth of CoFe for soft underlayers in CoCrPt:SiO_2 perpendicular magnetic recording media

S.N. Piramanayagam[a,*], M.J. Liau[b], J.Z. Shi[a], B.C. Lim[a]

[a]*Data Storage Institute, 5 Engineering Drive 1, Singapore 117608, Singapore*
[b]*ECE Department, National University of Singapore, Singapore*

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Abstract

CoFe alloy thin films were studied with the intention of potential use as a soft underlayer (SUL) for Co-based perpendicular recording media. The effect of composition and the effects of seedlayers on the formation of crystalline phase and crystallographic texture and the magnetic properties were investigated. Films deposited on Ta/Pd seedlayer were found to have a good FCC(1 1 1) texture than those deposited on glass substrates or on Ta seedlayers. The magnetic properties were also better when deposited on Ta/Pd seedlayers. On these seedlayers, Fe concentration of 15 at% was found to be suitable for the formation of FCC phase. Disks were prepared with CoFe SULs. The noise of CoFe SUL is one of the challenges to be solved.

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Keywords: Perpendicular recording medium; Intermediate layer; Crystalline soft underlayer

1. Introduction

Ferromagnetic materials with high permeability, low coercivity and high saturation flux density B_s are desirable as soft underlayers (SULs) for perpendicular recording media. Currently, amorphous CoTaZr or CoNbZr alloys are used as the SUL materials [1,2]. Since the SUL has an amorphous structure, there is a need for intermediate layers which can induce a HCP(0 0 2) orientation in the Co-alloy recording layers. Ruthenium (Ru) is widely used as the intermediate layer along with some seedlayers such as Ta and Pt [3–6]. However, with an amorphous SUL, the thickness of the intermediate layers needed to provide a good HCP(0 0 2) orientation could be high. Most of the published papers report a thickness of 20 nm or more for the intermediate layer. Thick intermediate layers increase the distance between the recording head and SUL, leading to poorer writability [7,8]. Therefore, thinner intermediate layers (3–7 nm) are desired for recording densities of the order of 400 Gb/in^2. One way to achieve a good *c*-axis orientation with thinner intermediate layers is to use crystalline SULs and to obtain a texture from it. Materials with a FCC(1 1 1) or HCP(0 0 2) texture are suitable for Co-based alloy media. Therefore, we have studied crystalline CoFe alloys as a soft magnetic layer.

CoFe alloy has been known to a have large magnetic moment per atom [9,10], and therefore has higher B_s as compared with current SUL materials such as amorphous CoTaZr or even pure Co. However, CoFe alloys show different phases at different compositions in the bulk phase [11,12]. At high concentrations of Fe (about 35%), highest magnetization is reported. However, at this composition, CoFe is in BCC phase and is not suitable for Co-based alloy media. In order to get a suitable FCC(1 1 1) texture with a high saturation magnetization, we have studied the composition dependence of CoFe alloys with and without different seedlayers and underlayers. The crystal structure and the magnetization data are also reported in this paper.

2. Experimental

Various sets of films such as CoFe(40 nm), Ta(4 nm)/CoFe(40 nm), Ta(4 nm)/Pd(10 nm)/CoFe(40 nm) were

*Corresponding author. Tel.: +65 68748550; fax: +65 67772406.
E-mail address: Prem_SN@dsi.a-star.edu.sg (S.N. Piramanayagam).

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deposited on glass substrate in a conventional DC magnetron sputtering system. The films were deposited at room temperature. The thickness and Fe and Co concentration in the films were varied by individually controlling the sputtering power and duration for the Fe and Co targets. The base pressure was less than 6×10^{-8} Torr. All thin films were deposited at a sputtering Ar gas pressure of 3 mTorr. The crystalline structure was investigated by X-ray diffraction (XRD) with a Cu–K$_\alpha$ radiation, and the magnetic properties were measured using an alternating gradient magnetometer (AGM). The recording performance was studied employing a Guzik spin-stand tester with a ring-head writer and a MR reader.

3. Results and discussion

Fig. 1 shows the XRD patterns of CoFe films with different Fe composition ranging from 10 to 20 at%. It can be noticed that the CoFe films do not grow with a good crystalline texture without any seedlayers. A weak FCC(1 1 1) is observed for films with about 10 at% of Fe. For films with Fe concentration of 20 at%, there is a BCC(1 1 0) peak. For intermediate concentrations, no clear peak is seen. The observation of FCC and BCC phases at 10 and 20 at% is in agreement with the results reported in phase diagrams of CoFe alloy [11]. As discussed later, the films showed a larger coercivity of about 50 Oe. The poor texture and a large coercivity in films directly deposited on glass substrates indicated that certain seedlayers or underlayers are needed to improve the crystallographic texture and magnetic properties. Therefore, Ta was tried as a seedlayer for CoFe films.

Fig. 2 shows the XRD patterns of CoFe films with Ta seedlayer deposited on glass substrates. It can be noticed that all the films show a better crystallographic texture, when compared to the films deposited directly on glass substrates, as shown in Fig. 1. It can also be noted that the

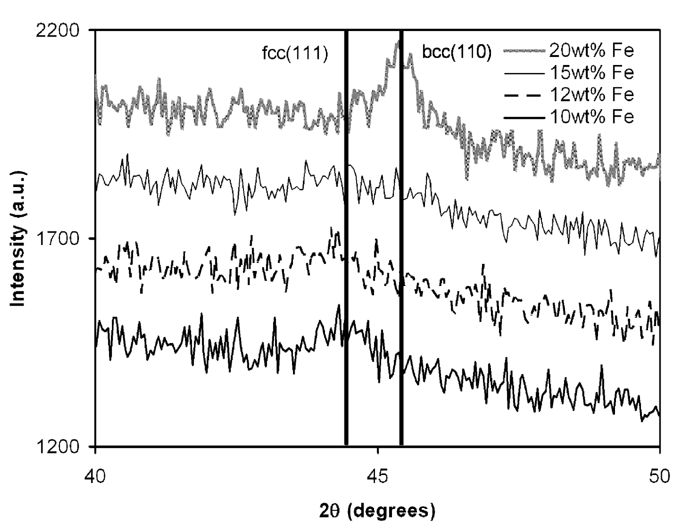

Fig. 1. XRD patterns of CoFe films deposited on glass substrates without any seedlayer.

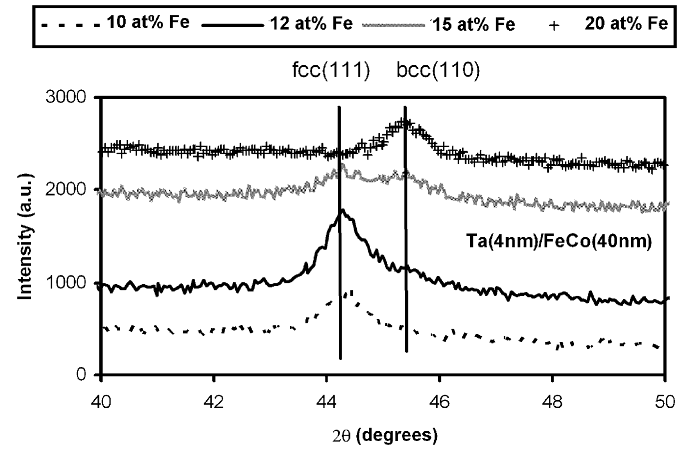

Fig. 2. XRD patterns of CoFe films with Ta seedlayer on glass substrates.

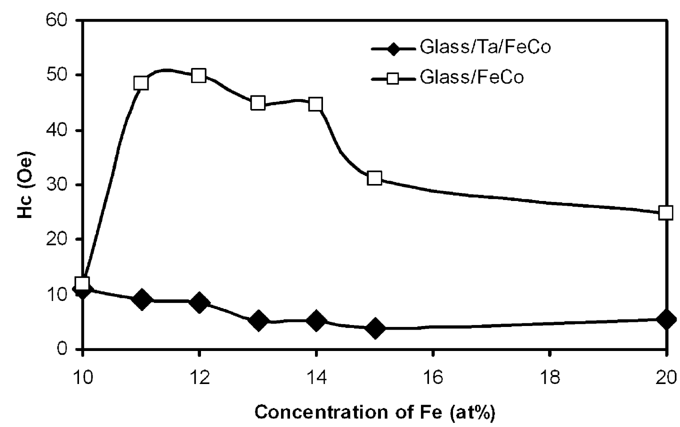

Fig. 3. H_c as a function of Fe composition for CoFe films with and without Ta seedlayer.

films show clear peaks corresponding to BCC(1 1 0) phase at Fe concentrations of 20%. At about 15% of Fe, the films show two weak peaks, one corresponding to FCC(1 1 1) and another corresponding to BCC(1 1 0). Below 15% of Fe, only FCC(1 1 1) peaks are observed.

Fig. 3 shows H_c as a function of Fe composition of CoFe films with and without Ta seedlayer. It can be noticed that the samples deposited directly on glass show a larger coercivity in the order of 10–50 Oe. In comparison, the films deposited on Ta seedlayers show a lower coercivity, not exceeding 10 Oe. From the results of all these samples, it appears that the samples that show a texture in the XRD tend to show a lower coercivity, indicating that there is a correlation between the texture and the coercivity. In addition to reducing the coercivity, a good texture in SUL will give rise to a good texture in recording layer and subsequently improve the recording performance of the media. However, the films deposited directly on glass substrates or Ta seedlayers exhibited a large dispersion in the FCC(1 1 1) orientation. The full-width at half-maximum (FWHM, or $\Delta\theta_{50}$) as measured by the rocking curves of FCC(1 1 1) peaks showed a large value (more than 11°).