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Magnetic properties of soft layer/FePt–MgO exchange coupled composite perpendicular recording media*

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The magnetic properties of exchange coupled composite (ECC) media that are composed of perpendicular magnetic recording media FePt–MgO and two kinds of soft layers have been studied by using an x-ray diffractometer, a polar Kerr magneto-optical system (PMOKE) and a vibrating sample magnetometer (VSM). The results show that ECC media can reduce the coercivities of perpendicular magnetic recording media FePt–MgO. The ECC media with granular-type soft layers have weaker exchange couplings between magnetic grains and the magnetization process, for ECC media of this kind mainly follow the Stoner–Wohlfarth model.

Keywords: exchange coupled composite media, perpendicular magnetic recording media, magnetic properties

PACC: 7550S, 7560

1. Introduction

Perpendicular magnetic recording technology has been used in mass production of hard disk drives since 2005. With magnetic recording density increasing, perpendicular magnetic recording media will replace the longitudinal media totally. However, the existing perpendicular magnetic recording media, Co alloy, cannot be used because of the worse thermal stability if the area recording density is increased further. As one of the candidates of perpendicular magnetic recording media for the area recording density above Tb/in^2, FePt has been studied by many research groups. It has a high coercivity because of its large magnetic anisotropy constant that is responsible for its high thermal stability. However the high coercivity is an obstacle for data writing because the writing field is restricted by the magnetization of writing head material. In order to reduce the coercivity and keep the high thermal stability, exchange coupled composite media (ECC media) were proposed by Victora *et al*[1,2] Since then they have received extensive attention from magnetic recording researchers and industries. The ECC media are composed of hard and soft layers. The hard layer provides a higher thermal stability for the written bits, while the soft layer reduces the coercivities of ECC media. In this paper, the magnetic properties of ECC media, composed of FePt and two kinds of soft layers, are studied in order to optimize the magnetic properties of FePt ECC media. These two kinds of soft layers are fcc FePt and CoCrTa, respectively.

2. Experiment

The composite media with fcc-FePt and CoCrTa soft layers were separately deposited on the hard layer fct FePt–MgO granular-type perpendicular media that had been obtained by annealing the multilayer [MgO4nm/FePt3nm]$_3$ at 550°C for 13 min. After annealing, the layer structure of hard layer was destroyed and the fct-FePt grains were isolated by the MgO matrix.[3] The detailed fabrication process of the hard layer was described in Ref.[4] The glass substrates were used for all the films. The deposition temperatures for fcc-FePt and CoCrTa were ambient temperature and 250°C, respectively. The thickness of fcc-FePt layer varied in a range between 0 and 3 nm.

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The thickness of CoCrTa varied from 0 to 4 nm. The crystallographic structures of the samples were characterized by using an x-ray diffractometer (XRD) with the Cu Kα radiation. The magnetic hysteresis loops of the recording media were measured by using a polar Kerr magneto-optical system (PMOKE). The laser wavelength was 516.7 nm. The coercivity angular dependence was measured by using a vibrating sample magnetometer (VSM).

3. Results and discussion

Figure 1 shows XRD patterns of fct-FePt–MgO hard layer with and without fcc-FePt soft layer separately. The perfect (001) textured fct-FePt films were obtained. On the glass substrate, sputter-deposited MgO film can easily grow into a (200) texture because the closest packed (200) plane has the lowest surface energy. It is expected that the heteroepitaxial growth of FePt film on a (200)-textured MgO underlayer can produce the (200) texture in this fcc FePt film and after annealing the (200)-textured fcc FePt film can be converted into a (001)-textured fct-FePt film. The fcc-FePt soft layer was deposited on the (001)-textured fct-FePt film. One can see that the fct-FePt (002) peak position slightly decreases with the thickness of fcc-FePt layer increasing, which is due to the larger lattice constant c of fcc-FePt whose (002) peak almost overlaps the (002) peak of fct-FePt.

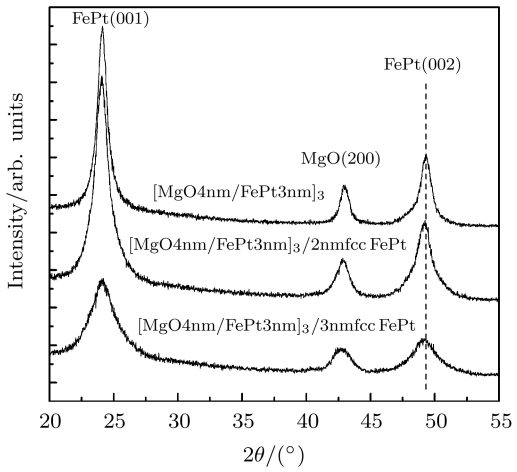


Fig.1. XRD patterns of the hard layer with and without fcc-FePt soft layer separately.

Figure 2 shows the hysteresis loops of hard layer medium and ECC media with two kinds of soft layers. The coercivities of ECC media decrease significantly compared with that of the hard layer medium. The hysteresis loops of the ECC media with fcc-FePt soft layer are the same as that with the hard layer when the thickness of soft layer is less than 2 nm, which may be due to the full exchange coupling between thin soft layer and the hard layer.[5] Figure 2 shows only the hysteresis loops of the ECC media which have coercivities around 0.5 T because the writing head field with using present technology only can write the media with coercivities of less than 0.5 T. Usually $\alpha(= 4\pi\ \mathrm{Ms}(\mathrm{d}M/\mathrm{d}H)_{\mathrm{Hc}})$ is used for characterizing the exchange coupling between magnetic grains in perpendicular magnetic recording media. The samples with higher values of α have stronger exchange couplings between magnetic grains than the samples with smaller values of α. Therefore, the exchange coupling between magnetic grains in the ECC medium with a 3 nm thick fcc-FePt soft layer is higher than the exchange coupling in the ECC medium with a 2 nm thick CoCrTa soft layer, which may be due to the magnetic segregation of nonmagnetic Cr elements that exist in the boundary of the magnetic Co alloy grains after annealing CoCrTa soft layer at 250°C.[6] The strong exchange coupling between magnetic grains increases the transition noise of the media.

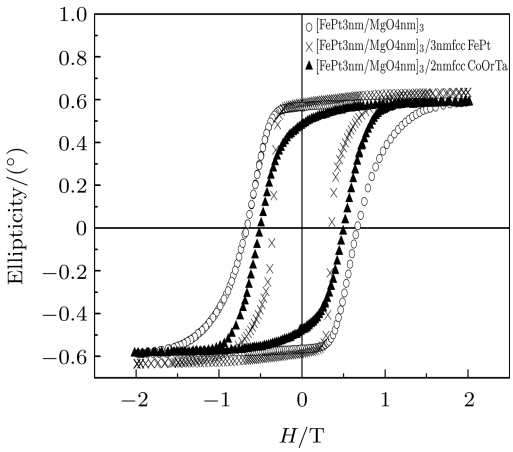


Fig.2. Hysteresis loops of media.

The magnetization mechanism is very important for studying the magnetic recording media. For the nanometre-scale magnetic recording grains with a small exchange coupling, the magnetization mechanism should be magnetic moment reversal mechanism. that is to say, the magnetization process should follow the Stoner-Wohlfarth model. In order to study the magnetization mechanism of these two kinds of ECC media, the coercivity angular dependence was mea-

sured by using the VSM. The result is shown in Fig.3. The coercivity angular dependence of domain wall motion model is also shown in Fig.3 for comparison. One can clearly see that the magnetization mechanism of

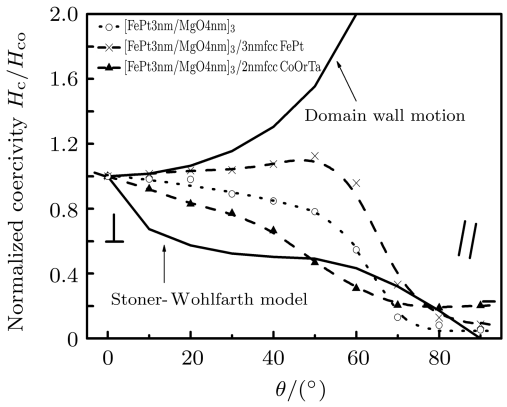


Fig.3. Coercivity angular dependences of media with an applied field being in the direction normal to the film for the case of zero degree and parallel to the film for the case of 90 degrees.

ECC media with a 2 nm thick CoCrTa soft layer mainly follows the Stoner-Wohlfarth model, while the magnetization mechanism of ECC media with 3 nm thick fcc-FePt soft layers follows a hybrid model composed of the Stoner-Wohlfarth model and the domain wall motion model. Therefore, the ECC media with CoCrTa soft layers are better recording media than the ECC media with fcc-FePt soft layers. However, the smaller squarenesses of the ECC media with CoCrTa soft layers are a source of DC noise and might induce a worse thermal stability. Increasing the exchange coupling between hard and soft layers and inducing a perpendicular anisotropy with an appropriate strength for the CoCrTa soft layer might be the solutions for the smaller squarenesses.

4. Summary

The magnetic properties of ECC media with two kinds of soft layers are studied. The coercivities of ECC media reduce compared with those of hard layer media. The exchange couplings between hard magnetic grains in ECC media depend on the exchange coupling between magnetic grains in soft layer. The ECC media with granular-type soft layers might be advanced ECC media in design.

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