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Magnetic properties of TbFeCo film with Ag under-layer

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Abstract

$Tb_{19.05}Fe_{22.01}Co_{58.94}$ (500 Å)/Ag (0–1000 Å) double films were deposited on nature oxidized Si(1 0 0) substrates at room temperature by DC magnetron sputtering. The TbFeCo /Ag films were sandwiched between two 300 Å SiN_x protective layers which were prepared by RF magnetron sputtering to prevent the films from oxidation. The effects of Ag under-layer on the magnetic properties of the TbFeCo film were investigated. It was found that increasing the thickness of Ag under-layer would rise the perpendicular coercivity of the TbFeCo film. The perpendicular coercivity value of the TbFeCo (500 Å)/Ag (500 Å) films was 3176 Oe. This film is a promising candidate for heat-assisted magnetic recording media applications.

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Keywords: Ag under-layer; Perpendicular remanence; TbFeCo/Ag double layer; Perpendicular coercivity

1. Introduction

Miyanishi et al. [1] had found that adding Al under layer into TbFeCo film would increase its perpendicular coercivity value due to the increasing of Al surface roughness. The pinning sites will be increased as the surface roughness between TbFeCo and Al is increased. On the other hand, Chou et al. [2] had found that the saturation magnetization (M_s) value and the perpendicular coercivity value were about 239 emu/cm^3 and 1900 Oe, respectively. In this work, we add Ag under-layer to the TbFeCo film in order to increase the perpendicular coercivity of the TbFeCo film.

2. Experiments

A protecting layer of Si_3N_4 with thickness of 300 Å was deposited by RF magnetron sputtering on nature oxidized Si (1 0 0) wafer. Then the Ag under-layer with different thickness (0–1000 Å) was deposited by DC magnetron sputtering on Si_3N_4. The TbFeCo (500 Å) magnetic film was deposited on Ag under-layer by DC magnetron sputtering with Ar pressure of 3 mTorr, then, 300 Å thickness Si_3N_4 capped layer was deposited on the magnetic film to avoid oxidation.

Magnetic properties of the film were measured by using a vibrating sample magnetometer (VSM) with a maximum applied field of 12 kOe. The surface morphology and the thickness of the films were detected by an atomic force microscope (AFM).

3. Result and discussion

Fig. 1 shows the effects of Ag under layer thickness on the surface roughness of Ag and perpendicular coercivity of the $Tb_{19.05}Fe_{22.01}Co_{58.94}$ film at room temperature. The surface roughness of Ag film is increased rapidly as the Ag film thickness is increased. When the Ag film thickness is higher than 175 Å, the surface roughness is almost kept at constant, it is about 30 Å. The growing mechanism of surface roughness is dominated by the surface morphology which is the combination of thermodynamics and kinetics [3]. In the initial stage of film growing (thickness is smaller than 80 Å), it was formed needles type which is not a result of kinetic limitations (see Fig. 2) [3]. Fig. 3 shows the surface energies of Ag, SiN_x and interface energy of

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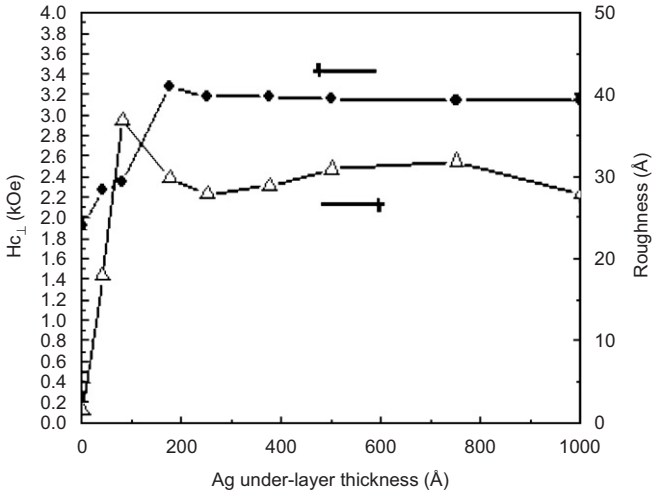

Fig. 1. The relationships among surface roughness, perpendicular coercivity and Ag under layer thickness.

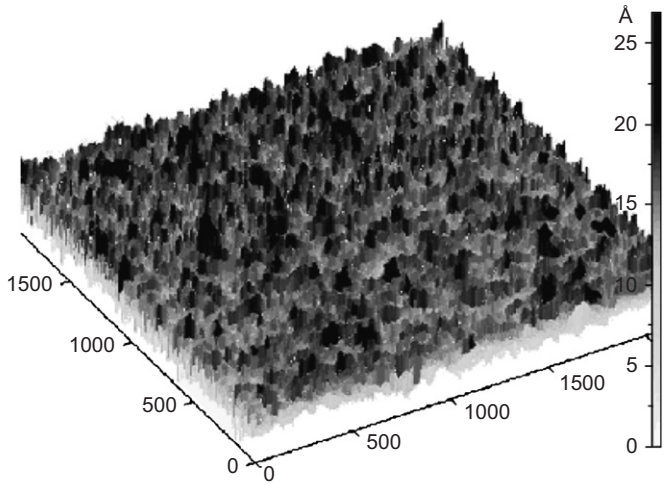

Fig. 2. AFM-3D surface morphology of Ag, the Ag under layer thickness is 40 Å.

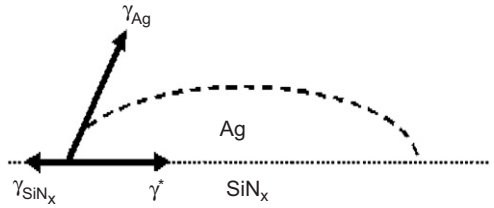

Fig. 3. The surface energy of Ag, SiN_x films and interface energy of Ag-SiN_x.

Ag-SiN_x. If γ_{Ag} is smaller than γ_{SiNx}–γ^*, where γ_{Ag}, γ_{SiNx} and γ^* are the surface energy of Ag, SiN_x and interface energy of Ag-SiN_x, respectively, Ag will grow in laminar type. But the morphology of Fig. 2 is needle, so γ_{Ag} is larger than γ_{SiNx}–γ^*. Therefore, when the thickness of Ag film is less than 80 Å, the increase of surface roughness with Ag film thickness is mainly due to the thermodynamic growing. If the thickness of Ag film is higher than 80 Å, kinetic factor will dominate the growing mechanism (γ_{Ag} is smaller than γ_{SiNx}–γ^*) and it forms in laminar type as shown in Fig. 4. These phenomenons are similar to that of Fournee et al. [3].

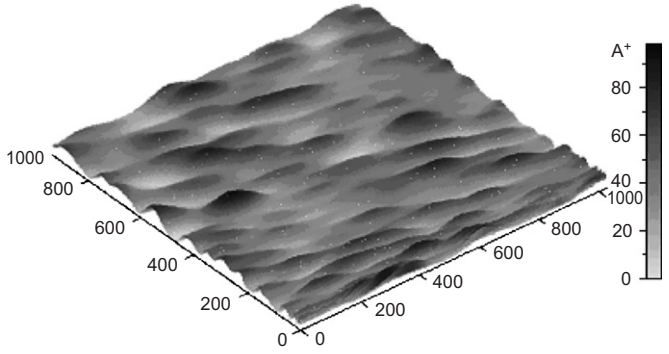

Fig. 4. AFM-3D surface morphology of Ag, the Ag under layer thickness is 175 Å.

When Ag under layer is below 80 Å, the TbFeCo magnetic film will contact with SiN_x under protective layer. Due to the surface roughness of SiN_x is smoother than that of Ag layer, the pinning site effect in Ag layer is larger than that of SiN_x. So, the perpendicular coercivity value increases slowly (see Fig. 1). When the Ag under layer was thicker than 80 Å, the perpendicular coercivity value is larger than that of thinner than 80 Å. It is because that as the Ag under layer is thicker than 80 Å, Ag under-layer becomes continuous layer and the contact of TbFeCo magnetic layer with SiN_x layer is less. The pinning sites on Ag under layer are larger than that of SiN_x. Therefore, the perpendicular coercivity value is increased as the surface roughness is reduced when the thickness of Ag under is lager than 80 Å. We speculate that the nanoscaled interface structure will decrease the exchange interaction between the Tb atom and the transition metal atom locally as the Ag underlayer is added [1,4,5]. The magnetic pinning sites will be formed at locations with weak exchange interactions and the perpendicular coercivity value is increased.

4. Conclusion

The effects of Ag under layer thickness on the morphology of Ag and magnetic properties of the $Tb_{19.05}Fe_{22.01}Co_{58.94}$ film have been investigated. It is found that the perpendicular coercivity value increases rapidly from 1925 to 3291 Oe as the Ag under-layer thickness increases from 0 to 175 Å. The perpendicular coercivity values are about kept at 3150 Oe as the Ag under-layer thickness further increases from 175 to 1000 Å.

The Ag under layer surface roughness is decreased as Ag film thickness is increased.

Acknowledgments

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