

Effect of Co Underlayer on the Magnetic Properties and Microstructures of TbCo Films

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The amorphous TbCo alloy film has excellent perpendicular anisotropy and large perpendicular coercivity (H_c) to resist thermal agitation of the magnetic moments, it is a promising material for heat-assisted magnetic recording (HAMR) media application [1]. However, the small saturation magnetization (Ms) at room temperature of TbCo film makes it difficult detection by giant magnetoresistive (GMR) head. In this study, a ferromagnetic Co film with large Ms value is introduced under ferromagnetic TbCo film in an attempt to enhance its magnetic properties.

The Tb₉₃Co₇ film with thickness of 90 nm is deposited on naturally oxidized Si wafer by dc magnetron co-sputtering of Tb and Co targets. The TbCo film is sandwiched with SiNx which prepared by rf magnetron sputtering of SiN target to prevent oxidation. The H_c and the Ms values of the Tb₉₃Co₇ film are about 4610 Oe and 194 emu/cm³, respectively. As introducing a 3 nm Co underlayer under the Tb₉₃Co₇ film, the H_c and the Ms values of TbCo/Co bi-layer films are increased to 4630 Oe and 264 emu/cm³, respectively. When the thickness of Co underlayers further increased to 15 nm, they are further increased to 6410 Oe and 330 emu/cm³, respectively. The increase of H_c value may be attributed to the exchange coupling [2] at the interface between ferromagnetic TbCo and ferromagnetic Co layer. The enhancement of Ms value is due to the contribution of the ferromagnetic Co layer which has large Ms value. As shown in Fig. 1, the HRTEM cross-sectional image shows that the Tb₉₃Co₇ film is still kept at amorphous state after introducing the amorphous-like Co underlayer that is consistent with XRD observation.

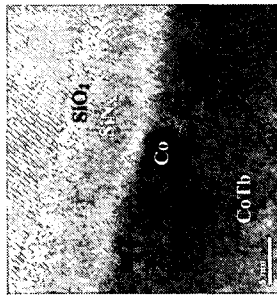


Fig. 1. The cross-sectional HRTEM image of the Co/TbCo/SiNx/SiO₂/Si multilayer films.

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Interfacial Energy in Tb₉₃Co₇/Tb₁₇Co₈₂ Bilayer Films

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The Tb₉₃Co₇(RE-rich)/Tb₁₇Co₈₂(TM-rich) bilayer films which sandwiched between two Si₃N₄ protected layers were fabricated to investigate their interfacial exchange energy $\Delta\sigma$. The interfacial energy of this TbCo/TbCo bilayer films can be derived from the following equation [1, 2]:

$$\Delta\sigma = 2H \times Ms \times t$$

where H, Ms, t are the biasing field, saturation magnetization and thickness of Tb₉₃Co₇ (RE-rich) layer. $\Delta\sigma$ of the TbCo/TbCo bilayer films estimated from hysteresis loop of Tb₉₃Co₇/Tb₁₇Co₈₂ bilayer films at room temperature (Fig. 1), is about 4.2 erg/cm², which is higher than that in the FM/AFM systems by two times.^{1,4} Based on the experiment results, we suggest that this strong exchange energy may be owing to the increase of the amount of uncompensated spins at the interface of Tb₉₃Co₇/Tb₁₇Co₈₂ bilayer film which is due to high roughness between TbCo/TbCo bilayer films that is caused by the high roughness between TbCo and Si₃N₄ under layer.^{1,4} From cross-sectional TEM image (Fig. 2.) of Si/Si₃N₄/Tb₉₃Co₇/Tb₁₇Co₈₂/Si₃N₄ film, it is found that the interface between Si₃N₄ and Tb₉₃Co₇ films is rough. From the relationship between H_c value of the Tb₉₃Co₇/Tb₁₇Co₈₂ bilayer films and temperature, it is found that the H_c value decreases rapidly from 5200 to 250 Oe as the temperature increases from 25 to 300 °C. This rapid decrease of H_c with temperature satisfies the writing requirement of heat-assisted magnetic recording (HAMR) medium.

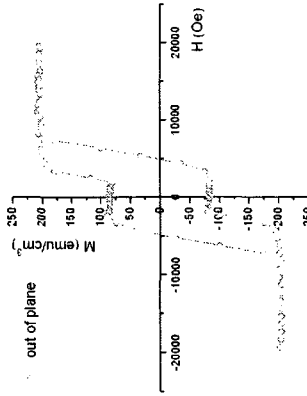


Fig. 1. Hysteresis loop of Tb₉₃Co₇/Tb₁₇Co₈₂ bilayer films at room temperature.

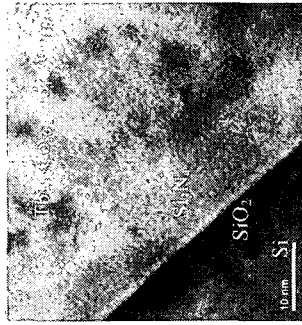


Fig. 2. The cross-sectional TEM image of the Si/Si₃N₄/Tb₉₃Co₇/Tb₁₇Co₈₂/Si₃N₄ films.

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