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Simulation Study of Magnetic and Recording Properties of Soft/Hard Stacked Perpendicular Magnetic Recording Media

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Recently, exchange coupled composite (ECC) magnetic recording media have much attention because of its possibility to reduce the switching field while maintaining thermal stability [1]. T. Shimatsu et al. has proposed modified ECC media with a thin soft magnetic capping layer [2], which are beneficial in fabrication. However, such structure inevitably suffers from large demagnetizing effect for the capping layer.

M-H loops were investigated by simulation for stacked media. The media were modeled using hexagonal grains on a soft magnetic underlayer with a 2.5 nm-thick soft layer (layer 1) and a 10 nm thick hard layer (layer 2) separated by 0.5 nm. The soft and hard layers were assumed to have the same saturation magnetization of 750 emu/cm^3. The grain size was 6.2 nm with an inter-grain separation of 0.5 nm. Figure 1 shows the inter-layer exchange field, H_{el}, dependence of the coercivity of layer 2, H_{c2}, for stacked media with various anisotropy fields of layer 1, H_{k1}. When H_{k1}=0.1 kOe, the H_{el} dependence showed that of the film with large negative anisotropy for layer 1. The shape anisotropy of the soft layer caused the negative anisotropy. The film with H_{k1}=4.7 kOe showed distinct dip in the curve, suggesting the effective anisotropy is around zero. This means the H_{k1} anisotropy field compensated the demagnetizing field around $(4\pi/2)M_1$.

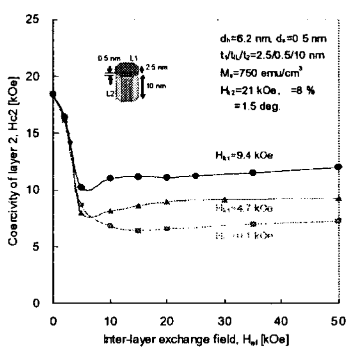

Fig. 1. Inter-layer exchange field, Hel,dependence of coercivity of layer 2, H_{c2}, for stacked films with various H_{k1}.

Figure 2 shows recording characteristics of the stacked media with H_{k1}/H_{k2} = 4.7/21 kOe and H_{el}=10 kOe for 2032 kFCI recording, comparing to reference single layer media with H_k=16 kOe which exhibits about the same total anisotropy energy. The stacked medium without the exchange coupling indicated about the same saturation recording field as that of the reference medium with the exchange coupling field of 5 kOe. It is concluded that introduction of the inter-granular exchange coupling is essential to obtain a reduced saturation field and an increased output even for stacked media.

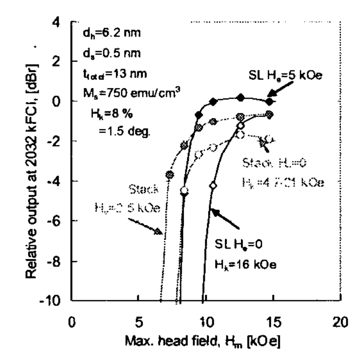

Fig. 2. Maximum head field, H_m, dependence of relative output at 2032 kFCI for stacked and single layer media with and without inter-granular exchange coupling field, H_e.

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Optimization of R/W and Thermal Stability of Exchange Coupled Composite Media for Perpendicular Magnetic Recording

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Introduction In perpendicular magnetic recording the trilemma between Signal-to-Noise ratio, thermal stability of a recording medium and writability of a writing head must be solved to achieve a higher areal recording density over 1 T bits/in^2. Exchange coupled composite (ECC) recording medium is one of the most promising candidate to solve the above mentioned problems [1][2]. Although several experimental and analytical studies have been done, the relationships between the R/W characteristics, thermal stability and magnetic property have not been clarified. In this study their relationships are investigated with micromagnetic simulations.

Calculation procedure ECC medium is modelled by a regular array of hexagonal prisms with a diameter of 6.0 nm. The recording medium is a double-layered-medium composed of a recording layer (RL) and a soft-under-layer (SUL) which are separated by an interlayer with a thickness of 5 nm. The RL consists of a soft magnetic layer and a hard magnetic layer of which the total thickness was kept to be 13 nm through all the calculations. Optimal thickness ratio between a soft and a hard layer, optimal magnitude of anisotropy constant of a hard layer and optimal vertical exchange interaction (Av) between a soft and hard layers are investigated systematically. The SPT head field was obtained by FEM calculation with JMAG studio. The maximum of the field was 1000 kA/m and the field gradient of the trailing side was 240 kA/m/nm.

Results Signal to noise ratios (SNR) improved with increased the soft layer thickness up to 6.5 nm and gradually decreased over 6.5 nm. Then, we investigated an optimal anisotropy constant of a hard layer with the optimized film thicknesses , resulting in an optimal anisotropy magnitude of a 11x105 J/m3. The SNR of ECC medium was, however, slightly inferior to that of the optimized granular medium. Thermal stabilities of ECC media were investigated with the Langevin equation. Fig. 1 shows the thermal decay of the DC erased magnetizations at 330 K. Thermal stability were strongly influenced by a vertical exchange interaction between the soft and the hard layers as shown in Fig. 1. Although a strong exchange of 10 pJ/m improves thermal stability in granular medium, a moderate exchange of 5 pJ/m for an ECC medium shows much more excellent thermal stability than a granular medium.

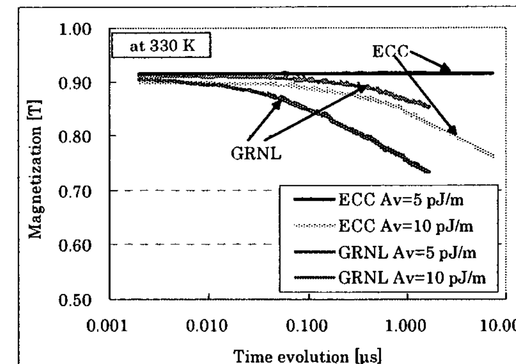

Fig. 1. Thermal decay of the DC-erased magnetizations at 330 K for ECC and granular media.

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