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Hysteresis Scaling in Exchange Bias System

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Magnetic recording media has long undergone development to enhance its areal density in order to satisfy the sharply increase of digital information [1]. However, the increment of areal density leads smaller number of magnet atoms in one magnetic grain. Therefore, this reduces ferromagnetic interaction and the media tends to loose its stability even at room temperature, i.e. superparamagnetic effect [1]. One of the phenomena considered as potential solution for this stability problem is Exchange Bias (EB) effect. EB effect was discovered for decades ago by coupling antiferromagnet (AFM) and ferromagnet (FM) together [2]. The coupling at the interface between an AFM and a FM causes unidirectional anisotropy in the FM layer, which results in a shift of the hysteresis loop along the magnetic field axis, called exchange bias shift (H_{EB}) [2, 3], and increment of hysteresis coercivity. Despite of these advantages, the explanation for the EB effect is still unclear. This study is, hence, conducted to gain further comprehension on EB effect for coupled FM and AFM in reduced geometries, i.e. thin-films, via Monte Carlo simulation. Utilizing Monte Carlo simulation, the system's thermal fluctuation is considered and, hence, providing high precision and good corresponding results with results where applicable [4]. In the simulation, the system evolved under single spin-flip algorithm based upon the energy minimization of an ensemble of spins calculated from Hamiltonian equation. Having varied the external parameters; i.e. temperature, field amplitude and frequency, the hysteresis loop (magnetization in response to the field profiles) was measured at different coupling ration and films thickness. From the hysteresis loop, hysteresis properties such as remnant, coercivity and hysteresis area, were analyzed. In order to gain further information for application purpose, the power laws scaling were then extracted from the data. The results revealed that the stronger coupling interaction shows tendency to increase the hysteresis coercivity but decrease the hysteresis area and remnant. Furthermore, the strong coupling was also found to reduce the changes and fluctuation caused by external parameters; i.e. saturated magnetization occured in higher applied field, loop squareness depended less on frequency and thermal fluctuation became less dominant. Larger field amplitude was observed to increase coercivity, remnant and hysteresis area. On the other hand, increasing field frequency only increased the coercivity but may increase or decrease the remnant and hysteresis area depending on the range of frequency used. These results provide prospects for further study with industrial application based purpose.

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CS08

Features of Epitaxial Garnet Films for Atomic Traps Technique

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High-coercive garnet films are useful in thermo-magnetic recording by laser beams or by contact printing. The films covered with composite mirror can be used as high-resolution and extra-sensitive magneto-optic (MO) converters in criminalistics [1]. Recently it has been established that garnets can be optimal media to assist trapping and propagation of neutral atoms. Their transparency and high Faraday rotation enable to visualize the routes after thermo-recording. Though the known experiments were successful [2], there are some complexities regarding the micro-relief, since the films are strained and networks of dislocations exist. In this work optimization of MO films properties, grown by means of liquid phase epitaxy, for creation of efficient atomic traps is provided.

The authors used mono-crystalline $Gd_3Ga_5O_{12}$ substrates with (111) orientation, positive substrate-film crystalline constants mismatch Δa = 0.04-0.1 Å. As grown films thicknesses h_g = 4-6 μm and after polishing and ion beam etching h_e = 1-3 μm. Saturation magnetization $4\pi M_s$ = 0.7-1.7 kGs. Main compositions of the films were: $(Bi, Sm, Lu, Yb, Ca)_3(Fe, Al)_5O_{12}$ and $(Bi, Sm, Lu)_3(Fe, Al, Sc)_5O_{12}$.

The films coercivity $H_c \sim 100$ Oe, Curie temperature $T_C \sim 200^oC$ (it was main difference from contact printing films) and nucleation field $H_n > 0.5\ H_c$ value. Periods of meta-stable domain structure after heating ($T > T_C$) $2w_t$ = 2-4 μm. Specific Faraday rotation θ = 0.5-1°/μm (633 nm).

To investigate morphology the films were etched in H_3PO_4 and HNO_3. Dependence of misfit dislocations density on Δa and h values was observed with interference microscopy. It is proposed to use the films micro-relief for "3d" traps design. Multi-layered films for "3d" trap are considered. Figure 1 presents images of surface relief (interference), stable and meta-stable domain structures (polarized light), obtained from the same area of a high-coercive garnet film sample.

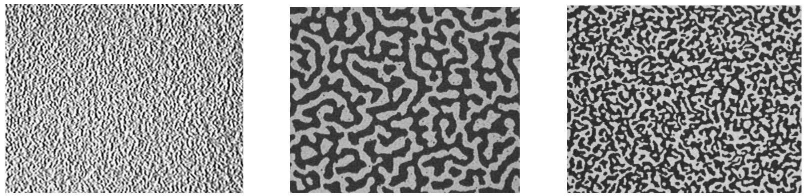

Fig. 1. From left to right: film surface, stable and meta-stable domain structure.

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