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Magnetic Properties of Patterned Amorphous TbFeCo Dot Arrays with Perpendicular Anisotropy

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Patterned magnetic media, where single domain magnetic nano-dots that are magnetically isolated, have been considered as one of the prominent candidates for next generation high-density magnetic recording media. The magnetic reversals of perpendicular systems such as nano-patterned Co/Pd multilayers, crystallized films, and hexagonal ferrite films have long been discussed. It is found that each nano-dot magnetically reverses at different value of applied field in those polycrystalline nanostrctures. The reason has been concluded as the distribution of crystal orientation and texturing that contributes to the distribution of intrinsic anisotropy field in the dot arrays. TbFeCo is an amorphous alloy. TbxFe88-xCo12 films show perpendicular magnetic properties with $20 \leq x \leq 35$. In this presentation, amorphous TbFeCo dot arrays were fabricated by focused ion beam (FIB) systems. The magnetic properties of the dot arrays have been discussed.

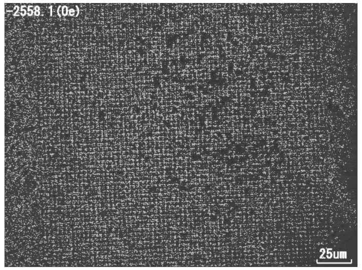

Fig. 1. Typical Kerr microscopy images of patterned amorphous TbFeCo dot arrays.

The films were deposited by a DC magnetron sputtering system. The substrates were Si (111) wafers. TbFeCo films, with thickness of 15 nm, have been deposited onto W underlayers with the thickness of 10 nm. An W top-layer, with thickness of 3 nm, has been used to protect the films from oxidation. The films have been patterned to magnetic island in the size from 80 nm to 3000 nm by FIB. The magnetic reversal processes in the dot arrays have been observed by a Kerr microscope equipped with an electromagnet that can apply magnetic field perpendicularly to the film plane.

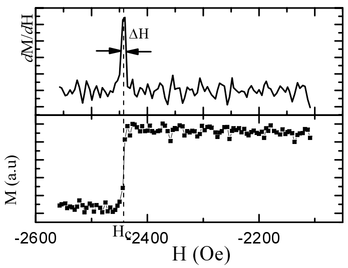

Fig. 2. dM/dH and M versus the magnetic field.

All the films show perpendicular magnetic magnetic properties. Fig.1 shows the typical Kerr microscopy images of the patterned dot arrays. The white contrast denotes magnetization point out of the film plane while the black contrast denotes magnetization point into the film plane. Kerr microscope could not detect the magnetization behavior of a single dot with size less than 1000 nm. However, the magnetization reversal process of the ensemble of the dot arrays can be detected by this technique. Hysteresis loops of the dot arrays were obtained by calculating the reversal area of the Kerr microscopy images at different applied field. The switching field distribution (SFD) can be calculated from the hysteresis loops as shown in Fig.2. It is found that SFD decreasing from 7% for the dot arrays with size of 3000 nm to 1.5 % for the dot arrays with the size of 250 nm.

Our results show that amorphous TbFeCo dot arrays with perpendicular anisotropy are prominent candidates for future high density patterned media with low SFD.

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On Characterizing the Magnetization Reversal of Bit Patterned Co/Pt Multilayer Recording Media

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Bit patterned media (BPM) recording is, at present, being considered as one possible approach proposed to delay the onset of the superparamagnetic limit beyond ~Tbit/in^2. BPM that has the sufficiently narrow switching field distribution (SFD) will have a major impact on the future of high density magnetic data storage and is currently the subject of active research [1]. In this work, e-beam lithography technique was used for providing patterned arrays, and studying the behavior of magnetization switching for the individual elements. The pattern size was ranged between 1000 nm (=1 μm) to 50 nm.

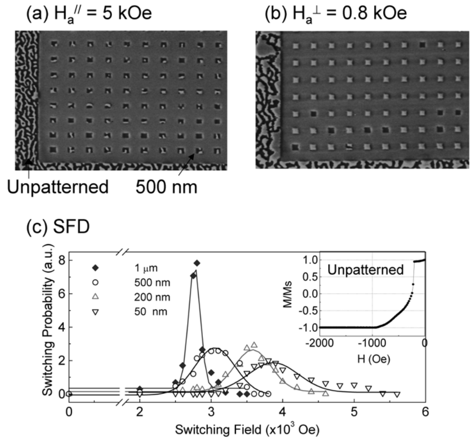

Fig. 1. MFM images of two different initial states; (a) in-plane ac demagnetized and (b) out-of –plane ac demagnetized. The pattern size was 500 nm. (c) SFD as a function of pattern size.

Figs. 1(a) and 1(b) show magnetic force microscopy (MFM) images of two different states, namely, (a) a demagnetized state obtained by applying an in-plane ac field of 5kOe (IF), and (b) a state obtained by following the initial state of (a) and then applying a perpendicular ac field of 0.8kOe (PF). $(Co0.6nm/Pt1.8nm)_{10}$ multilayer films deposited on Si (111) substrate/Ta(3nm)/Pt(5nm) and patterned with a size of 500 nm were used. The IF shows largely multi-domain states whereas the PF yields nearly all single domain states, having two opposite polarities of magnetization even with a small peak amplitude of 0.8 kOe. This suggests that the pinning field be relatively weak as an alternating magnetic field is applied *perpendicularly* to patterned elements of the Co/Pt multilayer films.

In Fig. 1(c), the SFD as a function of pattern size is shown for these samples. A reduction in pattern size resulted in an increase in switching field. The switching field (SF) for the patterned, including the elements as large as 1 μm in size, was substantially higher than that for the unpatterned. See the inset.

REFERENCES

[1] T. Thomson *et al*., Phys. Rev. Lett. 96, 257204 (2006).