구두발표 II-1

Direct real-space observation of stochastic behavior in magnetization reversal process on a nanoscale

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1. Introduction

With the bit size in high-densitiy magnetic recording media approaching nanometer length scale one of the fundamental and crucial issues is whether the domain nucleation during magnetization reversal process exhibits a stochastic or deterministic behavior. Repeatability of local domain nucleation and deterministic switching behavior are basic and essential factors for achieving high performance in high-density magnetic recording [1,2]. However, no direct observation on the stochastic behavior of domain nucleation during magnetization reversal in real space at the nanometer scale has yet been reported. The main reason is due to limitations of the microscopic measurement techniques employed. Thus, experimental confirmation for stochastic behavior of domain nucleation together with its clarification has to date remained a scientific challenge.

2. Experimental

50-nm thick $(Co_{83}Cr_{17})_{87}Pt_{13}$alloy film was prepared on a 40-nm thick Ti buffer layer using dc magnetron cosputtering of a CoCr alloy target and a Pt target at a base pressure better than 8×10^{-7} Torr and a sputtering Ar pressure of 3 mTorr at ambient temperature. To observe the magnetic domain configuration during the magnetization reversal process, we utilized the full-field magnetic transmission soft X-ray microscopy beamline (6.1.2) at the Advanced Light Source in Berkeley CA. To study magnetization reversal in the CoCrPt film images were recorded with varying an external magnetic field, generated by a solenoid with field strength up to 5 kOe. To distinguish structural contrast due to defects, inhomogeneities, etc., from magnetic contrast, the images were normalized to an image taken under an external field sufficient to saturate the film.

3. Results and discussion

Domain nucleation sites appear stochastically distributed with the repeated hysteretic cycles, where the correlation increases as the strength of an applied magnetic field increases in the descending and ascending branches of the major hysteresis loop. Figure1a demonstrates typical domain configurations taken at applied magnetic fields of +512, +383, +254, +124, and +5 Oe in the descending branch of the major hysteresis loop during two consecutive hysteretic cycles. Interestingly, one clearly notes that in most cases the nucleation sites appear different in two consecutive cycles, as representatively shown in the inserted circles. For a better visualization of the randomness of nucleation sites, we have overlapped two domain configuration images in a larger sample area of 7.6×7.6 m^2 obtained from the consecutive measurements. Figure1b shows

a typical overlapped image taken under an applied magnetic field of +400 Oe, where the red and green spots represent the first and second measurements, respectively, and the black spots indicate the coincident nucleation sites between the two measurements. This result clearly reveals that the domain nucleation process of CoCrPt alloy film is not deterministic, but mostly stochastic in the successive hysteretic cycles.

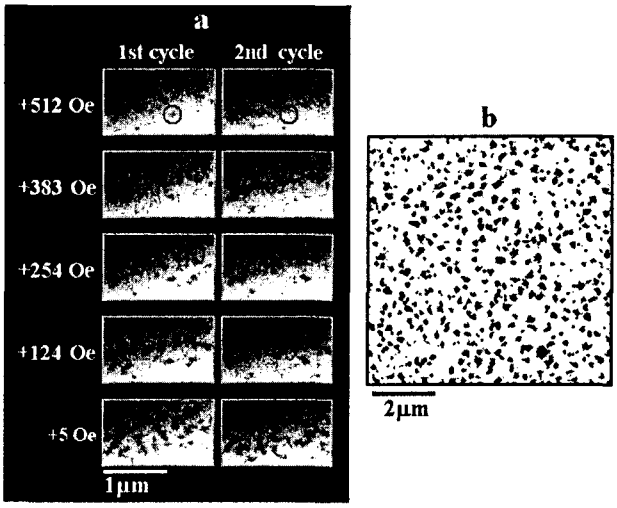

Figure 1. a, Magnetic domain configurations of $(Co_{83}Cr_{17})_{87}Pt_{13}$ alloy film taken at applied magnetic fields of +512, +383, +254, +124, and +5 Oe in the descending branch of the major hysteresis loop during two consecutive hysteretic cycles. b, Overlapped domain configuration image in a larger sample area of 7.6 7.6 m^2 taken at an applied magnetic field of +400 Oe.

4. Conclusions

We report here the first direct experimental observation of the stochastic nature of magnetization reversal processon a nanometer length scale in magnetic recording media, using a CoCrPt alloy film. Thermal fluctuations in the orientation of the magnetic moments of the grains are found to play a dominant role in the stochasticbehavior of domain nucleation during magnetization reversal of CoCrPt alloy film. Our resultsprovide a fundamental insight into the domain nucleation process during magnetization reversal of high-density magnetic recording media, and open the path to further technological developments in this area.

5. References

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6. Acknowledgements

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