U-2

Magnetization reversal process of the nanosized elliptical permalloy magnetic dots with various aspect ratios

Seoul National University, Korea Institute of Science and Technology J. H. Lee*

Seoul National University K. H. Oh
Korea Institute of Science and Technology K. Y. Kim

1. 서 론

Recently, there has been much interest in magnetic thin film patterned in submicron scale because of possible ultrahigh density storage media or logical device applications [1-3]. Various geometries such as rectangle, circle, ring and ellipse type dots have been studied to find the shape showing stable switching behavior from repeated cycles. However, rectangle and circle types may not be suitable for device applications because they have two uncontrollable different magnetization reversal modes: C state and S state, resulting in different coercivity and irreproducible switching [4]. Ellipse type dots without edge domains, showing stable magnetization reversal process, are recommended as more promising cell structure for information storage and signal cognition due to strong shape anisotropy. In this study, we have investigated magnetic configurations of ellipse type dots in magnetization reversal with varying aspect ratios, and analyzed their behaviors in the external magnetic fields.

2. 실험방법

OOMMF program utilizing Landau-Lifshitz-Gilbert equation has been used to investigate the magnetic configurations in patterned film elements. The magnetic dot thin film is modeled as an array of tetragonal shaped unit cells with the saturation magnetization Ms=800emu/cc, the uniaxial anisotropy Ku=10^3erg/cc and the exchange constant =0.5. The unit cell is 5 nm x 5 nm x 10 nm. The dots are set to ellipse type, of those minor axes are varied from 50 nm to 300 nm, while major axes are fixed as 300 nm. The random magnetization was given to initial cells. Hysteresis curves and magnetization configurations by applying 3 kOe external field were obtained.

3. 실험결과 및 고찰

In case of small aspect ratio (minor axes = 250 nm), to states of magnetization reversal (C state and S state) are obtained, showing the *single vortex state* and *double vortex state* as shown in Figure 1. This is similar to NiFe dot in the rectangular type in reported by Zhu et al [4]. In Figure 2, in case of medium aspect ratio (75 nm = minor axes = 200 nm), magnetization is reversed through only *double vortex state*. Finally, when the minor axis is much shorter than the major axis (major axes = 50 nm), magnetization is finished through internal magnetization reversal and propagation without vortex generation (*vortex free state*). In large aspect ratio, as the end of long axis is pinned strongly by shape anisotropy, so that previous magnetization can be maintained until the internal magnetization generated in the center is reached, resulting in vortex free state. The above micromagnetic analysis tells us that at submicron scale, different aspect ratio can give different switching modes and fields. In addition, it is considered that the magnetization configurations shown in Figure 1, and 2 with different aspect ratio depends on largely the shape anisotropy. From these results, even though elliptical shape is chosen for device applications, an optimum cell condition is to be examined for escaping the unexpected magnetization reversal. In conference site, we will present the dynamic magnetization process in more detail.

4. 참고문헌

[1] G. A. Gibson and S. Schultz, A. of Appl. Phys. **73**, 4516 (1993)
[2] J. Gadbois and J. -G. Zhu, IEEE Trans. Magn. **34**, 1066 (1998)
[3] R. P. Cowburn and M. E. Welland, Science, **287**, 1466 (2000)
[4] J. Gadbois and J. -G. Zhu, IEEE Trans. Magn. **34**, 1066 (1998)

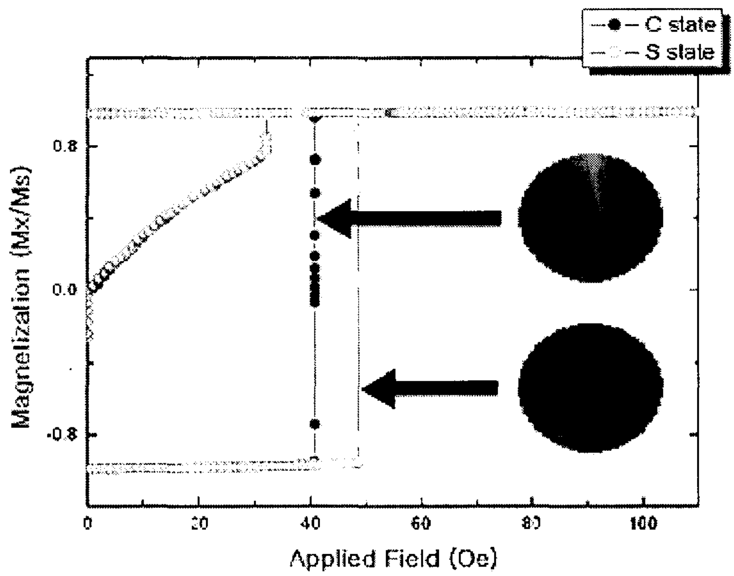

Fig. 1 Two magnetizaion modes of magnetic dot with small aspect ratio (minor axis length = 270 nm)

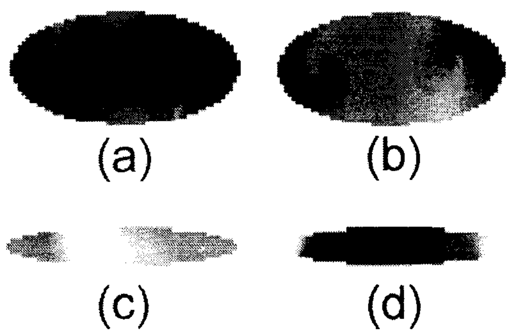

Fig. 2 Magnetization configurations of two magnetic dots of those minor axes are 150 nm and 50 nm. (a) and (b) shows *double vortex state*, (c) and (d) shows *vortex free state*.