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나노 입자의 자화 반전 모드

삼성종합기술원, Storage Lab. 이 경 진*
한국과학기술원 재료공학과 이 택 동

MAGNETIZATION ROTATION MODE OF NANO-SIZED PARTICLE

SAIT, Storage Lab. K. J. LEE*
KAIST, Dept. of Mater. Sci. and Eng. T. D. LEE

1. INTRODUCTION

We have investigated rotation mode of nano-sized magnetic particle by micromagnetic simulation. Since magnetic recording media those are comprised of nano-sized grains are subjected to head field with nano second pulse width, limits of dynamic coercivity and switching time become critical issues. This work is motivated by the fact that rotation mode can affect dynamic coercivity and switching time [1, 2]. We focus how magnetic parameters and geometries affect the rotation mode. In addition, effects of damping constant and exchange coupling strength on coercivity and switching time are examined.

2. MODEL

Tetragonal shaped particle with dimension of D by D by t nm^3 is assumed where L is the in-plane edge length and t is the thickness. To consider incoherent rotation mode properly, the magnetic particle is subdivided into lots of cubic cells with volume $V = (2\ nm)^3$, saturation magnetization $M_S = 250\ emu/cm^3$, and uniaxial anisotropy $K_u = 10^6\ erg/cm^3$. Other magnetic parameters are varied for broad range. Switching process is simulated by applying pulse-type external field along the easy axis of the particle with remanent state. Effective coercivity is defined as the smallest external field magnitude to switch magnetization. Switching time is defined as an elapsed time of the magnetization switching. Time evolution of magnetization is obtained from integrating of the Landau-Lifshitz-Gilbert equation.

3. RESULTS AND DISCUSSIONS

Complex incoherent rotation mode that includes curling (in-plane vortex) and two 180° domain walls along the easy axis is obtained in 40x40x40 nm^3 sized particle (Fig. 1), while coherent rotation mode is obtained in 12x12x40 nm^3 sized particle. Transition edge length ($D_T = 30\ nm$) from coherent to incoherent mode is about 67% of analytic critical length, L_C ($= 0.4d \cdot K_u/M_S^2 = 45\ nm$, where d is the 180° domain wall thickness [3]) that considers curling mode only.

We focus on the smaller particle with edge length less than 12 nm because this length is comparable with the grain size of current recording media. In this case, the only 180° domain wall formation is possible. Exchange energy normalized by 180° wall energy ($E_W = 4A(A_{ex}K_u)^{1/2}$, where A is the area of basal plane.) can measure degree of nonuniformity of magnetizations during rotation [1]. For instance, if magnetizations follow incoherent mode the exchange energy must be nonzero during rotation. When the particle edge length is smaller than 12 *nm*, we obtain universal relation between the normalized exchange energy and the particle thickness. For all edge length, transition thickness from coherent to incoherent rotation mode is $2\pi \cdot d$ (Fig. 2). The transition thickness of $2\pi \cdot d$ is valid for all ranges of damping constant and exchange coupling strength of current media. More results of dynamic coercivity and switching time will be presented.

4. REFERENCES

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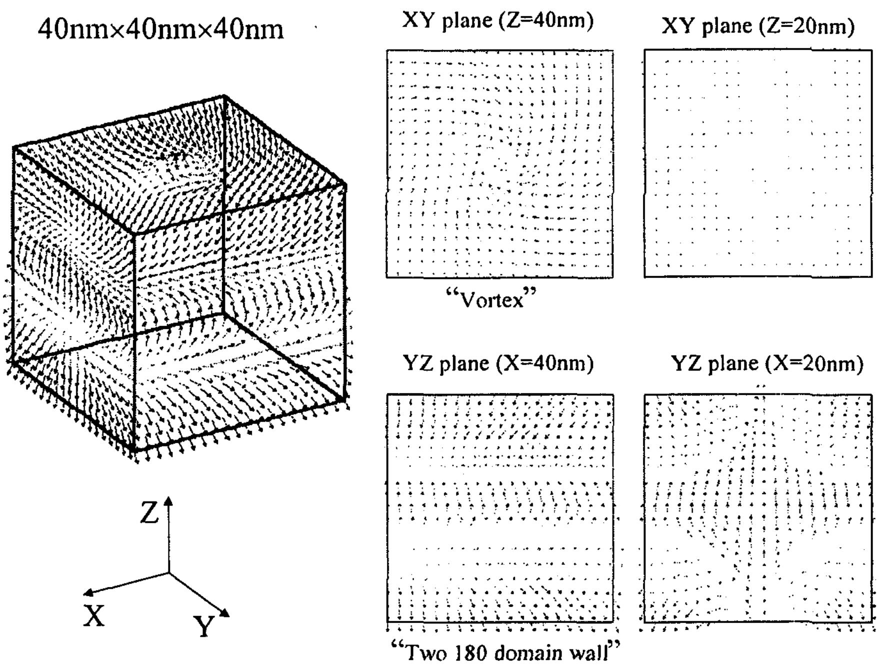

Fig. 1. Magnetization configurations of 40x40x40 nm^3 sized particle at <M_Z>=0.