CC04

Dynamic Transformation of a Single Domain Wall Moving in Ferromagnetic Nanostripes

Jun-Young Lee, Ki-Suk Lee, Sangkook Choi, Konstantin Y. Guslienko, and Sang-Koog Kim *
Research Center for Spin Dynamics & Spin-Wave Devices, Seoul National University, Seoul 151-744, Republic of Korea
Nanospintronics Laboratory, Department of Materials Science and Engineering, College of Engineering,
Seoul National University, Seoul 151-744, Seoul 151-744, Republic of Korea
*Corresponding author: sangkoog@snu.ac.kr, Phone: +82 2 880 5854, Fax: +82 2 885 1457

Domain wall (DW) dynamics in magnetic nanostripes is of considerableinterest due to theirpotential applications to ultrahigh-density information storage and logic devices [1]. Recent experimental studies have revealed complex dynamic transformations between different-type internal DW structures in a certain field range above the Walker field (H_w) [2]. However, their mechanism and underlying physics have not been clarified yet. Nowadays, the complex DW motion in two-dimensional nanostripes is currently a key problem to be solved.

In this presentation, we report dynamic transformations between different DW structures during the propagation of a single DW in magnetic nanostripes with distinct unique periodicities under applied magnetic fields above Hw, as studied by micromagnetic simulations. The different-type DW dynamic behaviors can be characterized by three different-type periodicities in which transverse wall (TW), antivortex wall (AVW), and vortex wall (VW) are transformed from one to another in periodic manner [3]. The observed oscillatory transitions are characterized according to the dynamic changes of the different DW internal structures in the characteristic transition periods, i.e., type I: $TW_V \rightarrow AVW_{up} \rightarrow TW_\Lambda \rightarrow AVW_{down}$, type II: $TW_V \rightarrow VW_{up} \rightarrow TW_\Lambda \rightarrow VW_{down}$, and type III: $TW_V \rightarrow AVW_{up} \rightarrow TW_\Lambda \rightarrow VW_{down}$ where the subscripts indicate the polarizations of TW, VW, and AVW. In addition, the V or Λ-shaped configuration of TWs determines the core orientation of VWs or AVWs to be formed in the transition process. The nucleation sites of the TWs at both the stripe lateral edges become the cores of vortices and antivortices determining type of the DW (VW or AVW) which will be created. Upon the nucleation of the cores of VWs and AVWs at either edge of the nanostripe, the cores of the VWs first move backward and then move forward through their gyrotropic motions along parabolic orbits. In contrast, the cores of the AVWs first move forward and then backward.

These oscillatory transformations will be presented in details on the basis of the calculated dynamic magnetization configurations. The shape of DW position vs. time curves together with the trajectories of the VW or AVW coreswithin the stripesduring their dynamic motions will be discussed. Analytical calculationof the observed periodic DW transformations yields the frequency of the oscillations, which coincides with the Larmor frequency and weakly depends on the stripe geometrical parameters. These results offer a better understanding of the complex dynamic motions of DWs in the turbulent regime in patterned magnetic films.

This work was supported by Creative Research Initiatives (ReC-SDSW) of MOST/KOSEF.

REFERENCES
[1] D. A. Allwood et al., Science 309, 688 (2005).
[2] M. Hayashi, L. Thomas, C. Rettner, R. Moriya, and S. S. P. Parkin, Nature Phys. 3, 21 (2007).
[3] J.-Y. Lee, K.-S. Lee, S. Choi, K.Y. Guslienko, and S.-K. Kim, unpublished.

CC05

Numerical Simulation for Current-Induced Magnetization Reversal in MTJs

<u>T. Takahashi</u>*[1], H. Tsuchiura[1, 2], and A. Sakuma[1, 2]
[1]Department of Applied Physics, Tohoku University, Aoba 6-6-05, Aoba-ku, Sendai 980-8579, Japan
[2]CREST, Japan Science and Technology Corporation (JST)
*Corresponding author: takahashi@solid.apph.tohoku.ac.jp , Phone: +81 22 795 5881, Fax: +81 22 795 5881

Current-induced magnetization reversal is a promising writing method in Magnetic Random Access Memory (MRAM) devices based on magnetic tunnel junctions (MTJs) consists of a hard magnetic layer with a reference magnetization and a free soft magnetic layer separated by a thin isolating tunnel barrier. At present, the threshold current density for the data writing is about 2×10^6 A/cm^2 [1], and further reductionof this value is required to put MRAM devices into practical use. One of the contributing factors for lowering the threshold current is magnetization patterns in the free layer. Thus we numerically study the current-induced magnetization reversal processes for two magnetization patterns in the free layer, so-called the c-state and the s-state [2], by using the Landau-Lifshitz-Gilbert equation with the spin-transfer-torque term proposed by Slonczewski [3].

Figure 1 shows the magnetization reversal processes start from the c-state and the s-state. Schematics of these states are shown in the inset of Fig.2. The obtained threshold currents for the c- and s-states are plotted in Fig.2, as functions of the pulse width of the current. We find that the threshold current in the s-state is about half of that in the c-state. We will discuss the physical reason for the lower threshold current for the s-state by taking account of the magnetic energy distribution within the reversal processes.

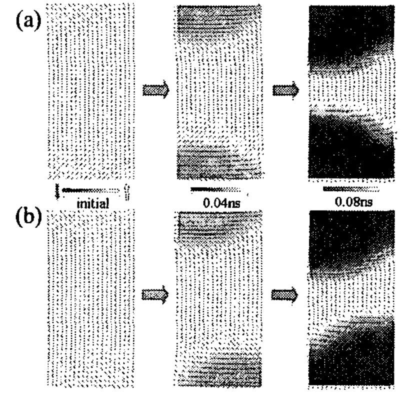

Fig. 1. The magnetization reversal processes start from the c-state (a)and the s-state (b). Spin-polarized currents are injected perpendicular to the planes.

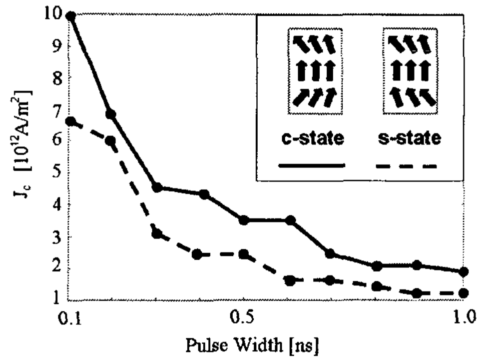

Fig. 2. The threshold current for the c- and s-states as functions of the pulse width of the current. The inset shows the schematics of the c- and the s-states.

REFERENCES
[1] Z. Diao, et al. Appl. Phys. Lett. **87**, 232502 (2005).
[2] T. Schrefl and J. Fidler, J.Appl.Phys. **89**, 11, 7000 (2001).
[3] J. C. Slonczewski, J.Magn.Magn.Mat. **159**, L1 (1996).