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Reflection and Refraction of Dipole-Exchange Spin Waves at a Single Magnetic Interface in Confined Geometry

Dae-Eun Jeong, Dong-Soo Han, Sangkoog Choi, and Sang-Koog Kim*
Research Center for Spin Dynamics & Spin-Wave Devices and Nanospinics Laboratory, Department of Materials Science and Engineering, College of Engineering, Seoul National University, Seoul, South Korea.
*Corresponding author: Sang-Koog Kim, e-mail: sangkoog@snu.ac.kr

Dipole-exchange spin waves (DESWs) in magnetically ordered materials of restricted geometry have attracted considerable interest in the current research areas of both nanomagnetism and magnetization (M) dynamics [1]. DESWs are, in principle, low-lying collective M excitations in confined magnetic elements, in which both long-range dipole and short-range exchange interactions between individual Ms should be taken into account. With the help of advanced fundamental understandings of a variety of DESW eigenmodes in patterned magnetic thin films, many now consider practical applications of DESWs to a new class of logic devices as well as other integrated electronic circuits [2]. In order to realize such promising DESW applications, it is thus necessary to understand the wave properties of DESWs in waveguide nanostructures, such as the reflection and refraction of optical waves between two dissimilar optical media. For example, negative refraction of DESWs has been demonstrated using a specific magnetic twin interface [3]. In the case of optical waves, the processes of reflection and refraction at an interface are just the result of the interaction of optical waves with matter on a submicroscopic level, the so-called scattering phenomenon. This phenomenon can be conveniently described macroscopically by Snell's Law of reflection and refraction. Analogously to optics, the laws of reflection and refraction of DESWs would provide much quantitative information on the reflection and refraction behaviors of DESWs, simply by using the refractive indices of different media, and would also allow us to manipulate SWs in magnetically ordered systems of confinements, such as nanowire.

In the presentation, we report on a theoretical approach to verifying the laws of reflection and refraction of DESWs by analytically deriving the dispersion relations of DESWs in two different soft ferromagnetic materials as well as the boundary condition of a specific interface. Moreover, computer simulations examine the laws of refraction and reflection for some specific cases. On the basis of the results, we elucidate the underlying physics of total reflection of DESWs in laterally confined, inhomogeneous soft magnetic thin films.

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DP13

Effect of Magnetic Properties on the Current-Induced Magnetization Switching with Perpendicular Anisotropy and Polarization-Enhancement Layer

Woojin Kim[1], Kyung-Jin Lee[2], and Taek-Dong Lee[1]*
[1]Dept. of Materials Sce. and Eng., KAIST, Daejeon, Korea
[2]Dept. of Materials Sce. and Eng., Korea University, Seoul, Korea
*Corresponding author: Taek-Dong Lee, e-mail: tdlee@kaist.ac.kr

Study on the current-induced magnetization switching (CIMS) with perpendicular anisotropy is of interest [1], especially in a magnetic tunnel junction (MTJ) [2] as a major candidate for high density MRAM. Soft magnetic polarization-enhancement layers (PELs) are generally inserted at both sides of MgO to enhance tunnel magnetoresistance and spin-transfer torque. We studied the effects of magnetic properties on the CIMS in MTJs consisting of Pinned Layer(PL, 20 nm)/Bottom PEL(1 nm)/MgO(1 nm)/Top PEL(1nm)/Free Layer(FL, 6 nm) using micromagnetic simulation. All the magnetic layers are discretized into 2x2x1 nm^3 unit cells. The Slonczewski spin torque is considered for the magnetizations adjacent to MgO, and the spin torque for non-uniform magnetizations inside magnetic layers is considered simultaneously. The results in Fig. 1 are obtained when PL and FL have saturation magnetization (M_s) of 400 emu/cm^3, perpendicular anisotropy (K_u) of 2.0x106 erg/cm^3, and exchange constant (A_{ex}) of 1.3x10-6 erg/cm. Fig. 1 shows the switching time (t_{sw}) as a function of current density (Je) for various Ms of PEL and interlayer exchange constant ($A_{ex,IL}$) between PEL and perpendicular layers. $A_{ex,IL}$ is assumed to be 40% of A_{ex} for variation of M_s, and M_s of PEL is 600 emu/cm^3 for variation of $A_{ex,IL}$. Increase of M_s reduces t_{sw} even though the magnitude of spin torque is decreased, and the reduction of tsw is more significant in switching from antiparallel (AP) to parallel (P) configuration. Decrease of $A_{ex,IL}$ also reduces t_{sw}. Moreover, continuous flip-flops of magnetizations were observed in switching from P to AP. Details of the result will be discussed in the presentation.

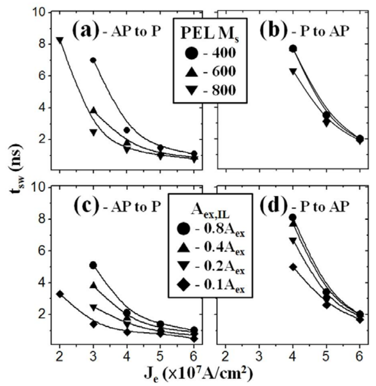

Fig. 1. t_{sw} vs. J_e for various M_s of PEL ((a),(b)), and $A_{ex,IL}$ ((c),(d)), and for switching from AP to P ((a),(c)) and P to AP ((b), (d)).

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