Effect of Spin-transfer Torque on Mode Interference of Spin Waves

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It is essential to capture the intrinsic nature of spin-transfer torque (STT) for understanding STT physics and utilizing it for devices. Recently, it has been reported that spin-transfer effect occurs in spin wave [1], which enables to study the intrinsic features of STT in a more obvious way. It is because spin wave propagation in nanowire is less sensitive to local defects and edge roughness than domain wall motion. In the previous studies, it was demonstrated that STT induces spin wave Doppler shift in frequency-domain [2] and time-domain measurement [3], which allowed the investigation of the nature of STT.

In this work, we study the effect of STT on mode interference of spin waves. As a result of the mode interference of spin waves, spin wave intensity locally increases or decreases in a nanowire and these intensity localized positions do not move with time. The spatial periodicity of the intensity locked positions, *L*, is $2\pi/(k_{x1}-k_{x2})$, where k_{x1} and k_{x2} are the first and second longitudinal wave numbers [4]. For exchange spin wave where exchange energy is more dominant than magnetostatic energy, they are determined by the following dispersion relation,

$$\omega_0 = \frac{-(k_{x1}+k_{x2})u_0 \pm \sqrt{\left\{(k_{x1}+k_{x2})u_0\right\}^2 - 4\left\{u_0^2 k_{x1}k_{x2} - \gamma^2\left(N_Z M_S + Dk_0^2\right)\right\}}}{2},$$

where $\omega_0 = 2\pi f$ is cyclic excitation frequency, $u_0 = \mu_B jP/eM_S$ is the magnitude of adiabatic STT, μ_B is the Bohr magneton, *j* is the current density, *e* is the electron charge, M_s is the saturation magnetization, γ is the gyromagnetic ratio, N_z is the demagnetization factor along the thickness, *D* is the exchange stiffness, and $k_0^2 = k_{x1}^2 + k_{x2}^2$. This theoretical prediction for the periodicity of the intensity locked positions is verified by micromagnetic study. We found that the periodicity of the locked positions with increasing current from micromagnetic study is in good agreement with that from above equations. Furthermore, this provides a way to measure the current-induced spin wave Doppler shift in spatial-domain.

참고문헌

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