低飽和磁化材料をフリー層とするbiquadratic 結合を用いたスピントルクオシレータの基礎検討

Investigation of spin torque oscillator under the biquadratic coupling in the free layer with small saturation magnetization

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[Introduction] Biquadratic coupling is one of magnetic interlayer exchange couplings, which acts on ferromagnetic (FM) layers consisted of FM/Interlayer/FM trilayer [1]. In this study, we investigated the spin torque oscillation (STO) in the presence of the biquadratic coupling in the top layer with a small saturation magnetization M_s by numerical simulations.

[Experiment] A micromagnetic model was used in the simulations [2]. The magnetization motion was calculated using the Landau-Lifshitz-Gilbert (LLG) equation with the spin torque term. In the calculations, we assumed a trilayer with top FM (small M_s = 50 kA/m)/Interlayer/Pinned FM layer ($Co_{90}Fe_{10}$), and the magnetization of $Co_{90}Fe_{10}$ was pinned in x-direction by IrMn. The thicknesses of each layer in the trilayer were 2 nm.

[Results] Figure 1 shows time evolution of magnetization components $M_{x,y,z}/M_s$ in the top layer when the current density j and the biquadratic coupling coefficient J_2 are -1.1×10^{11} A/m^2 and -0.6 mJ/m^2 without the external magnetic field. As shown in Fig. 1, the $M_{y,z}/M_s$ are clearly oscillated. The value of STO's frequency f_S estimated by Fast Fourier Transform is ~67 GHz. The value of f_S is increased with decreasing the value of J_2, whereas the f_S is zero when J_2 is 0 mJ/m^2, because the biquadratic field H_{bq} is very large (~ 12 T when J_2 is -0.6 mJ/m^2), leading to generate a high frequency of STO in the small M_s. These results were agreed with the analytical theory base on the LLG equation under the assumption of axially symmetric system.

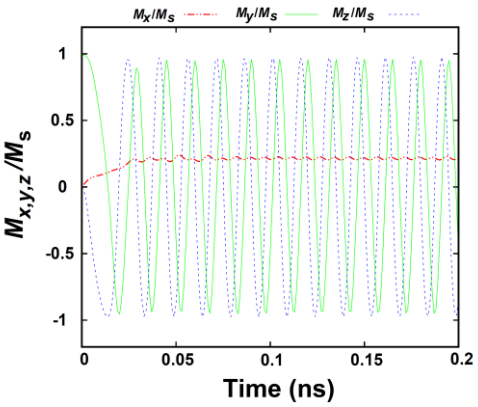

Fig. 1 Time evolution of magnetization components $M_{x,y,z}/M_s$ of the top layer when current density j is -1.1 × 10^{11} A/m^2 under external magnetic field $\mu_0 H_{app}$ = 0 mT.

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