Influence of spin polarization of SIL on oscillation behavior of a mag-flip spin-torque-oscillator (STO) device

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Microwave assisted magnetic recording (MAMR) is considered as one of good candidates for next generation higher areal density magnetic recording technology. For MAMR writer, mag-flip spin-torque-oscillator (STO) consisting of out-of-plane magnetized spin injecting layer (SIL) and in-plane magnetized field generating layer (FGL) is required. Microwave frequency of above 20 GHz induced by a current with its density below 1.0×10^8 A/cm^2 is required [1,2]. However, this has not been realized experimentally. In this work, we employed micromagnetic simulations to study the effect of spin polarization (β) of SIL on the oscillation behavior of a mag-flip STO devices.

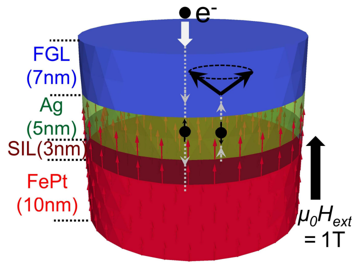

Fig.1: modelled mag-flip STO device for the micromagnetic simulation [4].

A cylindrically shaped pillar with a diameter of 30 nm consisting of a CFGG (7 nm) FGL, a Ag (5 nm) spacer layer, and a CFGG (3 nm) SIL were used for the calculations. The SIL was perpendicularly magnetized by a FePt (10nm). We employed a micromagnetic simulation code, magnum.fe, which solves the coupled dynamics of magnetization (***m***) and spin accumulations (***s***) simultaneously using the time dependent 3D spin diffusion equations and the Landau Lifshitz Gilbert (LLG) equation, respectively [3]. This will allow us to directly simulate the effect of locally varying spin accumulations on the magnetization dynamics. A constant spin polarization, β of 0.8 was assumed for the FGL while the spin polarization of SIL was varied from 0.50 to 0.90. A constant external magnetic field (μ_0H_{ext}) of 1.0 T was applied in a direction from the SIL to the FGL while the electrons were pumped from the FGL to the SIL of the pillar.

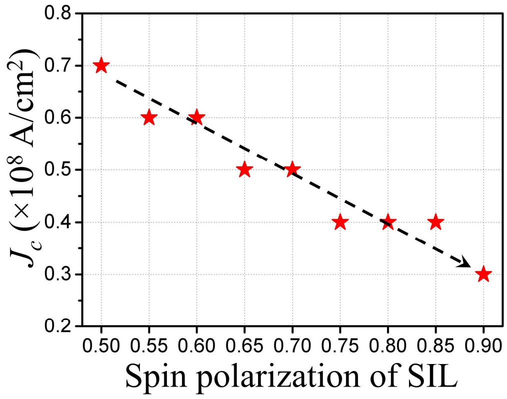

Fig.2: Critical current density versus spin polarization of spin injection layer (SIL). Applied magnetic field was 1.0 T [4].

Figure 2 shows the calculated critical current density (J_C) needed to induce microwave oscillation when the spin polarization of the SIL is varied [4]. In the simulations, the frequency spectrums were calculated by fast Fourier transform of M_x oscillation of FGL. J_C was defined as the critical current density at which the M_x oscillation of FGL was observed. These results show that J_C decreases from 0.7×10^8A/cm^2 to 0.3×10^8A/cm^2 by increasing the spin polarization of SIL from 0.50 to 0.90, suggesting that J_C can be substantially reduced by using a material with high spin polarization as a SIL. By increase of spin polarization of SIL, *i. e.* from 0.65 to 0.85, not only the oscillation frequency increases from 16.1 GHz to 22.5 GHz (Fig. 3), but also the oscillation cone angle of FGL magnetization rises from 23.6° to 59.8°. Calculated average spin accumulation showed that by increasing β^{SIL} the averaged spin accumulation in the X (S_x) and Y direction (S_y) of FGL increases, resulting in an increase of oscillation cone angle of FGL. In addition, increase of β^{SIL} led to increase of averaged spin accumulation in the Z direction (S_z) within FGL which caused the increase of microwave frequency peak.

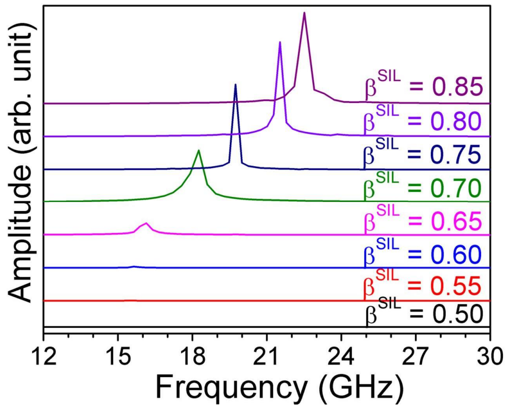

Fig.3: Influence of spin polarization of SIL on RF peak of STO device shown in Fig. 1. Applied magnetic field is 1.0 T and applied current density is 0.5×10^8 A/cm^2.

[1] Zhu J. *et al.,* IEEE Trans. Magn. 44, 125 (2008), [2] Takeo A. *et al.*, Intermag Conference 2014 (AD-02),
[3] Abert C. *et al.* J. Magn. Magn. Mater. 345 (2013) 29. [4] Bosu S. *et al*. Appl. Phys. Letters, submitted.