Stability of out-of-plane precession with the application of a tilted magnetic field in spin torque oscillator having a planar free layer and a perpendicular polarizer

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Excitation of out-of-plane (OP) precession was reported earlier in spin torque oscillators (STOs) having a planar free layer (FL) and a perpendicular polarizer [1]. Another study also revealed that the rotation direction can be controlled by current polarity [2]. These properties are beneficial to a high-frequency magnetic field generator for microwave assisted magnetization recording (MAMR); *i.e.*, it provides possibilities to synchronize the rotation direction of circularly polarized magnetic field to that of the magnetization of recording region, which gives rise to a significant reduction of the switching field [3]. So far, OP precessions have been studied under the application of the in-plane (IP) [1] or OP magnetic field [2]. However, in practical MAMR systems, the STO feels a tilted magnetic field, which is a composite of the OP magnetic field from the recording head and the IP magnetic field from the recording bits. For this reason, we studied the precession behavior of the STO under arbitrary magnetic field angles.

We fabricated an MgO-based STO composed of buffer/Ru 6.0/[Pt 0.16/Co 0.24]$_9$ 3.6/Ru 0.44/[Co 0.24/Pt 0.16]$_5$ 2.0/$Co_{80}B_{20}$ 0.4/W 0.2/$Fe_{80}B_{20}$ 1.0/MgO 1.0/$Co_{60}Fe_{20}B_{20}$ 3.0/MgO 1.0/capping (thickness in nm). The CoFeB is the FL. First, we measured the emission spectra of the STO as a function of magnetic field (H_B) at bias voltage (V_B) of -500 mV and various magnetic field angles (θ). Figure 1 shows the emission spectra and the device resistance at θ = 10°. When $|H_B|$ increased and reached a critical magnetic field ($H_B^{c\pm}$), the resistance jumped and the main peak shifted from 14 GHz to 4 GHz. These resistance and frequency changes correspond to the transition from the OP to IP precession [2]. Next, we measured $H_B^{c\pm}$ as a function of θ. When θ changed from the IP to OP direction, $H_B^{c\pm}$ increased monotonically. The IP component of $H_B^{c\pm}$ converged to a constant value regardless of θ. These experimental results are well explained by the macrospin analysis.

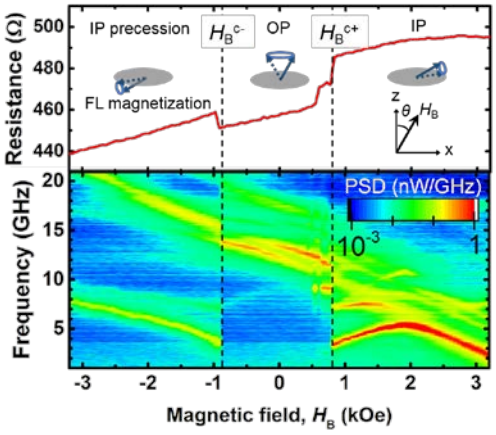

Fig. 1. Device resistance and emission spectra of the STO at V_B = -500 mV and θ = 10°. Inset shows the schematics of precession modes and the definition of θ.

References:

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[3] J.-G. Zhu and Y. Wang, IEEE Trans. Magn. **46**, 751 (2010).