Mag-flip spin torque oscillator using highly spin polarized Heusler alloy as spin injection layer for microwave assisted magnetic recording

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A major challenge for practical use of microwave assisted magnetic recording (MAMR) for next generation high areal density magnetic recording is the development of a mag-flip spin torque oscillator (STO)[1] consisting of an in-plane magnetized field generating layer (FGL) and a perpendicular magnetized spin-injection layer (SIL) that is able to generate a large oscillating magnetic field (H_{ac}) from the FGL with a frequency over 20 GHz at a small bias current density J_C<1.0 × 10^8 A/cm^2 [2]. Solid understanding of the underlying mechanism of the large angle out-of-plane precession (OPP) is equally essential. Recently, we reported [3] reduction of J_C by ~50% using highly spin polarized Heusler alloy $Co_2FeGaGe$ (CFGG)/FePt SIL compared to a reference Fe_2Co/FePt SIL for spin torque induced oscillation with frequency f ~ 15 GHz in STOs with CFGG FGL. In the present study, we have investigated the oscillation behavior in a 40 nm diameter circular pillar mag-flip STO device (Fig. 1(a)) using Fe_2Co FGL layer with high saturation magnetization $\mu_0 M_s$ ~ 2.3 T in order to acquire large H_{ac}, since H_{ac} is proportional to the magnetization volume of FGL. Fig. 1 (b) shows ΔR-$\mu_0 H_{ext}$ curves for different negative dc bias currents I_{dc} with $\mu_0 H_{ext}$ applied perpendicular to the film plane θ~0°. At $|I_{dc}|$ = 2.5 mA (J ~1.9×10^8 A/cm^2), a sudden jump to the intermediate resistance state at high H_{ext} region indicates excitation of magnetization dynamics by the reflected spin current from the SIL interface. Moreover, the resistance jump increases with increasing I_{dc}, and at $|I_{dc}|$ = 6mA, ΔR at $\mu_0 H_{ext}$ > 0.8 T is almost the same as that when $\mu_0 H_{ext}$ = 0, which suggests excitation of large angle ST oscillation. However, no rf electric output is expected from an ideal OPP mode since the system is symmetric along the film normal (Fig. 1(b) inset), i.e., variation of ΔR against time t is expected to be zero. In order to detect rf signal from the OPP mode excitation, therefore, $\mu_0 H_{ext}$ was tilted at θ ~ 5° from the film normal to obtain a finite $\Delta R(t)$. Figures 1(c) and (d) present, ΔR-$\mu_0 H_{ext}$ curve and the corresponding rf power spectrum, respectively, for $|I_{dc}|$~6 mA. A maximum f ~ 21 GHz has been observed for $\mu_0 H_{ext}$ ~ 1.09 T.

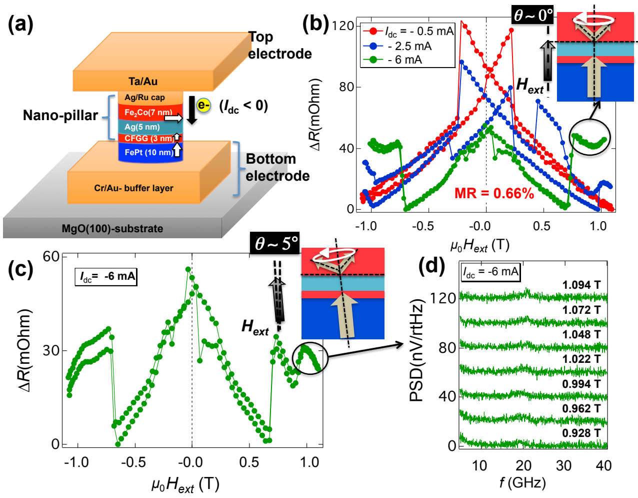

Fig.1: (a) Schematic diagram of the STO, (b) ΔR-H_{ext} curves for different I_{dc} with H_{ext} applied θ ~0°, (c) ΔR-H_{ext} curve at I_{dc} = -6mA for θ ~5°, and (d) corresponding rf spectra under various H_{ext}.

References: [1] Zhu *et al.,* IEEE Trans. Magn. 44, 125 (2008), [2] Takeo *et al.*, Intermag Conf. 2014 (AD-02), [3] Bosu *et al.*, (submitted)