Magnetization dynamics in mag-flip spin-torque oscillator with Heusler alloy $Co_2FeGa_{0.5}Ge_{0.5}$ electrodes for microwave assisted magnetic recording

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The main challenges for practical use of microwave assisted magnetic recording (MAMR) for next generation high areal density magnetic recording are development of a mag-flip STO[1)] consisting of the in-plane magnetized field generating layer (FGL) and the perpendicular magnetized spin-injection layer (SIL) that is able to generate a large H_{ac} from FGL with a frequency over 20 GHz at small bias current density $J_C < 1.0 \times 10^{12}$ A/m^2. Solid understanding of underlying mechanism of the large angle out of plane (OPP) mode uniform precession[2)] is equally essential. In this study we have investigated the oscillation behavior in a mag-flip STO device (Fig. 1(a)) with a 100 nm diameter circular pillar using well established highly spin polarized ferromagnetic Heusler alloy, $Co_2Fe(Ga_{0.5}Ge_{0.5})$, for SIL/FGL to reduce J_C. ΔR-H_{ex} curves with H_{ex} slightly tilted θ ~7° from the film normal are shown in Fig. 1 (b) for different negative dc bias currents I_{dc}. When $|I_{dc}|$ > 7.5 mA a sudden jump to the intermediate resistance state at high H_{ex} region appears in the R-H curves, indicating excitation of magnetization dynamics by the reflected spin current from the SIL interface. Fig. 1(c) presents detection of rf signal at f~12 GHz with large H_{ex}. In addition, the frequency systematically decreases with reducing H_{ex} following Kittle's equation. The rf frequencies as a function of H_{ex} are also plotted for different I_{dc} in Fig. 1(d). The blue shift of f with increasing I_{dc} at high H_{ex} region indicates detection of OPP mode STO for the bias current density $J_C \sim 0.95$ to 1.15×10^{12} A/m^2, which is close to the limit of desired J_C for practical application.

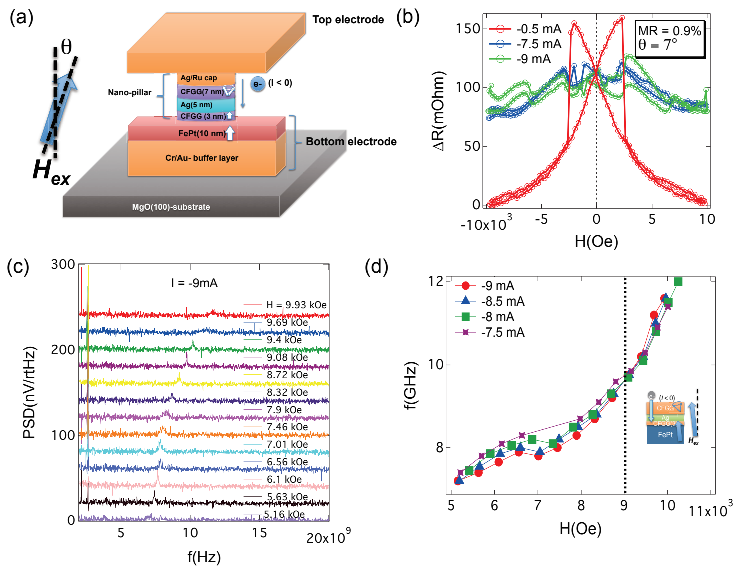

Fig.1: (a) Schematic diagram of the nano pillar STO device structure (b) ΔR-H_{ex} curves for different I_{dc}, (c) rf spectra at I_{dc} = -9.5 mA measured under various H_{ex}, and (d) frequency as a function of H_{ext} for I_{dc} = -7.5 mA to -9 mA ($J_C \sim 0.95$ to 1.15×10^{12} A/m^2).

References:

1) J. Zhu *et al.,* IEEE Trans. Magn. 44, 125 (2008)

2) A. Takeo *et al.*, Intermag Conference 2014 (AD-02),