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Spin torque diode effect in CoFeB/MgO/CoFeB magnetic tunnel junction with perpendicular magnetic anisotropy

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Spin transfer diode (STD) effect is one of new spin transfer torque (STT) related phenomenon which not only has great potential device applications, such as r.f. detector and amplifier but also provides us unique means to investigate STT in nano-magnet[1]. The bias dependence as well as angle dependence of STT has already been reported in in-plane anisotropy magnetic tunnel junctions (iMTJs)[2]. However, there are few studies on the STD in MTJs with perpendicular magnetic anisotropy (PMA)[3]. In this report we present our experiment measurement of STD using CoFeB/MgO/CoFeB perpendicular magnetic tunnel junction (pMTJs). pMTJs with diameter of 40 nm were fabricated and measure using conventional amplitude modulated STD measurement setup. Fig.1 shows the measured STD mixing voltage as function of r.f. current frequency under different applied magnetic field, where clear resonance peaks are observed. d.c. bias effect on STD resonance frequency, linewidth and amplitude were also analyzed and fitted based on microspin approximation using:

$$V_{STD} = \frac{A}{1+(f-f_0)^2/\Delta_0^2} - \frac{B(f-f_0)/\Delta_0}{1+(f-f_0)^2/\Delta_0^2} + y_0 \qquad (1)$$

where parameters A and B are proportional to Slonczewski torque and field-like torque respectively. As shown in Fig. 2, our results are similar to the reports using MTJs with in-plane magnetic anisotropy[1,2]. Qualitatively our results suggest that the Slonczewski torkance is symmetry to d.c. bias and shown non-zero value under zero bias whereas field-like torkance is zero under zero bias. In summary, we report the observation of spin torque diode (STD) effect in CoFeB/MgO/CoFeB tunnel junction with perpendicular magnetic anisotropy. Large bias voltage has been successfully applied and the bias dependence of STD signals implies similar torkances behaviors as reported for CoFeB/MgO/CoFeB iMTJ.

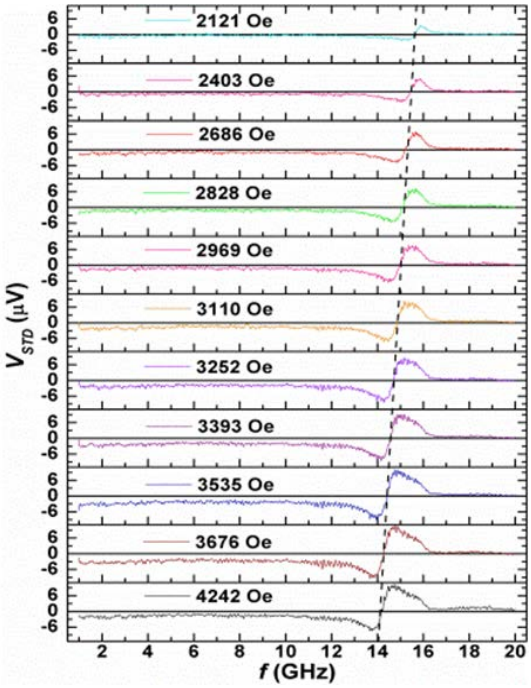

Fig.1 Frequency dependence of STD signals under various magnetic fields and zero bias voltage.

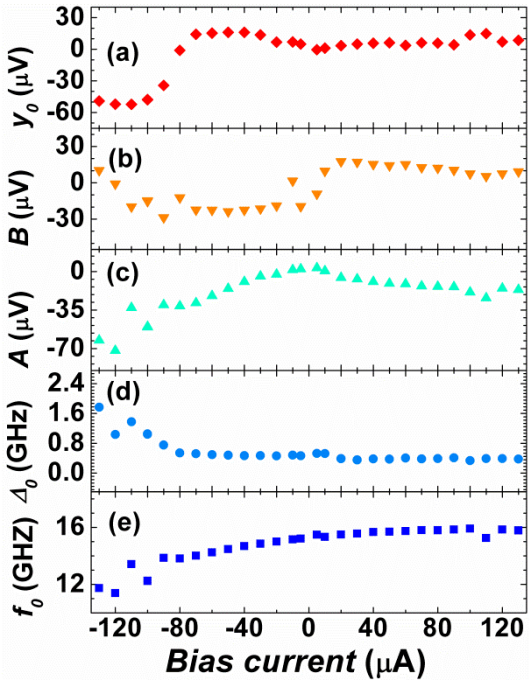

Fig. 2 Bias current dependence of STD signal: (a-c) fitting parameters A, B and y_0, (d) linewidth and (e) resonance frequency.

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