

CoFeB/MgO/CoFe/NiFe 磁気トンネル接合素子の スピントルクダイオード測定

Spin-Torque Diode Measurements of

CoFeB/MgO/CoFe/NiFe Magnetic Tunnel Junctions

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In the spin-torque diode effect, an applied rf current to the magnetic tunnel junction (MTJ) exerts an oscillating spin torque on the magnetization of the free layer, leading to excitation of the ferromagnetic resonance (FMR) mode. The dynamics of the free layer causes oscillations of the tunnel magnetoresistance (TMR). As a result, the oscillating resistance partially rectifies the rf current and dc voltage is obtained (V_{diode}). In spin diode spectra (V_{diode} v.s. frequency of the rf current), however, we often observe multiple-peak structure. In the previous study, in CoFeB(pinned)/MgO/CoFe/NiFe(free) MTJs (the purpose of which is to exploit their effective field by the field-like torque (H_{FLT})), two peaks were typically observed when in-plane magnetic field (H_{IP}) was applied^[1].

In this work, to investigate origins of the peaks, we fabricated CoFeB(5 nm)/MgO/CoFe(0.5 nm)/NiFe(1.5 nm) MTJs and conducted their spin diode measurements by applying perpendicular magnetic field (H_{perp}). H_{perp} is expected to suppress the additional FMR modes since H_{perp} leads to a uniform effective field (especially, demagnetization field, the Oersted field, and H_{FLT}) in the nanosized pillar of the MTJ in comparison with H_{IP} ^[2]. The MTJ which was fabricated into $50 \times 200 \text{ nm}^2$ -sized elliptic nanopillar exhibited the TMR ratio of 22% and the resistance of 179Ω in the parallel magnetic state at room temperature. Its diode spectra for H_{IP} along the hard axis and the spectra for H_{perp} at applied rf power of -20 dBm are shown in Fig. 1 and Fig. 2, respectively. While the well-separated two peaks are observed for H_{IP} , single peak is observed for H_{perp} . In the case of H_{IP} , a FMR mode in the free-layer can be considered to be split by non-uniform effective field in the free-layer of the MTJ.

[1] A. Chanthbouala, R. Matsumoto *et al.*, Nat. Phys. **7**, 626 (2011).

[2] S. Ishibashi *et al.*, APEX **3**, 073001 (2010).

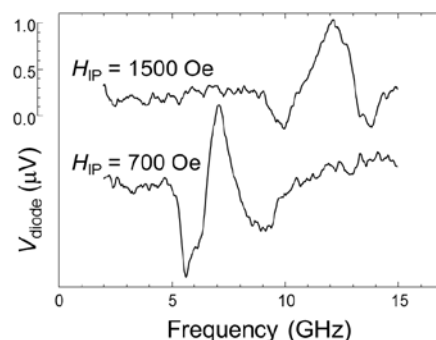


Fig. 1 Diode spectra for H_{IP}

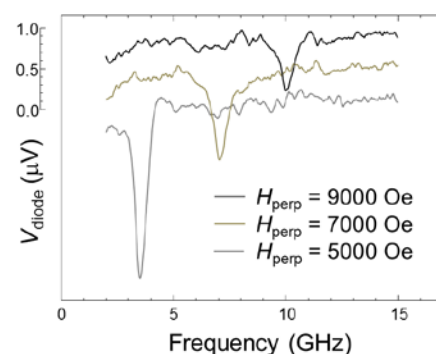


Fig. 2 Diode spectra for H_{perp}