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Bias Voltage Dependence of Field-like Torque in asymmetric CoFeB/MgO/CoFe/NiFe Magnetic Tunnel Junctions

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The spin torque has two components: the spin-transfer torque (STT) and the field-like torque (FLT). Not only STT, but also FLT can be useful to control the magnetization of spintronic devices. For example, in spintronic memristors, a magnetic domain wall in a magnetic tunnel junction (MTJ) is driven with the aid of FLT.[1] In spintronic memristors, larger FLT is desirable, and the polarity of FLT is required to be reversible by changing polarity of dc bias voltage for the reversible control of the magnetization. In conventional MgO-based MTJs with symmetric electrodes (e.g. CoFeB/MgO/CoFeB-MTJ), a relatively large FLT/STT ratio (~ 25%) was reported, but the polarity of FLT was not reversible.[2] In MTJs with asymmetric electrodes (e.g. CoFeB/MgO/CoFe/NiFe-MTJ), on the other hand, the polarity of FLT was theoretically predicted to be reversible.[3]

In this study, we conducted spin-torque diode measurements of the asymmetric CoFeB/MgO/CoFe/NiFe-MTJs to evaluate their dc bias voltage dependence of FLT. When the external in-plane magnetic field (H_{ext}) was applied in the hard-axis direction, the spin-torque diode spectra (output DC-voltage signal v.s. frequency of the input rf current) have a pair of anti-Lorentzian peaks which are related to FLT. The origin of the peaks was identified (one is the free-layer mode and the other is the reference-layer mode) from the evolution of the resonance frequency with H_{ext} at different angles. Figure 1 shows the bias dependence of FLT of the free-layer mode, where H_{ext} was applied parallel to the hard axis. As expected by theory,[3] FLT changed its polarity with respect to the polarity of the bias. However, the FLT/STT ratio was less than 10%. We expect that the FLT/STT ratio can be enhanced by increasing the magnetoresistance effect and by decreasing the linewidth of the peak in the spin-torque diode spectra.

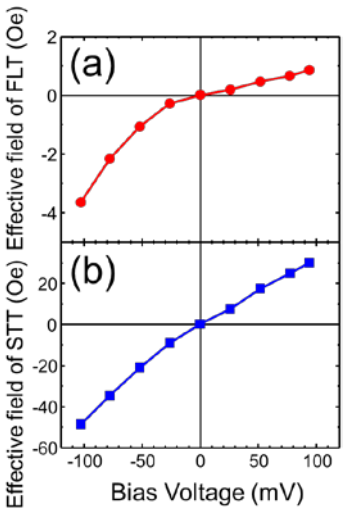

Fig. 1 Bias dependence of (a) FLT and (b) STT in CoFeB/MgO/CoFe/NiFe MTJ.

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References

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