

Switching Phase Diagram and Spin-torque Diode Spectra of MgO Magnetic Tunnel Junctions

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1. Introduction

When current passes from one ferromagnetic layer through a tunnel barrier into another ferromagnetic layer in magnetic tunnel junctions (MTJs), the spin-polarized current can exert a spin torque on the second ferromagnetic layer. Here we reports the tunnel magnetoresistance (TMR), current induced magnetization switching (CIMS), switching phase diagram (SPD), and spin torque diode spectra of nano-patterned MgO MTJs with a CoFeB single free layer. The measurements of SPD and spin-torque diode spectra are useful methods to quantify the magnitude of spin torque[1-4].

2. Experiments

We have prepared MgO MTJs consisting of substrate/ buffer/ CoFe/ Ru/ CoFeB/ MgO/ CoFeB/ capping layer using an ultra-high vacuum DC/RF magnetron sputtering system. The films were patterned into elliptical-shaped MTJs of 270 nm x 90 nm size using electron beam lithography and Ar ion milling.

3. Results

The TMR of MTJs having a 1.7-nm-thick free layer is 132% at room temperature. In CIMS measurements, the magnetization was reversed by spin polarized current. The magnetization switching from parallel (P) to anti-parallel (AP) state occurred at -0.6 mA, and AP to P switching at +0.7 mA at zero net magnetic field. The switching phase diagrams (SPD), where H_c is measured as a function of bias voltage or current, was investigated to quantify the spin transfer torque in this system.

The results obtained from the SPD measurements are analyzed in comparison with the measurements of spin torque diode spectra under various dc bias voltages at room temperature. We have observed small-amplitude oscillations in the spin torque diode spectra. The shape and amplitude of the resonance peak varies with the applied dc bias, presenting quantitative information of spin transfer torque. The SPD and spin-torque diode measurements allow us to study the bias dependence of spin transfer torque.

4. Conclusion

The magnitude of spin torque in MgO MTJs with a CoFeB single free layer is analyzed using the experimental measurements of TMR, SPD, CIMS, and spin torque diode spectra. This provides a consistent understanding of spin transfer torque in nano-patterned MTJs.

5. References

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