Electric field effect on the magnetic anisotropy of CoFeB/MgO/CoFeB magnetic tunnel junctions

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Electric field control of magnetism has been extensively studied in the past few years, not only for the interesting physics, but also due to its potential application in energy efficient devices. By applying an electric field, fundamental magnetic properties of ultrathin magnetic films, such as Curie temperature, paramagnetic-ferromagnetic phase transition, and magnetic domains, can be modified. [1, 2] In a magnetic tunnel junction structure, the electric field effect can be observed as a voltage dependent modification of the switching field or magnetization direction. [3-5]

In this study, we have investigated the electric field controlled magnetic properties of Co4Fe4B2/ MgO/Co4Fe4B2 perpendicular magnetic tunnel junctions by measuring the voltage dependent tunneling magnetoresistence (TMR). The saturation field of the CoFeB layer was seen to be modified with different applied voltages indicating that there is an electric field dependent interfacial magnetic anisotropy modification at the CoFeB/MgO interface. It was found that positive bias voltage (electron charging at CoFeB/MgO interface) increases the interfacial perpendicular magnetic anisotropy. To confirm the surface sensitivity of the electric field effect, an ultrathin (0.5~1ML) Hf layer was inserted in between the CoFeB and MgO layers. When the voltage dependent TMR of the Co4Fe4B2/MgO/Hf/Co4Fe4B2 was measured, the electric field dependent interfacial magnetic anisotropy modification was greatly enhanced at the CoFeB/Hf/MgO interface compared to the CoFeB/MgO interface. The larger electric field effect with the insertion of a Hf layer might be due to the fact that Hf is a large spin-orbit coupling material. Moreover, as calculated from TMR result, CoFeB/Hf/MgO/CoFeB structure has larger magnetic anisotropy change per voltage compare to CoFeB/MgO/CoFeB structure. These results assure that using spin-orbit coupling material has promising development of voltage controlled of magnetic switching in magnetic tunnel junction.

References:

1. K. Shimamura, et.al. Appl. Phys. Lett. 100, 122402 (2012)
2. D. Chiba, S. Fukami, K. Shimamura, N. Ishiwata, K. Kobayashi, and T. Ono, Nature Mater. 10, 853-6 (2011)
3. S. Ikeda et.al. Nature Mater. 9, 721-724 (2010)
4. W-G. Wang et. al. Nature Mater. 11, 64 (2012)
5. T. Maruyama et. al. Nature Nanotechnol. 4, 158 (2009)