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Large voltage-induced magnetic anisotropy change in Cr/ultrathin Fe/MgO/Fe magnetic tunnel junctions

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Voltage-control of magnetic anisotropy (VCMA) is expected as a promising approach to reduce the writing energy for future spintronic devices [1]. The anisotropy change slope of about 100 fJ/Vm have been demonstrated with fast response speed of the order of GHz [2]. However, in order to introduce this effect in nano-seized magnetic elements, for example for high-density memory, much higher effect of more than 1000 fJ/Vm is required.

In this study, we investigated the VCMA effect in an ultrathin Fe layer sandwiched by Cr buffer and MgO barrier layers and achieved the large VCMA effect with the slope of as high as 290 fJ/Vm.

Fully epitaxial magnetic tunnel junctions of Cr buffer (30 nm) / ultrathin Fe (t_{Fe} = 0.4-0.7 nm) / MgO (2.3 nm) / Fe (10 nm) were deposited on MgO (001) substrates by molecular beam epitaxy. The voltage-driven ultrathin Fe free layer exhibits perpendicular magnetic easy axis, while the top Fe reference layer magnetized in-plane direction. Perpendicular magnetic anisotropy energy E_{perp} was estimated from the normalized magnetization curve obtained from the tunnel magnetoresistance curve measured under in-plane magnetic fields. Saturation magnetization was evaluated by SQUID measurement. From the Fe thickness dependence of the $E_{perp}t_{Fe}$, interface anisotropy energy was evaluated to be 2.0 mJ/m^2, which is comparable to the previous repot [3].

Figure 1 shows an example of the bias voltage dependence of the $E_{perp}t_{Fe}$ for the case of t_{Fe} = 0.49 nm. The $E_{perp}t_{Fe}$ value increased linearly under the negative bias direction with the slope of 290 fJ/Vm. On the other hand, no clear change was observed in the positive bias direction.

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[3] J. W. Koo *et al*. Appl. Phys. Lett. **103**, 192401 (2013).

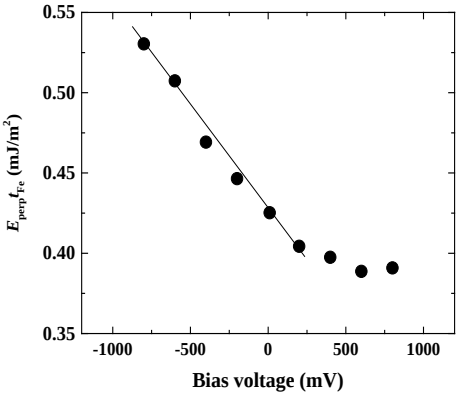

Figure 1 Bias voltage dependence of the $E_{perp}t_{Fe}$ for the ultrathin Fe (0.49 nm) layer sandwiched by Cr and MgO layers.