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

°T. Nozaki[1], A. Kozioł-Rachwał[1, 2], W. Skowroński[1,2], V. Zayets[1], Y. Shiota[1], S. Tamaru[1], H. Kubota[1], A. Fukushima[1], S. Yuasa[1], and Y. Suzuki[1,3]

(AIST Spintronics Research Center[1], AGH Univ.[2], Osaka Univ.[3])

E-mail: nozaki-t@aist.go.jp

Voltage-control of magnetic anisotropy (VCMA) is a promising approach to realize the electric-field based spintronic devices [1]. Short pulse voltage-induced dynamic magnetization switching has been demonstrated in magnetic tunnel junctions (MTJs) [2]. However, to show the scalability of the VCMA effect, for example for high-density memory, large anisotropy change slope of more than 1000 fJ/Vm is desired with high perpendicular magnetic anisotropy (PMA). In last autumn JSAP meeting, we reported the large VCMA effect of about 290 fJ/Vm observed in Cr/ultrathin Fe/MgO/Fe MTJs.

In this study, we'll report further systematic investigation of VCMA effect in this system with detailed structural analysis. Fully epitaxial magnetic tunnel junctions of Cr buffer (30 nm) / ultrathin Fe (t_{Fe} = 0.4-1.5 nm) / MgO (t_{MgO} nm) / Fe (10 nm) were deposited on MgO (001) substrates by molecular beam epitaxy. Orthogonal magnetization configuration between the free (out-of-plane) and reference (in-plane) layers was used to evaluate the VCMA effect from the bias voltage dependence of magnetoresistance curves. Spatially resolved electron energy-loss spectroscopy (EELS) was employed to analyze the interfacial structure and found that we have finite intermixing at the Cr/Fe interface, which may relate to the observed anomalies of the PMA and VCMA effect in the ultrathin Fe thickness region.

Figure 1 shows the MgO thickness dependence of the slope of the VCMA effect for the MTJ with t_{Fe} = 0.45 nm. Contrary to the expectation from the simple model based on electron accumulation/depletion effect on the interface anisotropy, we observed the monotonic increase in the slope with increasing the MgO thickness and obtained the maximum slope of 410 fJ/Vm at t_{MgO} = 2.8 nm.

This work was funded by the ImPACT Program of the Council for Science, Technology and Innovation.

[1] T. Maruyama *et al*. Nature Nanotech. **4**, 158 (2009).
[2] Y. Shiota *et al*. Nature Mater. **11**, 39 (2012).

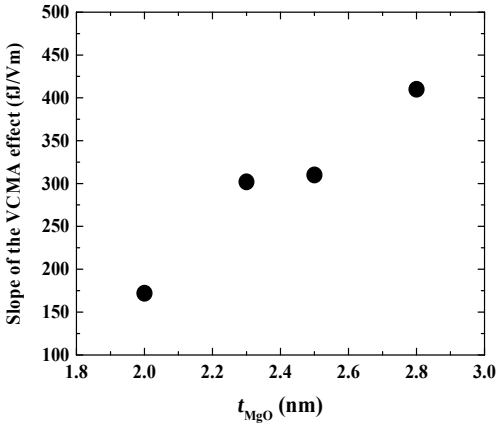

Figure 1 MgO thickness dependence of the slope of VCMA effect in Cr/ultrathin Fe (0.45nm)/MgO (t_{MgO})/Fe MTJs.