dc Bias Voltage Dependence of Magnetic Anisotropy in CoFeB/MgO Investigated by Electric Field-Induced Ferromagnetic Resonance

Laboratory for Nanoelectronics and Spintronics, RIEC, Tohoku Univ.[1], IBM TJ Watson Research Center[2], CSIS, Tohoku Univ.[3], WPI-AIMR, Tohoku Univ.[4]

○S. Kanai[1,3]*, M. Gajek[2], D.C. Worledge[2], F. Matsukura[1,3,4], and H. Ohno[1,3,4]

***E-mail: sct273@riec.tohoku.ac.jp**

By applying an electric field, the magnetic anisotropy in CoFeB/MgO can be modulated, and thus magnetization dynamics can be induced [1]. Here, we investigate the dc bias dependence of the magnetic anisotropy in a CoFeB free layer in a magnetic tunnel junction (MTJ) by ferromagnetic resonance (FMR) measurements, where the FMR is induced by the application of rf electric field.

The stack structure, Ta /Ru /Ta /$Co_{0.2}Fe_{0.6}B_{0.2}$ (0.9 nm) /MgO (1.4 nm) /$Co_{0.2}Fe_{0.6}B_{0.2}$ (1.8 nm) /Ta /Ru, is deposited by rf magnetron sputtering, and is processed into a 40-nm-diameter MTJ device sandwiched between coplanar waveguides by electron beam lithography and Ar ion milling. Both of the CoFeB layers have perpendicular magnetic easy axis, and the top CoFeB layer is a free layer. We apply the rf voltage to the MTJ to induce the FMR through the rf modulation of the magnetic anisotropy by the electric-field effect. We obtain the homodyne-detected FMR spectra by measuring reflected dc voltage as functions of dc bias voltage V_{bias} and an in-plane magnetic field H_{in} [2].

We determine the first- and second-order perpendicular anisotropy fields, H_{K1} and H_{K2}, in the free layer from the in-plane magnetic field dependence of the resonant frequency by considering the resonant condition and the magnetostatic energy equilibrium condition. Figure shows the bias voltage V_{bias} dependence of H_{K1} and H_{K2}, where H_{K1} depends almost linearly on V_{bias} with a slope of 64 mT/V while H_{K2} is constant. The dependence is consistent with that obtained previously by dc transport and X-band FMR measurements [3,4].

The authors thank D. Abraham, J. Z. Sun, K. Mizunuma, M. Yamanouchi, S.Ikeda, I. Morita, T. Hirata, and H. Iwanuma for their technical supports and discussions. This work was supported in part by JSPS through FIRST program, R&D for ICT Key Technology of MEXT, Grants-in-Aid for Scientific Research from JSPS (No. 26889007), MEXT (No. 26103002), and the GCOE Super-Internship Program.

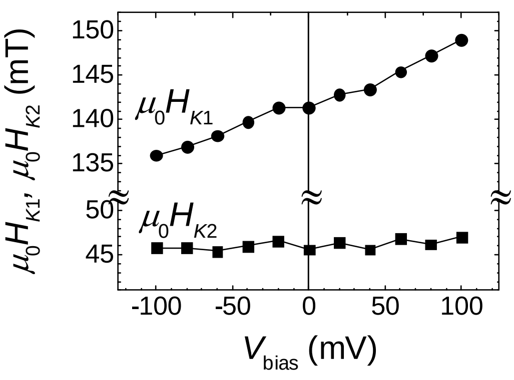

Figure: Bias voltage V_{bias} dependence of the anisotropy fields.

References

[1] S. Kanai *et al*., Appl. Phys. Lett. **101**, 122403 (2012).

[2] A. A. Tulapurkar *et al*., Nature **438**, 339 (2005).

[3] M. Endo *et al*., Appl. Phys. Lett. **96**, 212503 (2010).

[4] A. Okada *et al*., Appl. Phys. Lett. **105**, 052415 (2014).