X-ray spectroscopy of Pt and Bi atomic layers on Fe(001) under external voltage

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In order to realize magnetic random access memory (MRAM), it is important to electrically control magnetization direction. Voltage-controlled magnetic anisotropy (VCMA) is promising because of a low energy consumption property. [1] However, magnitude of VCMA in Fe(Co)/MgO system is more than ten times smaller than the requirement. [2] Interface magnetic anisotropy and VCMA are correlated to spin-orbit interaction, in this regards, materials with large spin-orbit interaction such as Pt and Bi are candidates. In the present study, we have characterized magnetic properties of Fe/Pt/MgO and Fe/Bi/MgO multilayers by x-ray absorption spectroscopy under external voltage.

V(30 nm)/Fe(0.5 nm)/Pt(0.2 nm) or Bi(0.15 nm)/MgO(2 nm) multilayers were epitaxially grown on MgO(001) substrate. After that, 5 nm-SiO_2 was prepared by sputtering. Finally, 2 nm-Cr and 5 nm-Pd were deposited by electron beam deposition. The multilayers were patterned to tunnel junctions whose designed junction sizes is 80 µm in a diameter. [Fig. 1(a)] To investigate electronic state and magnetic properties of Pt and Bi, x-ray absorption spectroscopy (XAS) and x-ray magnetic circular dichroism (XMCD) spectroscopy were conducted at BL39XU of SPring-8. Figure 1(b) shows element specific magnetization curve of 0.2-nm-Pt measured by applying magnetic field normal to film plane. A vertical axis is XMCD at incident x-ray energy of 11.570 keV (Pt-L_3 edge). Blue and red curves show results under +2.6 V and ī 2.6 V, respectively. An obvious difference between +2.6 V and ī 2.6 V shows VCMA at Pt/MgO interface. Perpendicular magnetic anisotropy increased at negative voltage, where the number of electron at Pt/MgO interface decreases. We also performed the similar measurements of 0.15 nm-Bi at L_1 edge (16.376 keV). Although we canât confirm XMCD of Bi, a clear XAS spectrum was obtained. In the presentation, XAS and XMCD spectra of 0.2 nm-Pt will be discussed in detail.

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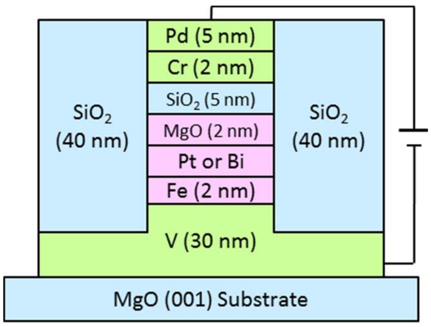

Fig. 1(a) Schematic of image of device

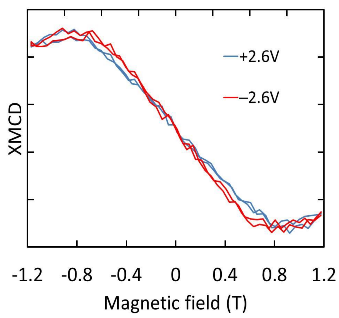

Fig. 1(b) element specific magnetization curve of 0.20 nm-Pt at L_3 edge.

[1] Y. Shiota *et al.*, Nat. Mater. 11, 39 (2012) [2] W. Skowronski *et al.*, Phys. Rev. B 91, 184410 (2015)