Fe/MgO-based magnetic tunnel junction with large spin-orbit interaction materials

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Establishing an efficient electrical method to control magnetization is the key to achieve memory devices employing magnetoresistance effect. It is known that voltage-controlled magnetic anisotropy, one of the ways to manipulate magnetization, can be enhanced by utilizing Pt which exhibits large spin-orbit interaction [1]. In this study, we report the fabrication and evaluation of magnetic tunnel junctions containing Bi, also known to possess large spin-orbit interaction, at the Fe/MgO interface of a multilayer structure.

An epitaxial single crystalline multilayer of MgO(001)substrate|V (30 nm)|Fe(0.29-0.71 nm)|Bi(0-0.4 nm)|Fe(0, 0.14 nm)|MgO barrier(1.4 nm)|Fe(10 nm)|Au(5 nm) is fabricated by molecular beam epitaxy under ultrahigh vacuum. Two compositions, Fe|Bi|MgO and Fe|Bi|Fe|MgO, are prepared for a claim in a theoretical report that perpendicular magnetic anisotropy and its modulation by external voltage influence not only the first nearest atoms, but also the second nearest atoms with the MgO barrier [2]. The multilayer is patterned into 2×5 μm^2 tunnel junctions by photolithography and Ar-ion milling as shown in Fig. 1a. Figure 2b shows magnetoresistance (MR) of Fe(0.57 nm)|Bi|MgO junctions (black) and Fe(0.43 nm)|Bi|Fe(0.14 nm)|MgO junctions (red) as a function of the inserted Bi thickness. Firstly, as the Bi thickness increases, the MR decreases and the MR effect vanishes at about 0.3 nm. Bi itself does not have spin polarization and so, an atomic layer insertion of it eliminated MR. Secondly, no difference in the amplitude of MR for two compositions is observed. From this result, it can be predicted that Bi|MgO interface is present in both compositions due to segregation of Bi. This work was supported by JSPS KAKENHI (No. 26103002) and ImPACT program.

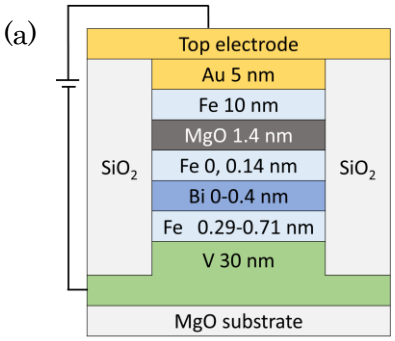
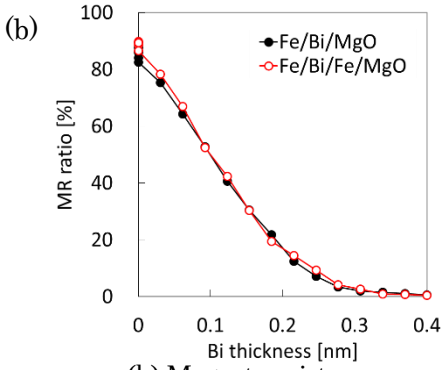


Fig. (a) Schematic of the device structure.



(b) Magnetoresistance

[1] S. Miwa *et al.*, Nat. Commun. **8**, 15848 (2017)
[2] F. Ibrahim *et al.*, Phys. Rev. B 93, 014429 (2016).