Influence of surface resonant state on voltage-controlled magnetic anisotropy

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Voltage-controlled magnetic anisotropy (VCMA) enables high-speed magnetization switching [1]. It has been found that VCMA can be increased by inserting heavy metal (e.g. Pt) [2]. Clarifying the mechanism is important for larger VCMA. In this study, we measured tunnel spectra of Fe-Pt-MgO-Fe tunnel junctions and observed the change in density of state (DOS) depending on Pt thickness.

The film stack, MgO (5 nm)|V (30 nm)|Fe (0.57 nm)|Pt (0~0.4 nm)|MgO (1.4 nm)|Fe (10 nm)|Au (5 nm) was deposited on an MgO(001) substrate by molecular beam epitaxy method. Figure 1 is color mappings representing the d^2I/dV^2 spectrum as a function of the Pt thickness and bias voltage. Black dots in Fig. 1 shows peak points of differential conductance (dI/dV) which are shifted by inserting Pt. The peak points shift on Fermi energy at Pt thickness 0.2 nm (1 ML) as shown by black circle. Figure 2 is first principles calculation of DOS for the Δ_1 band of V (5 ML)|Fe (4 ML)|Pt (0 or 1 ML)|MgO (5 ML). The blue and red line represents the DOS with and without the Pt 1 ML insertion, respectively. Comparing to first principles calculation in Fig. 2, we found interfacial resonant states appear at the Fermi level in the majority-spin DOS of V|Fe|Pt|MgO. It suggests that the surface resonant state affects magnetic anisotropy energy and its voltage control.

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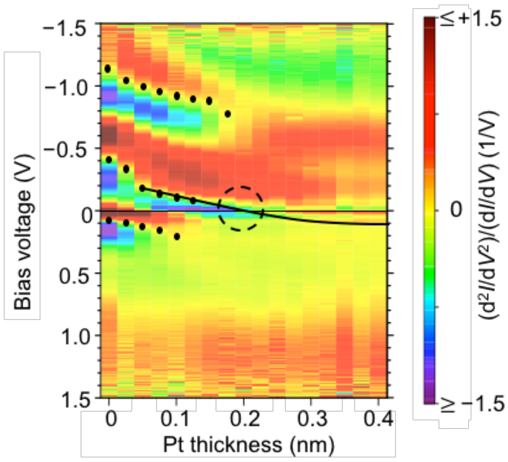

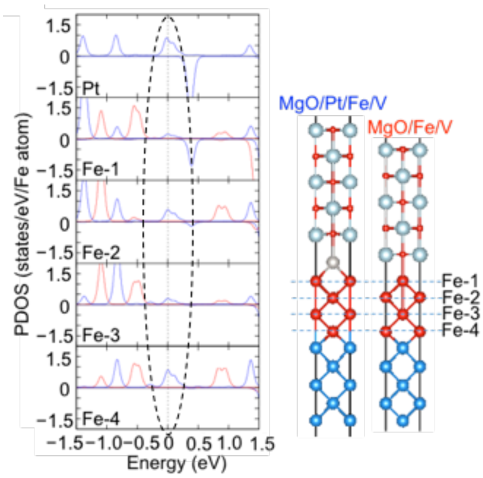

Fig. 1 tunnel spectra of Fe|Pt|MgO|Fe Fig. 2 DOS for the Δ_1 band

[1] Y. Shiota *et al.*, Nat. Mater. **11**, 39 (2012). [2] S. Miwa *et al.*, Nat. Commun. **8**, 15838 (2017)