Enhancement of electric control of magnetic anisotropy by high thermal resistance capping layers in magnetic tunnel junctions

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Magnetic tunnel junctions (MTJs) have attracted great attention due to their use in next-generation spintronic devices such as magnetic random access memories and microwave devices. One of the driving methods of MTJs is changing the magnetic anisotropy of the free layer by temperature change due to Joule heating [1]. The temperature change is attributed to the suppression of heat dissipation due to high interfacial thermal resistance at a metal | insulator interface [2], and the enhancement of the temperature change is significant. However, there has been little focus on thermal design in MTJs. Therefore, in this study, we researched Joule heating-induced magnetic anisotropy changes of MTJs with various capping layers to understand how best to suppress heat dissipation.

Film structure is buffer layer | IrMn | CoFe | Ru | CoFeB pinned layer | MgO barrier (1 nm) | FeB free layer (2 nm) | capping layer | metal electrode. We prepared two types of the capping layer: MgO (with thickness of 0.3 nm, 0.4 nm, 0.5 nm) and a composite of MgO (0.3 nm) | W (2 nm) | MgO (0.4 nm). Figure 1 shows the measurement circuit. The measurement of the spin-torque diode effect [3, 4] of the MTJ under the out-of-plane magnetic field provides the perpendicular magnetic anisotropy field. Figure 2 compares the DC power-driven magnetic anisotropy energy change θ between MTJs with different capping layers. θ increases as the thickness of the MgO capping layer increases, which indicates an enhancement of the interfacial thermal resistance at the FeB | MgO capping layer interface. This enhanced interfacial thermal resistance may be attributed to roughness at the FeB | MgO capping layer interface. Moreover, we observed larger θ of 3.21 $\mu JW^{-1}m^{-1}$ in the MTJ with the composite MgO (0.3 nm) | W (2 nm) | MgO (0.4 nm) capping layer. This project was supported by JSPS and VAST under the JSPS-VAST Joint Research Program and JSPS KAKENHI Grant Number JP19K15435.

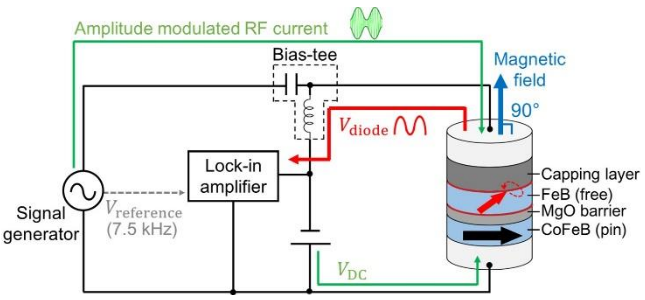

Fig. 1, Measurement circuit [5]

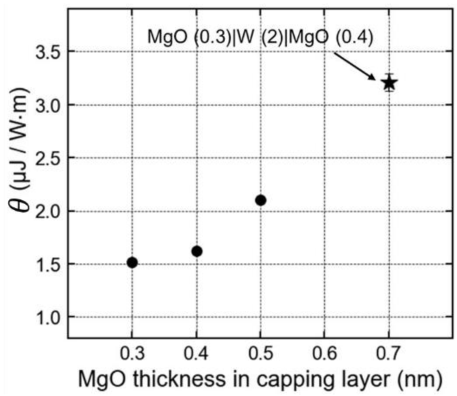

Fig. 2, Comparison of θ between MTJs with different capping layers [5]

[1] M. Goto *et al.*, Nat. Nanotechnol. **14** 40 (2019) [2] T. Bohnert *et al.*, Phys. Rev. B **95** 104441 (2017)
[3] A. A. Tulapurkar *et al.*, Nature **438** 339 (2005) [4] S. Miwa *et al.*, Nat. Mater. **13** 50 (2014)
[5] R. Okuno *et al.*, J. Phys. Condens. Matter, accepted (2020)