Field-free current induced perpendicular magnetization switching property in epitaxial Ta/CoFeB/MgO structure

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1. Introduction

Field-free current induced magnetization switching is an important technology for realizing spin-orbit torque based magnetic random access memory [1,2]. Ta/$Co_{20}Fe_{60}B_{20}$/MgO structure is one of the candidate to realize the field-free magnetization switching, whereas the origin of this field-free switching is still under debate [3]. In this presentation, we report the field-free switching property in Ta/$Co_{20}Fe_{60}B_{20}$/MgO structure by using epitaxial Ta under layer to look into the origin of the field-free magnetization switching in this system.

2. Experimental procedure

We made the following two different stacked structures by radio frequency magnetron sputtering: (A) Al_2O_3 (0001) substrate / epitaxial α-Ta (*d* nm) / $Co_{20}Fe_{60}B_{20}$ (1 nm) / MgO (2 nm) and (B) Si substrate / SiOx / amorphous Ta (*d* nm) / $Co_{20}Fe_{60}B_{20}$ (1 nm) / MgO (2 nm). Ta layer is the wedged film, but the other layers are not. Both of these samples are annealed at 300 ℃ for one hour after deposition in order to obtain the perpendicularly magnetized $Co_{20}Fe_{60}B_{20}$.

3. Results

Both epitaxial and amorphous Ta underlayer samples show the field-free switching as depicted in Fig. 1. The Ta layer thickness dependence of the critical current density shown in Fig. 2 indicates that the critical current density of epitaxial Ta samples is larger than that of amorphous samples, although the spin Hall angle in epitaxial Ta is about 1.5 times larger than that in amorphous Ta according to our previous research [4]. This result indicates that the switching current density is mainly governed by the interface effect such as Dzyaloshinskii-Moriya interaction [5].

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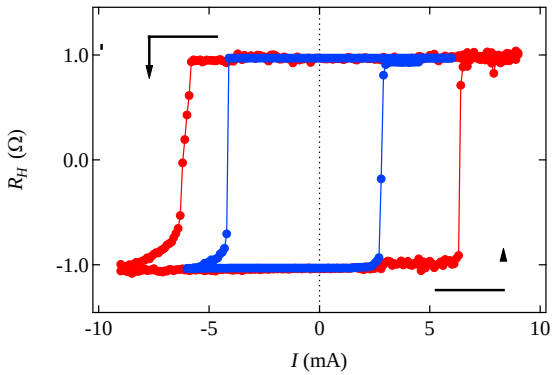

Fig. 1, Normalized anomalous Hall resistance as a function of the input pulse current for 1.3 nm of epitaxial (red circles) and 1.7 nm of amorphous (blue circles) Ta underlayer samples. External magnetic field was not applied during this measurement.

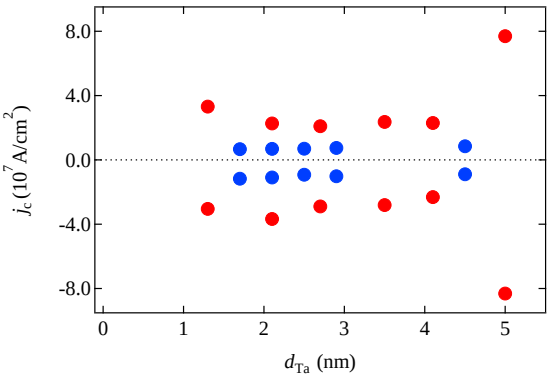

Fig. 2, Switching critical current density as a function of Ta layer thickness. The red circles and the blue circles are the results for the epitaxial samples and the amorphous samples, respectively.