Improvement of Spin-Orbit Torque efficiency for
high speed Operation of Tb/Co-based skyrmions

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Skyrmions are expected for application in next-generation spintronics-based devices because of their topologically protected properties and their possibility to be fast, high-density, and low power[1] .However, the transfer speed of skyrmions is proportional to its size and current density, resulting in a trilemma in which these three factors are incompatible. Therefore, in oder to overcome this trilemma, we try to increase the transfer efficiency by increasing the spin-orbit torque (SOT) without diminishing the Dzyaloshinsky-Moriya interaction (DMI) which is the condition required for skyrmion generation.

Ta(5)/[Pt(3)/Co(1.6)/Tb(1)]$_{10}$/Ta(3.5) and Ta(5)/[Pt(1.5)/Co(x)/Tb(1)/W(1.5)]$_{10}$/Ta(3.5) (the number is thickness in nm, x=1.6,1.8,2.0) were deposited by DC magnetron sputtering, where the Co/Tb is a perpendicular magnetic anisotropic material, Pt gives SOT to Co layer, and the Pt/Co interface has DMI. In the case of laminated structure, there is possibility that the SOT is given from the upper Pt to Co through Tb layer. To prevent it, W is inserted between Tb and top Pt. These samples were processed into Hall bars by photolithography. The SOT efficiency was measured by changing the current flowing through the Hall bar and the in-plane magnetic field applied along the current to measure the anomalous Hall effect [2].

Figure 1 shows the SOT effiency χ for above samples. While the χ was approximately 10×10^{-15}[T/Am] for Pt(3)/Co(1.6)/Tb(1) , it was 60×10^{-15}[T/Am^2] for Pt(1.5)/Co(1.6)/Tb(1)/W(1.5). The SOT effiency is successfully increased about six times by inserting W. H_{DMI} is advocated to be equal to the in-plane magnetic field H_x when the SOT efficiency χ saturates. The H_{DMI} value was about 90 mT for both samples without and with W. Thus, the SOT efficiency could be improved without changing the DMI. In addition, both DMI and SOT efficiency decreased with increasing thickness of the Co film in the sample with W. It was found that DMI and SOT efficiency can be improved by setting the film thickness to an appropriate value.
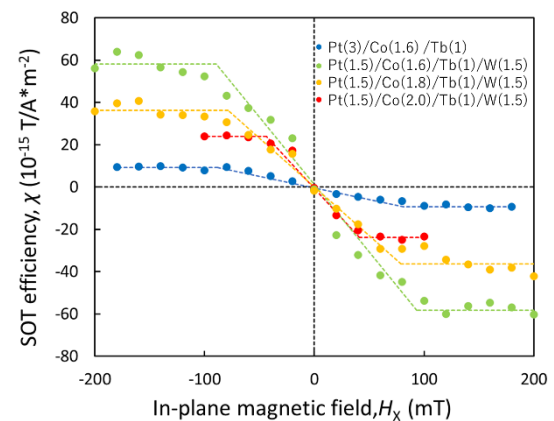

Fig.1 SOT efficiency as a function of H_X

[1] Kang et al., Proc.IEEE 104, 2040 (2016).

[2] C-F. Pai et al., Phys. Rev. B 93, 144409(2016).