Double heterostructure introduction in Pt/Ni/Co system for skyrmion with small size and fast transport

Lin Zhang[1*], Kazuhiko Tokunaga[1], Yuichiro Kurokawa[1], Ryuta Satone[1], Takehiro Tamaoka[2], Yuto Tomita[2],
Yasukazu Murakami[2, 3], and Hiromi Yuasa[1]

[1] Graduate School of Information Science and Electrical Engineering, Kyushu University

[2] The Ultramicroscopy Research Center, Kyushu University

[3] Department of Applied Quantum Physics and Nuclear Engineering, Kyushu University,

E-mail: *zhang@mag.ed.kyushu-u.ac.jp

Magnetic skyrmion is thermodynamically stable quasi-particle and attracting attention as a novel data carrier owing to its advantage; nano-scale size, and fast transport by low current [1]. However, the transport velocity is increased by increasing the electric current for spin orbit torque but decreased by decreasing the skyrmion size. To solve this problem, we choose to increase the spin mixing conductance at the interface. It has been reported that some insertion materials less than 1.0nm can improve the spin mixing conductance in spin Seebeck effect and spin Hall magnetoresistance [2]. In this report, we fabricate Ta 2nm/Pt 5nm/[Co 0.7nm/Ni 0.5nm/Pt 0.7nm]$_{30}$/Ta 5nm as our reference sample and by inserting insertion layer Gd between Pt and Co to change the spin mixing conductance, which is wrote as Ta 2nm/Pt 5nm/[Gd 0.3nm/Co 0.7nm/Ni 0.5nm/Pt 0.7nm]$_{30}$/Ta 5nm. Although the Co/Pt interface has the DMI around 0.2mJ/m^2 there is a risk of reduction by insertion layers [3]. The Gd layer as our first candidate can still ensure the generation of skyrmion. We use Lorentz TEM to observe and compare the skyrmion presence status of these two samples. By changing the external field, three states can be observed: the generation of skyrmion (I), only exist skyrmion (II) and the disappearance of skyrmion (III), which also correspond to the arrows in MH curves in Fig. 1. Figure 2 is a Lorentz TEM image under 0.18T (II). Bloch type bubbles and Néel type bubbles can be distunished by judging the position and intensity [4]. In the presentation, we compare samples with different insertion layers and fabricate devices to check their SOT efficiency respectively.

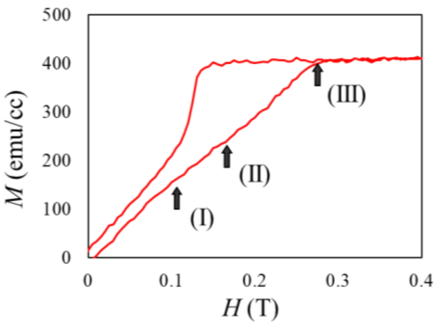

Fig. 1 Magnetization curve.

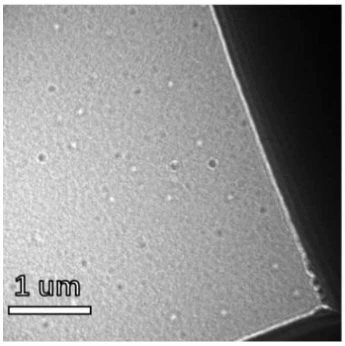

Fig. 2 Lorentz TEM image under out of plane magnetic field = 0.18T.

[1] Kang et al., Proc.IEEE 104, 2040 (2016). [2] Niimura et al., Phys. Rev. 102, 094411 (2020).
[3] Liu et al., APL Materials 9, 081114 (2021). [4] Nisrit Pandey et al., APL Mater 2021,9,081114.