Micromagnetic Study of Probabilistic Switching in Perpendicular Double Magnetic Tunnel Junctions

Fujitsu Limited, ○Chikako Yoshida, Tomohiro Tanaka, Tadashi Ataka, and Atsushi Furuya

E-mail: cyoshida@fujitsu.com

A double magnetic tunnel junction (DMTJ) which has two tunnel barriers and two reference layers (RLs) aligned anti-parallel can reduce a switching current, since the spin torques coming from both sides of the RL add up [1-2]. However, fabrication of DMTJ has many challenges [1]. On the other hand, a dynamic double RL (DD-) MTJ which has a fixed and a switchable RLs, exhibits a similar performance to the DMTJ, but it is easier to fabricate [3-4]. In this study, we investigated the switching performance of these MTJs with diameter of 30 nm using micromagnetic simulation [5] including the thermal fluctuation.

Figure 1 shows the perpendicular MTJs with three types of RLs (single (S)-RL, DD-RL, and D-RL) used for the simulations. We conducted 100 simulations to obtain a switching probability under a same applied voltage at 300K. Then an average switching time was extracted at 80% switching probability. Figure 2 summarizes the switching voltage (V_s) as a function of switching time for both P to AP and AP to P switching. The significant decrease in V_s for D-RL was observed both in P to AP and AP to P switching. The V_s for DD-RL decreased as much as that of D-RL for P to AP switching, while it resulted in the intermediate value between that of D-RL and S-RL for AP to P switching. This relatively small range of reduction in AP to P switching might be attributed to a lower spin torque efficiency of upper dynamic RL compared with the robust bottom RL which is ferromagnetically coupled to CoPt layer.

References: [1] G. Hu, et al., IEDM2015, p.668. [2] D. C. Worledge et al, IEEE Magn. Lett., 8 (2017), 4306505. [3] A. V. Khvalkovskiy et al., J. Appl. Phys. 124, 133902 (2018). [4] K. Tsunoda et al., IEDM Tech. Dig. (2012) p665. [5] Fujitsu Ltd. [Online]. Available: http://www.fujitsu.com/global/about/resources/news/press-releases/2013/1210-01.html

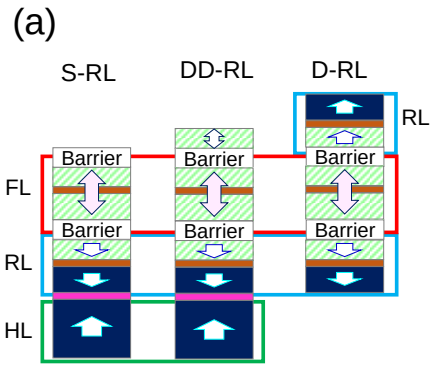

Fig. 1 Sketch of three types of perpendicular MTJ structures.

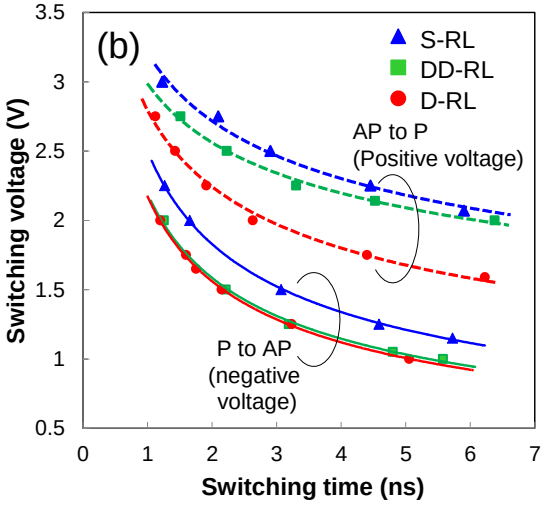

Fig. 2 Switching voltage as a function of switching time for the MTJs with three types of RLs.