Measurement of spin-orbit torque magnetization switching in Co/Gd multilayers

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Domain wall motion memory is a candidate for the next generation memory due to its excellent features such as high-density and non-volatility. In this memory, domains separated by domain walls (DWs) in ferromagnetic nanowires correspond to logic bits, and the DWs can be controlled by spin-transfer torque generated from an application of charge current, allowing the logic bits to be transported to any storage position. The vertical domain wall motion memory that we have recently proposed [1] has shown that low critical current density and high thermal stability can be achieved by tuning the parameters of each layer. In this study, we aim to achieve faster operation, suppression of dipolar interactions, and increased writing efficiency due to spin-orbit torque (SOT) by replacing the ferromagnetic material in the layer with high perpendicular magnetic anisotropy with the ferrimagnetic material of Co/Gd multilayers.

Multilayer films with Si-SiO_2//Ta(5)/Pt(10)/Co(0.6)[Gd(1.2)Co(0.6)]$_n$/Cu(5)/Pt(2) (n = 1~4) structures were fabricated by sputtering, where the unit in parentheses is nm. The films were fabricated into the Hall device. The anomalous Hall effect (AHE) measurements show that the multilayers exhibit perpendicular magnetization. Then, SOT switching experiments were performed to investigate the critical current density. The switching current density in ferrimagnetic Co/Gd multilayers was estimated to be smaller than that in the Si-SiO_2//Ta(5)/Pt(10)/Co(1.2)/Cu(5)/Pt(2) film measured as a reference experiment. From this result, it can be expected that our approach will be effective in creating energy-saving memories that can be written at smaller current densities by using ferrimagnetic materials instead of ferromagnetic materials.

[1] Y.M. Hung et al., J. Magn. Soc. Jpn., 45, 6-11 (2021)

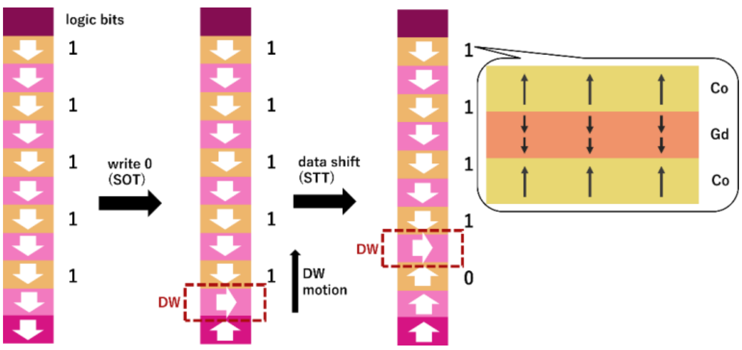

Fig. 1. The left figure illustrates the principle of operation of vertical domain wall motion memory. From the bottom write layer, the magnetization information is transferred to the pink layer with low magnetic anisotropy, and by driving the domain wall, the magnetization information is written to the orange layer with high magnetic anisotropy (the layer corresponding to the logic bits). In this research, a Gd/Co multilayer structure is used for the orange layer (right figure); at the Co/Gd interface, the direction of magnetization is opposite, resulting in a multilayer ferrimagnet.