Development of a vertical domain wall motion memory with perpendicular magnetic anisotropy

Kyoto Univ.[1], NIMS[2]

F. Ye[1], H. Jang[1], Y. Shiota[1], S. Sugimoto[2], S. Kasai[2], T. Ono[1]

Email: ye.feifan.56e@st.kyoto-u.ac.jp

Domain wall motion memory is promising to achieve high-density and non-violate storage as a candidate of the next-generation memory. In this memory, the logic bits are stored in domains and separated by domain walls in a ferromagnetic nanowire. By injecting electric current, the logic bits can be carried to desired storage position by domain wall motion. A vertical domain wall motion memory was designed in our previous work (Figure 1) and simulations showed that it is possible to obtain a low critical current density J_c ($<10^{11}$ A m^{-2}) and a high thermal stability ($\Delta > 60$, $\Delta = E_B/k_BT$) [1, 2] by tuning parameters of each layer. In this research, we investigate the feasibility of this novel structure starting from a simple 1-bit sample with the composition Si-SiO_2//Ta(5)/Pt(10)/[Co(0.2)/Pt(0.2)]$_n$/Co(0.2)/Cu(3)/[Co(0.23)/Pt(0.4)]$_{12}$/Ta(3)/Pt(3), n = 2, 3, 4.

The films were grown on a Si-SiO_2 substrate by sputtering and fabricated by electron beam lithography as well as Ar milling to form the desired patterns. Then, SiO_2 was deposited as insulator to avoid short circuit. The spin-transfer torque (STT) and spin-orbit torque (SOT) induced magnetization switching were measured through the giant magnetoresistance effect. A sudden change of resistance was observed by sweeping the out-of-plane magnetic field which indicates the strong perpendicular magnetic anisotropy provided by Co/Pt multilayers. When the current pulse was injected into the pillar, the free layer reversed by STT and the pillar magnetization was switched between parallel and anti-parallel states. The writing process using SOT induced by spin Hall effect was also observed in this device.

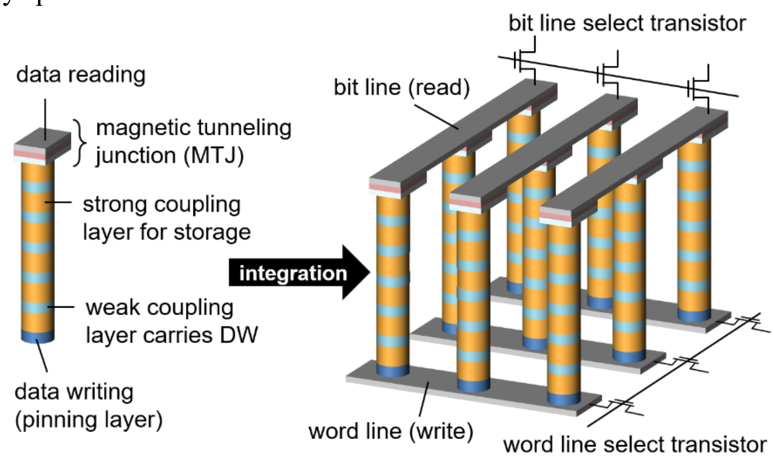

Figure 1. A vertical domain wall motion memory cell and integrated high-density storage arrays.

[1] Y. Hung et al., J. Magn. Soc. Jpn., **45**, 6 (2020). [2] Y. Hung et al., Appl. Phys. Express, **14**, 023001 (2021).