Domain wall motion at a step of Dzyaloshinskii-Moriya interaction

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To realize logic and memory devices using magnetic domain walls (DWs), it is important to control the DW position [1]. Recently, the interfacial Dzyaloshinskii-Moriya interaction (DMI) has attracted considerable interest [2]. By changing interface between ferromagnet and heavy metal, it is possible to control the interfacial DMI. We assume that two regions have different DMI, called DM step. In this work, we studied about DW motion at a DM step driven by an external field and a spin-orbit torque (SOT).

We performed one dimensional micromagnetic simulations with the following parameters; the exchange constant $A=110^{-6}$ erg/cm, the uniaxial anisotropy constant with easy axis $K=110^{7}$ erg/cm^3, and the spin hall angle =0.3. First we studied field-driven domain wall motion at a DM step. An effective field at DM step written as, where indicates a DM vector of which direction is in. When a Bloch type domain wall moving through the DM step, the effective field is almost zero [3]. In the absence of effective field, a Bloch type domain wall easily passes the DM step. On the other hand, the center magnetization of a Néel type domain wall is along the x direction, so that the effective field of DM step is always in z direction, the opposite sign of the external field. It makes a Néel wall difficult to pass the DM step. In the case of SOT-driven domain wall motion [4], the energy barrier of DM step depends on the sign and magnitude of DMI constant. Difference of two DMI constants builds up a potential barrier. We find that a threshold current density of DM step depends on the height of energy barrier.

We propose for domain wall device that it is possible to control the position of domain wall by a DM step. Using a DM step, it is possible to increase the retention of DW devices.

References

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