Influence of Dzyaloshinskii-Moriya Interaction on Magnetic Droplet Nucleation under In-Plane Field

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Dzyaloshinskii-Moriya interaction (DMI) between two atomic spins with an adjacent nonmagnetic atom having a strong spin-orbit coupling, is an essential phenomenon in the ferromagnet (FM)/non-magnet (NM) bi- (or multi-) layer system for developing state-of-the art spin-orbitronic devices [1-3]. Recently, sub 100-nm-sized skyrmion-like bubble has been found to be a stable magnetic object with a sizable DMI energy density (D) [4-5]. Also, few hundreds m/s velocity of a Neel type domain wall arising from DMI is achievable [6]. Furthermore, DMI influence the current-driven switching and diode effect of the magnetic tunnel junction [7,8]. Therefore, it is important to understand the DMI-related phenomena in FM/NM systems for realization of the next generation spin devices.

In this presentation, we demonstrate how the DMI affects the magnetic domain nucleation under in-plane magnetic field, which is closely related to the switching behavior of a magnetic device. First, we propose the extended droplet model to determine the nucleation field in terms of the in-plane field. DMI-dependent nucleation of several FM/NM systems, then, is shown from the simple anomalous Hall effect measurement, which can be explained by our extended droplet model. The results are clearly reproduced by the micromagnetic simulation with the application of the string model. Our result provides the general model of the DMI effect on the magnetization switching behavior in case of the perpendicularly magnetized system and the simple electrical measurement method to quantitatively determine the DMI energy density which is key factor for the next generation spin orbitronic devices.

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