Creation and annihilation of magnetic skyrmions in Ta/CoFeB/Ta junction by electric field

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Magnetic Skyrmion is one of the candidates for novel information carrier in spintronics applications such as magnetic racetrack memories and logics [1,2]. Unlike conventional electric devices, utilize of Brownian-motion of Skyrmions for computation is also proposed and confirmed in Ta/CoFeB/Ta junction at room-temperature [3]. Brownian motion of skyrmions can potentially realize unconventional computing such as stochastic calculations and ultra-low power computing. We previously reported confirmation of fundamental operation of Brownian circuit [4] and skyrmion cellular automaton [5] in continuous magnetic film. In such a computational device using skyrmions, it is essential to control the motion of the skyrmions externally to input and correlate information. The control of the magnetic domain structure by changing the ferromagnetic interaction by voltage has been confirmed in the junction of Co and insulator [6,7], and it has been shown that the generation and annihilation [8], the control of diffusion coefficient [9] and the detection[10] of skyrmions are also possible by applying voltage. The application of voltage is a promising method to control the skyrmion. In this work, we investigated external electric field dependence of magnetic domain structure in Ta/CoFeB/Ta junctions known as a heterostructure that hosts skyrmions.

Ta/CoFeB/Ta/MgO/SiO_2 junctions were deposited on silicon substrates with oxide film using magnetron-sputtering technique. In order to apply electric field, we deposited top and bottom Ru electrodes as shown in Figure 1. Ultra-thin(2nm) Ru was utilized as semi-transparent electrode and magnetic domain structures and skyrmions were observed by MOKE-microscope. 0.2nm of Pt was deposited on Ta/CoFeB/Ta/MgO/SiO_2 junction to partially enhance magnetic anisotropy.

Figure 2 shows MOKE microscope images observed with negative (a), zero (b) and positive (c) electric field. Densities of skyrmions were increased (decreased) by negative (positive) electric field. The difference of skyrmion densities may be originated from the change in the perpendicular magnetic anisotropy in the sample. Further experimental results including experiments to control the motion of skyrmion by electric filed will be discussed in presentation.

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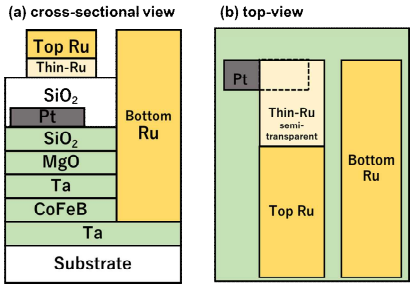

Figure 1 (a) Cross-sectional and (b) top-view of sample configuration.

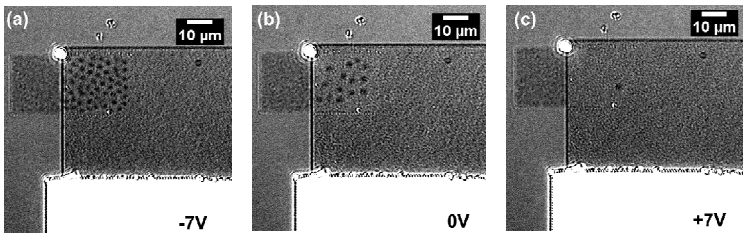

Figure 2 MOKE microscope images of the sample applying (a) negative, (b) zero and (c) positive electric field between top and bottom electrodes with fixed external magnetic field.