Current-induced domain wall motion in a perpendicularly magnetized Co_2MnGa/Pd

Graduate School of IST Hokkaido Univ.
○Takaya Koyama*, Yuki Nishioka, Tetsuya Uemura, and Michihiko Yamanouchi
*E-mail: eequalmcsquared@eis.hokudai.ac.jp

Current-induced domain wall (DW) motion is one of schemes for electrical manipulation of magnetization, which is essential for operation of spintronics devices. A perpendicularly magnetized Co_2MnGa (CMG) film which is considered to be a Weyl ferromagnet [1], is promising for the application to spintronics devices using DW motion because the DW created in it can be moved with low current density by recently proposed topological Hall torque (THT) [2]. Since perpendicular magnetic anisotropy has been reported in heterostructures composed of a CMG and a heavy metal Pd film [3], the heterostructures are suitable to examine the current-induced DW motion. Moreover, both spin-orbit torque (SOT) and THT are exerted on the DW in the heterostructures, and thus further efficient DW motion can be expected in them. In this study, we investigated current-induced DW motion in perpendicularly magnetized CMG/Pd.

A film structure consisting of, from the substrate side, MgO buffer (10 nm) / CMG (1.6 nm) / Pd (2.5 nm) was deposited on a (001) MgO substrate. After annealing the resultant stack at 350°C in vacuum under a perpendicular magnetic field, the stack was processed into a Hall-bar-shaped device with a 2-µm wide channel, a pair of Hall probes, and a Cr/Au Oersted line (Fig. 1). To examine the current-induced DW motion, a DW was prepared in the channel by applying a current pulse to the Oersted line to generate a local magnetic field. Then successive current pulses with 10 ms duration were applied to the channel. After the application of each current pulse, we measured transverse resistance R_{yx}, which reflects the perpendicular component of magnetization in CMG around the Hall probes, to monitor position of the DW. Figure 2 shows R_{yx} as a function of the accumulative pulse duration t_a. The R_{yx} increases with the successive application of the negative current pulses, whereas it shows no apparent variation with the positive current pulses, where positive (negative) current I flows into the $+x$ ($-x$) direction (Fig. 1). These results indicate I moves the DW in the direction opposite to I in the CMG/Pd. We measured modulation of DW propagation field H_c by I to clarify the mechanism behind the observed curren-induced DW motion. The value of H_c varies almost linearly with I, which indicates the I acts as an effective perpendicular magnetic field H_{eff} on the DW. We also measured H_c under constant I and various in-plane magnetic fields H_xs along the x axis. In the application of $|\mu_0 H_x| \leq 20$ mT, the H_c increases with increasing H_x. Assuming that a chiral DW, whose internal magnetization direction is realigned by H_x, is created in the CMG/Pd, this variation of H_{eff} with respect to H_x can be qualitatively explained by both SOT and THT because both torques depend on the internal magnetization direction in the DW. However, further studies are necessay to clarify the mechanism.

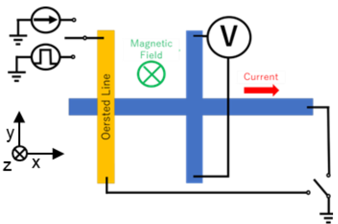

Fig.1. Schematic device structure and measurement setup.

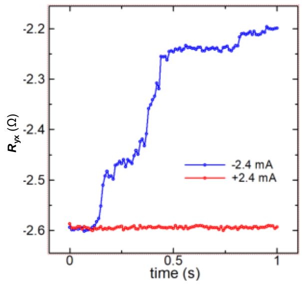

Fig. 2. Integrated pulse duration dependence of R_{yx}.

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References

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