磁壁クリープ速度を利用したスピン軌道トルク有効磁場の決定

Determination of spin-orbit torque effective field from magnetic domain wall creep velocity

○小山 知弘、千葉大地 (東大物工)

T. Koyama, and D. Chiba (The Univ. of Tokyo)

Email: tkoyama@ap.t.u-tokyo.ac.jp

Current induced magnetic domain wall (DW) motion has been intensively studied because it shows promise for the realization of future magnetic memory devices [1]. Recently, the spin orbit torque in the layered structure composed of thin ferromagnets and adjacent non-magnetic heavy metals, which is another DW driving mechanism, has received a lot of attention. In this work, we demonstrated the quantitative estimation of the spin orbit torque induced effective field from the DW creep velocity in perpendicularly magnetized Pt/Co systems [2].

Ta (2.8 nm)/Pt (3.0)/Co (0.4)/Pd (0.8) multilayer structure from the substrate side was deposited on an intrinsic Si substrate by rf sputtering. The film was patterned into a 30-µm-wide wire having two Hall probes by photolithography and Ar ion milling. The distance between the probes (L) was 345 µm. The DW velocity (v) was determined as L/t_P, where t_P is the time for the DW propagating between the two Hall probes. The sample stage temperature was kept at 290 K.

Figure 1 shows the plot of log v against $(\mu_0 H_\perp)^{-1/4}$ obtained under various values of current (I) injected into the Pt/Co wire. As shown in the figure, log v linearly depends on $(\mu_0 H_\perp)^{-1/4}$ when I was 2 µA, which corresponded to the field driven creep motion in ferromagnetic metal. When I became large, however, two characteristic features appeared; (i) v increased (decreased) when the direction of I was identical (opposite) to that of the DW propagation, (ii) log v - $(\mu_0 H_\perp)^{-1/4}$ relation deviated from the scaling law. By including current induced effective field into the conventional expression of the DW creep velocity, these behaviours can be clearly explained as shown in the fitting results in Fig. 1. From this fit, the magnitude of the effective field can be determined. On the other hand, above two features were not observed in sample with Pd underlayer instead of Pt. This indicates that the effective field is originated from the spin-orbit torque at the Pt/Co interface.

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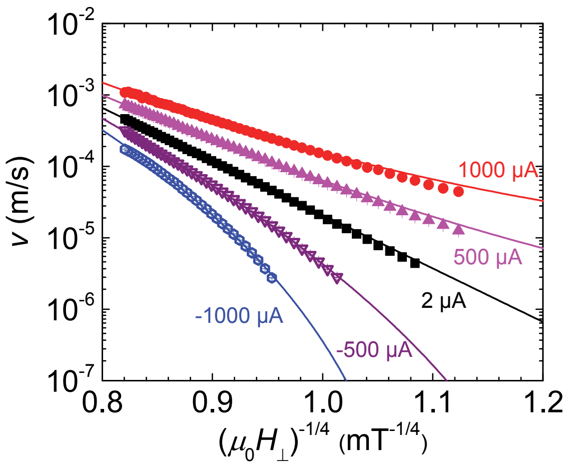

Fig. 1 log v as a function of $(\mu_0 H_\perp)^{-1/4}$ under various current values. The solid lines show the results of the fit using the creep law including the effective field.

[1]S. S. P. Parkin *et al.*, Science **320**, 190 (2008).
[2]T. Koyama and D. Chiba, Phys. Rev. B **92**, 220402(R) (2015).