# Quantification of Dzyaloshinskii-Moriya interaction from thermally-activated and flow regime domain wall motion

**RIEC[1]/CSRN[2]/CSIS[3]/CIES[4]/WPI-AIMR[5], Tohoku University**

**°Samik DuttaGupta [1,2], Chaoliang Zhang[1,3], Shunsuke Fukami[1-4], and Hideo Ohno[1-5]**

**E-mail:** sdg@riec.tohoku.ac.jp

Spin-orbit torque (SOT) induced domain wall (DW) motion in non-magnet/ferromagnet/oxide systems is a promising concept for three terminal spintronics devices[1]. The asymmetry of stack structure results in an interfacial Dzyaloshinskii-Moriya interaction (DMI) which plays a pivotal role for fast SOT-driven DW motion[2-4]. Thus, understanding the manifestation of DMI-induced effective field ($H_{DMI}$) is important. Thermally-activated DW motion under magnetic fields ($H_Z$ and $H_X$) is proposed to offer quantitative information about $H_{DMI}$[5]. However, the role of $H_{DMI}$ from this regime is greatly debated and demands a quantitative comparison of $H_{DMI}$ between dynamically different regime of DW motion, i.e., flow regime[6,7].

Multilayers utilized in this study are W(5)/CoFeB(1.1)/MgO(2)/Ta(1) (W/CoFeB) and Ta(4)/Pt(3)/Co(0.3)/Ni(0.6)/Co(0.3)/MgO(1.5)/Ru(1) (Pt/[Co/Ni]) (in nm). To evaluate DMI from thermally-activated regime, we investigate $H_X$ dependence of bubble expansion under $H_Z$. DW velocity ($v$) vs $H_X$ curve indicates $\mu_0 H_{DMI}$ = 14 ± 5 mT for W/CoFeB (Fig. 1(a)), whereas miniscule value ($\mu_0 H_{DMI} \approx 0$ ± 10 mT) for Pt/[Co/Ni] (Fig. 1(b)). We also investigate $H_X$ dependence of current-driven DW motion in flow regime for both the samples. The results shown in Fig. 1(c) and (d) indicate non-zero DMI for both the structures ($\mu_0 H_{DMI}$ = 14 ± 0.5 mT for W/CoFeB and 176 ± 10 mT for Pt/[Co/Ni]). Only the result for Pt/[Co/Ni] in thermally-activated regime does not agree with previous study. We find that an accurate determination of DMI strength is possible only when DW motion satisfies a creep scaling law for the thermally-activated regime, whereas the flow-regime experiment is versatile for quantification of DMI.

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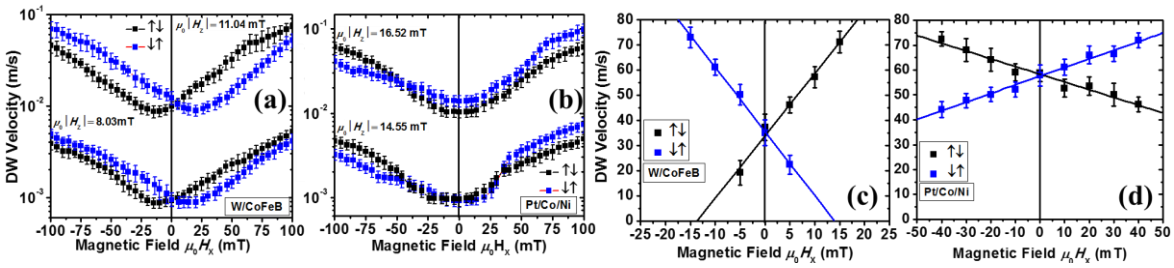


Fig. 1: (a) $v$ vs $H_X$ at constant $H_Z$ for W/CoFeB in TA regime. (b) $v$ vs $H_X$ for Pt/Co/Ni system in TA regime. (c) Flow regime $v$ vs $H_X$ curve at current ($J$) = 9.67 × $10^{11}$ A/m$^2$ for W/CoFeB system. (d) $v$ vs $H_X$ at $J$ = 1.04 × $10^{12}$ A/m$^2$ for Pt/Co/Ni system.