Ferromagnetic layer thickness dependent domain wall chirality and sign of effective Dzyaloshinskii-Moriya field in W/(Co)FeB/MgO systems

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Spin-orbit interaction in broken inversion symmetry systems is prospective for future spintronic devices. In-plane current applied to heavy-metal/ferromagnet (FM) heterostructures with spin-orbit coupling generates spin-orbit torques (SOTs) which allow efficient magnetization switching [1] and domain wall (DW) motion [2]. In these phenomena, interfacial Dzyaloshinskii-Moriya interaction (DMI) is known to play key roles, *e.g.*, stabilizing Néel DW [2] and skyrmion [3]. A W/CoFeB/MgO system is one of the promising material systems for device application owing to a large SOT [4,5] and DMI strength [6] as well as a low-depinning field [7]. However, interfacial DMI in W/CoFeB/MgO has posed a puzzling question concerning DW chirality; both left-handed [8] and right-handed [6] chiral DWs have been observed. Here, we systematically investigate DW chirality and effective DMI field (H_{DMI}) in W/(Co)FeB/MgO system to shed light on the factors relating to the interfacial DMI. The stacks consisting of Si sub./(α or β)W(4)/(Co)FeB(t_{eff})/MgO(1.6)/Ta(2) (in nm) are prepared by dc/rf sputtering. We investigate field-induced DW motion under simultaneous application of in-plane and perpendicular fields to evaluate DW chirality and H_{DMI} [9]. Antisymmetric contribution to DW velocity [10] is removed for a reliable determination of H_{DMI} and DW chirality. We find that the sign of H_{DMI} corresponding to the chiral direction of DW is reversed with varying t_{eff}, irrespective of the structural phase of W and FM material (CoFeB or FeB). We will discuss the possible scenarios to describe this intriguing behavior.

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[1] S. Fukami and H. Ohno, Jpn. J. Appl. Phys. **56**, 0802A1 (2017).
[2] S. Emori *et al*., Nat. Mater. **12**, 611 (2013).
[3] S. Heinze *et al*., Nat. Phys. **7**, 713 (2011).
[4] C.-F. Pai *et al*., APL **101**, 122404 (2012).
[5] Y. Takeuchi *et al*., APL **112**, 192408 (2018).
[6] J. Torrejon *et al*., Nat. Commun. **5**, 4655 (2014).
[7] C. Burrowes *et al*., APL **103**, 182401 (2013).
[8] G. W. Kim *et al*., PRA **9**, 064005 (2018).
[9] S.-G. Je *et al*., PRB **88**, 214401 (2013).
[10] D.-Y. Kim *et al*., NPG Asia Mater. **10**, e464 (2018).