Study of Spin-Orbit Interactions and Multilevel Switching in Co/Pt/Co trilayer

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Spin-orbit torque induced current magnetization switching (SOT-CIMS) provides an energy-efficient way of manipulating the magnetization in the ferromagnetic layers. We present a detailed study of Dzyaloshinskii–Moriya and spin-orbit interactions in the Ti(2)/Co(1)/Pt(0-4)/Co(1)/MgO(2)/Ti(2) (thicknesses in nanometers) patterned into micrometer-sized Hall-bar device. Here, the Pt is used as a source of the spin current, and as a nonmagnetic spacer whose variable thickness enables the magnitude of the ferromagnetic interlayer exchange coupling (IEC) to be effectively tuned [1]. From anomalous Hall effect (AHE), anisotropic magnetoresistance (AMR) and spin Hall magnetoresistance (SMR) measurements, we found that the increase in Pt thickness (t_{Pt}) leads to the reorientation of Co-magnetizations from the in-plane to the perpendicular direction at $t_{Pt} \approx 1.3$ nm. Further increase in Pt thickness, over 3 nm, reduces the ferromagnetic coupling and consequently, two weakly coupled Co layers become magnetized orthogonally to each other. From analysis of the Stokes and anti-Stokes peaks spectra measured by the Brillouin light scattering (BLS), the value of effective DMI constant (D_{eff}) was determined as a function of Pt spacer thickness. These quantities reach their highest value for Pt thicknesses of around 2 nm, where the perpendicular anisotropy is the largest [1]. Magnetic domain images obtained by the polar-magnetooptical Kerr microscopy (P-MOKE) demonstrated the skyrmion bubble domains in the region of strong coupling, which disappears with decreasing ferromagnetic coupling. The asymmetric expansion of the bubble domain indicates the counterclockwise (CCW) chirality of the Néel-type DWs. The results obtained for the trilayer were compared with the Pt(4)/Co(1)/MgO bilayer system. Finally, we investigated SOT-CIMS in both systems and analyse the switching mechanism using Landau-Lifshitz-Gilbert-Slonczewski equation.

References:

[1] P. Ogrodnik et al., ACS Appl. Mater. Interfaces 13, 47019 (2021)

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