

Spin wave frequency hysteresis in low-anisotropy epitaxial [Re/Co(2nm)/Pt] N multilayers driven by strong Dzyaloshinskii-Moriya interaction

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The effect of spin-wave frequency hysteresis in sputter-deposited (Ir/Co/Pt)₆ multilayers has recently been reported in [1]. Here, we present a combined study of the static and dynamic magnetic properties of epitaxially grown multilayers [Re(1 nm)/Co(2 nm)/Pt(1 nm)] _{N} , where $N = 1, 3, 5, 10$, using complementary techniques such as polar and longitudinal magneto-optic Kerr effect (PMOKE/LMOKE) and superconducting quantum interference device (SQUID)-based magnetometry, X-band (9.8 GHz) cavity ferromagnetic resonance, and Brillouin light scattering (BLS) spectroscopy. Magnetometric data indicate that in a low magnetic anisotropy system with the quality factor $Q < 1$, increasing N drives the magnetic ordering from an in-plane magnetized state ($N = 1$) to a hybrid domain structure ($N = 10$), where the in-plane magnetization is modulated with an out-of-plane component (vortex-like). For $N = 10$, magnetic force microscopy reveals an out-of-plane stripe-domain pattern with a period of ~ 200 nm, whereas for $N = 5$ no magnetic contrast is observed. Micromagnetic simulations reproduce the observed domain geometry and provide detailed information on the spatial magnetization distribution. BLS spectra were recorded in Damon–Eshbach geometry over a broad in-plane magnetic field range, including the remanent state. At sufficiently large fields (magnetic saturation), the frequency difference between Stokes (f_S) and anti-Stokes (f_{aS}) peaks, $\Delta f = f_S - f_{aS}$, measured as a function of the spin-wave vector k , reveals an interfacial Dzyaloshinskii–Moriya interaction (IDMI), from which an effective DMI constant $D_{\text{eff}} = -0.6$ mJ/m² (for $N = 1$) is derived. A clear hysteresis of both f_S and f_{aS} peaks is observed, with frequency jumps consistent with the coercive field from LMOKE measurements. The IDMI-induced asymmetric dispersion $f(k)$ results in different spin-wave group velocities propagating in opposite directions even at the remanent state (e.g., for $k = \pm 10$ rad/ μm , -0.55 and 0.75 km/s), which can be switched by an external magnetic field pulse. These results demonstrate that strong IDMI in [Re/Co/Pt] _{N} multilayers induces non-reciprocal spin-wave propagation and field-controlled switching of spin-wave frequencies, offering potential for magnonic applications such as reconfigurable magnonic crystals [2].

References:

- [1] R. Gieniusz et al., Phys. Rev. B 110 (2024) 184410.
- [2] K. Szulc et al., ACS Nano 16 (2022) 14168–14177

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