Tailoring spin wave nonreciprocity in magnetic thin film heterostructures by interface engineering

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The nonreciprocity in spin waves (SWs), i.e., asymmetry in the frequency-wavevector dispersion, is required to enable various functionalities in magnonic devices such as logic operations, signal routing, computing, and to improve device stability by reducing reflection-induced noise [1]. The interfacial Dzyaloshinskii-Moriya interaction (DMI) is being used as an efficient tool to induce nonreciprocity in SW dispersion [2,3]. In this study, we show the modulation of interfacial DMI and nonreciprocity of magnetostatic surface spin waves (MSSWs) in $Ta/Co_{20}Fe_{60}B_{20}/MgO/Al_2O_3$ heterostructures by dusting CoFeB/MgO interface with ultrathin (0.12 nm) nonmagnetic layers of Ta, Ru, Pt, W, with varying spin-orbit coupling (SOC) strength and *d*-orbital filling. The dispersions of MSSWs are measured by employing conventional Brillouin Light Scattering (BLS) spectroscopy in the backscattering geometry.

The Ta/CoFeB/MgO heterostructure without any insertion layer shows the highest nonreciprocity. The nonreciprocity gradually decreases with the insertion of Ta, W, Ru layers, and eventually flips its sign with the insertion of Pt layer. With the insertion of Ta, W, Ru layers at CoFeB/MgO interface, the overall DMI gradually decreases and eventually alters its sign for the insertion of Pt layer. We find a correlation between the *d*-orbital filling of the inserted material and the change in DMI value [4,5]. We infer that the SOC strength of the inserted material and variation in the diffusion of B atoms at Ta/CoFeB and CoFeB/MgO interfaces may also play crucial roles in determining the change in DMI. Overall, this study shows a guideline to design the future magnonic devices with controllable spin wave properties by interface and material engineering.

References:

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