Spin Device Applications using 2D Materials

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Recent breakthroughs in low-dimensional magnetic materials are reshaping the landscape of spin-based device engineering, and spin-orbit torque (SOT) has emerged as a promising alternative for ultrafast memory applications. Despite significant progress, achieving external magnetic field-free switching of perpendicular magnetization with short current pulses, minimal incubation delay, and low energy consumption remains a critical obstacle for the practical realization of high-speed SOT devices. We demonstrate field-free, wafer-scale control of perpendicular magnetization in 2D $CrTe_2$ or CoFeB via SOTs from WTe_2 or $PtTe_2/WTe_2$ [1,2]. We also report deterministic, field free switching of perpendicular magnetization using a Mn_3Ir spin current source at room temperature through anisotropic spin Hall effect, harnessing out of plane polarized spin currents [3]. In addition, we reveal above room temperature stabilization (up to 330 K) of a dense, zero field Néel type skyrmion lattice in non-centrosymmetric $Fe_{3-x}GaTe_2$, driven by intrinsic Dzyaloshinskii–Moriya interaction [4]. Finally, we present an ultrabroadband, zero-bias rectifier based on the nonlinear Hall effect in wafer-scale topological crystalline insulator SnTe thin film [5]. The SnTe device demonstrates rectification from 23 MHz to 1 THz, with sensitivity down to –60 dBm in key radio-frequency bands, without any external bias. Collectively, these advances underscore the promise of low-dimensional material systems for creating scalable, energy-efficient devices.

References

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