Electrical mutual switching in a noncollinear-antiferromagnetic–ferromagnetic heterostructure

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Spin-orbit torque (SOT) provides a promising mechanism for electrically encoding information in magnetic states. Unlike existing schemes, where the SOT is passively determined by the material and device structures, an active manipulation of the intrinsic SOT polarity would allow for flexibly programmable SOT devices. Achieving this requires electrical control of the current-induced spin polarization of the spin source. In this study, we demonstrate a proof-of-concept current-programmed SOT device. Using a noncollinear-antiferromagnetic/nonmagnetic/ferromagnetic (NCAFM/NM/FM) Mn_3Sn/Mo/CoFeB heterostructure at zero magnetic field, we show current-induced switching in the CoFeB layer due to the spin current polarized by the magnetic structure of the Mn_3Sn; by properly tuning the driving current, the spin current from the CoFeB further reverses the magnetic orientation of the Mn_3Sn, which determines the polarity of the subsequent switching of the CoFeB (Fig. 1). This scheme of mutual switching can be achieved in a spin-valve-like simple protocol because each magnetic layer serves as a reversible spin source and target magnetic electrode. It yields intriguing proof-of-concept functionalities for unconventional logic and neuromorphic computing [1].

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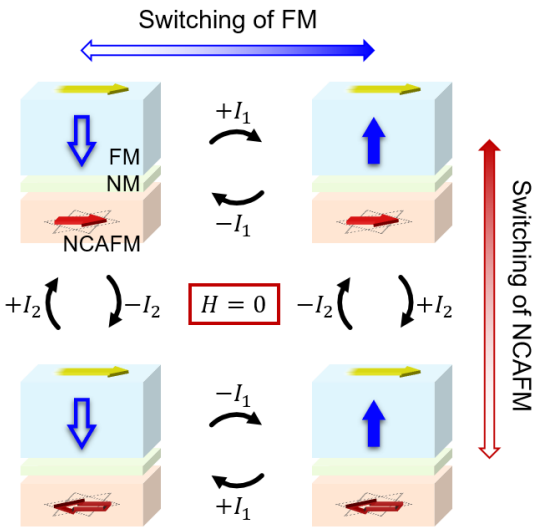

Fig. 1. Illustration of the electrical mutual switching in NCAFM/NM/FM stacks: switching of FM at current I_1 and switching of NCAFM at current I_2 ($I_2 > I_1$) in the absence of magnetic field.