Perpendicular and 100% switching of noncollinear antiferromagnetic order in the chiral antiferromagnet Mn_3Sn by electric current

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There has been a surge of interest in antiferromagnetic (AF) materials due to their favorable properties for device applications, including a vanishingly small stray field and faster spin dynamics than their ferromagnetic counterparts. Motivated by these intriguing properties, several breakthroughs have been made: an anisotropic magnetoresistance (an even-function response under time-reversal (TR)) for detecting collinear AF ordering [1]. Another breakthrough is an odd-function response under TR in the chiral antiferromagnet Mn_3Sn such as anomalous Hall effect (AHE) [2], anomalous Nernst effect [3], and magneto-optical Kerr effect [4]. Both theoretical and experimental studies have revealed that Mn_3Sn is a magnetic Weyl material (Weyl magnet) possessing a large and controllable Berry curvature in the momentum space for the large TR-odd responses because of the unique magnetic and electronic structures [5]. Recently, a number of methods have been found to electrically control the chiral AF order and Berry curvature induced TR-odd responses [6, 7].

In this study, we prepare epitaxial heterostructures of a heavy-metal/Mn_3Sn bilayer on MgO substrates by molecular beam epitaxy (MBE). The sample exhibits a sizable Hall conductivity of $\sigma_H \sim 40\ \Omega^{-1}\text{cm}^{-1}$ at room temperature, the largest value compared to all the previous reports for Mn_3Sn films, reaching those known for Mn_3Sn bulk single crystals [2]. The current-induced switching at room temperature demonstrates the full (100%) switching of the chiral AF domain and AHE signals [8]. We find epitaxial tensile strain in the Mn_3Sn layer causes the uniaxial magnetic anisotropy normal to the plane (perpendicular magnetic anisotropy (PMA)) [9] and enables the 100% electrical switching of the perpendicularly oriented magnetic octupole in the chiral AF order [8]. Given the high reliability and efficiency of the perpendicular and full SOT switching, our realization of low-power 100% switching using PMA and their efficient coupling to spin current forms a significant basis for further development of AF spintronics.

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