Fabrication and characterization of polycrystalline Mn_3Sn/Ta structures

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Time-reversal symmetry (TRS) breaking antiferromagnets (AFMs) are recently a topic of interest due to their large responses such as the anomalous Hall effect (AHE) and the anomalous Nernst effect that do not scale with their vanishingly small net magnetization [1,2]. In the case of the noncollinear Weyl AFM Mn_3Sn [3], these responses can be attributed to the ordering of the cluster magnetic octupole, an order parameter that encapsulates the TRS-breaking spin structure [4]. The magnetic octupole corresponds to the orientation of a pair of Weyl points in momentum space [3]. In thin films of Mn_3Sn [5], the octupole can be switched by a spin current injected from a neighboring layer with strong spin-orbit coupling, most commonly a heavy metal (HM) [6]. To study surface-dependent effects in Mn_3Sn such as spin-orbit torque, thinner films and smoother interfaces with other materials are desired.

Our work focuses on polycrystalline Mn_3Sn/Ta bilayers, where Ta caps the Mn_3Sn layer due to the prospect of using it as a spin source. We show that the immiscibility of these two materials allows for greater flexibility in the fabrication process than when HM = Pt, W [6]. Transmission electron microscopy and atomic force microscopy reveal that the resultant films yield a smoother Mn_3Sn/HM interface (RMS ~ 0.5 nm) compared to conventionally prepared polycrystalline films [5]. Furthermore, where previous works report Mn_3Sn films with thicknesses above 30 nm [5-8], large anomalous Hall conductivity comparable to that of bulk crystals [1] was retained in our Mn_3Sn layers as thin as 20 nm.

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