Spin-orbit torques, topological Hall effect, and current induced magnetization reversal in MBE-grown $Cr_{1+\delta}Te_2/Bi_2Te_3$ 2D-ferromagnet/topological insulator heterostructure

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In the last decade, spintronics research has ventured into the investigations of novel materials and highly engineered structures like Topological Insulators (TI) and artificial Rashba-Like systems [1,2]. Although these systems are predicted to allow advances in efficiency they also bring their own set of challenges such as interfacial quality and current shunting, for example. The discovery of two-dimensional ferromagnetic materials (2D-FM) brought about new perspectives to address these issues [3]. In the present work, we have studied epitaxially grown $Cr_{1+\delta}Te_2/Bi_2Te_3$ heterostructures [4]. $Cr_{1+\delta}Te_2$ is a quasi-2D ferromagnet where stacked Van der Waals (VdW) $CrTe_2$ trilayers have their VdW gaps partially filled by additional Cr atom. Bi_2Te_3 is a VdW topological insulator in which the fermi level crosses not only surface states but also the conduction band. We report, for the grown heterostructure, low temperature magnetization with Tc about 150 K and perpendicular anisotropy. We also report a puzzling magnetotranport result where the amplitudes of the Anomalous Hall Effect (AHE) curves inverts their signs at different temperatures below Tc. Furthermore, around the inversion temperature the AHE field profile exhibit peak-like features compatible with the Topological Hall Effect (THE) (see Fig. 1), which is generally attributed to skyrmion phases. Second Harmonic magnetotrasport techniques revealed large values of Field-like (FL) torques and FL to Damping-Like torque ratios. These both properties are compatible with an interfacial source for the spin current across the structure such as the Rashba and Topological surface states. Finally, current induced magnetization reversal experiments revealed a combination of SOT-compatible reversible switching and non-reversible thermally-induced domain nucleation.

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References

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Figures

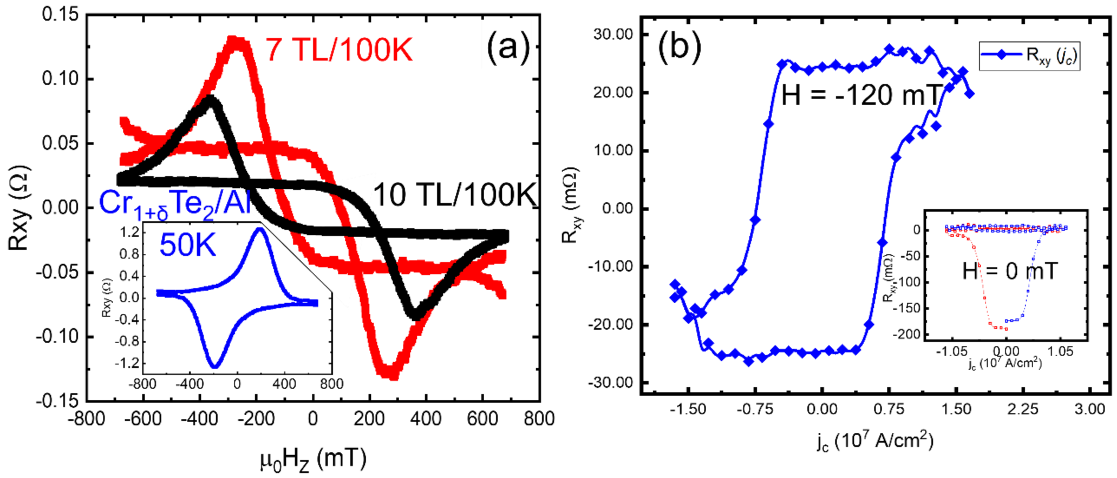

Figure 1: (a) AHE field profile for three different samples: $Cr_{1+\delta}Te_2$ covered Al at 50 K (in blue), $Cr_{1+\delta}Te_2$ (7 TL)/Bi_2Te_3 (10 nm) (in red), and $Cr_{1+\delta}Te_2$ (10 TL)/Bi_2Te_3 (10 nm) at 100 K (in black). (b) Current induced switching in at $Cr_{1+\delta}Te_2$ (10 TL)/Bi_2Te_3 140 K with an in-plane field of about 120 mT. The inset shows the same experiment with any applied field.