Coercive field enhancement in the quantum anomalous Hall insulators $V_y(Bi_xSb_{1-x})_{2-y}Te_3$ and $Cr_y(Bi_xSb_{1-x})_{2-y}Te_3$ grown on a GaAs buffer layer

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Thin films of three-dimensional topological insulators $(Bi_xSb_{1-x})_2Te_3$ doped with Cr or V are representative systems exhibiting the quantum anomalous Hall effect (QAHE) characterized by the quantized Hall resistance $R_{yx} = \pm h/e^2$ in the absence of an external magnetic field [1,2]. Intensive research on these materials has shown that the use magnetic modulation doping [3] and a magnetic capping layer [4] is effective in raising the QAHE observation temperature. On the other hand, the use of a buffer layer, which is known to improve the interface quality and thus the transport properties in undoped topological insulator thin films [5], remains unexplored for magnetically doped films and little is known about its effects on the magnetic properties and the QAHE.

Here, we report the significant enhancement of coercive fields (H_c) in $Cr_y(Bi_xSb_{1-x})_{2-y}Te_3$ (CBST) and $V_y(Bi_xSb_{1-x})_{2-y}Te_3$ (VBST) films grown on a GaAs(111)A substrate with a GaAs buffer layer, compared to those grown directly on an InP(111)A substrate (Fig. 1). The CBST and VBST layers and the GaAs buffer layer were grown by molecular beam epitaxy in separate chambers connected via ultra-high vacuum. We have confirmed the H_c enhancement for all the samples grown with different thickness, Bi/Sb and doping concentrations, Te flux, and growth temperature. It is noteworthy that the H_c is enhanced similarly (about twofold) for both CBST and VBST despite their coercivity differing by an order of magnitude. In particular, the H_c = 1.34 T of our VBST on GaAs is the largest among those reported for VBST. These results suggest that the interface plays an important role in determining the magnetic anisotropy energy that dictates H_c. We discuss possible mechanisms of the coercive field enhancement in the light of structural analysis by X-ray diffraction and transmission electron microscopy.

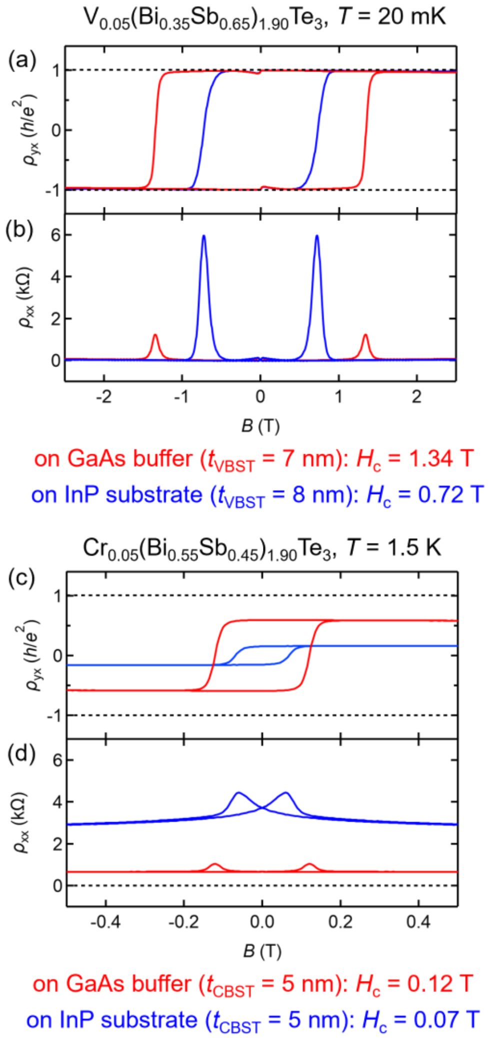

Fig. 1. (a) Hall (ρ_{yx}) and (b) longitudinal (ρ_{xx}) resistivity of $V_{0.05}(Bi_{0.35}Sb_{0.65})_{1.95}Te_3$ films grown on a GaAs(111)A substrate with a GaAs buffer layer (red) and an InP(111)A substrate (blue) measured at T = 20 mK. (c) ρ_{yx} and (d) ρ_{xx} of $Cr_{0.05}(Bi_{0.55}Sb_{0.45})_{1.95}Te_3$ films grown on the GaAs buffer layer (red) and the InP substrate (blue) measured at T = 1.5 K.

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