Transport Study on MBE-grown Topological Insulator Thin Films

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Introduction

The Dirac-like topological surface states of the three-dimensional topological insulators (TIs) are predicted to exhibit novel quantum phenomena. For example, the half quantum Hall effect (QHE) is proposed to be hosted by the surface states, but has not been observed by experiments so far due to the parasitic bulk conduction, poor surface state mobility, and low magnetic field.

We plan to search for the half QHE in high quality TI thin films grown by Molecule Beam Epitaxy (MBE). By employing the band structure engineering technique first reported by our group [1], we have achieved intrinsic surface state quantum transport in $(Bi,Sb)_2Te_3$ ternary TI. The film also has low carried density and relatively high mobility, making it a promising candidate for realizing the half QHE in pulsed magnetic field.

Experimental

5 QL $(Bi,Sb)_2Te_3$ thin films were grown by using MBE method. Their chemical potential is tuned to near the Dirac point of the topological surface band by accurate control of Bi/Sb flux ratio. The film is covered by a Te capping layer before being taken out the growth chamber to prevent contamination from ambient environment. The Hall effect were measured using the 65T short pulse magnet of NHMFL-PFF, LANL.

Results and Discussion

As shown in the figures below, the Hall effect in the *n* type TI thin film develops obvious quantum oscillations at high magnetic field and the strength of the oscillations diminishes with increasing temperature (a). By subtracting the linear background, the oscillation can be seen more clearly (b). The surface state Dirac fermions are squeezed into the lowest Landau Level at the highest magnetic field (c), but the Hall effect has not shown obvious quantization behavior.

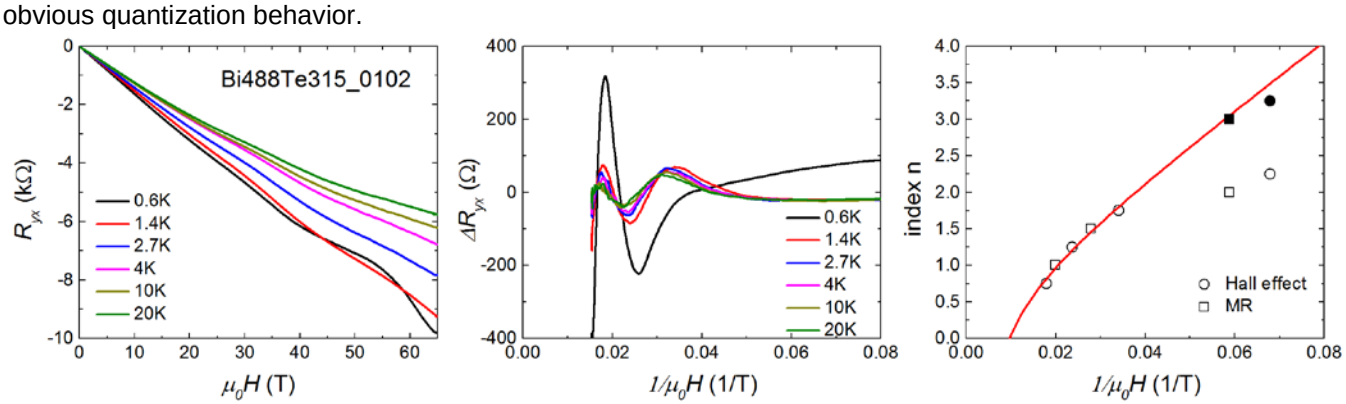

Figure 1. The Hall effect (a) and that after subtracting a linear background (b) of 5 QL $(Bi,Sb)_2Te_3$ thin film. (c) Landau index at high magnetic field

Conclusions

The results obtained on this sample indicate that it is promising to observe the half QHE in TI thin films. It will be helpful to grow samples with higher mobility and extend the measurements to even higher magnetic field. We also plan to use a back gate to tune the electronic structure of the sample *in situ*.

Acknowledgements

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References

[1] Zhang, J.S., *et al.*, Nature Communications **2**, 574 (2011).