High Field Transport Measurement on Topological Insulator Thin Films

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Introduction

Topological insulators [1] (TIs) are quantum materials with bulk insulating and topologically protected metallic surfaces. An outstanding challenge in the field of TIs is to reveal the intrinsic quantum transport properties of topological surface states. We report pulsed magnetic field measurements of the Hall effect and magnetoresistance in our MBE-grown TIs thin films up to 60 T. By applying a gate voltage, the Fermi level can be systematically tuned across the Dirac point.

Experimental

$(Bi,Sb)_2Te_3$ thin films were grown using MBE method on $SrTiO_3$ substrate. Their as-grown chemical potential was tuned near to the Dirac point of the topological surface band by controlling the ratio of Bi/Sb flux. A tellurium capping layer was used to protect the films when the sample is taken out of the MBE chamber. Magnetoresistance and Hall effect were measured using the 60T short pulse magnet of NHMFL-PFF, LANL.

Results and Discussion

We investigate the transport properties of TI thin film in the 60 T pulsed magnet. A complex and systematic evolution of magnetoresistance (MR) is observed when the Fermi level is tuned across Dirac point by gate voltage. In particular, an unusual negative MR prevails at the charge neutral point and gradually becomes positive at higher energy. This intriguing phenomenon is related to the exotic property of surface states that is only shown at the extreme quantum limit. Our results pave the road to realize the half quantum Hall effect in TIs.

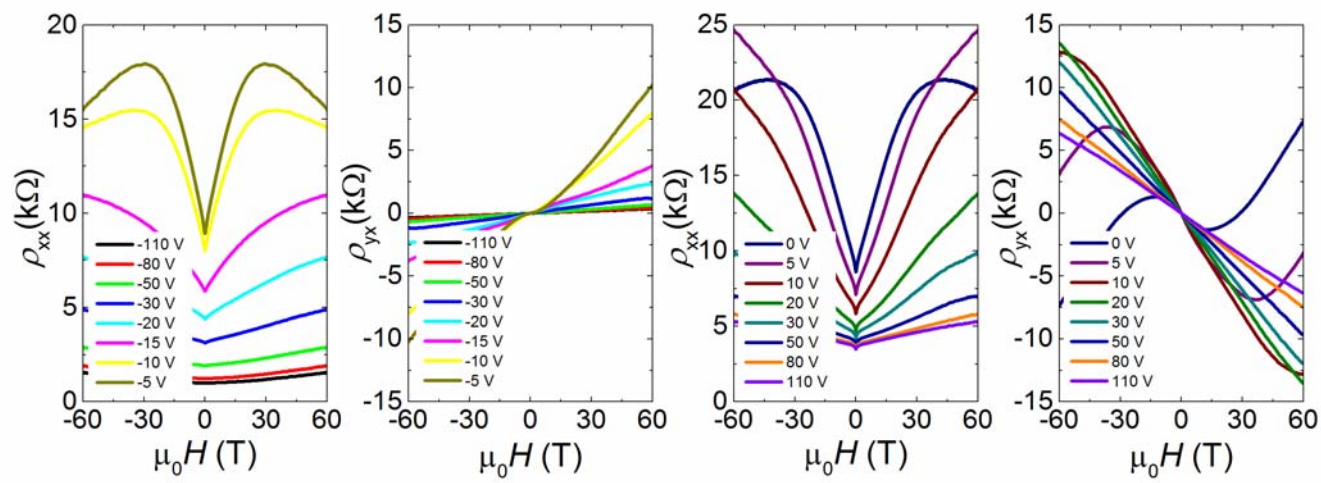

Fig.1 Magnetoresistance (a),(c) and Hall effect (b),(d) of $(Bi,Sb)_2Te_3$ thin film under various gate voltages.

Conclusions

Applying a gate voltage to thin film devices is a very challenging measurement in the pulsed field. The reliable results obtained from pulsed field unveil the unique properties in the topological insulator thin films These results will have broad impact in the field of TIs and spintronics.

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References

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