Magneto-transport in Bi_2Se_3: Shubnikov–de Haas Oscillation and Quantum Hall Effect

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Introduction

This project aims to study the electronic properties of topological insulators (TIs) and related materials. TI is a new class of quantum matter that has attracted great interests in condensed matter physics since 2009[1,2]. They are band insulators in the bulk, however, because of the band topology and strong spin-orbit coupling, have nontrivial *metallic* states on the surface. We aim to understand the new topological matter and topologically protected surface states (SS), and hope to generate novel concepts of designing new spintronic or magnetoelectric devices.

Experimental

In 2012, we had two weeks (Jan. 9th to Jan.13th and Jul. 2nd to Jul. 6th) in cell 9 (B up tp 31 T) with He-3 probe (T down to 340 mK), and one week (Dec. 10th to 16th) in SCM2 (B up to 18 T) with He-3 probe. We systematically studied the magneto-transport properties in Bi_2Te_2Se (BTS221) crystals with low bulk carrier density[3,4].

Results and Discussion

We have grown high quality Bi_2Te_2Se crystals by the Bridgeman method. The resistivity of BTS221 crystal increases as decreasing temperature from room temperature to ~10 K (as shown in **Figure 1a**), which indicates an insulating behavior in the bulk. Below 10 K, the resistivity saturates, which can be interpreted as due to the metallic surface states becoming dominant at low temperature. **Figure 1b** shows the magneto-transport of BTS221 with a freshly cleaved top surface at 340 mK. Both R_{xx} (4-terminal longitudinal resistance) and R_{xy} (Hall resistance) display obvious oscillations periodic in 1/B. This can be interpreted as Shubnikov–de Haas (SdH) oscillations. The overall non-linear background and low field anomaly of Hall effect indicates the surface (with charge mobility higher than 10,000 cm^2/Vs) and bulk acting as two conducting channels with different carrier mobility and density[5]. We have also compared transport properties of the samples before and after exposure to air. A giant cusp in magnetoresistance at zero B field was observed after exposure. Our studies may help understand the interplay between the surface and the bulk conduction channels and the degradation of SS due to environmental exposure.

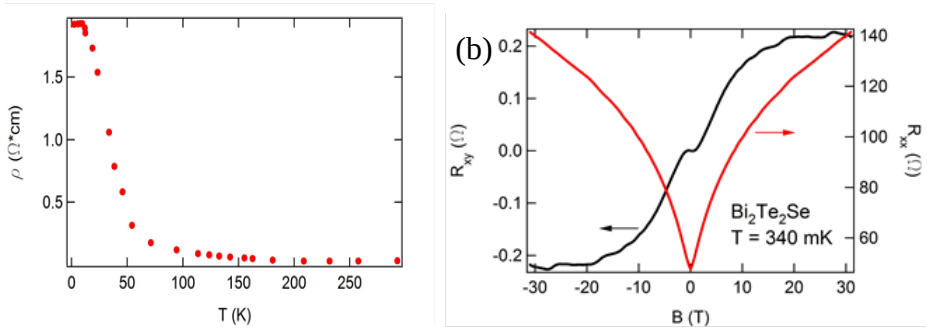

Figure 1 (a) Resistivity ρ of BTS221 as a function of temperature. (b) 4-terminal longitudinal resistance R_{xx} and Hall resistance R_{xy} as functions of B at 340 mK.

Acknowledgements

We acknowledge support from DARPA MESO program (Grant N66001-11-1-4107). The magnetotransport measurements were performed at National High Magnetic Field Laboratory (NHMFL), which is jointly supported by the National Science Foundation (DMR0654118) and the State of Florida.

References

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