NATIONAL HIGH MAGNETIC FIELD LABORATORY
2018 ANNUAL RESEARCH REPORT

Hall measurements on a topological insulator with 65 T pulse-fields

Kushwaha, S.K., Chan, M.K., McDonald, R., Harrison, N. (LANL, MPA-Mag); Rosa, P.F.S., Bauer, E.D., Ronning, F (LANL, CMMS); Ji, H., Cava. R.J. (Princeton U., Chemistry); Laurel, E.W.S. (LANL, MST-16)

Introduction

The 3-dimentional topological insulators with spin-momentum locked surface states are interesting candidates for the quantum Hall effect - QHE. However, the conduction in the crystals usually dominated from the defect-induced carriers and entangles with surface-states conduction. Recently, we have grown a crystal which entirely bulk insulating of intrinsic semiconductor nature with bulk resistivity ~ 120 Ohm-cm and hosting high quality surface states. Motivated from the recent observation of QHE in a topological insulator, we aimed to look for the consequences of QHE state at high magnetic fields of 65 T, and the signature for fractional-QHE. Another motivation of this work comes from an observation of the states of “annihilation of Weyl points” at extremely high magnetic fields, in Dirac/Weyl metals. To improve the sample geometry the measurements were aimed on a focused-ion-beam – FIB fabricated sample in a Hall and resistance geometry.

Experimental

The bulk single crystals were grown at Princeton University. The freshly exfoliated samples were mounted on a 2 mm x 2mm quartz substrate and FIBed for Hall and magnetoresistance, MR, geometry, shown in FIG 1 (a). The Hall/MR measurements were performed at He-3 and He-4 temperatures, in 65 T pulse field facility at the Mag Lab.

Results and Discussion

A micro structured FIBed sample for the Hall and MR and geometry is shown in FIG. 1(a). The MR and Hall signal were recorded at 3-He and 4-He temperatures. A typical Hall effect signal recorded at 0.75 K is shown in FIG. 1(b). As expected our sample reached into the quantum limit and we could observe the plateau corresponding to the Hall resistance of ~12.5 k.Ohm. However, the signal at high field regime becomes noisy and we could not infer the subtle features of Hall signal. Therefore, we could not collect the appropriate data with the current experimental sample-setup.

We still have to figure out the reason for the abnormalities in the results which we encountered during the cooling-heating cycles, and source of the noise in our measurements. The sample seems an ideal candidate for the further experimental plans, as it could be easily pushed into quantum limits even without gating-effects.

Conclusions

The sample could be pushed into a quantum limit with an observation of plateau of 12.5 k.Ohm. The fabricated device couldn’t produce high resolution data at higher fields.

Acknowledgements

The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida.

The research was also supported by LDRD and DOE BESMSE Science of 100 Tesla programs, ARO MURI on TIs, grant W911NF-12-1-0461, ARO grant W911NF-12-1-0461 and the MRSEC programme at the Princeton Center for Complex Materials, grant NSF-DMR-1420541

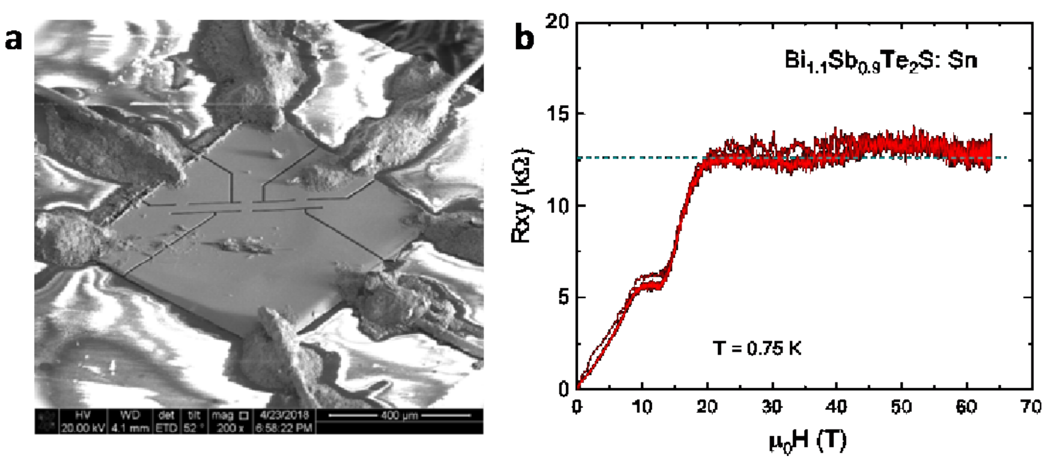

Fig.1 (a) A FIBed sample with Hall and MR geometry. (b) Hall signal recorded with 65 T pulse field at He-3 temperature of 0.75 K.