# Topological Crystalline Insulator SnTe Thin Films at High Magnetic Fields

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## Introduction

The recent discovery of the topological crystalline insulator phase in IV-VI semiconductors [1] has brought up new device promises to the field of topological matter.[1] Few attempts have however been made to understand the magnetotransport in thin films [2] of such materials. In addition to the existence of topological surface states, the bulk states of IV-VI semiconductors have been notoriously known to be peculiar. [3]

## Experimental

We thus performed magnetoresistance and Hall measurements in Cell 9 up to 31T and down to 1.5K. Temperature dependence and angular dependence were also studied. Four samples where studied. This report describes results from one sample that has been elaborately analyzed (1014Y – SnTe 30nm on $BaF_2$). [1]

## Results and discussion

The high field Hall conductivity and magnetoconductance (MC) were both fit with a two-carrier Drude model (Fig. 1(a)). The higher field results prove the existence of high-mobility (800cm$^2$/Vs) 2-dimensional minority carriers coexisting with bulk majority carriers having a significantly lower mobility. The 2-dimensional nature is inferred from the MC anisotropy when the field is rotated in the film plane. It was found that the bulk transport parameters extracted from MC were at odds with those extracted from the Hall conductivity. This problem is notorious in SnTe and PbTe, and is thought to be a consequence of their unusually shaped Fermi surface and is under further consideration.[3]

## Conclusions

In conclusion, our measurements allow us to identify the existence of two types of carriers contributing to the transport in SnTe, one type originates from 3D bulk bands, and a second high mobility type that is of 2D nature. We were not able to extract any direct Berry phase information that would provide direct evidence of topological 2D surface states. Further experiments on samples having and even higher mobility will shed more light on the nature of these 2D carriers.

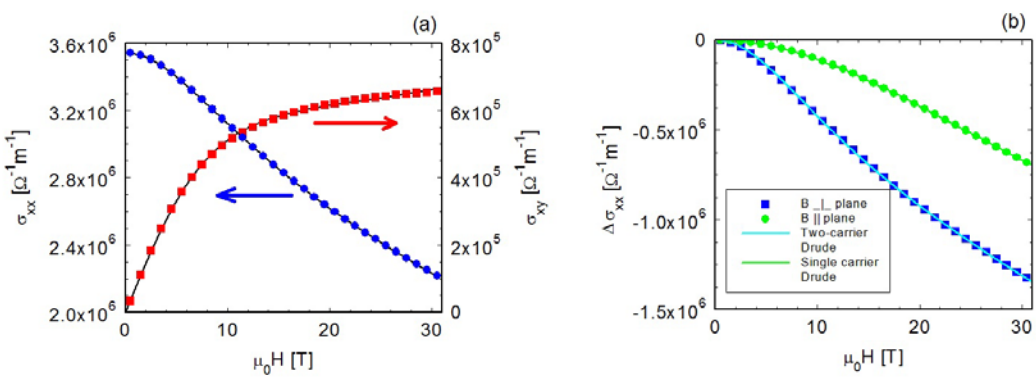


**Figure 1.** (a) $\sigma_{xx}$ (blue) and $\sigma_{xy}$ (red) at 1.5K fit independently with a two carrier Drude model (black). (b) $\sigma_{xx}$ versus magnetic field measured in-plane (green) and out-of-plane (blue). The in-plane MC fits well to a one-carrier Drude model suggesting that the second type of carriers is of 2D nature.

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## References

[1] Hsieh, T. H. *et al. Nat. Commun.* **3,** 982 (2012), Liu, J. *et al. Nat. Mater.* **13,** 178 (2014).
[2] Assaf, B.A. et al. *Appl. Phys. Lett.* **105**, 102108 (2014), Taskin A. A. et al. Phys. Rev. B **89** 121302 (2014).
[3] R. Tsu et al. Phys. Rev. **172,** 779 (1968).