Disentangling transport in topological insulator thin films down to the nanoscale

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Three-dimensional topological insulators (TIs) are prime candidate materials for application in future electronic devices due to the unique electronic properties of their two-dimensional topological surface states (TSS). In epitaxial TI thin films there are several parallel conduction channels which all can contribute to the charge transport through the sample and which are difficult to disentangle in transport experiments (Fig. 1). In the present study, we use multi-tip scanning tunneling microscopy to systematically analyze the charge transport properties of a pristine epitaxial $BiSbTe_3$ thin film under ultra-high vacuum conditions and down to the nanoscale.

We first determine the detailed structure and charge transport properties of the TI/substrate interface. We then disentangle the transport through the conduction channels of the $BiSbTe_3$ thin film, by gate-dependent four-probe measurements in combination with photoemission spectroscopy. From this experiment, we find that ~90% of the lateral current is transmitted by the TSS at the sample surface. To further analyze the charge transport through the TSS on the nanoscale, we use scanning tunneling potentiometry, which we implemented into the present multi-tip setup. In this experiment, we observe the largest localized voltage drop at domain boundaries, corresponding to a resistivity about four times higher than that of a step edge. In addition, we resolve resistivity dipoles at void defects in the sample surface with a typical diameter of 5 nm. We find that the observed defects in total contribute 44% of the resistance of the TSS.

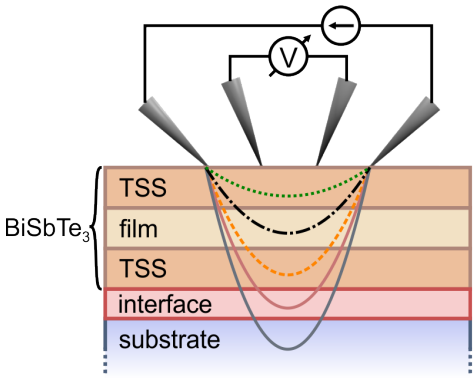

Fig. 1. Schematic of the experimental setup. The colored lines indicate the current through each of the parallel transport channels of the epitaxial $BiSbTe_3$ thin film sample.