Transport studies on ultrathin epitaxial Bi_2Se_3 Topological Insulator epilayers

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The so-called "*next generation*" of topological insulator (TI) materials including Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3 became a rich playground for studying the exotic electronic structure predicted in 3D TI [1]. The surface state electronic transport is a key tool for exploring the predicted novel phenomena and feasible applications of TIs. Despite considerable advances, the suppression or at least decoupling of the residual bulk states from the surface states as well as the ability to tune the carrier density remains an experimental challenge. Thin film technology potentially offers pathways to achieve these goals, hence, in the present study molecular beam epitaxy (MBE), was employed to grow Bi_2Se_3 films on Si (111) substrates with thickness down to 10 nm [2]. Subsequently, Hall bar structure based devices in the micrometer scale have been fabricated and the respective transport studies reveal an n-type carrier concentration around 2.3 x 10^{13} cm^{-2}, typical for a significant bulk contribution of charge carriers next to the surface state transport. Nonetheless, the pronounced weak antilocalization (WAL) feature observed in Fig. 1 for conductance measurements, as well its angular dependence in Fig. 2 renders immunity to localization generally caused by the transport of non trivial metallic states in this material. The fitting of the WAL feature to the low field Hikami-Larkin-Nagaoka (HLN) model [3] indicates a mixing or coupling of bulk and surface states in a single transport channel. Moreover, the fit excludes any possible decoupling of the channels via the reduction in the phase coherence time as the temperature increases [4]. In order to reduce the effect of the high bulk electronic concentration in the Bi_2Se_3 thin films, an effective tuning of the carrier densities through the top-gate voltage is evaluated by testing $LaLuO_3$, and ZrO_2 as dielectric materials.

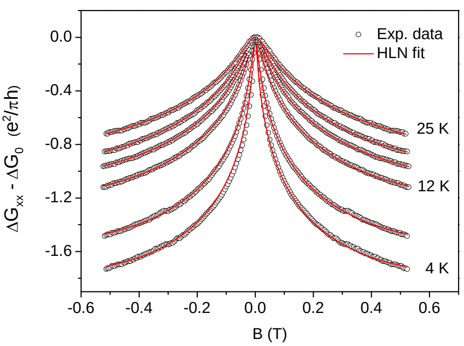

Fig. 1: Magnetoconductance at different temperatures. Fit to the HLN model (solid lines).

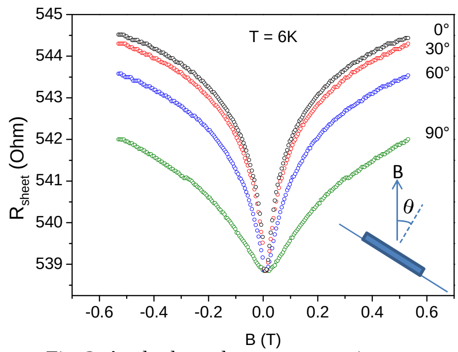

Fig. 2: Angle-dependent magnetoresistance. Inset: Angle definition in the experiment.

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