Transport properties of thin Bi_2Se_3 flakes in the presence of defects and disorder

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Topological insulators (TIs) are an intriguing class of materials which have electrically insulating states in the bulk and robust conducting states along the edges [1, 2]. One critical issue is the effect of disorder and defects on the helical surface states. We investigate the effects of the controlled combination of dimensionality and designed defect and metallic impurity structures on the transport properties of Bi_2Se_3 TIs.

Here we report on single crystalline exfoliated Bi_2Se_3 flakes grown by Bridgeman technique. The exfoilated flakes on a SiO_2 substrate are in the thickness range of 10 - 150 nm. Contacts for transport measurements are prepared by micro-laser lithography, followed by Cr/Au (10 nm/40 nm) sputtering and lift-off (Fig. 1 (a)). Samples are characterized using atomic force microscopy and energy-dispersive X-ray spectroscopy. Surface stability and composition are determined using photoemission electron microscopy. Transmission electron microscopy (TEM) analysis is used to identify the dislocation networks on the exfoilated flakes (extreme case see Fig. 1(b)). Low temperature transport measurements show metallic behavior, and weak-antilocalization (WAL) (Fig. 1(c)) is observed in the virgin state of samples. The dependence of electrical resistivity and carrier concentration of surface and bulk carriers on the defect concentration is investigated.

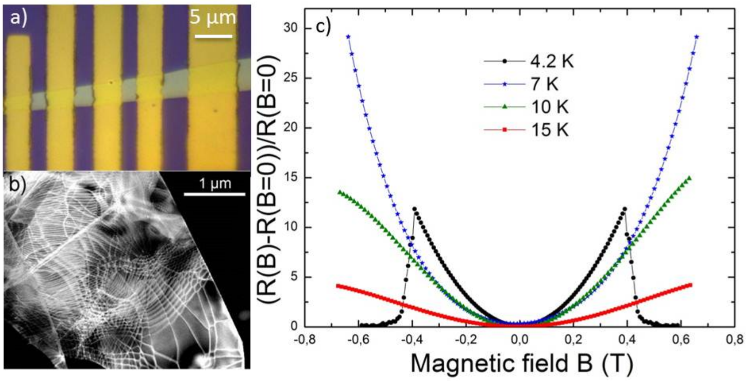

Figure 1: (a) Optical microscope image of a 70 nm thick Bi_2Se_3 device; (b) Annular dark-field TEM image of 20 nm thin exfoliated Bi_2Se_3 flakes, showing the presence of a complex dislocation net appearing after the exfoliation; (c) Magnetoresistance vs. magnetic field applied normally to layers of a Bi_2Se_3 sample at different temperatures. WAL behaviour is observed at 4.2 K.

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