Planar transport properties of SnTe/PbTe topological heterojunctions

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Narrow gap semiconductor SnTe is one of the first topological crystalline insulators (TCIs), for which protected boundary states were observed on highly symmetrical surfaces of bulk material [1, 2]. The presence of a surface conduction has been recently proved also for the epitaxial SnTe/CdTe quantum heterostructures, grown on (001) crystallographic direction [3]. In particular, the weak anti-localization (WAL) effect has been studied, which by symmetry arguments, occurs only for the topological states. The transport studies of 2D surface states in this system are, however, difficult because of *p*-type conductivity of intrinsic holes, which anchors the chemical potential deep within the valence band. In order to move the Fermi level at the interface towards a Dirac point, an epitaxial growth of PbTe/SnTe *n–p* hetrojunctions has been recently proposed and realized on (111) direction [4].

The PbTe/SnTe junction at low temperatures is a so-called type-II heterostructure, with the valence band edge of SnTe located much higher than the bottom of conduction band in PbTe [5]. Therefore it is expected, that carrier diffusion across the interface shifts the chemical potential towards the energy gap and only the 2D topological states contribute to transport along the junction plane. In this work we investigated PbTe/SnTe heterostructures grown by molecular beam epitaxy (MBE) on (001) CdTe undoped buffer. We choose the lowest possible substrate temperature of 230 °C and during the growth of the PbTe layer the Pb/Te flux ratio was adjusted to assure *n*-type conductivity with an electron concentration of the order of 10^{18} cm^{-3}. The conductivity of SnTe is always *p*-type, as already noted, with a hole concentration of the order of 10^{20} cm^{-3}. Thickness of PbTe layer was 100 nm, whereas for top SnTe layer ranged from 5 to 20 nm.

We studied electrical transport properties of these heterostructures, using the 6-terminal Hall bar devices patterned with electron beam lithography and wet etching techniques. From the same substrates we also prepared the 4-terminal, square samples of the van der Pauw geometry. In his case, we did not use lithography and thermal processing was avoided. All macroscopic contacts, made of silver paint, were connected in parallel to both SnTe and PbTe layers. We measured Hall voltage and conductivity in the temperature range 0.4 – 50 K and in magnetic field B up to 16 T. For all layers we have observed the weak anti-localization effect, which we attributed to the 2D quantum transport, occurring in the junction plane. We found that magnetic field characteristics of WAL and its temperature dependence were not affected by the e-beam lithography process. Furthermore, we analysed $\sigma_{xx}(B)$ and $\sigma_{xy}(B)$ components of the conductivity tensor and showed that the high field transport data cannot be described by a single-carrier Drude model, as expected. However, a more detailed analysis of the so-called mobility spectrum is required, in order to determine concentrations and types of current carriers contributing to planar transport.

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