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Quantum transport in nano-structures fabricated from three-dimensional crystalline topological insulator SnTe

Semiconductor compounds SnTe and (Pb,Sn)Te were the first to be recognized as members of a new group of topological matter - the so-called *crystalline topological insulators*. This dissertation presents the results of magnetotransport measurements carried out on macroscopic samples and nano-structures made of SnTe/PbTe heterojunctions and CdTe/SnTe/CdTe quantum wells by electron-beam lithography. Heterojunctions and quantum wells were fabricated by molecular beam epitaxy (MBE) on CdTe/GaAs substrates oriented along the crystallographic direction [001].

For SnTe/PbTe junctions, at low temperatures and weak magnetic fields, characteristic conductivity corrections were observed, related to the interference of the wave function of current carriers. The same phenomena were also observed for SnTe quantum wells. The results suggest that topological carriers located on the SnTe/PbTe and SnTe/CdTe interfaces are responsible for the effects of *weak anti-localization* (WAL), confirming the results of previous work on (Pb,Sn)Te alloys. A weak localization (WL) effect was also found in the studied macroscopic structures, the presence of which was attributed to quantum transport of non-topological carriers.

Classical magnetotransport in macroscopic samples was described using *mobility spectrum analysis* (MSA). It was shown that the electron-like and hole-like maxima, observed in the mobility spectra of SnTe/PbTe junctions, were associated with *single-carrier* transport in *single* topological band. The characteristic double spectral lines were found to originate from the concave and convex parts of the constant energy surface. This interpretation was based on numerical calculations of the conductivity tensor components σ_{xx} and σ_{xy} carried out for the (001) surface states. The presence of characteristic multiple maxima in the spectra of topological carriers was confirmed by MSA for samples made of CdTe/SnTe/CdTe quantum wells.

SnTe quantum wells were used to fabricate 6- and 8-probe nano-structures with conducting channel lengths of several microns and physical widths of less than one micron. It was found that the low-temperature electrical properties of such nano-structures were *significantly different* from macroscopic samples. In particular, the resistances of individual fragments of the structure were much higher than expectations based on purely geometrical factors. For such channels, unusual magnetic field dependencies of differential resistances, measured along the same and opposite edges of the sample, were observed.

These unusual results were interpreted as being related to the transport of topological carriers, whose energy spectrum was quantized due to the reduction of dimensionality. Calculations of 1-dimensional topological states, confined perpendicularly to the [100] direction suggest, that carriers involved in current flow are located at the edges of a channel. Furthermore, the energy of such edge states does not depend on *quasi*-momentum (*flat-band*). Under this assumption, the electron-electron interaction must strongly influence the charge transport along quantum channel. Therefore, the obtained data on the dependence of the resistance on the DC current were interpreted as an observation of the *Gurzhi effect*, associated with the *hydrodynamic flow* of a viscous fermionic liquid.

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