Topological protection length in HgTe/(Hg,Cd)Te quantum wells

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We present results of experimental studies of edge-channel transport down to 0.3 K in multiprobe Hall structures of modulation doped HgTe quantum wells (QWs) of the thickness $d = 8$ nm embedded between $Hg_{0.3}Cd_{0.7}Te$ barriers, the layout corresponding to a two-dimensional topological insulator (2D TI) [1]. The layers were grown by MBE [2], and the Hall bars of different linewidths (from 2 μm to 5 μm) have been patterned by e-beam lithography and wet-chemical etching. A top gate consisting of a 100 nm thick, HfO_2+Al_2O_3 composite (grown by atomic layer deposition) and a 30 nm thick gold film of the area $90 \times 90\,\mathrm{nm}^2$ has been used for tuning the QW conductance between the n- and p-type. In the intermediate (depletion) regime the conductance of 2D TIs proceeds exclusively *via* helical edge channels, which gives rise to pronounced nonlocal resistances [3, 4]. In agreement with the expectation for the edge transport, our results show that the electric potential measured on consecutive contact probes distributed around the structure perimeter increases monotonically in this regime. Since this is only possible if current flows only along the edges, we conclude that no parasitic parallel conductance [5] affects our data. We also show that edge channel sections extending between the large contact probes can be treated as resistors connected in series, again in accord with the scenario of edge channel transport. On the other hand, the resistances of the edge channels are significantly higher than the quantized values predicted by the modified Landauer-Buttiker model [3], pointing to breaking of topological protection in channels that are 100 μm long. From both local and nonlocal resistance values, we estimate the topological protection length L_{tp} to be between 2 μm and 10 μm in our structures. Possible mechanisms accounting for finite values of L_{tp} will be discussed.

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