Pressure-induced topological phase transition in HgTe quantum wells

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In HgTe quantum wells (QWs) two dimensional topological insulator (2DTI), characterized by gapless helical edge states, is realized provided that the band structure is inverted, *i.e.*, the QW electric subbands derived from the Γ_8 band are above the subbands originating from the Γ_6 band. This occurs if the QW thickness d is larger than a critical value $d_c \approx 6.3$ nm [1,2] and the magnitude of the magnetic field B is smaller than a critical value B_c at which the QW uppermost Landau level derived from Γ_6 band becomes higher in energy than the lowest Landau level originating from the Γ_8 band [3,4]. The existence of such a topological phase transition has indeed been shown as a function of the QW thickness [2] and temperature [4] that reduces a distance between the Γ_8 and Γ_6 bands. In our work we show how the stability boundary of the topological phase depends on the magnitude of hydrostatic pressure applied to HgTe QWs.

Our magnetotransport experiments have been carried out down to 1.8 K, up to 8 T and up to 1 GPa on a 8 nm HgTe/HgCdTe QW, grown by MBE on a GaAs substrate and patterned to a Hall bridge of dimensions $W \times L = 40 \times 20\ \mu m^2$. A gate electrode completed the structure. In the gate voltage region, in which charge transport proceeds *via* edge states we observe the existence of nonlocal resistance that is strongly reduced in a critical magnetic field B_c defining the boundary of the topological phase. With increasing hydrostatic pressure, B_c decreases and eventually vanishes at some critical pressure P_c. Analogous behavior is found in the local resistance, and in the Landau level charts extracted from the Shubnikov de Haas oscillations. The pressure-driven transitions are observed also in the temperature dependencies of local and nonlocal resistances.

The obtained results are interpreted in terms of the pressure-induced transition from the 2DTI phase to the normal band insulator phase. The determined pressure dependence of B_c shows good agreement with results of theoretical pressure dependent band structure computations within the eight-band $\boldsymbol{k \cdot p}$ model [5].

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