Conductivity and electron mobility of 2D massless Dirac fermions in HgTe quantum well

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Graphene was the first solid state system in which 2D massless Dirac fermions (DF), being highly investigated in physics of 2D electron systems now, were realized. Other possibilities to realize 2D massless DF in solids are 3D topological insulators and quantum wells (QW) based on semiconductors with inverted band spectrum. However, in comparison with 2D DF in graphene, caused by special symmetry of graphene, in these cases they are caused by strong relativistic effects and particularly spin-orbit interaction.

In the present work low-temperature conductivity and mobility of 2D massless DF in HgTe QW, having thicknesses $d = 6.3$-6.6 nm close to critical value, corresponding to the transition from normal to inverted spectrum, were investigated experimentally. A singularity of conductivity dependence on gate voltage (Fig. 1, a), expressed as a conductivity bend, was observed. In the case of mobility the singularity, expressed as a mobility maximum with a subsequent mobility minimum at electron concentrations $N_s = (0.6\text{–}1.5)\cdot 10^{11}$ cm^{-2} and $N_s \approx 3\cdot 10^{11}$ cm^{-2} correspondingly, was found to be more pronounced (Fig. 1, b). The singularity observed is supposed to be the consequence of the feature of 2D DF density of states in HgTe QW, predicted in [1] and associated with spin splitting of Dirac cones due to bulk inversion asymmetry of zinc blende lattice.

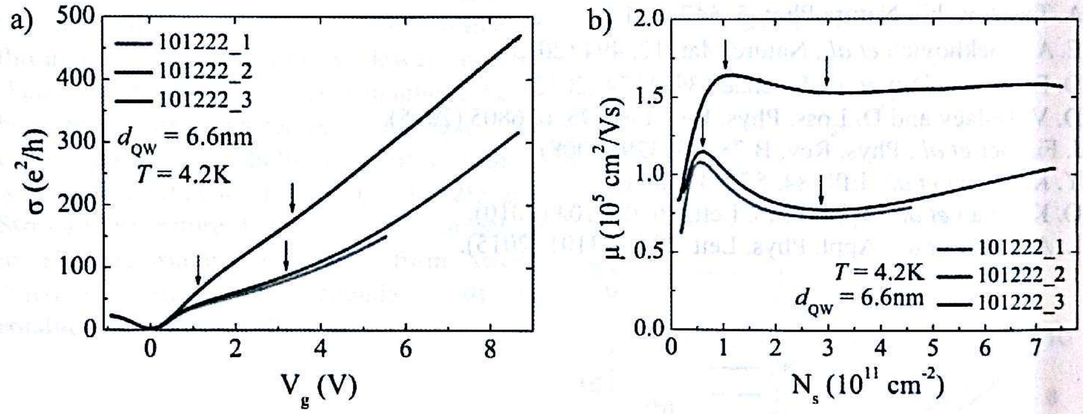

Fig. 1. Experimental results for 6.6 nm HgTe quantum well: conductivity (a) and mobility (b) versus electron concentration. Different colours correspond to different samples.

References

[1] S.A. Tarasenko *et al.*, Phys. Rev. B 91, 081302(R) (2015).