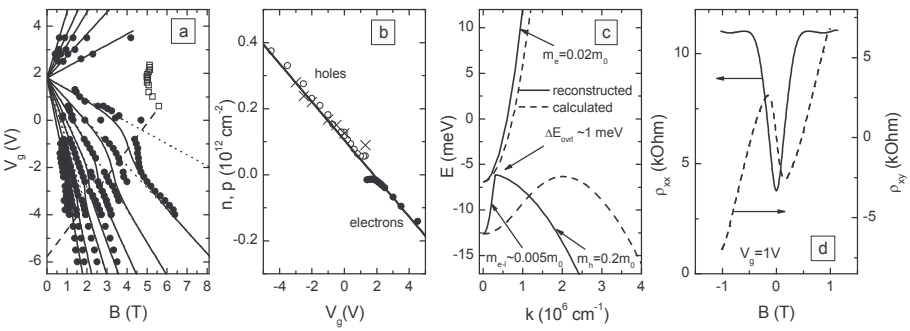
Two-dimensional semimetal in a wide HgTe quantum well: magnetotransport and energy spectrum

Grigory M. Minkov[1,2], Alexander V. Germanenko[1], Andrey A. Sherstobitov[1,2], Olga E. Rut[1], Sergey A. Dvoretski[3], and Nikolai N. Mikhailov[3]

[1] *Institute of Natural Sciences, Ural Federal University, 620000 Ekaterinburg, Russia*
[2] *Institute of Metal Physics RAS, 620990 Ekaterinburg, Russia*
[3] *Institute of Semiconductor Physics RAS, 630090 Novosibirsk, Russia*

Two-dimensional (2D) systems based on gapless semiconductors such as HgTe represent unique object. A great variety of two-dimensional electron and hole systems based on this materials can be realized depending on the quantum well width and content of cadmium in $Hg_{1-x}Cd_xTe$ barriers. The energy spectrum and transport phenomena of 2D carriers in HgTe based structures were studied intensively last decade both experimentally and theoretically. The experimental data on the energy distance between the different 2D subbands at zero quasimomentum are in satisfactory agreement with the theory. Electron energy spectrum, electron effective mass and their dependence on the quantum well width are in agreement with the calculation results also. As regards to the experimental data on the valence band energy spectrum, namely the value of bands overlapping, effective masses at $k = 0$ and at large quasimomentum (k), they are discrepant. In this report, we present the results of experimental study of the transport properties of the heterostructure with the 20 nm HgTe quantum well. The measurements were performed over wide range of electron and hole densities including the vicinity of the charge neutrality point. Simultaneous analysis of the gate voltage, V_g, dependences of the positions of the minima oscillations in ρ_{xx} (Fig.1a), periods of Shubnikov-de Haas oscillations and Hall densities (Fig.1b), holes effective mass found from temperature dependence of the oscillations allows us to reconstruct the valence band energy spectrum at $k > 8 \times 10^5$ cm^{-1}, which is plotted in Fig.1c. Already, these results show radical difference from $E(k)$ dependence calculated in framework of three-bands kP-method. The energy spectrum at $k < 8 \times 10^5$ cm^{-1} can be estimated from the analysis of electron (electron-like) and hole densities found from the magnetic field dependences of ρ_{xx} and ρ_{xy} (Fig.1d) at different V_g. These data are presented in Fig.1c also. Thus, the experimental E-vs-k dependence drastically differs from the calculated one. Accordance with other experimental data is discussed.



This work has been supported in part by the RFBR (Grant Nos. 11-02-12126, and 12-02-00098).