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Electron mobility in semi-metallic HgCdTe quantum wells at nitrogen temperature: application to THz bolometers

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In this work there were numerically modeled electron mobility, energy spectra and intrinsic carrier concentrations in n-type semi-metallic $Hg_{0.32}Cd_{0.68}Te$ / $Hg_{1-x}Cd_xTe$ quantum well (QW) at liquid nitrogen temperature (T = 77 K).

Energy spectra and wave-functions were calculated in terms of full 8-band k·p method, which allows one to describe the onsets of semi-metallic or semiconducting phases in QW depending on its growth parameters.

Mobility calculations accounted electron-hole scattering, longitudinal optical (LO) phonon scattering and charged impurities scattering, which are main scattering mechanisms in HgTe in the bulk. To account the inelasticity of LO phonon scattering, we used the iterative technique which allows one to solve Boltzmann transport equation directly. Also there were accounted such principal features of the considered material, as bands mixing, strong degeneracy and nonparabolicity of dispersion law.

Modeling revealed that at T = 77 K, increase of electron concentration in QW causes the sufficient growth of electron mobility as compared to the intrinsic case. This is explained by the enhancement of 2DEG screening and the decrease of holes concentration. The increase of electron concentration in QW could be provided by delta-doping of barriers or by top-gate.

Also modeling revealed that the high purity of samples is not of crucial importance for obtaining high electron mobilities in the well. Samples with 10^{14} cm^{-3} charged impurities concentration in the well should provide nearly the same peak electron mobilities as samples with 10^{15} cm^{-3} impurity concentration.

Obtained peak values of electron mobility are an order of magnitude higher than typical mobilities in graphene devices when graphene layers are grown on the substrate. Calculations were applied to model the resistivity and resistance of semi-metallic $Hg_{1-x}Cd_xTe$ quantum well channel for terahertz (THz) hot-electron bolometer. The modeling revealed that semi-metallic $Hg_{1-x}Cd_xTe$ QWs could be efficiently applied to different types of THz detectors operating at T = 77 K. Structure properties could be tuned to efficiently meet specific requirements of sub-THz and THz bolometric detectors and FETs utilizing plasma waves.