

Terahertz conductivity spectra contain information on charge transport mechanisms and charge confinement on nanometer distances. In this thesis, we make a substantial progress in understanding of terahertz conductivity in several regimes. First, we theoretically investigate linear terahertz conductivity of confined electron gas: while the spectra of degenerate electron gas exhibit geometrical resonances, the response in non-degenerate case smears into a single broad resonance due to the wide distribution of charge velocities. Then, we theoretically and experimentally analyze various TiO₂ nanotube layers: their linear charge transport properties strongly depend on the fabrication process, which influences the internal structure of the nanotube walls. In the main part of the thesis, we develop a framework for evaluation of the nonlinear terahertz response of semiconductor nanostructures based on microscopic Monte-Carlo calculations. The nonlinear regime is highly non-perturbative even in moderate fields as illustrated by efficient high harmonics generation. We investigate measurable nonlinear signals for various semiconductor nanostructures; metallic nanoslits filled with nanoelements are the most promising for the experimental observation of terahertz nonlinearities. These nonlinearities per unit charge are stronger than those in doped graphene which has been considered to be one of the most nonlinear terahertz materials.