Conductivity of quantum cascade laser with four-barrier active band

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In spite of the fact that the first quantum cascade laser (QCL) was created twenty years ago, the consequent theory of physical processes in this device, well correlating to the experiment, is still absent. The main reason is that the basic operating components or QCL (the same of quantum cascade detector (QCD)) are the open plain multi-layer nano-systems, the so called resonance tunnel structures (RTS). The theory of quasi-stationary states of electrons interacting with the other quasi-particles and different fields in such nano-systems is rapidly developing now.

According to the abovementioned, in the majority of papers the evaluation of radiation energies and some other laser characteristics was performed within the models of closed RTS. But, it was impossible to evaluate the life times and calculate the active conductivity of the respective nano-systems. In the papers based at the open RTS, the δ-barrier model was often used. Herein, the resonance widths were an order overestimated and, thus, the results were not well correlated to the experimental data.

In the proposed paper, we develop the theory of dynamic conductivity of electrons by four-barrier active region in the cascade under the influence of constant electric field using the models of effective mass and rectangular barriers. Using the established theory, we calculate the radiation energies, life times and dynamic conductivities for the experimentally designed RTS. We observe good correlation between theoretical and experimental results (the exactness is of several per cents) both for the radiation energy and geometric design of RTS.