Nanoscale physics

Effect of longitudinal optical phonons in quantum cascade lasers for midinfrared and teraherts spectral ranges

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Quantum cascade lasers, QCL, are unipolar devices based on the population inversion between quantized subbands in biased semiconductor heterostructures. The electron transitions between the states in QCLs are caused mainly by elastic (alloy, interface roughness, and impurity), inelastic (acoustic and LO phonons), and electron-electron scattering. Taking into account numerous parameters and complicated design of QCL *ab-initio* models are especially limited by the intricacy of a variety of scattering mechanisms and lead to complex models with high demands on the computation time. Furthermore, the very large number of input parameters and their uncertainties typically lead to an unsatisfactory agreement between simulations and experimental results. Here we have developed the temperature dependent self-consistent phenomenological scattering-rate model for simulation of the QCL characteristics. In our approach, the total intersubband scattering rate is written as the product of the exchange integral for the squared moduli of the envelope functions and a phenomenological factor that depends only on the transition energy. Using the model to calculate the scattering rates and imposing periodical boundary conditions on the current density, we find a good agreement with both low-temperature [1] and high-temperature data for current-voltage, power-current, and energy-photon flux characteristics for a number of MIR QCLs. Our approach allows to investigate and/or improve QCL design by electrical and optical characterizations.

1. *Kurlov S.S., Flores Y.V., Elagin M., Semtsiv M.P., Schrottke L., Grahn H.T., Tarasov G..G.., Masselink W. T.* Phenomenological scattering-rate model for the simulation of the current density and emission power in mid-infrared quantum cascade lasers // J. Appl. Phys.-2016.-**119**.-P. 134501-