Relaxation processes in a quantum well-quantum dot injection structure

A. Mielnik-Pyszczorski*, K. Gawarecki, P. Machnikowski
Wroclaw University of Technology, Department of Theoretical Physics,
adam.mielnik-pyszczorski@pwr.edu.pl
* Corresponding Author

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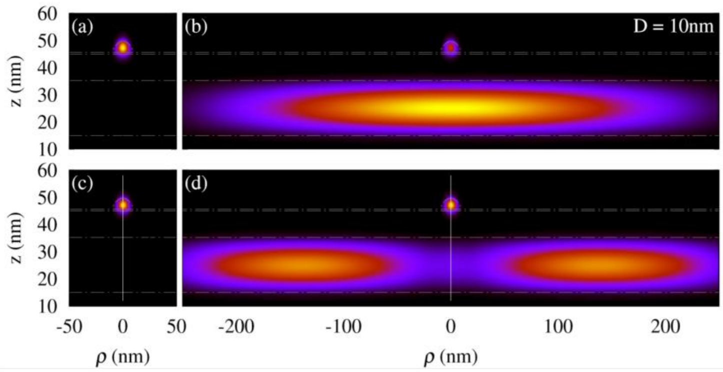
Abstract

Lasers based on quantum dots (QDs) have many advantages such as low threshold current, wide spectral tunability and high temperature insensitivity. However, low carrier density inside the dot, which is due to limited carrier injection to the zero-dimensional structure, implies reduced efficiency of QD lasers. One of the proposed solutions, is a quantum well-quantum dot injection structure, where a quantum well (QW) can be used as a carrier-collecting reservoir [1]. Due to phonon-assisted processes, carriers can tunnel through the barrier from the QW to the QD.

In this contribution, we study phonon-assisted tunneling of electrons in a system composed of a dome-shaped QD located above a QW. We analize non-radiative transitions assisted by acoustic phonons. We also study injection processes implied by optical phonons. The strain distribution is accounted for by a minimization of the elastic energy of the system [2]. We show that the strain field, which is generated by the QD in the QW region, acts on electrons like repulsive potential (Fig.1). The states of electrons are calculated using 8-band **k·p** method combined with the Lödwin elimination [3].



The probability density for the ground state and the first excited state in the case of neglected strain field (a,b) and in the presence of strain field (c,d).

We study the effects of the electron coupling to phonons and model the electron kinetics within the correlation expansion approach. We obtained non-monotonic relaxation as a function of the distance between the QW and the QD. We investigate also the dependence of the phonon-assisted tunneling rate on the temperature. Our results indicate the importance of a proper design of the system geometry and composition to obtain the shortest relaxation times, which provides increase of optical efficiency.

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