POWER-LAW TIME DECAY OF PHOTOLUMINESCENCE IN DIRECT GAP QUANTUM DOTS

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Abstract

The photoluminescence intensity generally decays in time exponentially, however, in some nanostructures, a significant power-law behavior is experimentally observed. In this work a possible theoretical background of this experimental observation is offered for the case of quantum dots with an indirect energy band gap. We calculate the photoluminescence decay in time, following the excitation of the quantum dot sample electronic system by a short optical pulse. In our model the effect is explained as a single dot property. Our model assumes:

- the effective mass model for electronic states
- the inter-valley deformation interaction potential of the excited conduction band electrons with lattice vibrations is considered in the self-consistent Born approximation to the electronic self-energy
- the theory is built on the non-equilibrium electronic transport theory.
- the non-adiabatic coupling beyond a finite-order perturbation theory

The numerical calculation of our model shows that in long-time asymptote of the photoluminescence decay the power-law time profile is found. Relation of numerical simulation is checked with the experimental results. Our work indicates that the role of the electron-phonon interaction in a single quantum dot may be responsible for the experimentally observed power-law photoluminescence decay in nanostructures.

Keywords: quantum dots, photoluminescence, electron-phonon coupling

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