On the importance of in plane coupling within the ensemble of InAs/InGaAlAs/InP quantum dashes

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Semiconductor quantum dashes can be fabricated in the InAs-InP material system by molecular epitaxy. They have been proven to be advantageous when employed as the active region of infrared photonic devices, especially when considering telecommunication and data communication applications, and have been demonstrated to be application relevant in lasers and optical amplifiers, as high gain, tunable or polarization insensitive emitters especially at fiber-based optoelectronics relevant wavelengths [1]. Furthermore, preliminary work on single quantum dashes [2-4] and their perspectives as emitters in quantum-electrodynamics-based experiments has recently been performed revealing possibility of realizing single photon sources at the telecommunication wavelengths. In all the cases, the electronic structure is discussed in the picture of independent dashes in spite of normally very high surface of these structures (even more than 10^{11} cm^{-2}) making the average in plane distances significantly smaller than the dash characteristic sizes. This makes possible an existence of finite and even efficient carrier tunneling between the dashes, which could significantly affect both the ensemble properties in the laser active region, as well as the subtle properties of single dashes, properties of which can appear to be dependent on that quantum mechanical coupling.

In this work, we discuss the electronic structure of the system composed of coupled InAs quantum-wire-like structures (the confinement in the longest dimension is neglected for simplicity) separated laterally by a thin barrier InGaAlAs barrier lattice matched to InP substrate. The respective confined states energy levels and the carrier probability densities are calculated within the $k \cdot p$ theory for different cross-sectional shapes and sizes of the dashes, and in function of the lateral distance between them. The results are confronted with the existing data on the optical transitions in such structures [5,6]. Eventually, it has been concluded that for realistic system parameters (geometry and spatial in-plane separation) the obtained direct coupling is indeed negligible and most of the applications the dashes can be considered individually and any carrier transfer is rather indirect, via e.g. the wetting layer states.

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