GAUSSIAN QUANTUM DOTS OF TYPE II IN IN-PLANE ELECTRIC FIELD

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Abstract

The growing interest is now focusing on electrically defined quantum dots, which in opposition to presently most popular self-assembled dots, trap electrons simultaneously repulsing positively charged holes (or oppositely), and are thus classified as quantum dots of type II [1]. These dots are especially interesting, as they offer more flexible parameters (allowing dynamic modelling of dot characteristics with applied pattern of external electric field) in comparison to self-assembled dots, and due to continuous improvement of electrode preparation techniques [2] are very promising in terms of practical applications. Although empty QD of type II attracts one type of carrier, and repulses the other, it is however possible for it to capture electron-hole pair (X exciton) due to electrical attraction of carriers. As shown earlier [3] with good correspondence with the experimental results, an unusually rich PL structure observed in this type of quantum dots (up to four PL peaks for higher levels of activation and in the presence of external magnetic field) may be well explained by the existence of metastable (against inter-band far-infrared dipole transition) states of exciton and multi-particle exciton-complexes (X^- and X^+ trions) [4] localized in the QD, due to interplay of bare confinement and geometry sensitive Coulomb e-h interaction. Application of additional in-plane electric field causes further modification of the effective confining potential shape, and so – allows to adjust the PL characteristics and modify them in a real-time. In the current paper a theoretical study for an exciton in semiconductor quantum dot of type-II in the presence of external in-plane electric field is presented. The dependence of the photoluminescence spectrum on the dot size and in-plane electric field is analysed within the Hartree approach for planar Gaussian confinement. The wave function of the ground state and a red-shift of the exciton energy is found as a function of the electric field and the dot size.

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