The impact of adjacent defects on the optical properties of quantum dots

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We present a theoretical study of optical properties of self-assembled quantum dots affected by the presence of adjacent structural defects in the matrix or on the interface between materials. We find that in such a case the radiative lifetime of excitonic states is increased and determine the main reason to be a reduction of the overlap of the electron and hole wave functions. This occurs if the additional potential produced by a defect is not negligible as compared to the Coulomb coupling between carriers.

The calculation of electron and hole wave functions is done within a multiband $\boldsymbol{k} \cdot \boldsymbol{p}$ theory including spin-orbit coupling and piezoelectric field up to the second order [1]. The structural defects are incorporated by means of the lattice deformation included in the calculation of strain and piezoelectric field in the continuum elasticity theory as well as, in the case of charged defects, via their electrostatic field. Next, excitonic states are found using a configuration interaction method [2]. Finally the interband momentum matrix elements are calculated to obtain the exciton radiative life times.

We study in detail the dependence of the radiative life time on the position and distance of defects with respect to the quantum dot and in the case of charged impurities we estimate the exciton energy shifts which may be compared with spectral diffusion observed in experiments.

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