Optical properties of polaron exciton in spherical and ellipsoidal quantum dots

I.P. Ipatova, A.Yu. Maslov, O.V. Proshina

Ioffe Physical Technical Institute, Polytechnicheskaya st., 26, 194021 St. Peterburg, Russia
maslov.ton@pop.ioffe.rssi.ru

In case of the strong electron–phonon interaction with longitudinal optical phonons, the polaron effect results in multiple phonon replicas of the exciton optical transition line [1,2]. It is shown that the maximum effect of electron–phonon interaction on optical spectra occurs in quantum dots.

The exciton states in many semiconductors are degenerate due to the valence band degeneration. In the approach of Luttinger Hamiltonian, the degeneration is classified according to the angular momentum of hole $J^{(h)} = 3/2$.

In quantum dots based on semiconductors with high ionicity, the optical transition is the transition into the state of polaron exciton that takes into account the electron and hole polarization of the medium. The allowed transition occurs into the exciton state with the angular momentum $J = 1$. The forbidden transition corresponds to $J = 2$. These exciton levels differ due to the exchange interaction [3].

It is shown in this paper that in case of the spherical quantum dot, the polaron exciton in the strong confinement regime creates the anisotropic polarization of the medium. Nevertheless the polarization does not split of the degenerate ground state of the polaron exciton. The average value of angular momentum component J_z vanishes, $\langle J_z \rangle = 0$. The optical emitted light from spherical dot is not polarized.

The picture is different in a case of ellipsoidal quantum dot. The reduction of symmetry results in the splitting of size quantization levels of the hole [4]. The splitting depends on the properties of the material and on the specific shape of the quantum dot. The ground state of the hole in ellipsoidal quantum dot is determined by the angular momentum component $J_z^{(h)} = \pm 3/2$ or $J_z^{(h)} = \pm 1/2$. When the hole with an angular momentum component $J_z^{(h)} = \pm 3/2$ contributes into the exciton transition, the average value of the polaron exciton angular momentum component $\langle J_z \rangle = \pm 1$. The light emitted from ellipsoidal dot has the specific polarization. The study enables us to make a conclusion on the quantum dot geometry.

Acknoledgements

This work supported by the Russian Foundation for Basic Research, grant number is 03-02-17577, and grant for Leading Scientific Schools 2160.2003.2.

References

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