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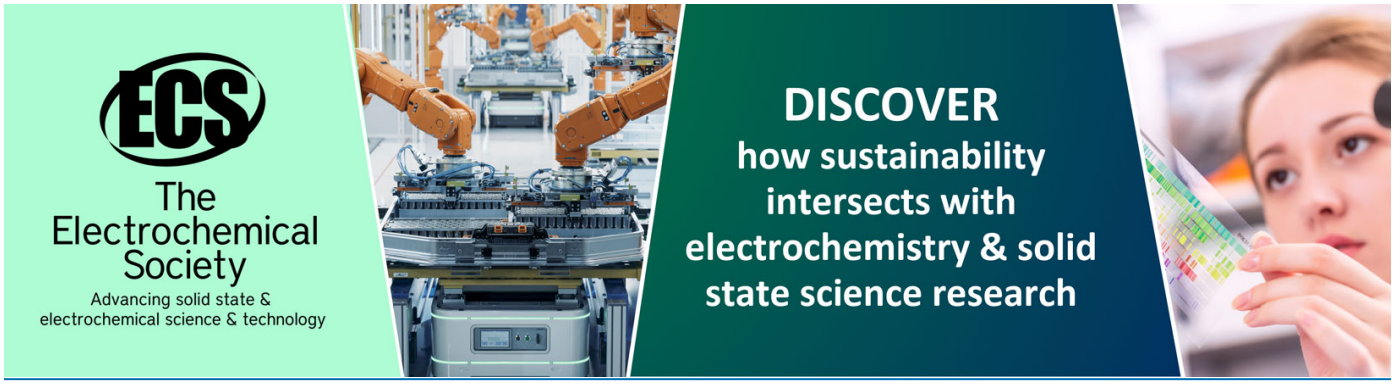

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Electron-phonon interaction in colloidal CdSe quantum dots embedded in different solid matrices

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Abstract. Colloidal semiconductor nanocrystals (quantum dots, QD) manifest specific temperature dependent luminescence. Here we analyse temperature dependences of CdSe QD luminescence spectrum shift for different composites: polymers, glasses, crystals. The analysis was performed in the terms of electron-phonon coupling, that allows to find and compare the parameters of this interaction. The matrix influence on the T-dependence is also discussed.

1. Introduction

Study of photo-physical properties and intrinsic dynamics of nanocomposites doped with semiconductor nanocrystals (quantum dots, QD) is an important and urgent trend of modern physics and materials science. Considerable efforts in modern science are aimed to search for and study new luminescence labels [1] and suitable matrices for functional quantum-dot-based materials, e.g., polymers [2], liquid crystals [3], etc. QDs have a number of specific photophysical and spectral properties, which are determined by their structure, size and microscopic features of interaction with the local environment. Developing of a new QD-based materials extremely requires the fundamental study of dynamical processes in QDs themselves whereas search for a new QD labels is related to clarifying the question about their interaction with a solid matrices, in particular, electron-phonon interaction. One of the most effective techniques to study dynamical properties of QD-doped solids is the photon echo spectroscopy [4, 5] but conventional luminescence spectroscopy supplemented by temperature measurements also may be useful in such type of studies (see, e.g. [6]).

2. Luminescence spectroscopy of QD-doped nanocomposites

In this paper we studied CdSe quantum dots (both only cores and ones coated with different shells) in free form and embedded in different solid matrices. In order to separate the contributions to the optical dephasing of the processes of interaction of quantum dots with the matrix from the processes inside the QDs themselves, we measured the temperature dependences of the luminescence spectra of nanocomposites.

Generally, with the temperature decrease, the maxima of the exciton bands in a luminescence spectra shift to the UV spectral range. Such phenomenon can be described taking into account the electron-phonon (exciton-phonon) interaction. The temperature shift of the exciton luminescence spectrum can be described using the equation, derived by O'Donnell and Chen [7]. Theoretical model

that takes into account the electron-phonon interaction made it possible to quantitatively describe the temperature dependences of the exciton luminescence spectra of QDs, as well as to determine the values of the Huang-Rhys factor and the average energy of phonons in nanocrystals. In our experiments no noticeable temperature changes in the exciton maxima widths have been observed, which is related, on the one hand, to the resolution of used experimental technique and, on the other hand, to the occurrence of significant inhomogeneous broadening of the spectra caused by a large dispersion of QD sizes.

Describing the temperature behavior of the position and width of the luminescence spectra of QDs one should take into account an interaction of the electronic transition of the impurity with vibrational excitations, e.g. with local or quasi-local phonons in a solid matrix. In this connection, we have studied the influence of the matrix on luminescence properties of QD-doped nanocomposites. The combination of the photon echo and luminescence spectroscopy is a powerful method to study the ultrafast processes of interaction of the impurity ensemble of QDs with a solid matrix as well as the intrinsic dynamics of quantum dots themselves.

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