Influence of Dopants on the Formation and Photoluminescent Properties of Colloidal CdTe Nanocrystals

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The unique properties of nanoscale systems led to their widespread use in several fields of science and technology. Recently, considerable interest to researchers cause II-VI semiconductor. The transition of the II-VI semiconductor particles size in the nanoscale leads to the spatial limitations carriers and quantum effects manifest that are uncharacteristic for bulk samples.

There is considerable interest in colloidal semiconductor nanocrystals (NCs) as active components for the next generation of solar cells and other optoelectronic devices. Potential advantages of colloidal NCs are that they can be deposited on any surface and that the band gap of a NC can be tuned by changing the size of the particle. However, along with the benefits in the synthesis of NCs is also a problem because the organic ligands using for the solution processing of the NCs, inhibit the separation of excitons and lead to a decrease in carrier mobility in densely packed layers NC.

Specific properties of some impurities [transition and rare earth elements (REE)] can use them for qualitatively new semiconductor materials with a wide range of opportunities to use in optoelectronics. Specific properties of some impurities [transition and rare earth elements (REE)] can use them for qualitatively new semiconductor materials with a wide range of opportunities to use in optoelectronics. Features of this application are due to unusual impurity states arising from the doping of II-VI semiconductors and related with the formation of heterovalent impurity centers. The behavior of REE impurities with unfilled 4f-shell in the semiconductors has been some peculiarities, for example, a combination of low solubility and an ability of REE to perform “cleaning” of the materials in which it is possible significantly reduce the concentration of background impurities and increase the electrons mobility.

Now especially actively researches concerned the doping characteristics and optical excitation local centers in terms of quantum limits in the semiconductor structures. The nature of radiating centers and radiating characteristics of optical transitions in the structures of II-VI semiconductor compounds, especially CdTe in polymer films and dielectric matrices is studying using luminescent methods.

Doping of CdTe NCs by the ions of transition elements and REE is of great interest due to the fact that allows substantially modifying their optical and electronic properties. Effective transfer of excitation energy from NCs to local center of REE and transition elements with quasiatom structure of energy levels opens the possibility of using these structures to create light emitting systems of

new generation. However, the introduction of heterovalent impurities into NCs is very difficult task and requires modification of synthesis methods.

Doping of CdTe NCs by ions of f-group is an interesting and promising task especially because their internal atomic transitions lie in the visible and near infrared spectral regions. For example, the maximum luminescence of Er is observed at a wavelength of 1550 nm, corresponding to the second window of transparency in optical fiber transmission system. However, these transitions are forbidden by the selection rules and the intensity of these lines is very small. Therefore the introduction of ion on NC, which characterized by strong absorptive ability and at the implementation of effective energy transfer, will significantly enhance the required luminescence.

The report will consider the problem of CdTe NCs doping during their colloidal synthesis and subsequent incorporation into the solid matrixes and their special and electronic properties.

At the synthesis, the introduction of a few impurity atoms into a NC that contains only a few hundred atoms may lead to their expulsion to the surface or degrade the crystalline structure. This will inherently create a heavily doped NC under strong quantum confinement. The electronic and optical properties in such circumstances are still unresolved.

Here, we describe a simple room-temperature method for doping CdTe NCs with f-elements impurities. Colloidal synthesis of CdTe NCs was carried out by the literature procedure [1], which was modified by a number of considerable alterations. Reaction chamber used was a 500 mL reactor equipped with partitions and valves, thermometer and electromagnetic stirrer. The process of CdTe synthesis was accomplished at 20°C in argon atmosphere with the use of the following reagents: 0.1 M solution of CdI_2 (reagent grade), thioglycolic acid (99 %), and electrochemically prepared hydrogen telluride. Nanocrystals of CdTe were modified with thioglycolic acid, while solution pH was maintained by addition of 1 M NaOH solution. f-Elements were used as an alloying agent in the synthesis. By changing the dopants and their concentration, it is possible to achieve a very high level of the electronic properties control, including the band gap and Fermi level energy.

1. Effect of thioglycolic acid on the stability and photoluminescence properties of colloidal solutions of CdTe nanocrystals / O.A. Kapush, L.I. Trishchuk, V.N. Tomashik, Z.F. Tomashik // Inorg. Mater., 2014, Vol. 50, No. 1, pp. 13–18.