Development of polymer nanocomposites containing semiconductor quantum dots

Al-Mayyahi Hayder Ali Naser

Abstract

Relevance of the research topic

One of the current trends in electronics is the creation of lasers with tunable radiation frequency, which are widely used for solving scientific and applied problems. The most accessible sources of frequency-tunable light are dye lasers. In dye lasers, it is possible to smoothly tune the wavelength of the generated radiation within the range determined by the width of the fluorescence line. However, this type of lasers has a number of disadvantages, such as the presence of thermo-optical distortions and low photochemical stability, which prevents their long-term use in polymeric active media. In addition, there are difficulties in working with liquid active media containing solvents (methanol, ethanol, toluene, benzene, acetone, etc.), due to their toxicity and flammability.

As an alternative to dye-based laser active media, solid-state polymer media activated by quantum dots can be used. Quantum dots (QDs) are unique nanostructures that have high photostability, which can solve the problem of dye degradation and increase the lifetime of the laser-active medium. Polymers used to create active media must have a set of properties: high transparency both in the region of quantum dot excitation and generation, sufficiently high radiation strength, good mechanical processing, ensure the stability of the generation radiation parameters, etc. As laser-active media, preference is given to optically transparent polymers with an amorphous structure, which have high hardness, heat resistance, high modulus of elasticity, as well as uniformity, which means the constancy of the refractive index in the volume of the material. Semiconductor quantum dots obtained by liquid-phase methods will be used as fillers for creating

laser active media. Quantum dots obtained by liquid-phase methods are characterized by a high degree of monodispersity, spectral purity, and the possibility of their direct introduction into a matrix to create laser active media.

Thus, the preparation of polymer nanocomposites containing quantum dots is an urgent task, since it opens up new possibilities for creating laser-active media.

Purpose and main objectives of the study

The main goal of the study is the development of polymer nanocomposites containing semiconductor quantum dots of composition CdSe, CdSe/CdS, CdSe/ZnS, CdSe/CdS/ZnS.

The goal identified the need to solve the following tasks:

1. Development of a method for obtaining QDs with the structure core/shell CdSe/CdS, CdSe/ZnS and core/shell/shell CdSe/CdS/ZnS by a one-pot method.
2. Study of the structural and optical characteristics of the obtained QDs.
3. Development of polymer nanocomposites based on PMMA containing CdSe, CdSe/CdS, CdSe/ZnS, CdSe/CdS/ZnS QDs.
4. Study of the optical and generation properties of the obtained nanocomposites.

Scientific novelty

A one-pot method for obtaining QDs in glycerol with a core/shell/shell structure is proposed. The structures of the CdSe/CdS/ZnS composition were characterized by improved photoluminescent properties compared to CdSe QDs. The use of glycerol as the reaction medium made it possible to minimize surface defects.

A technology has been developed for obtaining thin-film nanocomposites based on PMMA containing CdSe, CdSe/CdS, CdSe/ZnS, CdSe/CdS/ZnS QDs.

The effect of the concentration of introduced QDs on the photoluminescent properties of thin-film nanocomposites has been studied.

Optimum concentrations for each type of structures are selected to achieve the maximum intensity of photoluminescence without quenching.

Theoretical and practical significance

The developed method for obtaining semiconductor QDs in various reaction media has practical recommendations for creating highly efficient laser-active media.

The use of thin-film nanocomposites based on PMMA containing CdSe, CdSe/CdS, CdSe/ZnS, CdSe/CdS/ZnS QDs is shown to be promising. The obtained thin-film nanocomposite based on PMMA containing CdSe/CdS/ZnS QDs at a concentration of 0.01 M/l is characterized by the maximum photoluminescence intensity (more than 4 times compared to CdSe QDs) and can be used to create optical devices.

Provisions for Defense

1. Results of the study of CdSe/CdS, CdSe/ZnS, CdSe/CdS/ZnS QDs obtained by a one-pot method.
2. Results of the study of thin-film polymer nanocomposites containing CdSe, CdSe/CdS, CdSe/ZnS, CdSe/CdS/ZnS QDs.