Luminescence and Morphology Study of PbS Quantum Dots in a Porous Matrix

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We present some results obtained by steady-state and time-resolved fluorescence analysis of PbS quantum dots in solution and in a porous matrix. Distribution of QDs in the porous matrix was investigated by atomic-force and confocal microscopy to clarify an energy transfer in formed closed packed structures. Hardware and software for fluorescence measurements in near infrared region also are discussed.

Keywords—PbS; quantum dots; luminescence; time-decay; energy transfer

I. INTRODUCTION

Lead chalcogenide quantum dots (QDs) such as PbS and PbSe have replaced traditional photoluminescence (PL) dyes for the NIR region. They may have application in NIR photonic devices, solar energy and medical applications. Assemblies of close-packed QDs on different substrates or in matrices attract special attention. Here we present PL and morphology study of PbS QDs embedded into the porous matrix.

II. QD ASSEMBLIES IN A POROUS MATRIX

Recently we proposed the simple way to create assemblies of QD in a porous matrix. The method is based on soaking of a special filter paper into the colloidal solution of PbS QDs followed by drying. Optical properties of these samples were investigated as well as aging, which is important for such samples. The method let us check an anomalous size dependence of the room-temperature luminescence decay time observed in colloidal solutions. The established reduction of the decay time with the increase of the quantum dots' diameter was explained by the existence of phonon-induced transitions between the in-gap state and the fundamental state of the quantum dots, or thermalized luminescence [1]. While temperature is a crucial parameter of the scenario proposed, a preparation of QD assemblies in a porous matrix give us an opportunity to perform steady-state and time-resolved PL measurements at low temperatures.

III. ENERGY TRANSFER

We found that the matrix is a good media for energy transfer investigation. Due to the proximity of QDs after infiltration from solutions an energy transfer takes place. Energy transfer between QDs with different sizes embedded into a porous matrix has been studied by steady state and transition luminescence spectroscopy [2].

IV. MORPHOLOGY OF QDS

It is important to study the morphology of PbS in the matrix and their distribution, because they directly influence the energy transfer process. AFM and confocal microscope study show that the filter paper, used as porous matrix, can be described like a complex curved surface. Monte Carlo method is used for theoretical modeling of QD distribution. The experiment and the modeling confirm that QDs are not distributed evenly and there is a formation of the close-packed structures.

V. EXPERIMENTAL SETUP

Special attention is given to a home-made experimental setup, which was used for spectral and kinetic PL study of IR QDs. The one is based on a 90 degree detection geometry and provides spectral and time-resolved PL experiments with spectral selection at room and liquid nitrogen temperatures in the NIR. The setup consists of continuous and pulsed lasers, monochromators, InGaAs photodiodes, amplifiers, an oscilloscope, and auxiliary optical elements. In order to improve the signal/noise ratio, we developed software which accumulates the results of transition measurements up to tens of millions waveforms for a few hours [3].

REFERENCES


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