Self-assembled PbS QDs of different size

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Abstract—In this work self-organized nanostructures from PbS quantum dots of different size, fabricated by the evaporation of solvent on the mica substrate, are investigated. It is shown that, the obtained structures possess SAXS patterns similar to ones from real atomic crystals.

Keywords—superlattice, supercrystall, quantum dot, lead sulfide

I. INTRODUCTION

NIR-emitting quantum dots (QDs), such as lead sulfide (PbS) QDs, attract much attention due to their unique properties in order to use in diverse areas of applications, from bio-sensing to solar cells fabrication. The self-organization of these colloidal QDs in ordered structures gives rise to a new class of materials, which can combine the properties of quasi-isolated quantum dots and possess novel properties of three-dimensional structures, as superlattices or supercrystals [1]. Thereby, the aim of our work is the formation of three-dimensional structures based on PbS QDs and further investigation of their optical properties.

II. EXPERIMENTAL

Colloidal PbS quantum dots with a size of 4.6 nm were obtained using the high organometallic synthesis in organic solvent. Samples of two- and three-dimensional structures from PbS QDs were prepared by a well-known method based on the evaporation of a saturated solution. In our case, the slow evaporation of solvent from a stock QDs solution in tetrachlormethane (TCM) leads to QD self-organization on the substrate of a mica thin layer. To investigate the nano- and micrometer scale inhomogeneity, including size of the quantum dots, as well as their relative positions on the substrate, a SAXS technique is used. For investigation of optical properties of the samples obtained a spectrophotometer Shimadzu UV3600 and original IR spectrofluorimeter [2] are used.

III. RESULTS

SAXS patterns from samples of PbS QD solution as the TCM solvent evaporates are obtained. At the initial time the scattering intensity can be considered as the sum of scattering intensities from all quasi-isolated PbS QDs in saturated solution. It is shown in Fig.1 as dash line. With further TCM evaporation in SAXS patterns the peak caused by interparticle interference occurs. When TCM completely evaporated (after 24 hours from the sample preparing) the diffraction pattern contains the set of narrow peaks, as it shown in Fig. 1 as solid line. This SAXS pattern is similar to that observed for the real bulk atomic crystals but in area of smaller angles.

![SAXS patterns](image)

Fig. 1. SAXS patterns from sample PbS QDs with diameter of 4.6 nm: 1 hour (dash line with cubes) and more than 24 hours (solid line with circles) of TCM evaporation

The analysis of absorption and photoluminescence spectra shows that bands are broadened slightly as compared to the initial QD solutions with the maximum position remaining the same. The obtained PL lifetimes matches well with PL lifetimes from the PbS QDs in organic matrix [3].

IV. CONCLUSION

The data on the close-packed ordered structures from PbS QDs are of considerable interest for the development of solar cells based on QDs thin layers, absorbing light in NIR-region.

REFERENCES


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