ROZPRAWA DOKTORSKA

Synteza i charakteryzacja koloidalnych studni kwantowych na bazie kadmu oraz ich heterostruktur

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Streszczenie w języku angielskim

The research conducted as part of this doctoral thesis concerns the synthesis of cadmium-based colloidal quantum wells and their heterostructures. Its main goal was to identify the factors determining the optical and structural properties of the obtained nanoplatelets, and then to develop synthesis methods that would allow these properties to be easily controlled. The proposed methods are simpler compared to the previously existing ones due to the elimination of problematic aspects of the synthesis, such as the imprecise method of precursor administration or high reaction temperature.

The first part of the work is devoted to the mechanism of controlling the shape of CdS nanocrystals by the concentration of acetate precursor in a heating-up reaction. For different amounts of zinc acetate, zero-, one- and two-dimensional structures (quantum dots, rods and platelets) were obtained. For nanoplatelets, conditions were defined for the synthesis of mixtures of populations with a thickness of 2.5, 3.5, 4.5 and 5.5 monolayers and for the synthesis of single populations of 3.5 and 4.5 monolayers. Then, the effect of temperature on the course of the reaction was examined. The contribution of magic size clusters to the early stages of nanoplatelets growth was also analyzed.

In the next part, the heating-up and hot-injection methods were compared and a detailed analysis of the growth of CdSe nanoplatelets was conducted using *in situ* optical spectroscopy. The advantages and disadvantages of both methods were indicated. The main advantage of the hot-injection approach is the relatively better optical quality of nanocrystals (higher quantum yield, fewer defects), while the major advantage of the heating-up method is the simplicity and scalability of the synthesis. Energy transfer processes between nanoplatelets of different thicknesses synthesized by heating-up method were also observed.

The third part presents a unique low-temperature procedure for the growth of thick (up to 24 monolayers) CdS and CdZnS shells on CdSe nanoplatelets. Regardless of the core synthesis method (heating-up or hot-injection), the heterostructures showed similar properties after shell growth: emission in the red color range (590 - 650 nm), photoluminescence quantum yield (QY) at the level of several percent and full width at half maximum below 100 meV.

The fourth part of the dissertation concerns the impact of post-synthetic modifications on the quantum yield of CdSe/CdZnS nanoplatelets and is the answer to the problem of QY drop during nanoplatelets purification after shell deposition. Annealing after the synthesis or changing the purification method from precipitation to gel chromatography did not give satisfactory results. The best results (QY = 40%) were obtained by modifying the precipitation purification by adding trioctylamine and a combination of zinc acetate and nonanoic acid at the appropriate moments of the process.

The results of this work are a valuable contribution to the discussion on the growth mechanism of two-dimensional colloidal nanostructures, and the developed methods of synthesis allow not only to obtain nanoplatelets with narrow photoluminescence spectra, but also have great application potential due to the simplicity, limitation of the number of stages and selection of conditions that allow for precise control even on a larger scale. The properties of the obtained structures, in particular the narrow, clean emission lines, make them attractive for use in displays with a wide range of colors. On the other hand, the anisotropic shape combined with good optical quality is a positive feature when nanocrystals are used as the active layer in LED devices.