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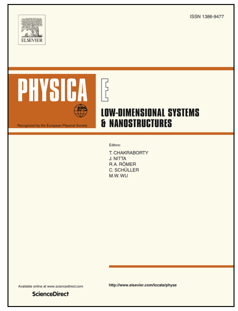

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Simultaneous effects of electric field, shallow donor impurity and geometric shape on the electronic states in ellipsoidal ZnS/CdSe core-shell quantum dots

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Abstract. Within the effective mass approximation the Schrodinger equation is solved by the finite element method for ellipsoidal ZnS/CdSe core-shell quantum dot. The effects induced by the external electric field, by the impurity position and by the geometric shape on the electronic properties of prolate and oblate spheroids core-shell systems are analyzed. The binding energies, the electron shell localization probabilities and the additional polarizability introduced by the shallow donor impurity are obtained and are investigated for various shapes of spheroid core/shell quantum dots.

Keywords: prolate/oblate ellipsoidal core-shell structures, electric field, shallow donor impurity, energy levels, polarizability .

1. Introduction

The development of modern crystal growth techniques has allowed the manufacture of small-scale systems such as quantum well, quantum well wires and quantum dots (QDs). In such systems, the structure of the energy levels is convenient modified through the quantum confinement effect. Various semiconductor devices with outstanding performance based on such nanostructures have been created like as: light emitting diodes [1], solar and photovoltaic cells [2-4], quantum protocol for cryptography [5], single-photon sources [6], memory storage and quantum computers [7-9].

By combinations of II-IV, II-V or IV-VI group semiconductors, very interesting nanostructures were manufactured **and were investigated from the point of view of the effects induced by impurities, electric and magnetic fields or by the dielectric mismatch of the covering layer [10 - 14].**

Cadmium selenide (CdSe) nanodot is a II-VI semiconductor structure which, due its optical properties, is the most attractive nanocristal. By changing the CdSe dot size the light emission is tuned covering almost whole visible spectrum.

Chemical synthesis methods have allowed coating a QD with one or more layers of another material [15,16] obtaining therefore the so called "core-shell quantum dots" (CSQDs) in which the fluorescence quantum yield and stability was increased [17] by supplementary confinement of the exciton (electron-hole) in the QD core [18, 19]. Generally, the CSQDs are characterized by a core material with narrow band gap. A slight red shift, usually around 10 nm, of the fluorescence due to some leakage of the exciton from the core into the shell is characteristic for a such structures. These structures have been extensively studied and are used in important applications like as: cancer diagnosis [20], nanotags in biological imaging labeling [21, 22] or sensing [23].

There are also other structures, so-called "inverted core-shell quantum dots" (ICSQDs), in which the shell material has a narrow band gape [24, 25], partially delocalizing charge carriers from the shell to the core. Inverted core-shell quantum dots are used when control is wanted over the red shifting of the fluorescence spectrum, as the shift can be controlled by changing the coating thickness.