Journal of Physics and Chemistry of Solids 106 (2017) 99–104

Contents lists available at ScienceDirect

Journal of Physics and Chemistry of Solids

journal homepage: www.elsevier.com/locate/jpcs

Intraband absorption of D^- center in CdSe/CdS/CdSe/CdS multilayer quantum dot

K. Suseel Rahul[a,b], Nayana Devaraj[b], Rosmy K. Babu[b], Smitha Mathew[b], K. Salini[b], Vincet Mathew[b,*]

[a] Depatrtment of Physics, Sree Vyasa NSS College, Thrissur, Kerala 680582, India
[b] Department of Physics, Central University of Kerala, Kasaragod, Kerala 671314, India

ARTICLE INFO

Keywords:
A. Multilayers
A. Nanostructures
D. Optical properties

ABSTRACT

Absorption characteristics of a D^- center in CdSe/CdS/CdSe/CdS multilayer quantum dot are studied within the framework of effective mass approximation. The energy eigen values and corresponding wave functions are obtained by solving the coupled Poisson-Schrondinger equations self-consistently, using finite difference matrix diagonalization method. Based on this, the effect of core radius, shell thickness and well width on absorption coefficient and absorption wavelength are investigated. This model predicts that, the D^- center has considerable intraband absorption, of the order of 10^3 cm^{-1}, in the far infrared region. The absorption characteristics can be finely tuned by varying the layer thicknesses.

1. Introduction

Within the past few decades low dimensional systems are in the front line research areas in physics, because of their fundamental importance and wide range of applications [1–9]. Quantum dots(QDs) are zero dimensional nanostructures, exhibiting quantum confined effects, containing several hundred to several thousand atoms. The attracting features of QDs are that, their energy levels, wave functions, density of states, etc. can be controlled by the shape, size and composition of the structure [10–16].

Nanostructure systems consisting of two or more different materials are known as nano-heterostructures. They exhibits diverse functionalities within a single heterostructure, which we cannot expect from the nanostructures of their individual component materials. A donor impurity atom, which bounds an electron to it in a QD is known as hydrogenic(D^0),because of their similarities with hydrogen atom. Hydrogenic impurity in a QD is considered as one of the best models for understanding many of the electronic and optical properties of nano heterostructures. Hydrogenic impurity effects in QDs have attracted many researchers, and a large number of investigations are done on nano-heterostructures, hydrogenic impurity and their combinations [17,18].

A system of two electrons in the attractive electrostatic field of a donor impurity in a nanostructure is known as a D^- center. If we consider a D^- center in a semiconductor quantum dot, its electronic and optical properties strongly depend on the coulomb interaction between the electrons in it. Using variational method Zhu et al. [19] have observed binding energy of D^- as a function of dot radius and barrier height. With parabolic confinement Xie has calculated the energy spectrum of a D^- center in a disc shaped QD [20]. He also examined magnetic field effects on the electronic properties and the second bound state binding energy spectra of D^- center in QD [21]. Gu and Liang worked on D^- centers in QD with a Gaussian confining potential [22]. Photoionization cross section and inter-sublevel transitions in a one and two electron spherical quantum dot with a hydrogenic impurity were studied by Sahin et al. [26].

To the best of our knowledge, investigations are hardly being done on the optical properties of D^- center in core-shell-well-shell quantum dot. In the present work, we investigate the absorption properties of a D^- center in CdSe/CdS/CdSe/Cds core-shell-well-shell spherical quantum dot. Here, we study the variation of absorption coefficient as a function of incident photon wavelength by varying layer thickness of the QD heterostructure. Without any lose of generality, the many body interactions are introduced by the Hartree approximation [23]. The calculations are based on effective mass approximation, and poisson-schrodinger equations are solved numerically and self consistently for determining the energy eigen values and corresponding wavefunctions.

* Corresponding author.
E-mail addresses: srkram1988@gmail.com (K. Suseel Rahul), nayanadevaraj@gmail.com (N. Devaraj), rosmybabuk@gmail.com (R.K. Babu), raphelmaria1991@gmail.com (S. Mathew), saliniphy@gmail.com (K. Salini), vincent@cukerala.ac.in (V. Mathew).

http://dx.doi.org/10.1016/j.jpcs.2017.03.013
Received 28 April 2016; Received in revised form 3 November 2016; Accepted 13 March 2017