Physica E 154 (2023) 115809

Contents lists available at ScienceDirect

Physica E: Low-dimensional Systems and Nanostructures

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

Electric field, magnetic field, and hydrostatic pressure effects on the absorption coefficient for GaAs/$Al_xGa_{1-x}As/Al_{0.3}Ga_{0.7}As$ staggered core–shell–shell spherical quantum dots

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ARTICLE INFO

Keywords:
Spherical quantum dot
Absorption coefficient
Intraband transitions
Terahertz

ABSTRACT

Quantum dot's optical properties are of great interest from the point of view of basic physics, as well as for their possible applications in optoelectronic devices. Among the large number of possible quantum dot materials, we are interested in GaAs/$Al_xGa_{1-x}As/Al_{0.3}Ga_{0.7}As$ staggered spherical core–shell–shell quantum dots. Here, we theoretically report, working within the effective mass approximation, on the effect of externally applied magnetic and electric fields, as well as hydrostatic pressure on the system. The main findings are that the magnetic field and the hydrostatic pressure slightly change the studied properties, while the electric field significantly modify both the peak position and the magnitude of the absorption coefficient, leading to an optical response for intraband transitions in the terahertz range of the electromagnetic spectrum.

1. Introduction

Nowadays, quantum wells, quantum wires and quantum dots have attracted great attention due to their several possible device applications [1]. Experimental techniques allow to grow these semiconductor quantum systems with almost any geometry. One of these systems are the core/shell quantum dots, which ideally consist of a spherical quantum dots (QDs) of some semiconductor material, covered with another semiconductor material shell, or even more that one shell. These quantum dots are typically grown using chemical methods, as well-documented in Ref. [2], or by physical growth methods as well presented by M. Cardona and P. Yu [3].

In recent years, the study of the core–shell QDs has been a very active field from both the experimental and theoretical points of view. Typically, the core/shell QDs are composed by II–VI, III–V, and IV–VI semiconductor materials, the authors reported that the optical properties are modified by the shape of the confinement potential, the incorporation of donor impurities, the presence of electric and magnetic fields and hydrostatic pressure. For instance, H. Asano et al. [4] experimentally reported the green photoluminescence emission from Zn(Te, Se)/ZnS core/shell colloidal quantum dots. In this line, from the theoretical point of view, we reported [5] the strain effect on the intraband absorption coefficient in CdSe/CdS/ZnSe core/shell/shell QDs. V. A. Holovatsky and co-workers [6,7] reported the electronic and oscillator strength for ZnS/CdSe/Zns and ZnS/CdS/SiO2 multishell spherical quantum dot. More recently, R. G. Toscano-Negrette and co-workers [8] reported ZnSe/CdS/ZnS core/shell/shell QDs optical properties as a function of electric and magnetic fields. The well-known GaAs/$Al_xGa_{1-x}As$ heterostructure has also been investigated, for example B.M.U.D Bhat and R.A. Zargar [9] theoretically report the electric field effect of a confined electron on the GaAs/$Al_xGa_{1-x}As$ core/shell QD, V. A. Holovatsky and M. V. Chubrei [10] investigated the effect of co-directed electric and magnetic fields on the absorption coefficient for an AlGaAs/GaAs core–shell quantum antidot, and we recently reported the intraband optical properties of the system [11, 12]. Not only does the spherically symmetric QD deserves attention, but there are also other novel QD symmetries reported in the literature. For instance, F. Ungan et al. [13] computed nonlinear optical properties for a GaAs/AlGaAs cylindrical QD with a Morse potential, as a function of electric and intense laser fields effects. Exciton states for conical QD under electric and magnetic fields were also recently reported [14], among others recent reports [15–21]. In this work we report the electronic structure and the intraband absorption coefficient of a GaAs/$Al_xGa_{1-x}As/Al_{0.3}Ga_{0.7}As$ staggered core–shell spherical

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https://doi.org/10.1016/j.physe.2023.115809
Received 16 April 2023; Received in revised form 18 July 2023; Accepted 26 July 2023
Available online 29 July 2023
1386-9477/