Theoretical Study of Quantum Confinement Effect and Optical Absorption Coefficient of Zinc Blende Quantum Dot

M. K. Shamer[1, a)] and Haider K. Fadel[1, b)]

[1]*Department of Physics, College of Education for Pure Sciences, University of Basrah, Basrah , Iraq.*

[a)] *Corresponding author: musashamer@yahoo.com*
[b)]*haider.qassim@uobasrah.edu.iq*

Abstract. In this paper, the effect of quantum confinement on the energy band structure and the absorption coefficient of the spherical quantum dot has been investigated. The quantum dot chosen from the zinc blende materials such as ZnS, ZnSe and ZnTe. The approximation of the effective mass and the degenerate valence energy band at the center of the first Brillion region are considered in our calculations. Our theoretical calculations included dispersion relation of the bulk and the effect of quantum confinement on the energy band gap, joint density of states and absorption coefficient of quantum dot. We will display the curves of ZnS only, because the curves of other zinc blende materials are in the same behavior. All results show a good agreement between our theoretical calculations and experimental evidence from the literature.

INTRODUCTION

The amount of space freedom permitted for electron mobility is proportional to the degree of confinement. The spatial restriction of motion of charge carrier in metals or semiconductors was achieved by reducing the physical dimension of matter to the nanoscale range. As a result, the continuous energy levels of bands are convert into discrete energy levels. Then, the band gap energy increased, which can be explained by the quantum confinement effect [1-4]. These two effects can be seen in the emission spectra and electronic absorption of semiconductor quantum dots with a direct band gap.

Many features of semiconductor nanomaterials are reliant on their physical dimension, such as dielectric constant and absorption cross section [5]. Quantum confinement size has an impact on all of these features. In ref.[6], the effects of incident light polarization, alloy mole fraction, quantum dot diameters, and doping were explored, and it was discovered that in-plane polarized light absorption is greater than perpendicularly polarized light absorption. A lower energy gap and a longer absorption wavelength result from increasing the mole fraction of the strain controlling layer. Surprisingly, changes in the dot diameter are very sensitive to changes in the absorption wavelength, but changes in the dot height are practically insensitive. The sensitivity analysis of several parameters that affect the optical transition energy explains this unexpected result.

Many studies has focused on the strong nonlinear optical behavior of low-dimensional materials such as quantum dots and core-shell quantum dots. Quantum dots could be beneficial in photoelectronics, photovoltaic nonlinear optics, light-emitting diode manufacture, and laser protections because their emission can be controlled by changing their size. Quantum dots increased nonlinear optical capabilities are defined by variations in core and shell shape and size, as well as chemical composition [7-9]. In ref.[10,] certain particular nonlinear optical features of CdTe and CdSe quantum dots (QDs), such as nonlinear refraction, optical limiting, saturable absorption, reverse saturated absorption, as well as core-shell QDs and their applications, were evaluated. Semiconductor materials are used to create quantum dots (from groups III-V and II-VI such as CdSe, CdS, InP, ZnS, ZnSe, ZnTe and PbTe). The electrical and optical properties of semiconductor materials are largely determined by their band gap energy.

The compound semiconductors of groups III-V and II-VI are usually found in two crystal forms: Zinc-Blende (ZB) and Wurtzite (W), the relative energy positions of the bands and the composition of the radial parts of the wave functions associated with an energy band are affected by the crystal structure. The cell radial section of the

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