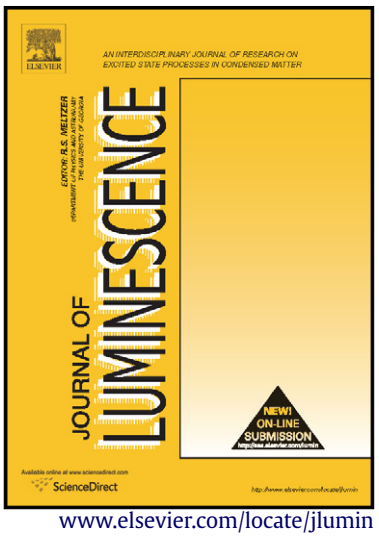

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Laser radiation effect on the optical properties of a spherical quantum dot confined in a cylindrical nanowire

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Abstract

An investigation is done in order to calculate the linear, third-order nonlinear and total optical absorption coefficient and refractive index changes of an impure $GaAs$ spherical quantum dot placed at the center of a $Ga_{1-x}Al_xAs$ cylindrical nano-wire. In this regard, the finite difference approximation is considered to calculate electronic structure as well as compact density-matrix approach is applied to investigate optical properties. In this study the effects of laser-field radiation along with aluminum (Al) concentration on optical properties are examined for three transitions between four first lower-lying electronic levels, i.e. $1 \rightarrow 2$, $2 \rightarrow 3$ and $3 \rightarrow 4$ transitions. Also the effect of relaxation time on saturation is studied and compared for these transitions. It is found that the magnitude of linear and third order nonlinear absorption coefficient and refractive index changes as well as the optical saturation can be modified by both Al concentration and the amplitude of laser-field radiation. Moreover, for $1 \rightarrow 2$ transition ($3 \rightarrow 4$ transition) the effect of quantum dot (nano-wire) is dominant whereas for $2 \rightarrow 3$ transition Al concentration is a major determinant factor. Additionally, for all transitions by increasing the value of laser field a red shift appears in optical spectrum where the extent of this red shift depends on the Al concentration and the energy levels between which the transitions occur. Finally, in contrast with QDs, a red shift appears in absorption spectrum as going up the transitions between higher energy levels.

Keywords: Absorption coefficient, Refractive index changes, Laser radiation, Spherical quantum dot, Nano-wire.

1. Introduction

Development of synthetic methods in fabricating semiconductor nanostructures have influenced and formed the new generation of technological and engineering sciences. Recently, novel properties of low-dimensional systems have drawn a large amount of researchers' interest to investigate in this revolutionary subject. Quantum dots (QDs) form one of the most fascinating low-dimensional systems, which are convenient tools that confine electrons in all spatial directions. Additionally, the shape of the QDs, which is determined by fabrication procedure, can distinctly alter the electronic and optical properties of low-dimensional systems. However, disregard to their shapes, all forms of QDs show features analogous to those of atoms [1, 2]. Additionally, QDs embedded into nano-wires are other attractive nanostructures [2]. Owing

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