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Nonlinear absorption coefficient and relative refractive index change for Konwent potential quantum well as a function of intense laser field effect

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ABSTRACT

Optoelectronic properties of semiconductor quantum wells are among the most studied issues in solid state device physics. However, this is a topic that deserves attention because of the particular potential energy shape which can consider important physical facts such as impurity diffusion, in combination with external factors such as electromagnetic fields or intense laser field effects, allowing to investigate of new possible behaviors for the optical properties of interest. In this line, we consider an GaAs/$Al_xGa_{1-x}As$ heterostructure with its conduction band profile described by the so-called Konwent potential which, as a function of the chosen parameters, can generate a single or double quantum well, shaped through aluminum concentration. We compute the corresponding electronic structure by working within the effective mass approximation and solving the one-electron Schrödinger equation. In accordance, we report the absorption coefficient and the relative refractive index change for the system as a function of Konwent potential parameters. Then, for a fixed set these quantities defining a quantum well shape, we investigate the effect of an electric field applied along the confinement direction (z), as well as an in-plane (x-directed) constant magnetic field. Finally, we investigate also the influence of a non-resonant intense laser field effect on the system. Here we can conclude that the Konwent potential parameters allow to tune the optical properties for energies ranging from 20 up to 100 meV; that the electric field induces a blue-shift, and a diminishing of the intensity, for the optical response; that the magnetic field also induces a small blue-shift, but practically without intensity lost; and that the intense laser field also causes a stronger blue-shift, together with an increase in the optical response.

1. Introduction

Analysis of charge-carrier quantum confinement is of paramount importance to understand the features of probability density for allowed band states in low-dimensional semiconductor structures (LDSS), together with the possible optical transitions of them and, eventually, their potential application as building blocks for optoelectronic devices. Within this context, it is well known that $Al_xGa_{1-x}As$/GaAs quantum heterostructures can be produced by using advanced crystal growth techniques such as Molecular Beam Epitaxy, Metal-Organical Chemical Vapor Deposition, and Chemical Beam Epitaxy, as discussed by Tsang and Miller, in their seminal article of 1986 [1].

Allowed energy states in LDSS are closely dependent on the band potential profile and the presence or absence of applied electromagnetic fields. In this sense, the choice of a specific geometry for the potential structure makes possible to suitably design optical responses based on transition between the involved quantum states. In particular, double-well model potentials have been used to describe the motion of carriers [2–8]. It is quite frequent to use effective mass theory to solve Schrödinger equation for band states in semiconducting LDSS. For that purpose, different approaches have been adopted, regarding a diversity of potential well profiles including, for instance, Morse and Gaussian quantum wells (QWs) as well as Tietz-Hua QW, either with the inclusion of external electromagnetic potential contributions or not and, in some of them, the consideration of a spatial dependence in

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