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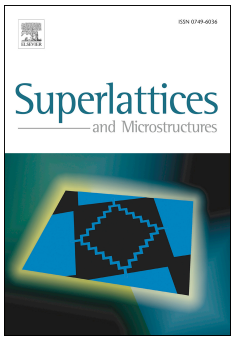

New way for determining electron energy levels in quantum dots arrays using finite difference method

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New way for determining electron energy levels in quantum dots arrays using finite difference method

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Abstract

Electronic states are investigated in quantum dots arrays, depending on the type of cubic Bravais lattice (primitive, body centered or face centered) according to which the dots are arranged, the size of the dots and the interdot distance. It is shown that the ground state energy level can undergo significant variations when these parameters are modified. The results were obtained by means of finite difference method which has proved to be easily adaptable, efficient and precise. The symmetry properties of the lattice have been used to reduce the size of the Hamiltonian matrix.

Keywords: Quantum dots array, Quantum dots solar cell, Intermediate band solar cells, Finite difference method

1. Introduction

Although the concept of intermediate band solar cells (IBSC) introduced by Luque [1] is about twenty years old, it is only recently that technological progress on the development of quantum dots have led to the realisation of promising solar cells. The cell consists of a PIN photodiode where the intrinsic zone contains quantum dots (QDs). Thus, the coupling of electronic states by tunneling between the dots induces an intermediate energy level which allows a two-steps photon absorption and an improvement of the efficiency by widening the absorbed light spectrum. The determination of energy levels in such systems has been attracting much interest. Some studies have been done on periodic arrays of cubic or orthorhombic QDs, either by generalising the Kronig-Penney model [2–4] or by using the finite difference method [5]. Ahn has studied two and three interacting two-dimensional QDs by means of finite difference method [6]. Baimuratov *et al.* [7] have investigated collective excitations in pyramidal quantum dots two-dimensional super-crystals with different Bravais lattices. They have shown that the type of lattice strongly influences the energy spectrum. Tomić *et al.* [8] have calculated the absorption coefficient due to the intermediate band induced by a three dimensional structure of pyramidal quantum dots. Boichuk *et al.* [9] have investigated the conductivity in 2D and 3D superlattices of cubic QDs. To our knowledge, there is no studies concerning three-dimensional arrangements of spherical quantum dots.

The purpose of this study is to describe the evolution of the ground state electron energy level according to the type of Bravais lattice corresponding to the arrangement of QDs, their size and the smallest distance separating two QDs. In a first step, we determine the electron energy in a single QD placed in another semiconductor material by solving analytically the Schrödinger equation. Secondly we compute the energy in a quantum dots array by means of finite difference method. At last we compare and discuss the results.

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