Exploration of electron confinement in multiple quantum well using III-V semiconductor materials

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ABSTRACT

Multiple quantum well laser diode has shown the advantage over other semi-conducting heterostructure laser. The electron transport phenomenon makes the multiple quantum well laser diode most powerful from existing laser diode. The Schrödinger equation has been solved to realize the electron confinement in multiple quantum well regions by using quasi-transmitting boundary method. The 30% of Aluminum mole fraction is taken for the analysis and the Eigen energy found to be 0.2356eV and 0.2070eV for three and four quantum well respectively.

Key words: Electron confinement, III-V semiconductor materials.

INTRODUCTION

Multiple quantum-well structures are currently attracting considerable interest for their applications in optoelectronics[1], such as modulators; light emitting devices and optical switching due to large refractive index and absorption variation. Multiple Quantum Well (QW) lasers diodes are expected to exhibit superior lasing properties like lower threshold current density, higher differential gain, and wide modulation, as compared to hetero-structure laser diodes. The GaN and their alloys are direct and wide band gap semiconductors provide a wide spectral light emission from blue to ultraviolet wavelength[2-3].

Mathematical analysis

Confinement of electrons leads to strongly modify physical properties in quantum structures. Hence, multiple quantum well are interesting from a fundamental point of view as they provide better and efficient laser diode. The electron confinement in multiple quantum well has been obtained, to analyze the electron phenomena and the various parameters like Eigen energy and wave vectors. The Eigen energy can be deduced by using Transfer matrix method. Therefore, it is necessary to realize first the band offset of the semiconductor layers and the variation of effective mass, which are very important in determining the Eigen energy. $\Psi(x)$ is the wave function that describes the spatial behavior and E is the energy of electron which is time independent Schrodinger equation. The standard Schrodinger equation can be written for each of semiconductor layer as follows

$$-\frac{h^2}{2m^*}\frac{\partial^2}{\partial x^2}\psi(x)+V(x)=E\psi(x)$$

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For solving the wave function two important boundary conditions are used. The first boundary condition is that ψ must be continuous and second $\partial\psi/\partial x$ must be continuous. The arbitrary constants are unknown so far finding them we use the normalization condition.

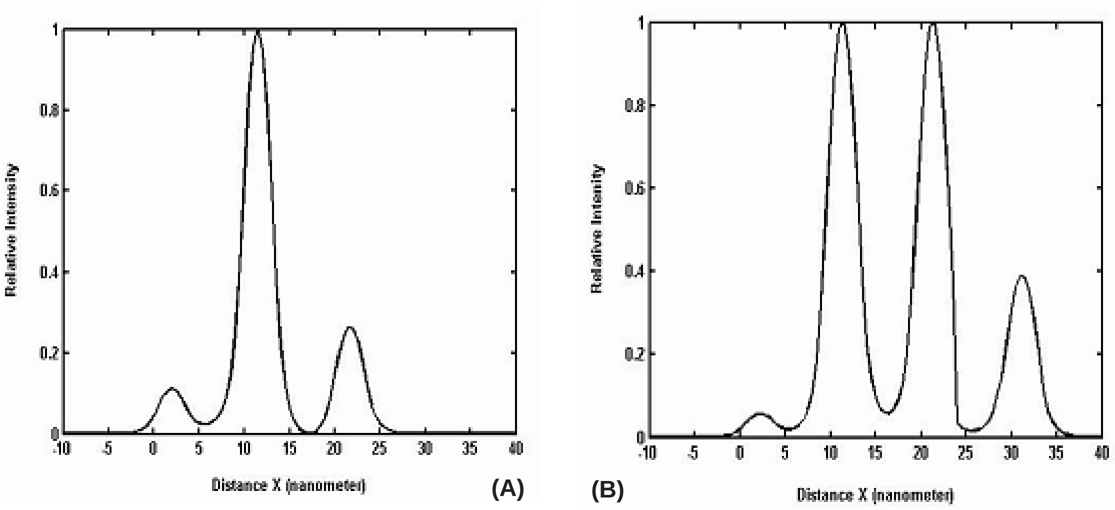

Fig. 1(a)-(b): Relative intensity of electron confinement in three and four quantum wells

RESULTS AND DISCUSSION

Schrödinger equation is very useful to understand the electron transport behavior in quantum well. The analysis of the three and four quantum well has been carried out for 30% of Aluminum mole fraction and the Eigen energy was found to be 0.2356eV and 0.2070eV respectively. The figure 1 (a) and figure 1 (b) shows the increasing and decreasing nature, due to the band alignment between well and barrier region. The electrons are confined in well region due band offset. The solution of Schrödinger equation consist of growing and decaying terms due to which wave function intensity increases in well region and decreases in barrier region. The figures show the electron confinement for three and four quantum wells. The electron confinement is greater for the innermost quantum well(s), as shown in the following results

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