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Gain Enhancement Study of Nanomaterial AlGaAs/GaAs Under GRINLs

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Abstract: This newly research paper has a critical contribution in the investigation of the gain enhancement study of nanomaterial AlGaAs/GaAs type heterogeneous structure under the various number of GRINLs (Graded Refractive Index Nano Layers). Various spectral performance of modal type gain with photonic wavelengths under number of GRINLs for nanomaterial AlGaAs/GaAs type heterogeneous structures have been illustrated. The behaviours of changes in peak modal type gain and peak gain compression with several type of number of GRINLs have also been presented graphically. Moreover, the parameters like anti-guiding type factor and change in index of refraction versus charge carriers per cube cm have been calculated. The achieved modal type gain results correspondence to maximum modal type light gain of wavelengths (~830nm) for lasing phenomenon have an essential contribution in current days for the applications of EM radiations (SWIR and NIR) as well as this type wavelength range has been also useful in fibre optic telecommunications by the method of TIR with diminished losses and attenuations in db/km of light signals.
Keywords: Modal type gain, Parameter of anti-guiding, GRINLs, AlGaAs, GaAs.

1. Introduction

In recent time under the nano-scale type technological and engineering sciences the performances of heterogeneous type structures are very critical because of their unique optical light properties. The various types of experimental and theoretical research based innovative work in the all over world have been done by the researchers. In several fields like medical science, industries, radar system, aerospace, photovoltaic and detectors areas, lasing type devices etc., the nano-scale type heterogeneous structures provide great role due to their several optical performances. The several types of optical properties of various nano scale type heterogeneous structure[1-5] have been investigated by the researchers. In general the heterogeneous type structures are formed by the process of combination of multiple hetero type junctions. The hetero type junctions are those junctions that are formed by interface between the dissimilar band gap nano materials. Among various nano-scale hetero type structures, the AlGaAs/GaAs nano technological materials have been very popular due to emission of radiations of ~ 830 nm wavelength. These type wavelengths have been of highly concern due to their potential performances in the fiber optic appliances based telecommunications due to diminish attenuation. These nano technological materials have been set up some additional reward such as gain stability at higher temperature, improved line width enhancement factor and photonic wavelength. The AlGaAs/GaAs nano technological materials have also been reported as a platform on which the nano technological devices can be fabricated. For example, the electrical results such as the I-V and C-V curves of the Schottky type diodes, which were fabricated on AlGaAs/GaAs nano technological materials, have been studied under the variations of barrier heights (potentials).

2. Simulation

For achieving the peak intensity of modal type gain at the photonic wavelength nearly about 830 nm of AlGaAs/GaAs nanomaterials based heterostructure have been simulated by me in this paper. This proposed hetero type structure has mono quantum well of AlGaAs ternary material having profile of GIC (graded index cladding). The entire proposed structure is let be grown on the substrate of GaAs whose lattice is lattice matched with the QW material. The gain intensity of light per cm has been estimated by using following formula.

$$G(\hbar\omega) = \frac{2\pi e^2}{nc\varepsilon\,\omega L m^2} \sum_{\sigma U,L} \sum_{n,m} \int \left| \left(\hat{e}.M_{nm}^{\eta\sigma}\left(k_t\right) \right) \right|^2$$

$$\times \frac{\left(f_n^c\left(k_t\right) - f_{\sigma m}^v\left(k_t\right) \right)\left(\frac{\gamma}{\pi} \right)}{\left(E_{\eta,\sigma nm}^{c,v}\left(k_t\right) - \omega\hbar \right)^2 + \gamma^2} \frac{k_t dk_t}{2\pi}.$$

In above formula, the brief detail of appropriate terms is exhibited in Chuang[6]. The modal confinement parameter provides vital role in the determination of modal type gain enhancement. The modal confinement parameter is given by following expression.

$$\Gamma = \left(\int_{-L_W/2}^{L_W/2} |\varepsilon(z)|^2 \, dz \right) \left(\int_{-\infty}^{\infty} |\varepsilon(z)|^2 \, dz \right)^{-1} .$$

The combined effect of gain enhancement and modal confinement parameter generates the modal type gain. An essential expression of modal type gain in terms of modal confinement parameter and gain enhancement is given by following relation.

$$G_m(\hbar\omega) = \Gamma \times G(\hbar\omega) .$$

The relation between change in modal type gain per unit carriers and index of refraction per unit carriers is expressed by parameter of anti-guiding. The parameter of anti-guiding is given by following equation.

$$\alpha = 2K \left(-\frac{dn(E)}{dN} \right) \left(\frac{dG(E)}{dN} \right)^{-1} .$$

In above equation, the brief details of appropriate terms is exhibited[7-9].

3. Simulation Results

The degree of amplification of intensity of light can be measured as enhancement of light per cm. Generally, the enhancement in light is the net amount of the stimulated emission that a photon generates as it travelled in given appropriate distance. In the hetero type structures, the optical profit or enhancement is caused by photon induced transition of electrons from the CB (conduction band) to the VB (valence band). If the rate of downward transitions exceeds the rate of upward transitions, there will be a net generation of photons and enhancement or profit in optical gain[10,11] can be achieved. The modal type gain enhancement per cm versus photonic wavelengths for various GRINLs and peak modal gain enhancement in intensity of light per cm versus number of GRINS layers of nanomaterial AlGaAs/GaAs type heterogeneous structure under the various number of GRINLs (Graded Refractive Index Nano Layers) have been illustrated graphically in figure 1.

The value of peak modal gain enhancement tends to higher value as reduce in number of GRINLs due to increase in value of parameter of modal confinement. The highest value of enhancement in intensity of modal type gain per cm is achieved at the wavelength of 830 nm. This range of wavelength of light has critical importance in the utilisation of NIR applications to achieve the combination of higher penetration power and cellular interaction performances without any type absorption losses. The achieved modal type gain results correspondence to maximum modal type light gain of wavelengths (~830nm) for lasing phenomenon have an essential contribution in current days for the applications of EM radiations (SWIR and NIR) as well as this type wavelength range has been also useful in fibre optic telecommunications by the method of TIR with diminished losses and attenuations in db/km of light signals.

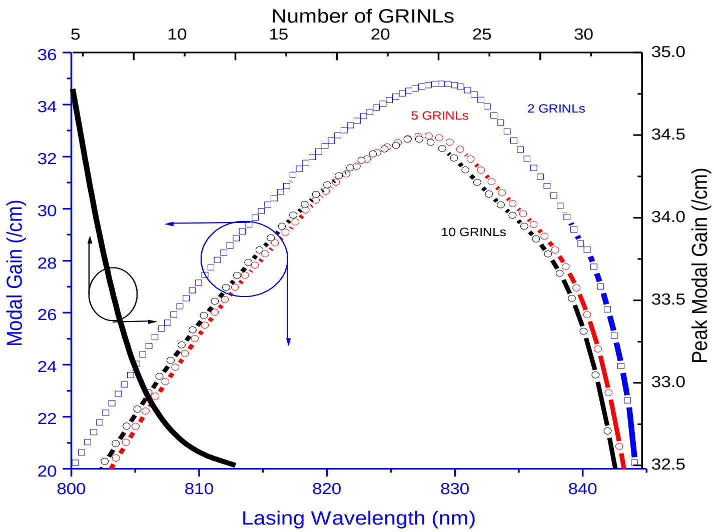

Figure 1. Modal type gain versus lasing wavelength and Peak modal type gain versus various numbers of GRINLs for nanomaterial AlGaAs/GaAs

The variations in the index of refraction and changes in parameter of anti-guiding with charge carriers per cube cm of nanomaterial AlGaAs/GaAs type heterogeneous structure under the various number of GRINL have been presented by graphically in figure 2. The compression in peak gain with various numbers of GRINLs and range of parameter of anti-guiding versus peak change in index of refraction for nanomaterial AlGaAs/GaAs type heterogeneous structure are shown in figure3.

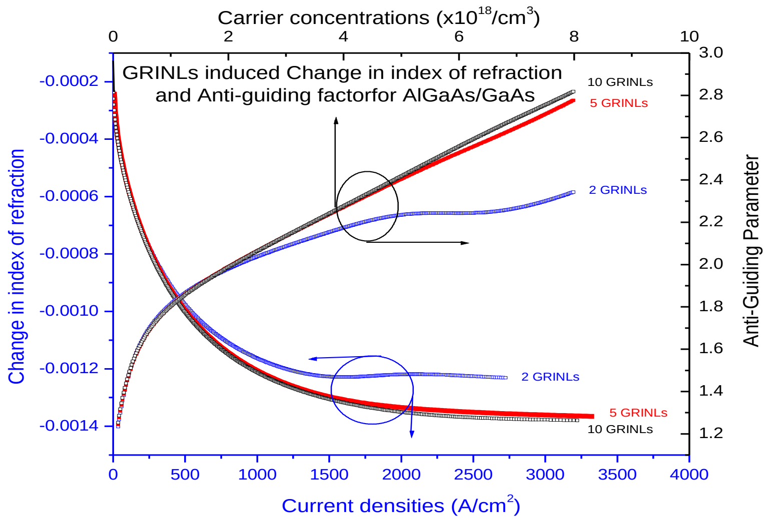

Figure 2. Change in index of refraction and parameter of anti-guiding versus current densities and carrier concentrations respectively for nanomaterial AlGaAs/GaAs under the various number of GRINLs.

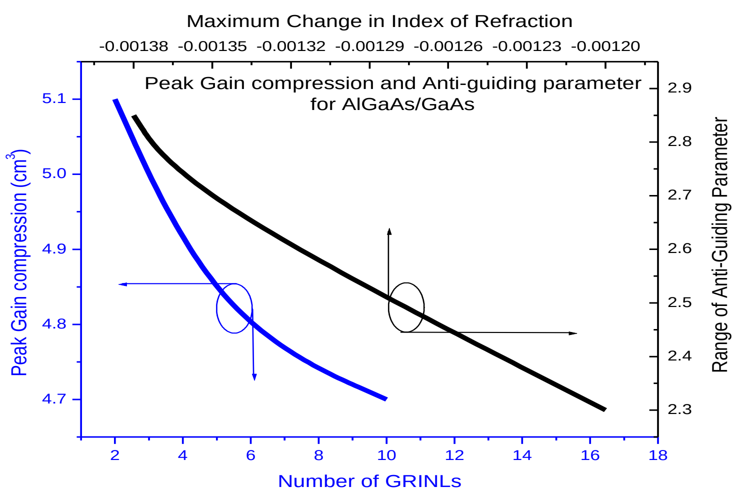

Figure 3. Compression in Peak gain versus various numbers of GRINLs and Range of parameter of anti-guiding versus peak change in index of refraction for nanomaterial AlGaAs/GaAs .

4. Conclusion

Under the various numbers of GRINLs (Graded Refractive Index Nano Layers), this research paper has a vital contribution in the investigation of the gain enhancement study of nanomaterial AlGaAs/GaAs type heterogeneous structure. The various spectral performance of modal type gain with photonic wavelengths under number of GRINLs for nanomaterial AlGaAs/GaAs type heterogeneous structures have been illustrated. The behaviours of changes in peak modal type gain and peak gain compression with several type of number of GRINLs have also been presented graphically. Moreover, the parameters like anti-guiding type factor and change in index of refraction versus charge carriers per cube cm have been calculated.

The achieved modal type gain results correspondence to maximum modal type light gain of wavelengths (~830nm) for lasing phenomenon have an essential contribution in current days for the applications of EM radiations (SWIR and NIR) as well as this type wavelength range has been also useful in fibre optic telecommunications by the method of TIR with diminished losses and attenuations in db/km of light signals. The highest value of enhancement in intensity of light per cm is achieved at the wavelength of 830 nm. This type range of wavelength of light has critical importance in the utilisation of NIR applications to achieve the combination of higher penetration power and cellular interaction performances without any type absorptions.

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