Chapter 6

CONCLUSIONS

Theoretical investigation of the 980 nm InGaAs/GaAs strained quantum well ridge waveguide lasers suitable for pumping Er^{3+} doped fibre amplifiers was carried out, using the theory described in Chapter 3. The required 980 nm lasing wavelength is well within the range of achievable wavelengths using the modeled structure of $In_{0.2}Ga_{0.8}As$/GaAs/GaAs QW laser diode. This field distribution indicates that the strained quantum well layer acts as an optical cavity that the optical wave are confined in this region which dominates the stimulated emission process. The calculation of the optical gain in this active medium was performed using the known approach to the optical properties of a semiconductor laser. Optical gain is one of the most basic and important parameters that characterize the behavior of a semiconductor laser diode. TE polarization is substantially enhanced while the TM mode is comparatively depressed in a compressive strained QW layer. The optical gain is polarization sensitive and is controlled by strain in the quantum well layer. The calculated values of peak gain show a regular correlation to the injected level of free carriers. The gain band is rather wide and its peak moves to the longer wavelength side as the pumping level of carriers grows. Strained and unstrained QW designs were compared and it shows that he compressive strain induced in quantum well results in the enhancement of the optical gain in TE mode and in turn lowers the injection level of carriers. In addition, the mode gain as the amplification coefficient of the confined wave in the two-dimensional optical structure of the laser was calculated. The mode gain in the spectral peak appears to be nearly a linear function of the material gain although its value is much smaller than the latter. This is to provide a more adequate modeling of the spectral properties of laser diode. A low threshold current density of 90 A/cm^2 is estimated for this QW laser. This result shows that further improvement of the threshold current density should be possible.

When designing high-performance laser diodes, a detail understanding of the optical properties of the active medium is very essential. The strained quantum well layer provides significant advantages over the conventional quantum well medium as follows:

- It broadens the range of materials available for tuning the properties of interest, such as the band offset and the emission wavelength.
- Strain has strong effects on the valence band and therefore provides another too for band engineering.
- It allows the use of a much wider range of material in the heterojunction. Strained layer epitaxy provides more material choices than lattice matched layer epitaxy and the strained layer quantum wells can be used to generate laser emission at new wavelengths.

These theoretical results would be useful for the design and further performance improvement of the 980 nm strained QW laser diodes or other optoelectronic devices using $In_xGa_{1-x}As$ material system. By their nature, strained QW laser is a very new type which has only been explored since 1992. It provides many desirable characteristics such as broader choice of material system, reduced lasing threshold current and higher gain. Further improvement should be carried out in view of the great potential of the strained QW laser diode.