**Project 1:** GaAs/AlGaAs Double Heterostructure Laser Simulation

In this project, we will simulate a simple double heterostructure GaAs edge emitting laser. Hand calculations for this waveguided laser are simple, and we will compare their results against those of sentaurus simulations. For all extracted values from sentaurus show either in a screen shot of the output text or from an attached graph what point is extracted.



**Figure 1**. GaAs/AlGaAs double heterostructure laser with 0.1 µm GaAs active gain region with 1 µm of Al0.4Ga0.6As on either side, respectively doped p- and n-type. Assume a simple edge emitting laser 1µm wide and 200 µm Long with end facet reflectivities of 0.3.

We will make the following assumptions for hand calculations:

Optical loss, **αi** = 20 cm-1

Gain cross-section, **a** = 5e-16 cm-2

GaAs permittivity, **εl** = 13.1

Al0.4Ga0.6As permittivity, **ε** = 11.9

Minority Carrier Lifetime, **τ** = 5e-9 s

GaAs transparency condition, **Ntr** = 1.4e18 cm-3

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Hand Calculated** | **Sentaurus** |
| Confinement Factor |  |  |
| Round-Trip Loss [1/cm] |  |  |
| Threshold Gain [1/cm] |  |  |
| Threshold Carrier [cm-3] |  |  |
| Threshold Current [mA] |  |  |
| External Quantum Efficiency |  |  |

**Table 1**. Calculated and simulated laser values.

1) Calculate the confinement factor using the V parameter approximation, assuming a lasing wavelength of 870nm. Find the calculated confinement factor from sentaurus. Explain any possible differences.

2) What is the round trip loss? Extract the value of the round trip loss from sentaurus using the gain/loss vs. bias plot.

3) Using your calculated confinement factor, calculate the threshold gain condition. Extract the value from sentaurus using the material gain plot.

4) Using the linear gain approximation, calculate threshold carrier concentration. From the material gain curve, what is the threshold carrier density in sentaurus?

5) Calculate the threshold current needed to obtain lasing. From the L-I-V curve in sentaurus, extract the threshold current. Zoom in or change graph axes as needed to show the appropriate feature demonstrating lasing threshold.

6) Calculate external quantum efficiency for the laser and also extract using the L-I curve in sentaurus.

7) It can be seen that the temperature increases as drive current increases, which is due to increased carrier recombination, which produces heat. Why would the lasing wavelength increase as well?

(Hint: For GaAs, Eg=1.519 – 5.405e-4 T2/(T+204) where T is temperature in K).