ECE 536 Integrated Optics and Optoelectronics

SPRING 2022
Problem Set No. 5 Due: 3/8/2022, Tuesday

When using software for plots and calculations, please attach code to end of homework.

NOTE: The deadline has been pushed a few days forward to give ourselves a little more time to discuss lasers

1. Problem 9.2 in the textbook by Prof. Chuang.

2. Problem 9.17 (a) in the textbook by Prof. Chuang.

3. Consider a double heterostructure (DH) laser consisting of a GaAs active layer between two AlGaAs cladding layers, which emits at $\lambda_0 = 840$ nm. Assume:

   - a carrier density at transparency $N_{tr} = 1.2 \times 10^{18}$ carriers/cm^3
   - cavity length $L = 300$ μm
   - differential gain g' $= 3.6 \times 10^{-16}$ cm^2
   - radiative lifetime $\tau_e = 4$ ns
   - thickness of the active layer $d = 100$ nm
   - collection efficiency in the active region $\eta_i = 0.95$
   - total loss per pass $\gamma = 1.43$
   - refractive index of the active layer $n_1 = 3.6$
   - refractive index of the cladding layers $n_2 = 3.4$

   Calculate the current density at threshold.

4. Consider a quantum well (QW) laser which in most respects is very similar to the one described in Problem 3 above. The physical parameters remain the same, except that the QW laser has a higher differential gain g' $= 6 \times 10^{-16}$ cm^2 and that the QW active layer results in a confinement factor estimated to be $\Gamma = 1.8 \times 10^{-2}$. The active layer now becomes the quantum well width, selected to be $d = 10$nm, approximately. We can assume that a step-index separate confinement structure results in the confinement factor as given above. Other relevant parameters are the same as in Problem 3.

   (a) Estimate the current density at threshold required for this QW laser.

   (b) Compare the result with the one obtained for the DH laser in Problem 3 and comment briefly on the interplay of the various physical parameters leading to the difference in the result for the QW laser. Do you conclude that this device performs better or worse than the DH laser in Problem 3?