ECEn 555, Fall 2009
Homework #7
Due December 7, 5:00 pm

7.1 Design a single-mode double-heterostructure laser for an emission wavelength of 1.50 μm. Design the heterostructure with particular attention to carrier and mode confinement. Use InP-based lattice-matched materials for your design.

7.2 The following equations hold for a junction laser:

$$\frac{dn}{dt} = AI - \frac{n}{\tau} - \frac{Bn\varphi}{\tau}$$

$$\frac{d\varphi}{dt} = \frac{Bn\varphi}{\tau} - C\varphi$$

Here n is the excess carrier population, φ the photon density, $\frac{Bn\varphi}{\tau}$ the stimulated emission, Cφ the loss of photons through the end walls, n/τ a relaxation term, I the current, and AI the injection rate. A, B, and C are appropriate parameters. Find

(a) The steady-state solution

(b) The threshold current for laser action

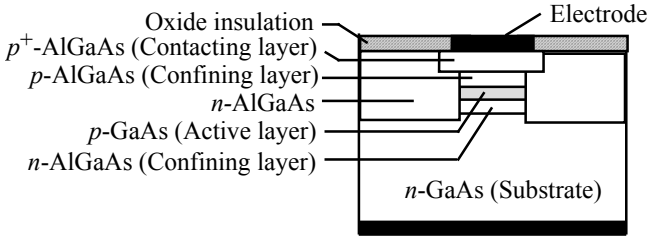
7.3 Design an InP-based lattice-matched single quantum well laser to emit at 1.6 μm.

7.4 Estimate the relative change in output wavelength arising from a refractive index change of one part in 10^7 in a cleaved facet diode laser 1 mm long.

7.5 Single frequency lasers Consider a DFB laser operating at 1550 nm. Suppose that the refractive index n = 3.4 (InGaAsP). What should be the corrugation period Λ for a first order grating q = 1. What is Λ for a second order grating, q = 2. How many corrugations are needed for a first order grating if the cavity length is 20 μm? How many corrugations are there for q = 2? Which is easier to fabricate?

7.6 The SQW laser Consider a SQW (single quantum well) laser which has an ultrathin active InGaAs of bandgap 0.70 eV and thickness 10 nm between two layers of InAlAs which has a bandgap of 1.45 eV. Effective mass of conduction electrons in InGaAs is about $0.04m_e$ and that of the holes in the valence band is $0.44m_e$ where m_e is the mass of the electron in vacuum. Calculate the first and second electron energy levels above E_c and the first hole energy level below E_v in the QW. What is the lasing emission wavelength for this SQW laser? What is this wavelength if the transition were to occur in bulk InGaAs with the same bandgap?

7.7 Buried heterostructure laser diode The figure below shows a structure of a buried heterostructure laser diode based on GaAs and AlGaAs. Discuss how you would change the semiconducting materials to use the same structure for operation at 1.3 μm and at 1.55 μm?



Schematic illustration of the cross sectional structure of a buried heterostructure laser diode.