ECE 228B
Practice Problem Set 2

Problem 1

In this problem we first consider a semiconductor gain medium used as an optical amplifier, then embedding this gain medium in a cavity to realize a tunable laser. An InGaAsP-InP 350μm long active waveguide with zero reflection at the facets (AR coated), has a peak gain coefficient that can be approximated by

$$g_p \approx \left(\frac{\Delta n}{\Delta n_T} - 1 \right)$$

Assume $\Delta n_T \approx 1.75 \text{ X } 10^{18}$ cm^{-3}, $\alpha = 600$ cm^{-1}, a FWHM gain bandwidth of approximately 5nm, the gain peak at 1565nm, and a mode refractive index of $n'_{eff} = 4$.

Part A (20 pts)

Calculate the unsaturated total optical gain when the amplifier is biased to $\Delta n = 1.5\Delta n_T$ and optical coupling losses into and out of the amplifier are 3dB each facet.

Part B

Next, this active optical waveguide is fabricated into a DBR laser with a Bragg mirror on one end and a cleaved un-coated facet on the other end. Calculate the tuning current for a Bragg reflector that operates based on the free-carrier plasma effect so that the peak aligns with the gain peak of the semiconductor gain medium. Assume the lasing wavelength is set solely by the location of the Bragg mirror peak (i.e there is a Fabry-Perot resonance located at the gain peak). The mirror region is fabricated in a semiconductor waveguide with bandgap λ_g = 1300nm with an un-tuned Bragg peak at λ_B = 1550nm, β_{pl} = -1.3 x 10^{-20} cm^3, L=400 μm, d = 0.3μm, w = 2μm and an optical mode confinement factor Γ_t = 0.3. For the material assume an infinite spontaneous recombination time constant, bimolecular recombination constant B = 10^{-10} cm^3/s and Auger recombination constant C = 3 x 10^{-29} cm^6/s.

Problem 2

The output of a mode-locked laser is a 1550nm repetitive pulse train that can be characterized by the pulse repetition rate and the pulse width as shown below. We want to design a semiconductor mode-locked laser for a 40Gbps communications system where the pulse repetition rate is 40GHz and the pulse FWHM is 11ps.

Part A
Assuming the semiconductor waveguide mode index is $n'_{eff} = 4.0$, what must the length of the active cavity be?

Part B
What is the required minimum FWHM width of the semiconductor gain medium?

Part C
Draw an example of what an integrated semiconductor mode locked laser would look like (i.e. the basic components). What are the issues that will limit the performance and operation at the above data rates?