# ECE 536 Integrated Optics and Optoelectronics

SPRING 2022
Problem Set No. 8 Due: 4/15/2022 Friday

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

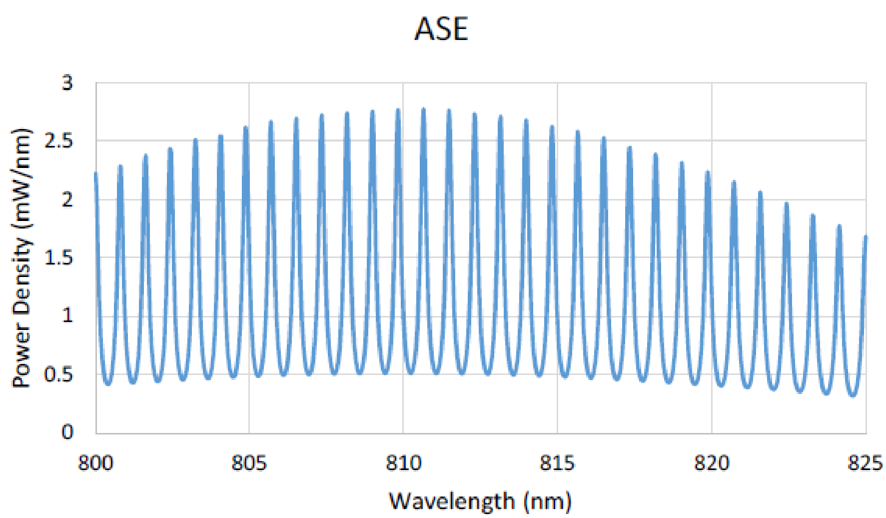
1. The chart below shows the amplified spontaneous emission (ASE) spectrum collected from a laser cavity of length L = 100μm with end reflectivities $R_1 = R_2 = 30\%$.

   Consider the following data points from the graph:

   - Max: (809.825nm, 2.77mW/nm),
   - Min: (810.225nm, 0.51mW/nm),
   - Max: (810.65nm, 2.77 mW/nm).

   (a) Estimate the group index $n_g$

   (b) Estimate the net modal gain $G = \Gamma g - \alpha_i$



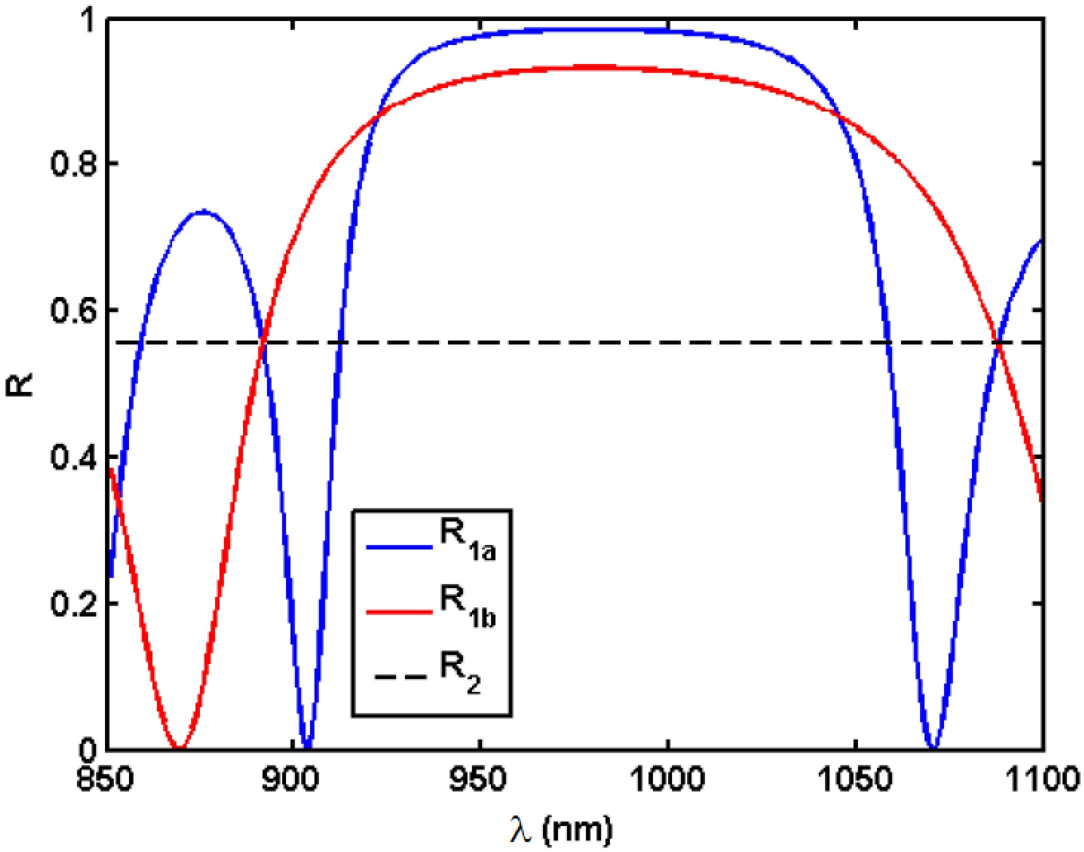

2. Consider two edge-emitting lasers with a distributed reflector as one mirror and a cleaved facet as the other consisting of an 8nm $In_{0.2}Ga_{0.8}As$ single quantum well active region. The reflection spectrum for the mirrors is given below. The lasers have the following parameters: $\alpha_i$ = 5cm-1, $\eta_i$ = 0.8, $\Gamma$ = 0.032, L = 100μm, and laser width w = 5μm.

   (a) From the reflection plots, sketch the loss spectrum for the two lasers, predict the lasing wavelength, and estimate the threshold material gain for the two lasers.

   (b) Plot the empirical relation for g(n) given in Coldren (Table 4.4). Calculate the threshold carrier density based on your result from (a).

(c) Using Eq. 4.108 in Coldren and the parameters given in Table 4.5, calculate the threshold current density and threshold current for the two lasers.

(d) Plot the curves of emitted power as a function of injected current for both lasers and comment on the differences.




3. Fabry-Perot-type semiconductor lasers generally oscillate on several longitudinal modes, as in Figure 3.1.

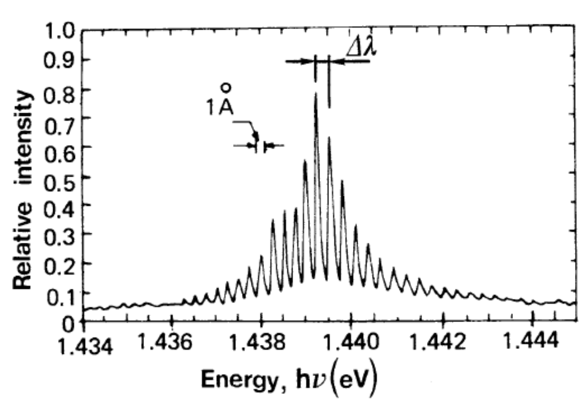



Figure 3.1 – Example of longitudinal spectrum for a typical Fabry-Pérot semiconductor laser

To achieve oscillation on a single mode, distributed feedback **(DFB)** structures are widely used. Consider the **DFB** laser structure in Figure 3.2.

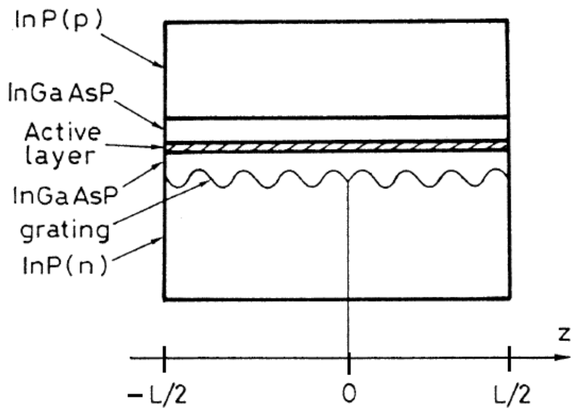



Figure 3.2 – Example of a λ/4-shifted DFB laser

Calculate the period Λ of refractive index modulation assuming that the laser oscillates on a single mode at λ = 1.55 μm and that the average refractive index in the cavity is $\langle n_{eff} \rangle$ = 3.5, assuming a perturbed index profile

$$n_{eff}(z) = n_0 + n_1 \sin\left[\left(2\pi|z|/\Lambda\right) + \varphi\right]$$

(Hint: no need for fancy models, just consider the Bragg condition)