Final take-home exam

1. Tunable diode laser (2/2)

A tunable three-section DBR as in Fig. 3.22 is constructed to operate near 1.55 μm from InGaAsP/InP materials. Above threshold, the wavelength is tuned by changing the effective indices in the phase and DBR passive sections by injecting current. For no current injection, the operating wavelength is 1.57 μm, the effective index in all sections is 3.4, $\partial \bar{n}/\partial N = 10^{-21}$ cm^3, $\eta_i =$ 70%, and the carrier lifetime is independent of carrier density and equals 3 ns in all sections. The waveguide cross section in all regions is 0.2×3 μm; the gain, phase shift, and grating regions are each 200 μm long; and the grating has a reflectivity per unit length of 100 cm^{-1}. The other mirror is a cleaved facet. Plot the wavelength vs. current to the grating:

(a) Assume no current is applied to the phase shift region and show at least three axial mode jumps.

(b) Repeat for a phase shift current sufficient to maintain operation at the grating's Bragg wavelength.

(c) In (b) also plot the required phase shift current on the opposite axis. Stop plots when any current reaches 50 mA.

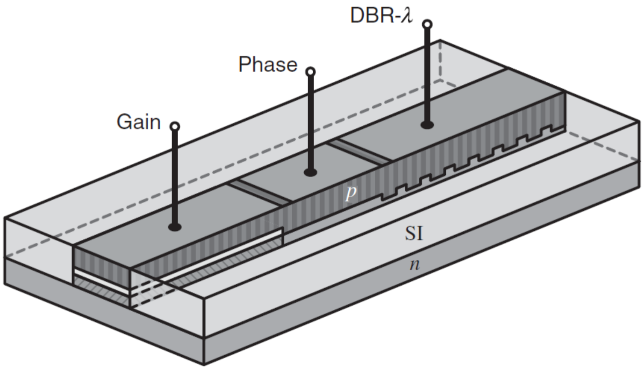

FIGURE 3.22: Illustration of a tunable single-frequency three-section DBR laser. The laser consists of a gain section, phase section, and DBR mirror section.

2. Reflectivity of a DBR mirror (3/3)

Consider a dielectric DBR mirror consisting of Al_2O_3 (n=1.7) and HfO_2 (n=2.1) quarter-wave stacks, designed to be centered at 600nm. Estimate the number of periods needed to reach reflectivity values of 99% at 600nm. For this number of periods, calculate and plot the reflectivity spectrum versus wavelength, neglecting absorption effects, and showing at least two minima on either side of the central maximum.

3. Gain of a quantum well (5/5)

Calculate and plot the TE and TM optical gain spectra of a 14nm GaAs quantum well with infinite barriers, for five different values of sheet carrier densities between 10^{12} and 10^{13} cm^{-2}. For each carrier density, estimate the respective quasi-Fermi levels.

Consider only the first two electron, heavy-hole and light-hole levels. Produce two plots, one for TE and one for TM polarization. In the plots, make sure to indicate the $\pm g_{max}(E)$ curves in dashed lines and mark by arrows the relevant optical transitions. Operating temperature T=300K. Ignore line-shape broadening.

Deadline: Monday, 11th of January 2021