3.46 PHOTONIC MATERIALS AND DEVICES

Homework Assignment 5—March17, 2006

Due: 5pm, March 24, 2006

1. Quantum Wells

(a) Write the expression relating the quantized energy states of a 1D quantum well with well width.

(b) Make a plot of the confined E_n values versus quantum well layer thickness, d, for a GaAs/AlAs quantum well (refer to Fundamentals of Photonics pg. 550 for bandgap energy values). The range of your d values should be from 5 nm to 100 nm.

2. LEDs

Consider a GaAs Light-Emitting Diode. In a photoluminescence experiment, you measure the lifetime at temperature T = 4.2 K (the temperature of liquid helium) to be 100 ns. You assume that at this very low temperature, you have successfully damped phonons and all possible non-radiative sources of de-excitation; you assume τ_r = 100 ns. You slowly raise the temperature of your cryostat sample holder back up to room temperature, and now measure a lifetime of 50 ns.

At 300 K,

(a) What is the non-radiative lifetime τ_{nr}?

(b) What is the internal quantum efficiency η_i?

(c) For an LED design, assume an absorption coefficient of $\alpha = 10^4$ cm^{-1}, LED device top layer thickness of t = 2 μm, and the GaAs refractive index n = 3.6. What is the external quantum efficiency η_{ext}?

(d) Sketch a schematic plot the output optical power P_o versus input current I. Sketch a schematic plot of wall plug efficiency η_W versus applied voltage V. (Note: a schematic plot means that no numbers need to be present on the two graph axes; the plot should show a qualitative trend.)