ECE170A Project 2

Note: All the codes should be submitted in (.mlx) form and remember to write comments/scripts for your codes for easier understanding. For problem 4-5, you can still use MATLAB to calculate the results, or you can solve problems by hand and scan them to PDF file. All the files should be named in ID_Name_problem.

Assignments:

1. **InGaAs LED:** Calculate the emission spectrum of a GaAs LED with bandgap energy equal to 1.4 eV at 350K, assume the emission spectrum is given by n(E)=g(E)*f(E), with g(E)=(E-E_c)^(1/2), f(E)=e^(-(E-E_c)/KT). then assuming the density states, Fermi distribution and electron concentration are normalized so that the absolute amplitude value of it is not important. We are only interested in the shape of the spectrum. Its absolute magnitude is not needed.

   (a) plot the density of states g(E) versus energy (eV) for wavelength ranged from 0.8μm to 1.0 μm
   (b) plot the distribution f(E) versus energy (eV) for wavelength ranged from 0.8μm to 1.0 μm
   (c) plot the electron concentration n(E) versus Energy (eV) for wavelength ranged from 0.8μm to 1.0 μm
   (d) calculate the full-width-at-half-max linewidth
   (e) estimate the emission peak wavelength (in microns) and frequency (in THz)

2. **GaAs LED and SiO2 (glass) Fabry-Perot (FP) Cavity**: Assume the GaAs LED output spectrum is now being passed into a SiO2 resonant cavity (similar to the one in Project 1). Assume mirror separation is 500 μm and the mirror reflectivity are 95%, and the Sellmeier coefficients of SiO2 can be found in chapter 1 lecture slide.

   (a) plot the output spectrum of FP cavity versus energy (eV) from 0.8μm to 1.0 μm
   (b) plot the same versus wavelength from 0.8μm to 1.0 μm
   (b) find the nearest resonance mode at 870 nm

3. **Temperature dependence of GaAs LED and SiO_2 Fabry Perot Cavity:** Instead of assuming the temperature is constant at room temperature, now, consider GaAs LED bandgap changes with temperature by using Varshni equation.

   (a) plot the bandgap energy with temperature ranged from 298K to 398K
   (b) plot the wavelength corresponding to the bandgap energy with temperature ranging from 298K to 398K
   (c) plot the peak emission wavelength with temperature ranging from 298K to 398K. How much does the peak emission change?
   (d) compare the full-width-at-half-max linewidth for 298K, and 398K, does the linewidth broadened as temperature increases?

Varshni constants for GaAs are, E_{go} = 1.519 eV, A = 5.41×10^{-4} eV K^{-1}, B = 204K.
Varshni equation:
Eqs. (3.11.1) → $E_{ph} = h\nu_0 \approx E_g + (1/2)\, k_B T$
Eqs. (3.11.2) → $E_g = E_{go} - AT^2/\,(B + T)$

4. **LED efficiencies (problem 3.29):** A particular 890 nm infrared (IR) LED for use in instrumentation has an AlGaAs chip. The active region has been doped *p*-type with 4×10^{17} cm^{-3} of acceptors and the nonradiative lifetime is about 60 ns. At a forward current of 50 mA, the voltage across it is 1.4 V, and the emitted optical power is 10 mW. Calculate the PCE, IQE, EQE, and estimate the light extraction ratio. For AlGaAs, the lifetime parameter is $B \approx 1\times10^{-16}$ m^3 s^{-1}.

5. **LED luminous flux (problem 3.30):**

(a) Consider a particular green LED based on InGaN MQW active region. The emission wavelength is 528 nm. At an LED current of 350 mA, the forward voltage is 3.4 V. The emitted luminous flux is 92 lm. Find the power conversion efficiency, external quantum efficiency, luminous efficacy and the emitted optical power (radiant flux)? (Data for Osram LT CPDP)

(b) A red LED emits 320 mW of optical power at 656 nm when the current is 400 mA and the forward voltage is 2.15 V. Calculate the power conversion efficiency, external quantum efficiency and the luminous efficacy. (Data for thin film InGaA1P Osram LH W5AM LED)

(c) A deep blue LED emits at an optical power of 710 mW at 455 nm when the current is 350 mA and the forward voltage is 3.2 V. Calculate the power conversion efficiency, external quantum efficiency and the luminous efficacy. (Data for a GaN Osram LD W5AM LED)