EEE337/348: Tutorial 4

1) i) One of the limitations of LED is the internal reflection at the semiconductor-air interface. The refractive index of GaAs is 3.66 while that of the air is 1.0. Calculate the reflection coefficient for normal incidence.
   ii) Calculate the incident angle for total internal reflection, which another loss mechanism in LEDs.

2) Consider a GaAs pn diode with the following parameters
   Electron diffusion coefficient, $D_e = 30\ cm^2/V\text{-}s$
   Hole diffusion coefficient, $D_h = 15\ cm^2/V\text{-}s$
   p-doping, $N_a = 5x10^{16}\ cm^{-3}$
   n-doping, $N_d = 5x10^{17}\ cm^{-3}$
   Electron minority carrier lifetime, $\tau_e = 10^{-8}\ s$
   Hole minority carrier lifetime, $\tau_h = 10^{-7}\ s$

   i) Calculate the injection efficiency of the GaAs LED, assuming no recombination due to traps.
   ii) The electron injected in the p-region, on the top, will be responsible for the photon generation. Calculate the injection current at a forward bias of 1 V.
   iii) If the GaAs LED has a radiative recombination efficiency of 0.5, calculate the photons generated per second.

3) Describe a typical structure of a GaN LED that produces high power and narrow emission spectrum.

4) Recombination due to traps and Auger process limits the efficiency of a laser. In mature semiconductors such as GaAs and InP, the defect density is low so that recombination due to traps can be kept low. On the other hand the Auger process depends on the intrinsic band structure. What are the material parameters that control the Auger recombination?

5) Explain why fabrication of room temperature laser is increasingly difficult at infrared wavelengths. Propose how semiconductor infrared laser can be fabricated.

6) To achieve high radiative recombination, it is necessary to achieve population inversion. Discuss strategies to reduce the threshold current required to achieve population inversion.

7) List the advantages of multiple quantum well lasers over bulk lasers.