**Assignment**

1. An engineer has two Ga1-xAlxAs LEDs: one has bandgap energy of 1.540 eV and the other has x = 0.015.
   1. Find the aluminium mole fraction x and the emission wavelength for the First LED.
   2. Find the bandgap energy and emission wavelength of the other LED
2. A double-heterojunction InGaAsP LED emitting at a peak wavelength of 1310 nm has radiative and non-radiative recombination times of 35 and 100 ns respectively. The drive current is 25 mA.
   1. Find the internal quantum efficiency and the internal power level.
   2. If the refractive index of the light source material is n = 3.5, find the power emitted from the device.
3. Assume the injected minority carrier lifetime of an LED is 5 ns and that the device has an optical output of 0.30 mW when a constant dc drive current is applied. Plot the optical output power when the LED is modulated at frequencies ranging from 20 to 100 MHz. Note what happens to the LED output power at higher modulation frequencies.
4. A ruby laser contains a crystal of length 4 cm with a refractive index of 1.78. The peak emission wavelength from the device is 550 nm. Determine the number of longitudinal modes and their frequency separation.
5. An injection laser has an active cavity with losses of 30 cm-1 and the reflectivity of the each cleaved laser facet is 30%. Determine the laser gain coefficient for the cavity when it has a length of 600 µm.
6. A GaAs injection laser has an optical cavity of length 250 µm and width 100 µm.
   1. At normal operating temperature the gain factor β is 21x 10-3 A cm -3 and the loss
   2. Coefficient α per cm is 10. Determine the threshold current density and hence the threshold current for the device. It may be assumed that the cleaved mirrors are uncoated and that the current is restricted to the optical cavity. The refractive index of GaAs may be taken as 3.6.
7. What are the different structures for current confinement in Laser and explain them in detail.
8. Write a note on Modulation of laser diodes and explain the bandwidth limitation of such devices.
9. When 3 × 1011 photons each with a wavelength of 0.85μm are incident on a photodiode, on average 1.2 × 1011 electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at 0.85μm.
10. A photodiode has a quantum efficiency of 65% when photons of energy 1.5 × 10−19 J

are incident upon it.

a. At what wavelength is the photodiode operating?

b. Calculate the incident optical power required to obtain a photocurrent of 2.5 μA

when the photodiode is operating as described above.

1. GaAs has a bandgap energy of 1.43 eV at 300 K. Determine the wavelength above

which an intrinsic photo detector fabricated from this material will cease to operate.

1. An APD with a multiplication factor of 20 operates at a wavelength of 1.5 μm. Calculate the quantum efficiency and the output photocurrent from the device if its responsivity at this wavelength is 0.6 A W−1 and 1010 photons of wavelength 1.5 μm are incident upon it per second.
2. Given that the following measurements were taken for an APD, calculate the multiplication factor for the device. Received optical power at 1.35 μm = 0.2 μW Corresponding output photocurrent = 4.9 μA (after avalanche gain) Quantum efficiency at 1.35 μm = 40%
3. An APD has a quantum efficiency of 45% at 0.85 μm. When illuminated with radiation of this wavelength it produces an output photocurrent of 10 μA after avalanche gain with a multiplication factor of 250. Calculate the received optical power to the device. How many photons per second does this correspond to?