1] The radiative & non radiative recombination life times of minority carrier in active region of a double heterojunction LED are 60 nsec & 90nsec resp. Determine the total carrier recombination life time & optical power generated internally if the peak emission wavelength is 870nm & the drive current is 40mA

Sol^n $\lambda = 870nm = 0.87\times10^{-6}m$

$\tau_r = 60nsec$; $\tau_{nr} = 90ns$

$I = 40mA = 0.04A.$

i] Total recombination life time

$$\frac{1}{\tau} = \frac{1}{\tau_r} + \frac{1}{\tau_{nr}} = \frac{1}{60} + \frac{1}{90} = \frac{150}{5400}$$

$$\boxed{\tau = 36ns}$$

ii) Internal optical power

$$P_{int} = \eta_{int}\,\frac{hcI}{q\lambda}$$

$$= \left(\frac{\tau}{\tau_r}\right)\left(\frac{hcI}{q\lambda}\right)$$

$$= \left(\frac{36}{60}\right)\left[\frac{6.625\times10^{-34}\times3\times10^{8}\times0.04}{(1.602\times10^{-19})(0.87\times10^{-6})}\right]$$

$$= 0.0342\ Watt$$

$$= 34.22\ mW$$

2] A double heterojun^n InGaAsP LED operating at 1310nm has radiative & non-radiative recombination times of 30 & 100ns resp. The current injected is 40mA Calculate · Bulk recombination life time · Internal quantum efficiency Internal power levels.

Given: $\lambda = 1310\ nm$

$\tau_r = 30ns$

$\tau_{nr} = 100ns$

$I = 40mA = \underline{\underline{0.04A}}$

& Bulk Recomb lifetime (τ)

$$\eta_{int} = \frac{\tau}{\tau_r}$$

$$\frac{1}{\tau} = \frac{1}{\tau_r} + \frac{1}{\tau_{nr}} = \frac{1}{30} + \frac{1}{100} = \frac{13}{300}$$

$$\underline{\tau = 23.077\ ns}$$

Internal quantum efficiency (η_{int})

$$\eta_{int} = \frac{23.077}{30} = 0.769$$

Internal power Level (P_{int}):

$$P_{int} = \eta_{int} \frac{hcI}{q\lambda}$$

$$= 0.769 \times \frac{6.625 \times 10^{-34} \times 3 \times 10^{8} \times 0.04}{1.602 \times 10^{-19} \times 1310 \times 10^{-9}}$$

$$= 0.02913$$

$$= \underline{\underline{29.13\ mW}}$$

8] In a 100ns pulse 6×10^6 photons at wavelength of 1300 nm fall on the InGaAs photodetector On the Average 5.4×10^6 electron hole pairs are generated. Calculate the quantum efficiency.

$\lambda = 1300nm$

$$\eta = \frac{\text{no. of } \cancel{\text{photons}} \text{ electron hole pair}}{\text{no. of photons}}$$

$$= \frac{5.4 \times 10^{6}}{6 \times 10^{6}}$$

$$= 0.9 \simeq 90\%$$

Q) Photons of energy 1.53×10^{-19} are incident on a photodiode which has a responsivity of 0.65 A/w. If the optical power level is 10 μW Calculate the photo current generated

Photo current $I_p = R P_{in}$

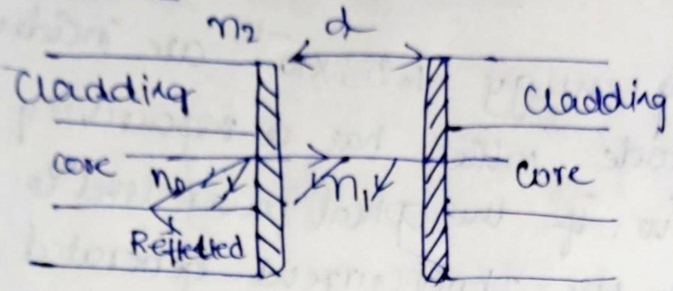
$$= 0.65 \times 10 \times 10^{-6}$$

$$= \cancel{0.65}\ 6.5\ \mu A$$

* Sources & detectors
* Coupler. Butt. connector

Till splicing → Test 2

* Connector return loss

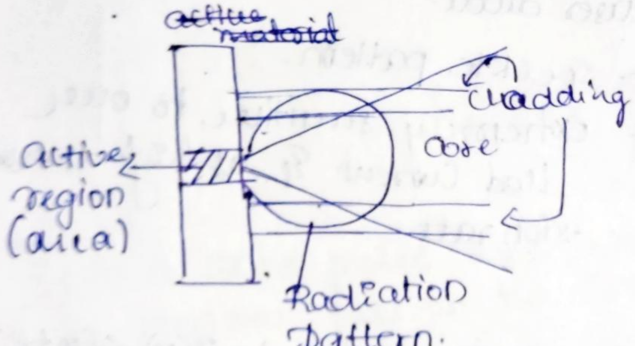


* Index matching material.

?? $-10 \log (2R_1$.

$R_1 = n_0 - n$

* Power coupled to the GRIN & SI



Power fed in step index

$P_{LED, STEP} = \pi^2 r_s^2 B_0 (NA)^2$

$B_0 \to$ axial radiance

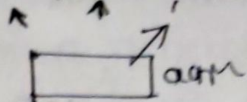
$r_s \to$ radius of SI

Light Emitter

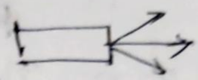
↳ Light emitting diode

* Surface emitting (SLED): . difficult to focus, see ocq

Surface radiation

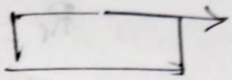


* Edge emitting (ELED): easier to focus faster



↳ Laser Diode

* narrow beam
* fastest



Quantum efficiency & power:-

Internal quantum efficiency (η_{int}) is radio of radiative recombination (R_r) rate to the total recombination rate

$R_{nr} \rightarrow$ non radiation

$$\eta_{int} = \frac{R_r}{R_r + R_{nr}}$$

$$\tau_r = \frac{n}{R_r}$$

If n are the excess carrier, then radiative life time, & non-radiative life time -th

$$\tau_r = \frac{n}{R_{nr}}$$

The internal quantum eff is given. The recombination of carriers in active region (Bulk recombination life time)

$$\eta_{in} = \frac{1}{1 + \frac{R_{nr}}{R_r}}$$

$$\boxed{\frac{1}{\tau} = \frac{1}{\tau_r} + \frac{1}{\tau_{nr}}}$$

$$\eta_{int} = \frac{1}{1+\frac{\tau_r}{\tau_{nr}}}$$

$$\therefore \quad \eta_{int} = \frac{\tau}{\tau_r}$$

if current in LED I & q is the electron charge

recombination per second

$$R_r = R_{nr} = \frac{I}{q}$$

$$\eta_{int} = \frac{R_r}{I/q}$$

$$R_r = \eta_{in} \times \frac{I}{q}$$

Optical Power generated by LED

$$P_{int} = R_r h\nu$$

$$P_{int} = \left(\eta_{int} \times \frac{I}{q}\right) h\nu$$

$$P_{int} = \left(\eta_{int} \times \frac{I}{q}\right) h\frac{c}{\lambda}$$

Not all internally generated photons will available from output of device. The external quantum eff is used to calculate the emitted power. The ext quant eff is defined as the ratio of photons emitted

$$\boxed{P = \frac{1}{n(n+1)^2} P_{int}}$$