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Optical Sources Assignments

1. Known Two $Ga_{1-x}Al_yAs$ LEDs
   1. Has E_g = 1.540 eV
   2. Has x = 0.015

   Questions: a. Find x for the first LED
   b. Find E_g for the second LED & λ

   Answer :

   a. E_g : $1.35 - 0.72y + 0.12y^2 = 1.540$

   $0.12y^2 - 0.72y - 0.19 = 0$

   $y = 6.2532$

   $y = 2.20\,x$

   $x = \frac{6.2532}{2.20} = 2.84$

   b. $E_g = 1.35 - 0.72y + 0.12y^2$; $y = 2.20x$

   $y = 2.20 - 0.015$

   $y = 0.035$

   $E_g = 1.35 - 0.72(0.035) + 0.12(0.035)^2$

   $E_g = 1.35 - 0.02376 + 0.00015012$

   $E_g = 1.326$ eV

   $\lambda = \frac{1.24}{E_g} = 0.935\,\mu m$

2. Known : InGaAsP LED → λ = 1310 nm
   τ_r = 25 ns , τ_{nr} = 90 ns
   I = 35 mA

   Question : a. Find the internal quantum efficiency and the internal power level
   b. If n = 3.5, find the power emitted

   Answer : a. $\eta_{ic} = \frac{1}{1 + (\tau_r/\tau_{nr})} = \frac{1}{1 + (25/90)} = \frac{1}{1.0.28} = 0.78$

   $P = \eta \cdot \frac{hcI}{q\lambda} = 0.78 \cdot \frac{(6.625 \times 10^{-34})(3 \times 10^8)(35 \times 10^{-3})}{(1.602 \times 10^{-19})(1310 \times 10^{-9})}$

   $P = 0.0258\,W = 25.8$ mW

3. Known : GaAlAs laser → $\alpha = 10\ cm^{-1}$
   $R_1 = R_2 = 0.32$

   Question : a. Optical gain at the lasing threshold?
   b. If $\eta = 90\%$, what is the optical gain at the lasing threshold?
   c. If $\eta = 0.65$, what is the external quantum efficiency in case (a) and (b)?

   Answer : a. $\Gamma_{th} = \alpha + \frac{1}{2L} \ln\left(\frac{1}{R_1 R_2}\right)$

   $= 10 + \frac{1}{2(500 \times 10^{-4})} \ln\left(\frac{1}{0.32 \cdot 0.32}\right) = 33.7\ cm^{-1}$

b. $\eta = \frac{R_r}{R_r + R_{ar}}$

$0.9 = \frac{0.32}{0.32 + R_{ar}}$

$0.288 + 0.9 R_{ar} = 0.32$

$R_{ar} = 0.0356$

$\Gamma_{th} = \alpha + \frac{1}{2L} \ln\left(\frac{1}{R_1 R_2}\right)$

$= 10 + \frac{1}{(500 \times 10^{-4}) 2} \ln\left(\frac{1}{0.32 \times 0.0356}\right)$

$= 10 + \frac{1}{2(500 \times 10^{-4})} \ln 4.4798$

$= 10 + 4.4748 \times 10^{-3}$

$\Gamma_{th} = 10.004 \text{ cm}^{-1}$

c. $\eta_{ext} = \frac{\eta_i (g_{th} - \alpha)}{g_{th}}$

For (a) $\eta_{ext} = \frac{0.65 (33.7 - 10)}{33.7} = 0.457$

For (b) $\eta_{ext} = \frac{0.65 (10.004 - 10)}{10.004} = 2.6 \times 10^{-4}$

4. Known: GaAs laser → $\lambda = 800 \text{ nm}$

$L = 400 \mu m$

$n = 3.6$

$750 \text{ nm} < \lambda < 850 \text{ nm}$

Question: How many modes will exist in the laser?

Answer: