Jordan University of Science and Technology
Department of Electrical Engineering
Optical Fiber Communication Systems (EE555) 2nd Exam

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Q1 What are the materials which can be used in optical sources and in optical detectors? Which of them are used in the third window?

Q2 Draw the structure, the refractive index profile and the energy band diagram for a double-heterostructure light emitting diode.

Q3 What are the three conditions necessary for the operation lasers? What are the three confinement methods used in lasers?

Q4 An $In_{1-x}\ Ga_x\ As_y\ P_{1-y}$ LED has x = 0.2, y = 2.2x, and a refractive index n = 3.5. The radiative and nonradiative recombination life times are 30ns and 90ns, respectively. The drive current is 30 mA. Find E_g, the wavelength, the internal optical power, and the external optical power emitted to air.

Q5 A GaAs laser has: λ_o= 850 nm, an optical cavity of length 500 μm and width 10 μm, uncoated facets with reflectivities $R_1=R_2$= 0.32, a peak optical gain g(0) = 60 cm^{-1}, gain spectral width σ = 5 nm, an absorption coefficient α = 20 cm^{-1}, a confinement factor Γ=0.8, and a gain factor β= 0.02 A/cm^3. Find the optical gain threshold g_{th}, the threshold current I_{th}, and the number of excited modes.

Q6 What are the two techniques used to restrict the laser to have only a single-mode? Why single mode laser is better than multimode laser?

Q7 An APD photodiode has a band-gap energy E_g= 0.75 eV, a quantum efficiency η = 0.9 and a multiplication ratio of M = 40. Calculate the cutoff wavelength and the generated photocurrent if the incident optical power is - 40 dBm at 1550 nm.

Q8 What are the four types of noise generated in a photodiode receiver? Which of them is the largest in pin photodiode and in APD?

Q9 Draw the structure of a pin and an APD photodiodes showing the biasing circuit. How can we increase their quantum efficiency?

Q10 Calculate the number of electron-hole pairs generated in a pin photodiode and in an APD with multiplication gain of 50 if the incident optical power is 50 μW, the quantum efficiency is 0.9 and λ = 1300 nm.

$$\lambda(\mu m) = \frac{1.24}{E_g(eV)},\quad \eta_{int} = \frac{\tau_{nr}}{\tau_r + \tau_{nr}},\quad \eta_{ext} = \frac{1}{n(n+1)^2},\quad P_{int} = \eta_{int}\frac{hcI}{q\lambda}$$

$$\gamma_m = \bar{\alpha} + \frac{1}{2L}\ln\left[\frac{1}{R_1R_2}\right],\quad g_{th} = \beta J_{th},\quad g(\lambda) = g(0)\exp\left[-\frac{(\lambda-\lambda_0)^2}{2\sigma^2}\right]$$

$$\Delta\lambda = \frac{\lambda^2}{2Ln},\quad R_{pin} = \frac{q\lambda}{hc},\quad R_{APD} = M R_{pin},\quad I_p = R_{pin}P_o,\quad I_M = M I_p$$

$$q = 1.6\times10^{-19},\quad h = 6.625\times10^{-34},\quad C = 3\times10^8\ m/s.$$

$$\frac{I_p/q}{P_o/h\nu} = \frac{\#\text{holes}}{\#\text{Photons inc}}$$

2"