SRM Institute of Science and Technology
College of Engineering and Technology
DEPARTMENT OF ECE
SRM Nagar, Kattankulathur – 603203, Chengalpattu District, Tamilnadu

Academic Year: 2021-2022 (EVEN)

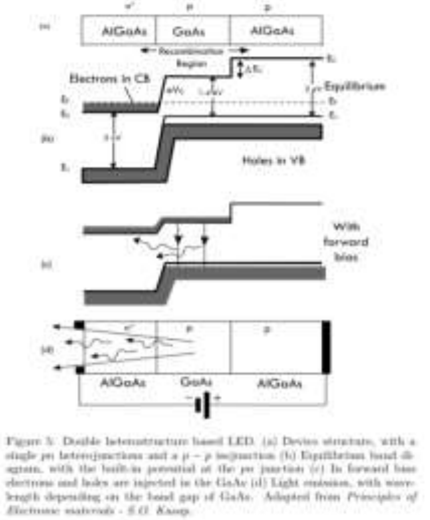
Mode of Exam
OFFLINE
SET B

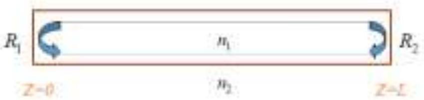
Test: CLAT- 2 | **Date:** 25-5-2022
Course Code & Title: 18ECE322T – OPTOELECTRONICS | **Duration:** 08:00 –09:40 PM
Year & Sem: II / 4th Sem | **Max. Marks:** 50

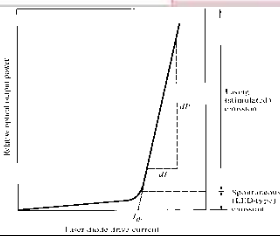
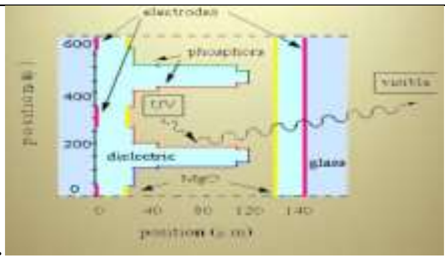
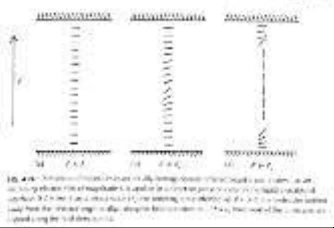
Course Articulation Matrix with PI:

	18ECE322T- Optoelectronics		Program Outcomes (POs)																								PSO		
COs	Course Outcomes	BL	1	PI	2	PI	3	PI	4	PI	5	PI	6	PI	7	PI	8	PI	9	PI	10	PI	11	PI	12	PI	1	2	3
CO-1:	Define the basic concepts of optics and semiconductor optics.	1	3	1.4.1	-		-		-																				1
CO-2:	Demonstrate the working principle of various photonic sources and display devices.	3	3	1.2.1	3	2.1.2	-		2	4.1.1																			3
CO-3:	Analyze the principle and operation of various detectors and noise associated with it.	4	-		3	2.1.3	2	3.1.1	3	4.1.2																			3
CO-4:	Interpret the various optoelectronic modulators, switches, and interconnects.	3	3	1.3.1	2	2.2.1	3	3.2.1	-																				2
CO-5:	Apply the concepts of integrated optoelectronic components and its application in various fields.	3	3	1.4.1	-		3	3.2.2	3	4.2.1																			3

Part - A
(10 x 1 = 10 Marks)
Instructions: Answer ALL the Questions

Q. No	Question	Marks	BL	CO	PO	PI
1	D)Low thermal dissipation	1	1	2	1	1.2.1
2	B)Model separation	1	1	2	1	1.2.1
3	A)Optical pumping	1	2	2	1	1.2.1
4	C)Electroluminescent	1	2	2	1	1.2.1
5	C)Several hundreds of volts	1	1	2	1	1.2.1
6	B)Photo detector performance	1	2	3	3	3.1.1
7	C)Nano Sec	1	1	3	3	3.1.1
8	A)High voltage carriers causing Impact Ionization of the lattice atoms	1	2	3	3	3.1.1
9	A)InGaAs	1	1	3	3	3.1.1
10	A)No bias is applied	1	2	3	3	3.1.1
	Part – B **(4 x 10 = 40 Marks)**					
	SECTION B1 **Instructions: Answer ANY 2 Questions**					
11		5	4	2	1	1.2.1
	$\tau = \frac{\tau_r \tau_{nr}}{\tau_r + \tau_{nr}} = \frac{30\times 100}{30+100} ns = 23.1\ ns$ $\quad \eta_{int} = \frac{\tau}{\tau_r} = \frac{23.1}{30} = 0.77$ $P_{int} = \eta_{int}\frac{hcI}{q\lambda}$ $= 0.77\frac{(6.6256\times10^{-34} J\cdot s)(3\times10^{8} m/s)(0.040A)}{(1.602\times10^{-19} C)(1.31\times10^{-6} m)}$ $= 29.2 mW$	5	4	2	2	2.1.2
12	**a.**The radiation intensity of a photon at energy varies exponentially with a distance z	6	4	2	1	1.2.1

<table>
<tr><td></td><td>amplified by factor g, and attenuated by factor according to the following relationship:
$$I(z)=I(0)\exp[(\Gamma g(h\upsilon)-\overline{\alpha}(h\upsilon))z]$$


$$I(2L)=I(0)R_1R_2\exp[(\Gamma g(h\upsilon)-\overline{\alpha}(h\upsilon))(2L)]$$
Γ : Optical confinement factor, g : gain coefficient
$\overline{\alpha}$: effective absorption coefficient, $R=\left(\frac{n_1-n_2}{n_1+n_2}\right)^2$
Lasing Conditions: $\boxed{\begin{array}{l} I(2L)=I(0) \\ \exp(-j2\beta L)=1 \end{array}}$

</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>$$\Delta\lambda=\frac{\lambda^2}{2nL}\Delta m,$$
b. for the neighboring modes ($\Delta m = 1$) we obtain $\Delta\lambda = 8.3$ Å.</td><td>4</td><td>3</td><td>2</td><td>3</td><td>3.1.1</td></tr>
<tr><td>13</td><td>a. 
</td><td>5</td><td>2</td><td>2</td><td>4</td><td>4.1.1</td></tr>
<tr><td></td><td>b. There are three basic types of ordering in liquid crystals, which are termed nematic, cholesteric and smectic. Only the first two of these are of importance in display devices at present and are illustrated in Fig. 4.23. In nematic ordering, the molecules (or, rather, the directors) are aligned parallel to each other, but apart from remaining parallel the molecules are free to move relative to each other so that the phase has liquid properties. A nematic liquid crystal molecule usually consists of two benzene rings linked with a central group. A typical example is 4-methoxybenzylidene-4-butylanaline (MBBA), which has the chemical formula CH_3—O—⬡—CH=N—⬡—C_4H_9. MBBA shows liquid crystal behaviour over the temperature range 20°C to 47°C. For more general details concerning liquid crystal materials the reader is referred to ref. 4.10.
</td><td>5</td><td>2</td><td>2</td><td>4</td><td>4.1.1</td></tr>
<tr><td></td><td colspan="6">SECTION B2
Instructions: Answer ANY 2 Questions</td></tr>
<tr><td>14</td><td>The PIN photodiode is structured with p and n regions separated by a lightly n-doped intrinsic (i) region. Incident photon with energy ≥ band-gap energy of the photodiode will generate free electron-hole pairs, known as photo-carriers. The high electric field present in the depletion region causes the carriers to separate and be collected across the reverse-biased junction. This gives rise to a photo-current flow in an external circuit, with one electron flowing for every carrier pair generated. In the absence of light, PIN photodiodes behave electrically just like an ordinary rectifier diode. If forward biased, they conduct large amount of current.</td><td>5</td><td>2</td><td>3</td><td>4</td><td>4.1.2</td></tr>
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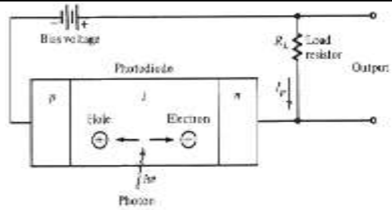
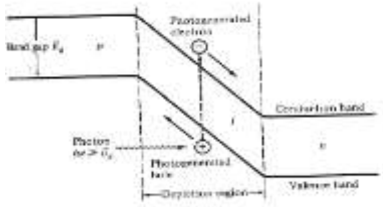
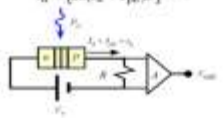
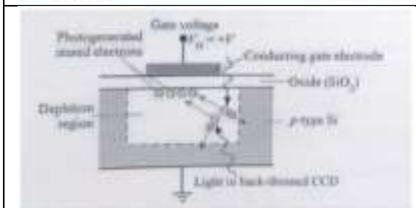
<tr><td></td><td>

a.

</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Solution
The incident light intensity I = 0.1 mW cm^{-2} means that the incident power for conversion is
$P_o = AI = [\pi(0.02 \text{ cm})^2](0.1\times10^{-3} \text{ W cm}^{-2}) = 1.26\times10^{-7}$ W or 0.126 μW.

The responsivity is
$R = I_{ph}/P_o = (56.6 \times 10^{-9} \text{ A})/(1.26\times10^{-7} \text{ W}) = \mathbf{0.45\ A\ W^{-1}}$

The QE can be found from

$$\eta = R\frac{hc}{e\lambda} = (0.45 \text{ A W}^{-1})\frac{(6.62\times10^{-34} \text{ J s})(3\times10^{8} \text{ m s}^{-1})}{(1.6\times10^{-19} \text{ C})(700\times10^{-9} \text{ m})} = 0.80 = \mathbf{80\,\%}$$</td><td>5</td><td>3</td><td>3</td><td>2</td><td>2.1.3</td></tr>
<tr><td>15</td><td>Noise in pn and pin Photodetectors
Quantum noise: The photodetection process involves the interaction of discrete photons with valence electrons. The quantum nature of photons gives rise to a statistical randomness in the EHP photogeneration process, and thus the photocurrent will always exhibit fluctuations about its mean value
$$i_{n-quantum} = [2eI_{ph}B]^{1/2}$$
The total noise will be
$$i_n^2 = i_{n-dark}^2 + i_{n-quantum}^2 \qquad i_n = [2e(I_d + I_{ph})B]^{1/2}$$
There will be a sampling resistor for measuring the current and an amplifier. The total noise should also include the thermal noise in the resistor and the noise in the input stage of the amplifier.
</td><td>4</td><td>4</td><td>3</td><td>4</td><td>4.1.2</td></tr>
<tr><td></td><td>Soln:
η = 60% = 0.6
P_{in} = 200 nW = 200x10^{-9} watt
λ = 0.9 μm = 0.9x 10^{-6} meters
I_d = 3 nA = 3 x 10^{-9} Ampere
R_L = 4 kΩ = 4 x 10^3 ohms
B = 5 MHz = 5 x 10^6 Hz
Photocurrent (I_p) is given by:
$$I_p = \frac{\eta P_{in} q\lambda}{hc}$$
$$I_P = \frac{0.6(200\times10^{-9})(1.602\times10^{-19})(0.9\times10^{-6})}{6.626\times10^{-34}\times2.998\times10^{8}} = \frac{1.73\times10^{-32}}{1.98\times10^{-25}} = 87.37nA$$
Mean square quantum (or) shot noise current for a pin photodiode is
$$\langle i_Q^2\rangle = \sigma_Q^2 = 2qI_pB$$
$$= 2\times1.6\times10^{-19}\times87.37\times10^{-9}\times5\times10^{6}$$
$$= 1.3979\times10^{-19} A^2$$
$\langle i_Q^2\rangle^{1/2}$ = 0.37388 nA</td><td>6</td><td>3</td><td>3</td><td>2</td><td>2.1.3</td></tr>
<tr><td>16</td><td><table>
<tr><th>S. No</th><th>Parameters</th><th>PIN</th><th>APD</th></tr>
<tr><td>1</td><td>Sensitivity</td><td>Less sensitive (0-12 dB)</td><td>More sensitive (5-15 dB)</td></tr>
<tr><td>2</td><td>Biasing</td><td>Low reverse biased voltage (5 to 10 V)</td><td>High reverse biased voltage (20 - 400 volts)</td></tr>
<tr><td>3</td><td>Wavelength region</td><td>300 -1100 nm</td><td>400 - 1000 nm</td></tr>
<tr><td>4</td><td>Gain</td><td>No Internal gain</td><td>Internal gain</td></tr>
<tr><td>5</td><td>S/N Ratio</td><td>Poor</td><td>Better</td></tr>
<tr><td>6</td><td>Detector Circuit</td><td>Simple</td><td>More complex</td></tr>
<tr><td>7</td><td>Conversion efficiency</td><td>0.5 to 1.0 A/W</td><td>0.5 to 100 A/W</td></tr>
<tr><td>8</td><td>Cost</td><td>Cheaper</td><td>More Expensive</td></tr>
<tr><td>9</td><td>Support circuitry required</td><td>None</td><td>High voltage and temperature compensation</td></tr>
</table></td><td>5</td><td>4</td><td>3</td><td>4</td><td>4.1.2</td></tr>
<tr><td></td><td>
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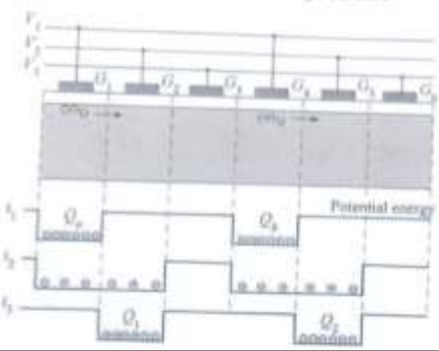
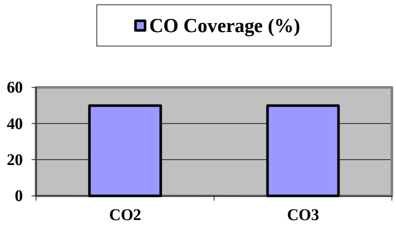
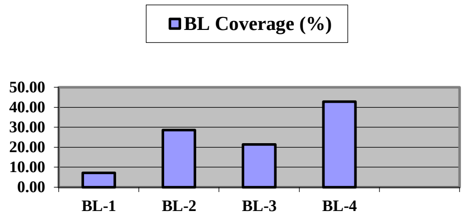
						

Course Outcome (CO) and Bloom’s level (BL) Coverage in Questions





Approved by the Course Coordinator **Signature of the Question paper setter**