

# Indian Institute of Technology, Delhi

## Semiconductor Optoelectronics (EPL336)

Major May 2010

Answer all questions

Max = 40 marks

Bullet point explanation is just enough

1. (a) Compare the features (at least five points) of Mott and Frenkel excitons and estimate first and second order exciton peaks in a pure GaAs semiconductor\*. ( check footnote for useful details)  
(b) Differentiate between terms/terminologies spontaneous emission, stimulated emission, optical gain and laser.  
(c) Describe (briefly) the radiative recombination process at different quantities of carrier injection.  
(d) Show "graphically" how degenerate and non-degenerate nature of semiconductor changes with the increase of doping concentration in bulk and Quantum Wells.

... 15 marks

2. (a) Categories basic mechanism of photodiode detectors (how photons are collected and converted into current).  
(b) What is the usual electric bias operation of photodiode detector, why?  
(c) What are the advantages/drawbacks of Avalanche photodiode detector?  
(d) Explain the advantages of p-i-n photodiode over conventional p-n photo diode.  
(e) What is quantum efficiency and responsivity of photodiode?

.... 10 marks

3. (a) Write a short note on nonlinear refraction and nonlinear absorption. Discuss any one of the application of such nonlinearity in optoelectronics.  
( b) If two optical beams, 1000nm and 600nm, are incident on a nonlinear material, assuming 2<sup>nd</sup> order nonlinearity, what are the possible wavelengths be generated from this material?

....5 marks

4. Explain *briefly* the following electro-optic device operation. What kind of EO effect, is it Kerr or Pockel type?  
(a) Quantum confined stark effect (QCSE) device  
(b) LiNbO<sub>3</sub> crystal phase modulator  
(c) Liquid crystal display device

.... 10 marks

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\* Useful Constants: GaAs ( $E_g=1.424\text{V}$ ,  $m_h^*=0.51m_0$ ,  $m_e^*=0.063m_0$  ; static dielectric constant = 12.9)

$k_B= 8.617\cdot 10^{-5} \text{ eV K}^{-1}$ , Electron rest mass  $m_0= 9.1\cdot 10^{-31} \text{ kg}$ ,  $\hbar = 1.05\cdot 10^{-34} \text{ J-s}$