K19P 0114

Reg. No. : .....

Name : .....

IV Semester M.Sc. Degree (Reg./Suppl./Imp.) Examination, April 2019
(2014 Admission Onwards)
PHYSICS
PHY 4E06 : Optoelectronics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer both questions (either **a** or **b**).

1. a) Explain the semiconductor statistics. Arrive an expression for electron concentration in a conduction band, hole concentration in valence band, Fermi-level in intrinsic crystal.

   OR

   b) What is mode locking ? Explain the techniques for producing mode-locking.

2. a) i) Explain the principle and operation of the phototransistors.
      ii) Briefly explain Avalanche noise in the APD.

   OR

   b) Briefly explain the following non-linear optical processes.
      i) Second harmonic generation
      ii) Sum and frequency generation
      iii) Optical parametric oscillation. **(2×12=24)**

SECTION – B

Answer **any four**. (**1** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Write and explain the Fermi-Dirac function.
   b) Explain degenerate and non degenerate semiconductors.
   c) Consider a GaAs LED. The band gap of GaAs at 300 K is 1.42eV, which changes (decreases) with temperature as $\frac{dE_g}{dT} = -4.5 \times 10^{-4} eVK^{-1}$. What is the change in the emitted wavelength if the temperature change is 10°C ?

P.T.O.

4. a) What is meant by surface emitting LEDs ?

   b) Explain Q-switching with a rotating mirror as a shutter.

   c) Compute the mode-locked pulse width Δt_p and the separation between pulses Δt_{sep} for the Helium-Neon laser operating at 632.8 nm with mirror cavity spacing of d = 0.5 m. For the He-Ne laser we assume that modes will lase over the FWHM emission line width of the 632.8 nm transition of 1.5×10^9 Hz.

5. a) What is a PIN photodiode ?

   b) Briefly explain the acousto-optic effect.

   c) Consider a silicon PIN photo diode with an intrinsic region of width 10 μm. Light from a GaAs laser at energy 1.43 eV impinges up on the diode. The optical power is 1 W/cm^2. Calculate the photocurrent density in the detector. (The absorption coefficient for Si at GaAs wavelength is 700 cm^{-1}).

6. a) What is Pockels effect ?

   b) Briefly explain birefringence of calcite crystals.

   c) Given the following data for a $PbMO_4$ acousto-optic modulator, we may calculate the Bragg angle, the maximum change in refractive index of the material and the maximum width of the optical beam of wavelength 633 nm that may be modulated with a bandwidth of 5 MHz. The modulator length is 50 mm, diffraction efficiency 70%, while the acoustic wavelength is 4.3×10^{-5} m and the acoustic velocity is 3500 m/s.

7. a) What is meant by optical bistability ?

   b) How to achieving phase matching in birefringent optical materials ?

   c) Briefly describe the theory of third-order nonlinear optical processes.

8. a) What is meant by self focusing of light ?

   b) Explain two-photons absorption.

   c) Sketch and explain carrier concentration profiles across the pn junction under forward bias.

(4×9=36)