2018

M.Sc.

4th Semester Examination

PHYSICS

PAPER – PGS-403 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

The figures in the right hand margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

(Gr. A –Semiconductor Devices)
Answer Q1 and Q2 and any one from Q3 and Q4.

1. Answer any five bits: 5 X 2 = 10

(i) Describe the band structure of the material which leads to Gunn Effect oscillation. Why mobility varies with application of field in such material?

(ii) Describe the working principle of a phototransistor.

(iii) Write down the conditions of a system to observe quantum Hall effect.

(iv) A sample of silicon is doped with 10^{17} phosphorous atoms per cm^3. Find the Hall voltage, if the sample has 100 μm thickness and I_x = 1 mA and $B_z = 10^{-5}$ Wb/m^2.

(v) For n-channel silicon (dielectric constant=12) FET with a channel-half width, a = 3 x 10^{-6} m is doped with a concentration $N_d = 10^{21}$ m^{-3}. Find the pinch-off voltage.

(vi) What is the advantage of the use of MOSFET (CMOS) in memory circuits?

(vii) At a given temperature, prove that an extrinsic semiconductor has minimum electrical conductivity σ_m given by $\sigma_m = 2en_i\left(\mu_n\mu_p\right)^{1/2}$

(viii) In an *n-type* intrinsic semiconductor at absolute temperature 300K find the donor concentration for which the Fermi level coincides with the edge of the conduction band. Assume that the effective mass of the electron equals the true mass.

2. (a) What is Coulomb Blockade effect in Single Electron Transistor (SET)?

(b) For a possible electron tunneling in SET what should be the biasing voltage?

(c) Explain the advantage of the gate electrode in SET. Draw the current-voltage characteristics of SET for different values of gate voltage and explain the electron tunneling mechanism. (2+2+6)

3.a) What are non-degenerate and degenerate semiconductor? Assuming Boltzmann transport equation derive the Seebeck Coefficient of n-type nondegenerate semiconductors $S_n = -\frac{1}{eT}\left[\frac{\langle \tau E \rangle}{\langle \tau \rangle} - E_f\right]$, where symbols have their usual meanings. (2+6)

b) Considering both p-type and n-type impurity of the degenerate semiconductors write down the expression for Seebeck Coefficient (2)

(Gr. B – *Applied Optics*)

1. Answer any five bits: 5 X 2 = 10

(i) Write some characteristics of V parameter.

(ii) Consider a symmetric step-index waveguide with $n_1 = 1.5$, $n_2 = 1.46$, $d = 4$ μm operating at $\lambda_0 = 0.6328$ μm. Calculate the number of symmetric and anti-symmetric modes.

(iii) What is quasi-phase matching condition?

(iv) The power of a 2 mW laser beam decreases to 15 μW after traversing through 25 km of a single mode optical fiber. Calculate the attenuation of the fiber.

(v) What is Kerr effect? How it is different from Pockel's effect?

(vi) Consider a bare fiber consisting of a core of refractive index (n_1) 1.48 and having air ($n_2 = 1$) as cladding. What is NA? What is the maximum incident angle up to which light can be guided by the fiber?

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(vii) Using any switching mechanism, draw the ray diagram of 'OR' and 'NOT' (optical) gate.

(viii) What are main causes of attenuation of power within optical fiber?

2. (a) Write down the differential equation of TE modes in case of light propagating along z direction through a symmetric step-index planar waveguide where the refractive indices [n(x)] are n_1 in the core ($|x| < d/2$) and n_2 in the cladding (($|x| > d/2$) regions. (1)

(b) For the symmetric modes prove the expression $\xi tan\xi = \left(\frac{1}{4}V^2 - \xi^2\right)^{1/2}$, where all the symbols have their usual meanings. (3)

(c) Only mention the related expression for anti-symmetric modes. Explain how you can determine the allowed values of propagation constant (β). (1+1)

(d) Deduce an expression for the material dispersion broadening of a light pulse propagating through an optical fiber. (4)

3. (a) What do you mean by second harmonic generation? Discuss, in detail, how the phase matching condition is obtained in a nonlinear material. (2+3)

(b) What is holography? Discuss the holographic recording and reconstruction of a point object by using the amplitudes of the incident, reference and reconstruction waves. (1+4)

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(Internal Assessment – 10)