Paper Code: MEC-905	Roll No.									

M.Tech.(Microelectronics)
(SEM I) ODD SEMESTER EXAMINATION 2015-16
PHYSICAL ELECTRONICS

Time: 3 Hours ***Maximum Marks:100***

Note: ***Attempt all questions. Assume suitable data if not given. Notations have usual meanings.***

Useful Constant : Planck constant , h = 6.626 x 10^{-34} J-sec,& Effective mass : For GaAs, $m_e^* = 0.067\ m_o$ & $m_h^* = 0.48\ m_o$ and For Si, $m_e = 1.1 m_o$ and $m_h = 0.56 m_o$ $\varepsilon_{r \text{ for silicon}} = 11.8$,Permittivity of free space , $\varepsilon_0 = 8.85 \text{ X} 10^{-14}$ F/cm,

Q.1. *Attempt any **TWO** parts of the following.* **10x2=20**

(a) *(i)*Why is it natural that three quantum numbers are needed to describe an atomic electron (apart from electron spin)?
*(ii)*What are the various quasi-particles in semiconductors? Explain them in detail.

(b) *(i)*A hydrogen atom is 5.3 X 10^{-11} m in radius. Use the uncertainty principle to estimate the minimum energy an electron can have in this atom.
*(ii)*Consider an electron travelling at a velocity of 10^7 cm/sec. Calculate the deBroglie wavelength of the particle.

(c) State and explain the Schrodinger wave equation in three dimensions. Consider an electron in an infinite potential well of width 5Angstroms. Calculate the first three energy levels of the electron in the potential well.

Q.2. *Attempt any **TWO** parts of the following.* **10x2=20**

(a) *(i)*A photon of monochromatic light of wavelength 5000 A^0 is absorbed in GaAs and excites an electron from the valence band into conduction band. Calculate the velocity of electron.
(iiDraw neat and clean sketches of The k-Space Diagrams of Ge and GaAs and explain them. Discuss the various features of the diagrams and mention the conclusion obtained, if any.

(b) (i) Show the (243) plane and the [243] direction in a cubic crystal lattice.
(ii)Determine the atomic density (in atoms/cm^2) in (100) plane of silicon (a= 5.43 Å).

(c) (i) Calculate the relaxation times for electrons and holes in Silicon and GaAs crystal.
(ii) Derive the simple diffusion equation for electron. How is diffusion length related with mobility of carrier? Also define and explain the diffusion length of carrier.Derive the equation which gives the distribution of excess holes as a function of x for steady state condition.

Q.3. *Attempt any **TWO** parts of the following.* **10x2=20**

(a) Explain the formation of built-in potential across a p-n junction diode at equilibrium condition. Derive an expression for it assuming step junction. How is this built-in potential modified by the application of bias voltage?

(b) An abrupt Silicon p-n junction has 5 x 10^{17} Boron atoms/ Cm^3 on one side and 3 x 10^{15} Phosphorus atoms/ Cm^3 on the other. Calculate the diffusion potential and draw an equilibrium energy band diagram for the junction . Show the Fermi level position and also calculate the diffusion potential from the diagram. Verify your result.

(c) Explain with suitable necessary energy-band diagrams the formation of schottky contact and ohmic contact in the case of metal and p-type semiconductor.

Q.4. *Attempt any **TWO** parts of the following.* **10x2=20**

(a) Define and derive the expression for the threshold voltage for MOS transistor. What are the factors which affect it? Explain.

(b) A p-type silicon sample has a uniform acceptor concentration, N_a = 5 X 10^{15} cm^{-3}. Calculate the surface potential required,

(i) to make the surface intrinsic, and

(ii) to bring strong inversion at the surface.

(iii) Also find the maximum width of the depletion region for this sample and charge per

unit area in the depletion region.

(c) What is the difference between homo-junction and hetero-junction? Explain them with neat sketches. How will you draw the band diagram for a hetero-junction accurately? Explain step by step with suitable example.

Q.5. *Attempt any **TWO** parts of the following.* **10x2=20**

(a) What do you mean by gettering? How will you achieve it for semiconductor technology? Explain with example.

(b) Describe Hall Measurement Technique to characterize the semiconductors.

(c) What is sheet resistance? Explain Four Point Probe method for its measurement.