(This Question paper contains 2 printed page)

Your Roll No............

Sr. No. of Question Paper : 8052
Unique Paper code:
Name of the paper: Semiconductor device modeling and simulation
Name of course: B.Sc(H) Instrumentation
Semester: VIII
Duration: 2 Hours
Maximum Marks: 60

Instructions for Candidates:

1. **Question No.1 is compulsory. All questions carry equal marks. Attempt any 5 questions in all.**
2. **Use of scientific calculator is allowed.**

Q.1 (a) Under equilibrium conditions and $T > 0K$, what is the probability of an electron state being occupied if it is located at Fermi level? (2)

(b) What are degenerate semiconductors? Draw energy-band diagram of degenerated p-type semiconductor (2)

(c) Draw Energy - Momentum diagram for an indirect band gap semiconductor. (2)

(d) Mention any two industry standard softwares used for semiconductor device simulation. (2)

(e) Differentiate between FinFET and HEMT. (2)

(f) The hole concentration in a piece of Si maintained at 300K under equilibrium conditions is $10^6/cm^3$. What is the electron concentration? (2)

Q.2 (a) What is the significance of Modeling in semiconductor industry? What are the three levels of modeling w.r.t semiconductor industry? (5)

(b) Define density of states. Express it mathematically (4)

(c) State the three fundamental equations that form the basis of most classical semiconductor device models in Technology Computer Aided Design (TCAD) simulators? (3)

Q.3 (a) Plot and compare Fermi function F(E) vs ($E-E_F$) at T=0K and T=500K (5)

(b) A silicon ingot is doped with 10^{17} Arsenic atoms/cm^3. Find the carrier concentrations and the Fermi level at room temperature (300 K). (4)

(c) A Si wafer is uniformly doped n–type with $N_D = 10^{16}/cm^3$. At T=0K, what are the equilibrium electron and hole concentrations? (3)

Q.4 (a) For a non-degenerate n type semiconductor, plot- energy band diagram, density of staes, Fermi distribution function and carrirer concentration (5)

(b) Define mobility w.r.t semiconductors. How is mobility related to effective mass of the carrier? (4)

(c) Assume that, in an n-type semiconductor at T = 300K, the electron concentration varies linearly from 1×10^{18} to 7×10^{17} cm^{-3} over a distance of 0.1 cm. Calculate the diffusion current density if the electron diffusion coefficient is D_n = 22.5 cm^2/s. (3)

Q.5 (a) Differentiate between Lattice scattering and ionized impurity scattering. (5)

(b) What is Generation of charge carriers? Explain any two types of generation processes using suitable energy-band diagrams. (4)

(c) State the general form of the continuity equation for holes in a semiconductor. Explain what each term physically represents? (3)

Q.6 (a) Draw a flowchart illustrating the sequential steps involved in simulating a p-MOSFET using an industry-standard Technology Computer Aided Design (TCAD) tool to analyse its electrical characteristics. (5)

(b) Derive the expression for built in potential for a p-n junction under equilibrium conditions. (4)

(c) A Si step junction maintained at room temperature under equilibrium conditions has a p-side doping of N_A= 2×10^{15} cm^{-3} and n-side doping of N_D= 10^{15} cm^{-3}. Calculate (i) Electric field at the metallurgical junction (x=0) (ii) Depletion width on n side- x_n (3)

Q.7 (a) Compare the distribution of the electric field and the space charge density in a step-graded p-n junction under two conditions: (i) at thermal equilibrium (zero bias), and (ii) after the application of a forward bias. (5)

(b) What is Gummel Poon model? What is the primary advantage of the Gummel-Poon model over the Ebers-Moll model for bipolar junction transistors? (4)

(c) Solve one dimensional Poisson's equation to obtain expressions for electric field, potential and depletion width in a step graded p-n junction under equilibrium conditions. (3)