Ref. No. : Ex/PG/ETC/PC/T/111C/2025

M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING FIRST YEAR FIRST SEMESTER - 2025

Subject : SEMICONDUCTOR DEVICE PHYSICS AND MODELING Time : 3 hours Full Marks : 100

Instructions : Answer all parts of a question together

Answer any six questions from 1 to 9 and Q10 [6×15+10=100]

1. a) Explain the family of cubic lattice alongwith its configurations with the help of diagrams. [10]
   b)Find the Miller indices for a plane that intercepts the crystallographic axes at a, 2b, and 3c in a cubic crystal system. [5]

2. a) Explain the process of doping in semiconductor. Find the position of Fermi level for a silicon doped by 10^{16} donor atoms/cc. [8+2]
   b)Draw and label a energy band diagram of a pn junction. [5]

3. a) Find the expression for intrinsic carrier concentration. The number of available electronic states per unit volume per unit energy is given by: $g_c(E) = \frac{8\pi\sqrt{2}m_n^{3/2}}{h^3}(E - E_c)^{1/2}$ [10]
   b)Given that N_C (Effective Density of States in the Conduction Band) is 10^{19} /cc. Calculate the intrinsic carrier concentration in Silicon. [5]

4. a)How does temperature affect the mobility of electrons and holes? [5]
   b)Derive the equation of current density for both drift and diffusion components. [10]

5. Find the expression for total current of a p-n junction. [15]

6. a)Explain Fermi level pinning.
   b)Draw energy band diagram of Schottky contact in n-type semiconductor showing schottky barrier height and built in potential clearly. Given Metal work function: Φ_M=4.9 eV, Electron affinity of silicon: χ=4.1 eV, Bandgap of silicon: Eg=1.12 eV, Doping concentration: $N_d=10^{16}\,cm^{-3}$. [5] [10]

7. a)Explain the ideal MOS C-V curve at Low-Frequency (LFCV) and High-Frequency (HFCV) characteristics. [10]
   b)Find the threshold Voltage for an n-channel MOS having following parameters: oxide thickness: t_{ox}=5 nm, oxide permittivity: $\varepsilon_{ox}=3.9\varepsilon_0$, silicon permittivity: $\varepsilon_s=11.7\varepsilon_0$, doping concentration: $N_A=10^{17}cm^{-3}$, intrinsic carrier concentration: $n_i=1.5\times10^{10}$ cm^{-3} and work function difference between metal and semiconductor: Φ_{MS}=0.5 V. [5]

8. a)Describe the different types of oxide charges and their effect in MOS capacitor. [8]
   b)Draw the energy band diagram of a MOS structure with $\Phi_M < \Phi_S$. [7]

9. Explain the short-channel MOSFET effects, focusing on: a) Threshold voltage change with channel length scaling b)Drain Induced Barrier Lowering (DIBL) and c)Velocity saturation. [15]

10. Derive the simplified I-V equation for a long-channel MOSFET in linear and saturation regions. [10]

    OR

    Describe the steps to find output and transfer characteristics of MOSFET using TCAD. [10]