Register No.: ..... Name: .....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

THIRD SEMESTER B.TECH DEGREE EXAMINATION (R,S), DECEMBER 2023
ELECTRONICS AND COMMUNICATION ENGINEERING
(2020 SCHEME)

Course Code : 20ECT201

Course Name: Solid State Devices

Max. Marks : 100 **Duration: 3 Hours**

PART A

(Answer all questions. Each question carries 3 marks)

1. Explain the concept of fermions and fermi level.
2. Distinguish between elemental and compound semiconductors with examples.
3. Describe the significance of continuity equation and write the expression of continuity equation of holes.
4. Explain the effect of temperature on doping.
5. Sketch the potential, charge density and electric field distribution within the transition region of an abrupt pn junction with $N_D < N_A$.
6. Sketch the energy band diagram of a p-n junction at i) equilibrium ii) under forward biased.
7. Explain body effect in MOSFET.
8. Sketch the drain and transfer characteristics of n-channel MOSFET.
9. Explain the subthreshold characteristics of an n-channel MOSFET.
10. Explain the operation of FINFET.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Derive the expressions for charge concentrations of semiconductor doped with both pentavalent and trivalent impurities. (8)

    b) Calculate the hole and intrinsic carrier concentration of a semiconductor with given parameters. (6)
    $N_C = 10^{19}\ cm^{-3}$, $N_V = 5x10^{18}\ cm^{-3}$, $E_g = 2eV$, $T = 900K$, $n_0 = 10^{17}\ cm^{-3}$.
    Also sketch the band diagram.

OR

12. a) A semiconductor is doped with $2x10^{16} cm^{-3}$ Boron atoms and $1x10^{16} cm^{-3}$ of Phosphorus atoms at 300 K. Calculate (8)
    i) The type of the sample,
    ii) Electron and Hole concentrations,
    iii) The fermi level position with respect to intrinsic energy level,

iv) Also, plot the energy band diagram (n_i= 1.5x10^{10}cm^{-3} for Silicon at 300 K).

b) Explain indirect recombination through traps. (6)

MODULE II

13. a) Derive the expression for diffusion current density in a semiconductor (10)

b) Electron mobility and life time in a semiconductor at room temperature are 0.36 m^2/V-s and 340 μs respectively. Compute the electron diffusion length. (4)

OR

14. a) Define Hall Effect. Also, derive the expressions for majority carrier concentration and mobility in terms of Hall voltage. (8)

b) A potential of 100mV is applied across a semiconductor bar and the resulting current is 1mA. A magnetic field of 10^{-4} Wb/cm^2 is applied perpendicular to this semiconductor bar. The hall voltage measured is -2 mV. The dimensions of the bar are, width = 0.1mm, length= 5 mm and thickness = 10 μm. Determine (6)

i) the type of the semiconductor bar,

ii) the concentration and the mobility of majority carriers.

MODULE III

15. a) Derive the expression for current flow through a p-n junction. Describe the reverse bias currents. (8)

b) Explain base width modulation and describe its effect in input and output characteristics of a BJT. (6)

OR

16. a) List out the assumptions and derive the terminal current equations of a transistor. (10)

b) Sketch the energy band diagram of a metal n-type semiconductor with $\phi_m > \phi_s$ when it is i) under equilibrium and ii) when it is biased. (4)

MODULE IV

17. a) Derive the expression for drain current of MOSFET in the saturation and linear region. (8)

b) A silicon n channel MOSFET has μn=600cm^2/V s, Cox=1.2×10^{-7} F/cm^2, W=50μm, L=10μm and V_{th}=0.8V. Find the drain current when (6)

(i) V_{GS}=2V and V_{DS}=1V

(ii) V_{GS}=3V and V_{DS}=5V

OR

18. a) Explain with diagrams the working and characteristics of n-channel enhancement MOSFET (5)

b) Explain the energy band diagrams of an ideal MOS capacitor under i) equilibrium ii) depletion iii) inversion and iv) strong inversion conditions. (9)

MODULE V

19. a) Explain the concept of Drain Induced Barrier Lowering in MOSFETs and its effect on the threshold voltage of a MOSFET. (8)

b) Explain velocity saturation and hot carrier effects. (6)

OR

20. a) Explain the need for scaling in MOSFET. Describe about constant voltage scaling and constant field scaling. (9)

b) Explain short channel effect in MOSFET. (5)

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