

Code : 041308

B.Tech. 3rd Semester Exam., 2014

SOLID-STATE PHYSICS AND DEVICES

Time : 3 hours

Full Marks : 70

Instructions:

- (i) The marks are indicated in the right-hand margin.
- (ii) There are **NINE** questions in this paper.
- (iii) Attempt **FIVE** questions in all.
- (iv) Question No. 1 is compulsory.

1. Answer any seven from the following : $2 \times 7 = 14$

- (a) What are the methods used for epitaxial growth?
- (b) Define direct and indirect semiconductors.
- (c) Define the effective mass and express it in terms of (E, k) .
- (d) Define conductivity and mobility.
- (e) Find the resistivity of intrinsic germanium at 300 K. Given that the intrinsic density of carriers is $2.5 \times 10^{19} / \text{m}^3$, $\mu_e = 0.39 \text{ m}^2/\text{V.s.}$, $\mu_n = 0.19 \text{ m}^2/\text{V.s.}$

- (f) What is diffusion length and mean life time?
- (g) Define the varactor diode.
- (h) What is emitter injection efficiency and current transfer ratio?
- (i) What is thermionic emission?
- (j) Define MOSFET and BJT. akubihar.com

2. (a) Write short notes on (i) vapour-phase epitaxy and (ii) molecular beam epitaxy.

4×2=8

- (b) In a very long p -type Si bar with cross-sectional area = 0.5 cm^2 and $N_a = 10^{17} \text{ cm}^{-3}$, we inject holes such that the steady-state excess hole concentration is $5 \times 10^{16} \text{ cm}^{-3}$ at $x=0$. What is the hole current there? Assume that $\mu_p = 500 \text{ cm}^2/\text{V.s}$ and $\tau_p = 10^{10} \text{ sec.}$

6

3. (a) Write short notes on direct and indirect recombination in a semiconductor.

8

- (b) What is ion implantation? akubihar.com

6

4. (a) Derive the diffusion equation for steady-state distribution for electron and hole.

8

- (b) Derive Einstein relation with respect to both carriers in semiconductor.

6

5. (a) What is reverse breakdown? Describe the different reverse breakdown mechanism. 6
- (b) Derive the relationship between width of transition region in terms of contact potential and doping concentrations on each side of the junctions. 8
6. (a) An abrupt Si p - n junction has $N_a = 10^{18} \text{ cm}^{-3}$ on one side and $N_d = 5 \times 10^{15} \text{ cm}^{-3}$ on the other has a circular cross-section with a diameter of $10 \mu\text{m}$. Calculate χ_{no} , χ_{po} , Q_i and ξ_0 for this junction at equilibrium (300 K). Sketch $\xi_{(x)}$ and charge density. 7
- (b) Explain the operating principle of JFET using suitable sketches. 7
7. (a) For an n -channel MOSFET with a gate oxide thickness of 10 nm , $V_T = 0.6 \text{ V}$ and $Z = 25 \mu\text{m}$, $L = 1 \mu\text{m}$, calculate the drain current at $V_G = 5 \text{ V}$ and $V_D = 0.1 \text{ V}$. Also calculate the drain current for $V_D = 7 \text{ V}$. Assume an electron channel mobility of $\mu_n = 200 \text{ cm}^2/\text{V.s}$. 6
- (b) Draw energy band diagram of pnn transistor in unbiased condition. 4

- (c) Draw energy band diagram of pnp transistor in common base mode. Discuss why the base of a transistor is thin and lightly doped. 4
8. (a) Write short notes on any two of the following : $4 \times 2 = 8$
- (i) Solar cell
- (ii) LED
- (iii) Laser diode
- (b) What is silicon controlled rectifier and unijunction rectifier? $3 \times 2 = 6$
9. (a) Write a short note on charge coupled devices (CCD). 4
- (b) What is Schottky barrier diode? 4
- (c) Define triodes, tetrads and pentodes. 6
