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 : 2×7=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 $2{\cdot}5\times10^{19}/\mathrm{m}^3$, $\mu_e = 0{\cdot}39\ \mathrm{m}^2/\mathrm{V.s.}$, $\mu_n = 0{\cdot}19\ \mathrm{m}^2/\mathrm{V.s.}$

(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.

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 = $0{\cdot}5\ \mathrm{cm}^2$ and $N_a = 10^{17}\ \mathrm{cm}^{-3}$, we inject holes such that the steady-state excess hole concentration is $5\times10^{16}\ \mathrm{cm}^{-3}$ at $x = 0$. What is the hole current there? Assume that $\mu_p = 500\ \mathrm{cm}^2/\mathrm{V.s}$ and $\tau_p = 10^{10}$ sec. 6

3. *(a)* Write short notes on direct and indirect recombination in a semiconductor. 8

(b) What is ion implantation? 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 $N_a = 10^{18}\ cm^{-3}$ on one side and $N_d = 5 \times 10^{15}\ cm^{-3}$ on the other has a circular cross-section with a diameter of 10 μm. Calculate χ_{no}, χ_{po}, Q_t 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, $V_T = 0{\cdot}6$ V and $Z = 25\ \mu m$, $L = 1\ \mu m$, calculate the drain current at $V_G = 5V$ and $V_D = 0{\cdot}1$ V. Also calculate the drain current for $V_D = 7V$. Assume an electron channel mobility of $\mu_n = 200\ cm^2/V.s$. 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 : 4×2=8

(i) Solar cell

(ii) LED

(iii) Laser diode

(b) What is silicon controlled rectifier and unijunction rectifier? 3×2=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

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