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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 2019

Course Code: EC203

Course Name: SOLID STATE DEVICES (EC,AE)

Max. Marks: 100

Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks.

Marks

- 1 a) Derive the expression for conductivity and mobility of carriers in a semiconductor subjected to an electric field. (7)
- b) Explain the temperature dependence of carrier concentration in extrinsic semiconductors. (3)
- c) Calculate the hole and intrinsic carrier concentrations. Sketch band diagram. $N_c=10^{19}/\text{cm}^3$, $N_v=5 \times 10^{18}/\text{cm}^3$, $E_g=2\text{eV}$, $T=900\text{K}$, $n_0=10^{17}/\text{cm}^3$. (5)
- 2 a) Derive Einstein's relation. (6)
- b) Explain why indirect recombination is a slow process. (4)
- c) A Si sample is doped with $10^{16}/\text{cm}^3$ In atoms and a certain number of shallow donors. The In acceptor level is 0.16eV above E_v and E_f is 0.26eV above E_v at 300K. How many In atoms are un-ionised? (5)
- 3 a) Derive the expression for electron, hole and intrinsic concentrations at equilibrium in terms of effective density of states. Formulate the relation between these concentrations at equilibrium. (8)
- b) An n-type Si sample with $N_d = 10^{15} \text{ cm}^{-3}$ is steadily illuminated such that $g_{op} = 10^{21} \text{ EHP/cm}^3\text{s}$. If $\tau_n = \tau_p = 1\mu\text{s}$ for this excitation, calculate the separation in the quasi-Fermi levels, $(F_n - F_p)$. (7)

PART B

Answer any two full questions, each carries 15 marks.

- 4 a) Derive ideal diode equation. State any two assumptions used. (10)
- b) Draw the potential, charge density and electric field distribution within the transition region of an abrupt pn junction with $N_d < N_a$. Label the diagram. (5)
- 5 a) Illustrate how a metal – n type contact behave as rectifying contact and ohmic contact with supporting energy band diagram. (10)
- b) If a metal with a work function of 4.6 e V is deposited on Si (electron affinity of 4 eV) and acceptor doping level of 10^{18} cm^{-3} . Draw the equilibrium band diagram and mark off the Fermi level, the band edges, and the vacuum level. Is this a Schottky or ohmic contact, and why? (5)
- 6 a) Illustrate the operation of a tunnel diode with supporting diagrams and explain its VI characteristics (10)

- b) 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. If the junction has a circular cross section with a diameter of $10 \mu\text{m}$, Calculate V_o , x_{no} , Q_+ , and ϵ_o for this junction at equilibrium (300 K). (5)

PART C

Answer any two full questions, each carries 20 marks.

- 7 a) Derive the expression for minority carrier distribution and terminal currents in a BJT. State the assumptions used. (12)
- b) Explain the basic performance parameters α , β & γ . (3)
- c) Assume that a p-n-p transistor is doped such that the emitter doping is 10 times that in the base, the minority carrier mobility in the emitter is one-half that in the base, and the base width is one-tenth the minority carrier diffusion length. The carrier lifetimes are equal. Calculate α and β for this transistor. (5)
- 8 a) Derive the expression for drain current at linear region and saturation for a MOSFET. (10)
- b) An Al-gate p-channel MOS transistor is made on an n-type Si substrate with $N_d = 5 \times 10^{17} \text{ cm}^{-3}$. The SiO_2 thickness is $100 \text{ \AA}$ in the gate region, and the effective interface charge Q_i is $5 \times 10^{10} \text{ q C/cm}^2$. Find W_m , V_{FB} , and V_T , if the gate to substrate work function difference $\Phi_{ms} = -0.15 \text{ V}$. (5)
- c) Draw and explain the transfer characteristics of an n-channel MOSFET. (5)
- 9 a) Explain the principle of operation of MOS capacitor with suitable energy band diagram. (10)
- b) Explain base width modulation. Explain its effect on terminal currents. (5)
- c) Draw and label the minority carrier distribution curve of a BJT in active mode. (5)
