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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third semester B.Tech examinations (S) September 2020

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) Explain Hall effect? Derive the expression for carrier concentration and mobility in terms of Hall voltage. (7)

b) Explain the effect of temperature on mobility. (5)

c) A Si sample is doped with 10^{16} cm^{-3} boron atoms and a certain number of shallow donors. The Fermi level is 0.36 eV above *Ei,* at 300 K. What is the donor concentration N_d? (3)

2 a) Derive the expression for diffusion current density in a semiconductor. (6)

b) Show that diffusion length is the average length a carrier diffuse before recombination. (5)

c) A Si sample with $10^{15}/cm^3$ donors is uniformly optically excited at room temperature such that $10^{19}/cm^3$ electron-hole pairs are generated per second. Find the separation of the quasi-Fermi levels .Electron and hole lifetimes are both 10 μs. $Dp = 12$ cm^2/s and μ_n=1300cm^2/Vs. (4)

3 a) Derive the law of mass action, starting from the fundamentals. (10)

b) Consider Si doped with 2 x 10^{15}donors/cm^3.Assume that $\tau_n = \tau_p$ = 5 μs. Calculate the recombination coefficient α_r for the low-level excitation. Using this value of recombination coefficient α_r , find the steady state excess carrier concentration $\Delta n = \Delta p$, if the sample is uniformly exposed to a steady state optical generation rate $g_{op} = 10^{19}$ EHP/cm^3-s (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Derive the expression for contact potential and width of depletion region of an abrupt PN junction at equilibrium. (10)

b) A Si p+-n junction has a donor doping of 5 x 10^{16} cm^{-3} on the n side and a cross sectional area of 10^{-3} cm^2. If τ_P = 1μs and Dp = 10 cm^2/s, calculate the current with a forward bias of 0.5 V at 300 K. (5)

5 a) Derive the expression for junction capacitance and storage capacitance of a step PN junction diode. (8)

b) The work function of chromium is 4.5V. The dielectric constant and the electron affinity of Si are 12 and 4.01V respectively. If the density of states Nc=2.8x10^{19} (7)

cm^{-3}, compute the maximum electric field in the case of a junction formed by these two materials at 300 K, when the applied reverse voltage is 5V. Compute the junction capacitance per unit area for this case. Assume that Si is doped with $10^{17}/cm^3$ n type dopants.

6 a) With suitable energy band diagram explain a Schottky contact. (6)

b) Differentiate between Zener and avalanche breakdown mechanisms with supporting diagrams (4)

c) Draw the energy band diagram of a p-n junction at a) equilibrium b) Forward bias c) Reverse bias. (5)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Derive an expression for base transport factor of a BJT. (10)

b) Explain Early effect. (5)

c) A pnp BJT has emitter (N_E), base (N_B), and collector (Nc) doping of $10^{20}cm^{-3}$, 10^{18} cm $^{-3}$ and 10^{17} cm^{-3} respectively, and a base width of 0.5 micron. Calculate the peak electric field at the CB junction, and the CB depletion capacitance per unit area for the normal active mode of operation with a V_{CB} = 50 V. (5)

8 a) Draw and explain the C-V Characteristics of an Ideal MOS capacitor. Derive the expression for threshold voltage. (10)

b) For a MOSFET with V_T = 1V and W = 50 μm, L = 2 μm, calculate the drain current at (5)

(i) V_G = 5 V, V_D = 0.1V

(ii) V_G = 3V, V_D = 5V.

Assume an electron channel mobility μ_n= 200 cm^2 /V-s, gate oxide thickness tox= 100Å, and the substrate is connected to the source.

c) Draw and explain the subthreshold characteristics of an n-channel MOSFET. (5)

9 a) With the aid of necessary band diagrams, explain equilibrium, accumulation, depletion and inversion stages of a MOS capacitor. (12)

b) Explain the effect of real surfaces in the threshold voltage of a MOS capacitor. (4)

c) Explain the terms emitter injection efficiency and base transport factor of a BJT. (4)

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