Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree (S,FE) Examination December 2020 (2015 Scheme)

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) Define Fermi-Dirac distribution function. Explain each term in it. With the help of plots, characterize temperature dependence of this function. (5)

b) Starting from fundamentals, derive an expression to calculate the intrinsic carrier concentration of semiconductors. What are the factors on which intrinsic carrier concentration depends? (10)

2 a) With suitable assumptions, derive Einstein's relation for mobility of electrons in a semiconductor (7)

b) 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) Plot the energy band diagram indicating the band edges, E_f, E_i and the band gap energy.

(n_i= $1.5x10^{10}cm^{-3}$ for Silicon at 300 K)

3 a) Derive one dimensional continuity equation for holes in a semiconductor. With suitable assumptions, obtain the diffusion equations for holes and electrons. (10)

b) With suitable energy band diagram, explain the indirect recombination mechanism via traps. (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Plot the energy band diagram of a PN junction under (6)

i) Equilibrium ii) Forward bias iii) Reverse bias

b) With suitable assumptions, derive Ideal Diode equation. List the current depending factors (9)

5 a) Plot the Volt Ampere characteristics of a tunnel diode. Differentiate the energy band diagrams of forward biased, reverse biased and equilibrium conditions of the tunnel diode. (8)

b) $1x10^{16}cm^{-3}$ of Donor atoms are implanted to an n type Silicon sample forming an abrupt junction of square cross section, with area $2x10^{-3}cm^{2}$. Assume that the acceptor concentration in the P type region is $4x10^{18}cm^{-3}$. Calculate (7)

i) The built in potential

ii) Width of the depletion layer

iii) Extension of depletion layer to the n side and the p side of the junction

iv) Junction capacitance

(relative permittivity ε_r= 11.9 and n_i= $1.5x10^{10}cm^{-3}$ for Silicon at 300 K)

6 a) With the help of energy band diagrams, distinguish behaviour of metal- n type Schottky contact and metal-n type Ohmic contact. (10)

b) Distinguish between Zener and Avalanche breakdown mechanisms. (5)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Draw the structure of a PNP transistor. Clearly Indicate the current components on the figure. (4)

b) Define the basic performance parameters of BJTs? What is the effect of doping and dimensions of emitter, base and collector regions on these parameters? (9)

c) The following parameters are given for a PNP transistor. I_{EP}= 2 mA, I_{En}= 0.01 mA, I_{cP}= 1.98 mA and I_{cn}= 0.001mA. Determine (7)

i) The base transport factor

ii) The emitter injection efficiency

iii) α and β

iv) I_E, I_C and I_B

8 a) Draw the structure and band diagram of a MOS capacitor with P type substrate, under equilibrium and under strong inversion. Give the condition for strong inversion with reference to band diagram. (6)

b) Draw and explain the transfer characteristics of an enhancement type MOSFET. (4)

c) An n channel MOS transistor is made on a P type silicon substrate with (10)

$N_A = 5x10^{15} cm^{-3}$. The oxide thickness is 100 A^o and the effective interface charge is $Q_i = 6.4x10^{-9}$ C/cm^2. Work function difference is given as Φ_{ms} = -0.95 V. Calculate,

i) Surface potential needed to make the surface strongly inverted.

ii) Flat band voltage

iii) Threshold voltage

(relative permittivity $\varepsilon_r = 11.9$ and $n_i = 1.5x10^{10} cm^{-3}$ for Silicon at 300 K)

9 a) Derive the expression for the drain current of a MOSFET. How will the equation modifies in (10)

i) Linear region ii) Saturation region of operations.

b) What is base width modulation? How does it affect the BJT characteristics in CE and CB configurations? (6)

c) Plot the distribution of minority carriers in the bulk of a PNP transistor in active mode of operation. (4)

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