Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree (S,FE) Examination January 2022 (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) Show that the probability that a state ΔE above Fermi level (E_F) is occupied by electron is same as the probability that a state ΔE below E_F is empty. (4)

b) Plot carrier concentration versus temperature for silicon doped with 10^{17} atoms/cm^3. Comment about the causes of variations in concentration with the temperature (5)

c) A sample of silicon is doped with $10^{17}\,cm^{-3}$ phosphorous atoms. What Hall voltage would you expect in a sample 100 μm thick if $I_x = 1\,mA$ *and* $B_z = 10^{-5}\,Wb/cm^2$. (6)

2 a) With suitable assumptions, derive Einstein's relation for mobility of electrons in a semiconductor (8)

b) A n- type silicon sample with $N_d = 10^{17}$ atoms/cm^3 is steadily illuminated such that $g_{op} = 10^{20}$ EHP/cm^3 sec. If $\tau_n = \tau_p = 1\mu s$ for this excitation, Draw the energy band diagram with the quasi Fermi levels at 300K. Intrinsic carrier concentration of silicon is 1.5×10^{10} cm^{-3}. (7)

3 a) With the schematic of particle flow and corresponding current directions , give the mathematical expressions for total current density (8)

b) Differentiate direct recombination and indirect recombination of excess carriers with suitable energy band diagrams (7)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Draw the energy band diagram of a p-n junction at a) equilibrium b) Forward bias c) Reverse bias. (6)

b) An abrupt Si p-n junction has $N_A = 10^{18}$cm^{-3} on one side and $N_D = 5\times10^{15}$cm^{-3} on the other. It has a circular cross section with a diameter of 10μm. Given, for Si at 300K, n_i=1.5 x 10^{10} /cm^3 and $\epsilon_r = 11.8$. (6)

a) Calculate Fermi level positions in the p and n regions.

b) Find the contact potential V_o.

c) What are the assumptions taken for the derivation of the general form of Diode equation? (3)

5	a)	Derive the expression for depletion capacitance of a PN junction.	(6)
	b)	What is a tunnel diode? Draw V-I characteristic of tunnel diode	(4)
	c)	Differentiate Zener breakdown and Avalanche breakdown.	(5)
6	a)	With suitable assumptions, derive the expression for open circuit contact potential of a p-n junction	(8)
	b)	What is work function? Give schematic explanation for energy band diagram of Schottky barrier formed between metal and n-type semiconductor	(7)

PART C

Answer any two full questions, each carries20 marks.

7	a)	Schematically represent the hole and electron flow in a PNP transistor in active mode. Describe base, emitter and collector current components in a PNP transistor and write expressions for terminal currents in terms of the component currents.	(8)
	b)	What is Early effect mechanism in BJT and what is Early voltage? What are the effects of this mechanism to the terminal currents of BJT	(6)
	c)	Draw and label the minority carrier distribution in a PNP transistor in active mode.	(6)
8	a)	With the help of necessary band diagrams, explain equilibrium, accumulation, depletion and inversion stages of a MOS capacitor.	(10)
	b)	A silicon n channel MOSFET has μn=600cm 2/V-sec, Cox=1.2 × 10-7 F/cm2, W=50μm, L=10μm and VTH=0.8V. Find the drain current when (i). VGS=2V and VDS=1V (ii) VGS=3V and VDS=5V	(5)
	c)	Give schematic view of n-channel MOSFET. Plot the output characteristic and describe it with equations	(5)
9	a)	Derive equations for excess hole distribution and terminal current equations of NPN transistor.	(10)
	b)	What is MOSFET scaling? What are the advantages and disadvantages of scaling	(5)
	c)	An n+ -polysilicon gate n-channel MOS transistor is made on a p-type Si substrate with Na = $5\times10^{15}cm^{-3}$. The SiO_2 thickness is 100Å in the gate region, at the onset of inversion and the effective interface charge Q_i is $4\times10^{10}\ q\ C/cm^2$. Find i. maximum width of depletion layer ii. threshold voltage,V_T. [Given ε_r of Si = 11.8 and ε_r of SiO_2 = 3.9]	(5)

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