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0800ECT201122102 Pages: 3

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree Regular and Supplementary Examination December 2022 (2019 scheme)

Course Code: ECT201

Course Name: SOLID STATE DEVICES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1 Define Fermi-Dirac distribution function of semiconductor. (3)

2 Draw the energy band diagrams under equilibrium for i) Intrinsic ii) n-type iii) p-type semiconductors. (3)

3 Differentiate drift and diffusion movement of carriers in semiconductors. (3)

4 Derive continuity equation. (3)

5 Explain the terms emitter injection efficiency and base transport factor of a BJT. (3)

6 Differentiate Ohmic and rectifying contacts metal-Semiconductor contacts. (3)

7 What is meant by body effect in MOSFET? (3)

8 Draw and explain the transfer characteristics of an enhancement type MOSFET. (3)

9 Define Sub threshold conduction in MOSFET (3)

10 Define threshold Voltage of MOSFET. How it can be varied? (3)

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11 (a) Derive the expression for electron concentration (n_0) and hole concentration (p_0) at equilibrium. (8)

(b) For a silicon sample at 300K, the equilibrium hole concentration is $4x10^{12}$ cm^{-3}. Determine (i) equilibrium electron concentration (ii) the acceptor concentration if the donor concentration is 10^{12} cm^{-3}. (Assume ni for silicon is $1.5x10^{10}$ cm^{-3}). (6)

12 (a) Explain different types of recombination mechanisms. (7)

(b) A silicon sample doped with $10^{16}cm^{-3}$ donors at 300K is optically excited such that the optical generation rate is 10^{20} EHP/(cm^{-3} s^{-1}). Find the separation between Quasi Fermi levels and show the positions of equilibrium and quasi Fermi levels if $\tau_p = \tau_n = 2$ μs. (7)

Module 2

13 (a) State and prove Einstein's relation. (9)

(b) An n type silicon bar 0.1 cm long and 100 μm^2 in cross sectional area has a majority carrier concentration of $5x10^{15}$ cm^{-3} and electron mobility μ_n=1300 cm^2/Vs at 300K. What is the resistance of the bar? (5)

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

(b) Derive the expression for diffusion current density in a semiconductor. (7)

Module 3

15 (a) Derive ideal diode equation. State any two assumptions used. (8)

(b) Draw the energy band diagram of a metal-n type semiconductor with $\varphi m > \varphi s$ when it is i) under equilibrium and ii) when it is biased. Is the contact rectifying or ohmic? (6)

16 (a) Derive the expression for Built in potential of an abrupt PN junction at equilibrium. (7)

(b) An abrupt silicon PN junction has $N_A=10^{17}$ cm^{-3} on the p-side and $N_D=10^{15}$ cm^{-3} on the n-side. The area of cross section of the diode is 10^{-4} cm^2. The relative permittivity of Si is 11.8. Calculate the built in voltage (V_0) and depletion layer width (W_0) at 300K. (7)

Module 4

17 (a) Derive the expression for drain current at linear region and saturation region for a MOSFET. (7)

(b) An Al-gate p-channel MOS transistor is made on an n-type Si substrate with $N_D = 5x10^{17}$ cm^{-3}. The SiO_2 thickness is 100 Å in the gate region, and the effective interface charge Qi is 5×10^{10} q C/cm^2 . Find W_m , V_{FB} , and V_T, if the gate to substrate work function difference Φms = -0.15V. (7)

18 (a) With the help of necessary band diagrams, explain the working and CV characteristics of a MOS capacitor. (8)

(b) Derive the equation for threshold voltage of MOSFET. (6)

Module 5

19 (a) What is drain induced barrier lowering. Discuss its effect on MOSFET performance. (6)

(b) What is MOSFET scaling? Explain different types of scaling. Discuss the advantage and disadvantage of scaling. (8)

20 (a) Explain different types of short channel effects in MOSFET. (8)

(b) Draw and explain the structure and working of Fin FET. (6)

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