Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S3 (S,FE)/S1 (PT)(S) June 2024 (2019 Scheme)/S3 (WP)(R) December 2023 Examination

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	Explain the indirect recombination mechanism in semiconductors.	(3)
2	What are Quasi-Fermi levels?	(3)
3	How the mobility of carriers varies with temperature?	(3)
4	Derive Einstein relations.	(3)
5	An abrupt p-n junction made of Silicon has $N_A=10^{18}$ cm^{-3} on the p-side and $N_D=5x10^{15}cm^{-3}$ on the n-side. At 300K, calculate built-in potential using its expression.	(3)
6	Describe the rectifying behaviour of a metal-n-type Semiconductor contact.	(3)
7	Draw the equilibrium energy band diagram of an ideal MOS capacitor.	(3)
8	Derive the expression for threshold voltage of a MOS capacitor.	(3)
9	Compare constant voltage scaling and constant field scaling	(3)
10	Explain DIBL.	(3)

PART B

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

Module 1

11a	Derive the expression for electron, hole and intrinsic concentrations at equilibrium in terms of effective density of states.	(8)
b	A Silicon sample is doped with 10^{17} As atoms/cm^3 .What is the equilibrium hole concentration p_0 at 300K? Where is E_f relative to E_i? Draw the energy band diagram	(6)
12a	Draw and explain Fermi-Dirac Distribution function and apply it to semiconductors. Also draw the plot of FDD and energy band diagram.	(10)
b	Explain the different excess carrier generation mechanisms.	(4)

Module 2

13a Derive the expression for diffusion current density in a semiconductor. (9)

b Explain Hall effect. (5)

14a Derive Continuity Equations and hence derive the steady state Diffusion equations for electrons and holes. (10)

b An n-type silicon bar 0.1cm long and $100\mu m^2$ in cross sectional area has a majority carrier concentration of $5x10^{20}$ cm^{-3} and electron mobility $0.13m^2/Vs$ at 300K. What is the resistance of the bar? (4)

Module 3

15a Derive ideal diode equation. List out the various approximations used. (10)

b An abrupt Silicon p-n 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. Determine the following at 300K. (4)

(a) the built-in voltage
(b) the depletion layer width W_0, Xp_0, Xn_0
(c) the maximum electric field

16 With the aid of energy band diagram, explain how a metal-N type junction functions as a rectifying and ohmic contact. (14)

Module 4

17a Starting from the fundamentals, derive the expression for drain current of a MOSFET in its two regions of operation. (10)

b Draw the transfer characteristics of an n-channel enhancement MOSFET in linear and saturation regions. (4)

18a With the help of energy band diagrams, explain the three regions of operation of a MOS capacitor (8)

b A Silicon MOS system with p-substrate having $NA=10^{15}cm^{-3}$ and oxide thickness $100A^0$ is at the onset of strong inversion. Determine (6)

(a) width of the depletion layer.
(b) the charge density in the depletion layer.
(c) the threshold voltage.

Given $\varepsilon_{rox}=3.9$, $\varepsilon_{rsi}=11.8$.

Module 5

19 Summarize the various short-channel effects in MOSFET. (14)

20 Draw and explain the structure and operation of FinFET. List out its advantages. (14)

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