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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree Examination December 2020 (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	With suitable examples, distinguish between elemental and compound semiconductors. Give their applications.	(3)
2	Draw the energy band diagrams under equilibrium for the following semiconductors. i) intrinsic ii) n type iii) p type	(3)
3	Write down the current equations in a semiconductor.	(3)
4	What is the significance of quasi fermi level? If there is gradient in quasi fermi level, what does it indicates?	(3)
5	Draw the V-I characteristics of a P N junction diode & mark the regions of operation. Write down the ideal diode equation.	(3)
6	Draw the structure of a PNP transistor. Clearly Indicate the current components on the figure.	(3)
7	Plot the transfer characteristics of an n-channel MOSFET. Give the current equation.	(3)
8	An nMOS transistor has W/L= 4/2, gate oxide thickness 40 A^o, Mobility of electrons 180 $cm^2/Vsec$. The threshold voltage is 0.4 V, relative permittivity of gate oxide ϵ_{ox}=3.9. Calculate the drain current when Vgs = 1.5 V, Vds = 1.8 V.	(3)
9	What is channel length modulation in MOSFETs? How does it affect the output characteristics of the MOSFET?	(3)
10	Explain the principle of operation and advantage of FinFET.	(3)

PART B

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

Module 1

11	a)	Derive the equation for hole concentration in a semiconductor under thermal equilibrium in terms of n_i, E_f and E_i.	(8)

b) A silicon sample doped with $2x10^{16}cm^{-3}$ of Boron atoms. (n_i= $1.5x10^{10}cm^{-3}$ for Silicon at 300 K) Determine,

i. The equilibrium electron and hole concentrations

ii. Position of fermi energy level in the band gap (6)

iii. Plot the energy band diagram

12 a) Plot and explain the temperature dependence of intrinsic carrier concentration in semiconductors (4)

b) With suitable sketches explain the indirect recombination mechanism via traps. (5)

c) An n-type Si sample with Nd = 10^{15} cm^{-3} is steadily illuminated such that g_{op} $=10^{21}$ EHP/cm^3s. If $\tau_n = \tau_p$ = 1 μs for this excitation, calculate the separation in the quasi-Fermi levels, (F_n - F_p). (n_i= $1.5x10^{10}cm^{-3}$ for Silicon at 300 K) (5)

Module 2

13 a) Explain the term mobility with respect to semiconductors. What are the factors on which the mobility depends on? Explain the variation of mobility with temperature and doping. (8)

b) A potential of 100 mV is applied across a semiconductor bar, and the resulting current is 1 mA. A magnetic field of 10^{-4} Wb/cm^2 is applied perpendicular to this semiconductor bar. The hall voltage measured is -2 mV. The dimensions of the bar are width = 0.1 mm, length = 5 mm and thickness = 10 μm. Find (6)

i. the type of the semiconductor bar

ii. the concentration and the mobility of majority carriers

14 a) Derive continuity equation for holes. (4)

b) Solve the continuity equation, under steady state conditions assuming the semiconductor is long and no drift current is present. Plot the solution. (6)

c) A p type semiconductor injected at one end with minority carrier electrons, under steady state conditions. Na = 10^{15} cm^{-3} ,, τ_n = 0.1 μs, μ_n = 700 cm^2/V Sec. Calculate the electron diffusion length. (4)

Module 3

15 a) With the help of energy band diagrams, explain the behaviour of the contact between a metal and an n -type semiconductor. Clearly distinguish between Schottky and ohmic contacts. (10)

b) What is base width modulation? How does it affect the input and output characteristics of a BJT? (4)

16 a) Derive the equation for the built in potential of a PN junction under thermal equilibrium. (7)

b) A PN junction, doped on one side with 10^{18} cm^{-3} Boron atoms and the other side with 10^{16} cm^{-3} of Arsenic atoms at 300 K. (n_i = $1.5x10^{10} cm^{-3}$ at 300 K and ϵ_r=11.9 for Silicon). Calculate, the built in potential. (3)

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

i. The base transport factor

ii. The emitter injection efficiency (4)

iii. α and β

Module 4

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

b) Draw the energy band diagrams, of an ideal MOS capacitor under equilibrium, and strong inversion conditions. (6)

18 a) Draw the structure of n channel MOSFET. Derive the expression for drain current of a MOSFET in the two regions of operation. What are the assumptions made in deriving the expression? (10)

b) What is meant by body effect in MOSFET? How does it affect the threshold voltage of the MOSFET? (4)

Module 5

19 a) What is meant by scaling in MOSFETs? Explain the challenges in device scaling? (7)

b) Explain the concept of constant voltage scaling and its limitations. (7)

20 a) What is meant by DIBL in MOSFETs? How does it affect the threshold voltage of a MOSFET? (7)

b) Explain the concepts of velocity saturation and hot carrier effects in a MOSFET. (7)

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