Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION(S), MAY 2019

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) Explain Fermi Dirac distribution function. Plot the Fermi Dirac distribution function for an intrinsic semiconductor. (4)

b) Explain diffusion. Derive an expression for diffusion current density for an n-type semiconductor. (7)

c) A Si 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? (4)

2 a) Draw the graph showing the distribution of excess carrierswith respect to time in an n-type semiconductor. (3)

b) Derive the expressions for equilibrium concentration of electrons and holes using Fermi Dirac distribution function. (6)

c) A direct bandgap semiconductor hasn_i = 10^{10} cm^{-3} donors. Its low level carrier lifetime τ is$\tau_n = \tau_p = 10^{-7}$s. (6)

i) If a sample of this material is uniformly exposed to a steady optical generation rate of $g_{op} = 2x10^{22}$ EHP/cm^2-s; Calculate the excess carrier concentration $\Delta_n = \Delta_p$

Note : The excitation rate is not low level but assume that α_r is the same.

ii) If the carrier lifetime (τ) is defined as the excess carrier concentration divided by the recombination rate, what is τ at this excitation level?

3 a) Explain High field effects. (4)

b) Derive and explain Einstein relations. (6)

c) A Ge sample is doped with 10^{17} Boron atoms/cm^3.Determine the carrier concentration & Fermi level position at room temperature.n_i for Ge = 2.5 x 10^{13} cm^{-3} at room temperature. (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Draw and explain the VI characteristics of PN junction diode. (4)

b) Explain the different types of capacitances associated with a p-n junction. (6)

c) The following data are given for a Si abrupt pn junction at 300k, $A=1cm^2$,V_o= 0.6V. (5)

P- side	N-side
$N_A = 10^{18}\ cm^{-3}$	$N_D = 10^{16}\ cm^{-3}$
τ_n= 50 µs	τ_p= 10 µs
D_n= 34 cm^2 / s	D_p= 13 cm^2 / s

Calculate $I_p(x_n = 0)$; $I_n(x_p = 0)$ & the total diode current ; (Given kT/q = 0.026 V)

5 a) Derive the ideal diode equation. (10)

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

6 a) Derive an expression for the contact potential of an open circuit p-n junction. (7)

b) Write short notes on metal semiconductor contacts. (8)

PART C

Answer any two full questions, each carries20 marks.

7 a) Explain the principle of operation of MOS capacitor with suitable energy band diagrams. (10)

b) Explain base width modulation with neat diagrams. (4)

c) Briefly explain (6)

i) MOSFET scaling.

ii) Hot electron effect.

8 a) Derive the expression for minority carrier distribution and terminal currents of a pnp transistor. (14)

b) Explain the capacitance – voltage relation for a MOS capacitor with neat diagram. (6)

9 a) Explain the principle of operation of FINFET. (7)

b) With neat diagrams, explain the flow of different current components in a pnp transistor under active mode of operation. (7)

c) Draw and explain the drain characteristics of an n-channel MOSFET. (6)

****

Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

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 Hall effect. Derive the expressions for majority carrier concentration and mobility. (7)

b) Explain the variation in energy levels of a semiconductor when an electric field is applied? (3)

c) Consider a semiconductor bar with w=0.1mm, t=10µm and L=5mm. For B=10kg (1kg= 10^{-5}Wb/cm^2) and a current 1mA, we have V_{AB}=-2mV, V_{CD}=100mV, Find the type, concentration, and mobility of the majority carrier. (5)

2 a) Prove that $n_0p_0 = ni^2$. (7)

b) The Fermi level position in a Si sample at 300K is 0.29eV below E_c. Determine the carrier concentration and conductivity of the specimen. Given that n_i=1.5 x 10^{10}cm^{-3}, μ_n=1350cm^2/Vs, μ_p=480cm^2/Vs. (8)

3 a) Derive an expression for drift current density. (7)

b) Explain the effect of temperature on mobility. (3)

c) Calculate the thermal equilibrium electron and hole concentration in Si at T=300K, when the Fermi energy level is 0.27eV below the conduction band edge E_c. The effective densities of states in the conduction band and valance band are 2.8 x 10^{19} cm^{-3} & 1.04 x 10^{19} cm^{-3} respectively at 300K. (5)

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) Differentiate Ohmic contact and Rectifying contacts with neat diagram. (9)

5 a) Explain with neat diagrams (7)

(i) Zener breakdown.

(ii) Avalanche breakdown.

b) With appropriate energy band diagram explain the operation of a tunnel diode. (8)

6 a) Determine the junction capacitance of a silicon pn junction at T = 300 K when a reverse bias voltage of 5V is applied across the junction. The doping concentrations of p&n regions are $8x10^{21}$ m^{-3}& $3x10^{22}$ m^{-3} respectively & the cross-sectional area of the junction is $5x10^{-9}$ m^2. (Assume n_i for Si at 300K is $1.5x10^{10}cm^{-3}$ and ε_r=11.7) (7)

b) Derive the expression for open circuit contact potential of a p-n junction under equilibrium. (8)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Derive the expression for drain current at saturation for a MOSFET. (8)

b) Explain the basic performance parameters α, β & γ. (6)

c) Explain early effect and early voltage. (6)

8 a) Derive the expression for minority carrier distribution in a pnp transistor. (10)

b) Explain the principle of operation of MOS capacitor with suitable energy band diagram. (10)

9 a) Explain the principle of operation of FINFET with neat diagrams. (5)

b) Plot the sub-threshold characteristics of MOSFET and explain. (5)

c) Describe the C-V Characteristics of an Ideal MOS capacitor. Derive the expression for threshold voltage. (10)

****

C **B3C051** **Total pages:2**

Reg No._____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, JANUARY 2017

Course Code**: EC203**

Course Name**: SOLID STATE DEVICES (AE, EC)**

Max. Marks: 100 Duration: 3 Hours

PART A

Question No. 1 is compulsory. Answer question No. 2 or 3

1. (a) Derive the expression $n_0p_0 = n_i^2$ from fundamentals. (5)

   (b) A germanium sample is doped with 10^{16} boron atoms per cm^3. Find the electron concentration. Intrinsic carrier concentration of germanium is $2.5 \times 10^{13}/cm^3$ at 300K. (5)

   (c) An n- type silicon sample with $N_d = 10^{15}$ $/cm^3$ is steadily illuminated such that $g_{op} = 10^{20}$ EHP/cm^3-sec. If $\tau_n = \tau_p = 1\mu$sec 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} $/cm^3$ (5)

2. (a) Explain the temperature dependence of carrier concentration of an extrinsic semiconductor with the help of graph. (5)

   (b) What is Hall Effect? Derive the expression for finding the carrier concentration of a semiconductor from Hall voltage. (10)

OR

3. (a) What is Einstein Relation? Derive the expression**.** (5)

   (b) Derive Continuity equation. Find the expression for the distribution of carriers in a semi-infinite semiconductor bar if steady injection of carriers occurs at one end. (10)

PART B

Question No. 4 is compulsory. Answer question No. 5 or 6

4. (a) Draw the charge density and electric field distribution within the transition region of a PN Junction with $N_d < N_a$. Label all the details. (5)

   (b) An abrupt silicon PN junction has $N_d = 10^{15}$ $/cm^3$ and $N_a = 10^{17}$ $/cm^3$. Draw the energy band diagram of the junction at equilibrium at 300K and find its contact potential

from the diagram. Energy gap of silicon is 1.11eV and intrinsic carrier concentration is $1.5 \times 10^{10}/cm^3$. (5)

(d) Explain the working of Tunnel diode. Draw its characteristics curve. (5)

5. (a) Derive Ideal diode equation. (10)

(b) Draw the electron and hole component of current in a forward biased PN junction. Given that $N_d<N_a$ (5)

OR

6. (a) Explain the break down mechanisms occurred in abrupt PN junctions. (10)

(b) What is the depletion capacitance of a PN junction? Explain its variation with reverse bias voltage. (5)

PART C

Question No. 7 is compulsory. Answer question No. 8 or 9

7. (a) Derive the expression for terminal currents of a transistor. (10)

(b) Draw the energy band diagram of a MOS capacitor in accumulation and in inversion condition. (5)

(c) Explain the CV characteristics of a MOS capacitor (5)

8. (a) What are the mechanisms which cause base current in a transistor? (5)

(b) Draw the minority carrier distribution in PNP transistor during active mode**.** (5)

(c) Explain the amplification action of a transistor. (5)

(d) What is base width modulation? (5)

OR

9. (a) Explain the output characteristics of a MOSFET. (5)

(b) Derive the expression for drain current of MOSFET. (10)

(c) A silicon n channel MOSFET has $\mu_n=600cm^2/V\text{-}sec$, $C_{ox}=1.2 \times 10^{-7}\ F/cm^2$, $W=50\mu m$, $L=10\mu m$ and $V_{TH}=0.8V$. Find the drain current when

(i). $V_{GS}=2V$ and $V_{DS}=1V$

(ii) $V_{GS}=3V$ and $V_{DS}=5V$ (5)

C **B3C053S** **Pages: 3**

Reg. No._____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, JULY 2017

EC203: SOLID STATE DEVICES (AE, EC)

Max. Marks:100. Duration: 3 Hours

PART A

Answer any One from Qn. No.2 and 3. Qn. No. 1 is Compulsory.

1. a) Plot the Fermi Dirac distribution function versus Energy for different temperatures. Justify the plot using necessary equations. (5)

   b) Show that L_n is the average distance an electron diffuses before it recombines. (5)

   c) Derive the expression for conductivity of a Semiconductor. (5)

2. a) For the given data, calculate hole and intrinsic carrier concentrations. Also sketch the band diagram. $N_C = 10^{19} cm^{-3}$, $N_V = 5x10^{18} cm^{-3}$, E_g=2eV, T=900^0K, n=$10^{17} cm^{-3}$ (5)

   b) Define Hall Effect. Derive the expressions for i) majority carrier concentration ii) mobility. (5)

   c) Prove that the minimum conductivity of a semiconductor occurs when $n_o = n_i(\mu_p / \mu_n)^{0.5}$. Also find the expression for minimum conductivity. (5)

OR

3. a) A p-type Si with minority electron lifetime of 0.1μs, is uniformly illuminated by a light having photon energy of 2.5eV.

   i) Determine the rate of excess carrier generation that is required to generate a uniform electron concentration of 10^{10} cm^{-3}. (2)

   ii) What is the optical power (cm^{-3}) that should be absorbed to create the excess carrier population of part (i)? (2)

   iii) How much optical power per cm^3 will be generated if the carriers recombine via photoemission? (2)

   b) Derive Steady state diffusion equations. (6)

   c) State and explain the different recombination mechanisms. (3)

PART B

Answer any One from Qn. No.5 and 6. Qn. No. 4 is Compulsory.

4. a) Draw the energy band diagrams of a pn junction when it is i) under equilibrium ii) forward biased iii) reverse biased. (6)

   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? Justify your answer. (6)

   c) What is the difference between depletion and diffusion capacitance in a diode? Which one dominates in forward bias? (3)

5. a) Derive the expressions for i) Contact potential ii) transition region width iii) maximum value of electric field. (8)

   b) A p^+n Si diode has $N_A=10^{15}cm^{-3}$ and $N_D=10^{17}cm^{-3}$, area of cross section $\mathbf{A}=10^{-3}cm^2$ and the lifetime in n and p regions be 1 μs at 300K. Determine the diode current for applied voltage of i) V = 0.1V ii) V = 0.6V. Given $D_p = 10cm^2/s$, $D_n = 36cm^2/s$. (4)

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

OR

6. a) A Schottky barrier diode is formed by depositing tungsten on n-type Si. If $N_D = 10^{15}cm^{-3}$, $q\varphi_m = 4.9eV$, $q\chi_s=4.15eV$ (electron affinity of silicon), at 300K, determine:

   i) Built in Voltage ii) width of depletion region and iii) Maximum electric field. (6)

   b) Draw and explain the characteristics of a tunnel diode. (4)

   c) Derive the expression for the time variation of voltage across a p-n junction as it is switched from forward bias to reverse bias condition. (5)

PART C

Answer any One from Qn. No.8 and 9. Qn. No. 7 is Compulsory.

7. a) Illustrate the minority carrier distribution in a PNP transistor in the active mode of operation. Give values of minority carrier concentrations in the three region. (4)

   b) Define Early effect. What is its effects on I_c, I_B, α and β of a transistor? (4)

   c) Draw the band diagrams for ideal MOS structure at i) equilibrium ii) accumulation iii) depletion and iv) Inversion. (8)

   d) Draw the structure of a FINFET . Plot its output characteristics. (4)

8. a) Derive the terminal current equations of a npn transistor. List the assumptions made for the derivation. (12)

   b) Define with expressions i) Base transport factor ii) Emitter injection efficiency iii) Current transfer ratio iv) Base to collector current amplification factor. (8)

OR

9. a) Draw and explain the capacitance- voltage characteristics of an n-channel MOS capacitor. (5)

   b) What are the effects of real surfaces on the threshold voltage of a MOS capacitor? Derive the threshold voltage equation of a real MOS capacitor? (10)

   c) An n^+-polysilicon gate n-channel MOS transistor is made on a p-type Si substrate with $N_a = 10^{15}cm^{-3}$. The SiO_2 thickness is 100Å in the gate region, at the onset of inversion. Find i) width of depletion layer and ii) V_T. Given ε_r of Si and SiO_2 are 11.8 and 3.9 respectively. (5)

*****

Total Pages: 2

Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2017

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) Derive the expression for electron, hole and intrinsic concentrations at equilibrium in terms of effective density of states. Formulate the relation between these concentrations at equilibrium. (8)

b) A Silicon sample is doped with 10^{17} boron atoms/cm^3. What is the equilibrium electron and hole concentrations at 300K? Where is E_F relative to E_i. Draw the energy band diagram. Intrinsic carrier concentration of Silicon is 1.5 x 10^{10} at 300K. (7)

2 a) A Silicon bar of 100 cm long and 1 cm^2 cross sectional area is doped with 10^{17}Arsenic atoms/cm^3. Calculate electron and hole concentrations at 300K. Also find the conductivity and the current with 10V applied. Electron mobility at this doping is 700 cm^2/V-sec. (7)

b) What is Hall effect? Derive the expression for carrier concentration and mobility in terms of Hall voltage. (8)

3 a) Describe diffusion process. Derive the expression for diffusion current density. (7)

b) Prove that under steady state carrier injection, the injected excess carrier concentration is an exponentially decreasing function of distance. (8)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Draw the energy band diagram of a PN junction (6)
i) at equilibrium, ii) under forward bias and iii) under reverse bias.

b) A Silicon sample having circular cross section with diameter 10μm is doped with 10^{18} cm^{-3} acceptor impurities on one side and 5x10^{15} cm^{-3} donor impurities on the other side. If the sample is at equilibrium, calculate contact potential, width of depletion region, penetration of depletion region on both N side and P side, and total charge on both N side and P side at 300K. (9)

5 a) An abrupt Silicon PN junction has the following parameters at 300K. (10)
P side:- Na=10^{17} cm^{-3}, τ_n=0.145, μ_n= 700 cm^2/V-sec.
N side:-N_d=10^{15} cm^{-3}, τ_p=1045, μ_p= 450 cm^2/V-sec.
The junction is forward biased by 0.5V. What is the forward current. What is the current at reverse bias of (-0.5V).

b) Differentiate between ohmic and rectifying contacts. (5)

6 a) Derive the expression for depletion and diffusion capacitance of a PN junction. (7)

b) With the help of necessary diagrams, explain the working of a tunnel diode. (8)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Derive the expression for minority carrier distribution and terminal currents in a transistor. (12)

b) Describe early effect in a transistor. (5)

c) What are the factors which cause base current in a transistor? (3)

8 a) With the help of necessary band diagrams, explain equilibrium, accumulation, depletion and inversion stages of a MOS capacitor. (12)

b) What are the effect of real surfaces of a MOS capacitor. (4)

c) Draw and explain the structure of FINFET. (4)

9 a) Derive the expression for drain current of a MOSFET. (10)

b) Draw and explain the transfer characteristics of an n-channel MOSFET. (5)

c) A Silicon n-channel MOSFET has μ_n= 600 cm^2/V-sec, C_{ox}= $1.2x10^{17}$ F/cm^2, z=50 μm, L=10 μm and V_{TH}= 0.8V. Find he drain current when (5)

i) V_{GS}=2V and V_{DS}=1V ii) V_{GS}=3V and V_{DS}=5V

****