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## APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 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. 1 a) Derive the expression for conductivity and mobility of carriers in a (7)

- semiconductor subjected to an electric field. b) Explain the temperature dependence of carrier concentration in extrinsic (3) semiconductors.
- c) Calculate the hole and intrinsic carrier concentrations. Sketch band (5) diagram. Nc= $10^{19}$ /cm<sup>3</sup>, Nv= $5x10^{18}$ /cm<sup>3</sup>, Eg=2eV, T=900K, n<sub>0</sub>= $10^{17}$ /cm<sup>3</sup>.
- 2 a) Derive Einstein's relation.
  - b) Explain why indirect recombination is a slow process. (4)
  - c) A Si sample is doped with  $10^{16}$ /cm<sup>3</sup> In atoms and a certain number of shallow (5) donors. The In acceptor level is 0.16eV above  $E_V$  and  $E_f$  is 0.26eV above  $E_V$  at 300K.How many In atoms are un-ionised?
- 3 a) Derive the expression for electron, hole and intrinsic concentrations at (8) equilibrium in terms of effective density of states. Formulate the relation between these concentrations at equilibrium.
  - An n-type Si sample with  $Nd = 10^{15}$  cm<sup>-3</sup> is steadily illuminated such that gop = b) (7) $10^{21}$  EHP/cm<sup>3</sup>s. If T<sub>n</sub> = T<sub>p</sub> = lµs for this excitation, calculate the separation in the quasi-Fermi levels, (Fn - Fp).

# PART B

# Answer any two full questions, each carries 15 marks.

4 a) Derive ideal diode equation. State any two assumptions used.

- b) Draw the potential, charge density and electric field distribution within the (5) transition region of an abrupt pn junction with Nd<Na. Label the diagram.
- 5 a) Illustrate how a metal -n type contact behave as rectifying contact and ohmic (10)contact with supporting energy band diagram.
  - b) If a metal with a work function of 4.6 e V is deposited on Si (electron affinity of (5) 4 eV) and acceptor doping level of  $10^{18}$  cm<sup>-3</sup>. Draw the equilibrium band diagram and mark off the Fermi level, the band edges, and the vacuum level. Is this a Schottky or ohmic contact, and why?
- 6 a) Illustrate the operation of a tunnel diode with supporting diagrams and explain (10)its VI characteristics

Marks

(6)

(10)

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b) An abrupt Si p-n junction has  $N_a = 10^{18} \text{cm}^{-3}$  on one side and  $N_d = 5x \ 10^{15} \text{cm}^{-3}$  on (5) the other. If the junction has a circular cross section with a diameter of 10µm, Calculate Vo,  $x_{no}$ ,  $Q_+$ , and Eo for this junction at equilibrium (300 K).

# PART C

### Answer any two full questions, each carries20 marks.

- 7 a) Derive the expression for minority carrier distribution and terminal currents in a (12) BJT. State the assumptions used.
  - b) Explain the basic performance parameters  $\alpha$ ,  $\beta \& \gamma$ . (3)
  - c) Assume that a p-n-p transistor is doped such that the emitter doping is 10 times (5) that in the base, the minority carrier mobility in the emitter is one-half that in the base, and the base width is one-tenth the minority carrier diffusion length. The carrier lifetimes are equal. Calculate α and β for this transistor.
- 8 a) Derive the expression for drain current at linear region and saturation for a (10) MOSFET.
  - b) An Al-gate p-channel MOS transistor is made on an n-type Si substrate with  $N_d = (5) 5 \times 10^{17} \text{ cm}^{-3}$ . The SiO<sub>2</sub> thickness is 100 Å in the gate region, and the effective interface charge  $Q_i$  is 5 x  $10^{10}$  q C/cm<sup>2</sup>. Find  $W_m$ ,  $V_{FB}$ , and  $V_T$ , if the gate to substrate work function difference  $\Phi ms = -0.15V$
  - c) Draw and explain the transfer characteristics of an n-channel MOSFET. (5)
- 9 a) Explain the principle of operation of MOS capacitor with suitable energy band (10) diagram.
  - b) Explain base width modulation. Explain its effect on terminal currents. (5)
  - c) Draw and label the minority carrier distribution curve of a BJT in active mode. (5)

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