



Printed Pages : 4

TEC – 403

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 3083

Roll No.

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B. Tech.

(SEM. IV) EXAMINATION, 2006-07

SEMICONDUCTOR MATERIALS & DEVICES

Time : 3 Hours]

[Total Marks : 100

- Note : (1) Attempt *all* the questions.
(2) All the questions carry *equal* marks.

1 Attempt any **two** parts of the following :

- (a) (i) Define the Fermi-Dirac distribution function and Fermi energy level of a material. Describe briefly the temperature dependence of the above distribution function. **3+3**
- (ii) Consider a particular material with Fermi energy of 6.25 eV and that the electrons in the material follow the Fermi-Dirac distribution function. Calculate the temperature at which there is a 1.0 per cent probability that a state 0.30 eV below the Fermi energy level will not contain an electron. **4**
- (b) (i) Derive an expression for the thermal-equilibrium concentration of electrons in the conduction band of a semiconductor. **5**
- (ii) Define the effective density of states function in the conduction band. Find the **2+3**

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numerical value of the same for a semiconductor in which the effective mass of an electron is $1.5 m_0$ where m_0 is the mass of a free electron.

- (c) (i) Let the donor and acceptor concentrations **6**
in a semiconductor be N_a and N_d
respectively. Show that the electron
concentration in the semiconductor can
be given by

$$n_0 = \frac{N_d - N_a}{2} + \sqrt{\left(\frac{N_d - N_a}{2}\right)^2 + n_i^2}$$

where n_i is the intrinsic carrier concentration.

- (ii) A device is doped with a donor **4**
concentration of $N_d = 3 \times 10^{15} \text{ cm}^{-3}$. For
the device to operate satisfactorily, the
intrinsic carrier concentration must remain
less than 5 per cent of the total electron
concentration. What is the maximum
temperature that the device may operate?

2 Attempt any **two** parts of the following :

- (a) A 0.46μ m-thick sample of GaAs is **3+4+3**
illuminated with monochromatic light of $h\nu =$
 2eV . The absorption coefficient is GaAs is
 $5 \times 10^4 \text{ cm}^{-1}$. The power incident on the sample
is 10 mW. Assume that the bandgap energy
of GaAs is 1.43 eV.
- (i) Find the total energy absorbed by the
sample per second (J/s).
- (ii) Find the rate of excess thermal energy
given up by the electrons to the electrons
to the lattice before recombination (J/s).

- (iii) Find the number of photons per second given off from recombination events, assuming perfect quantum efficiency.
- (b) Define the following terms with suitable examples : **10**
 Photo luminescence
 Cathodoluminescence
 Electro luminescence
 Carrier life time.
- (c) Write short notes on : **4+3+3**
 (i) Photoconductivity
 (ii) Quasi-Fermi Level
 (iii) Electroluminescence.

3 Attempt any **two** parts of the following :

- (a) (i) Derive an expression for the built-in potential in p-n junction in terms of the donor and acceptor concentrations of n- and p-type materials. **4**
- (ii) Show that the total depletion width in a p-n junction at thermal equilibrium condition can be given by **6**

$$W = \sqrt{\frac{2\epsilon_s V_0}{q} \left(\frac{1}{N_a} + \frac{1}{N_d} \right)}$$

where, ϵ_s is the permittivity of the semiconductor, V_0 is the built-in potential of the junction, N_a is the acceptor concentration in the p-type material, N_d is the donor concentration in the n-type material and q is the electronic charge.

- (b) Derive an expression for the current-voltage relation in an ideal p-n junction diode. **10**

- (c) Write short notes on : **4+6**
(i) Zener breakdown
(ii) Avalanche breakdown.

4 Attempt any **two** parts of the following :

- (a) In reference to a bipolar junction transistor, define the following quantities: **2+2+2+4**
(i) The emitter injection efficiency
(ii) Current transfer ratio
(iii) Base-to-collector current amplification factor
(iv) Early effect.
- (b) Discuss briefly the principle of operation of a GaAs MESFET. Also derive an expression for the I-V characteristic of the device. **4+6**
- (c) Write short notes on :
(i) Double heterostructure LED
(ii) p-i-n photodetector
(iii) Solar cell

5 Attempt any **two** parts of the following :

- (a) Describe briefly the principle of operation of an IMPATT diode. **10**
- (b) What are the basic constructional differences between a conventional p-n junction diode and a tunnel diode? Explain briefly the operation of a tunnel diode. **2+8**
- (c) Write short notes on : **5+5**
(i) The Gunn diode
(ii) Silicon Controlled Rectifier.