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Printed Pages : 4 **TEC – 403**

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

PAPER ID : 3083 Roll No.

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**

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

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

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

where n_i is the intrinsic carrier concentration.

(ii) A device is doped with a donor concentration of $N_d = 3x10^{15}$ 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? **4**

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

(a) A 0.46 μ m-thick sample of GaAs is illuminated with monochromatic light of $h\nu$ = 2eV. The absorption coefficient is GaAs is $5x10^4$ cm^{-1}. The power incident on the sample is 10 mW. Assume that the bandgap energy of GaAs is 1.43 eV. **3+4+3**

(i) Find the total energy absorbed by the sample ser 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
Cathodoluminiscence
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**

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

where, ε_s is the permittivity of the semiconductor, V_o 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.
