Code: AE25 **Subject: PHYSICAL ELECTRONICS AND SOLID STATE DEVICES**
Time: 3 Hours **Max. Marks: 100**

DECEMBER 2007

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x10)

a. For a MOS capacitor fabricated on p-type semiconductor, strong inversion occurs when

(A) surface potential is equal to Fermi potential.
(B) surface potential is zero.
(C) surface potential is negative and equal to Fermi potential in magnitude.
(D) surface potential is positive and equal to twice the Fermi potential.

b. The electron and hole concentrations in a intrinsic semiconductor are n_i and p_i respectively. When doped with a p type material, these change to n and p respectively. Then

(A) $n + p = n_i + p_i$. **(B)** $n + n_i = p + p_i$.
(C) $np_i = n_i p$. **(D)** $np = n_i p_i$.

c. The static characteristic of an adequately forward biased p-n junction is a straight line if the plot is of

(A) log I vs log V. **(B)** log I vs V.
(C) I vs log V. **(D)** I vs V.

d. A zener diode works on the principle of

(A) tunnelling of charge carriers across the junctions.
(B) thermoinic emission.
(C) diffusion of charge carriers across the junction.
(D) hopping of charge carriers across the junction.

e. The drift velocity of electrons in silicon

(A) is proportional to the electric field for all values of electric field.
(B) is independent of the electric field.
(C) increases at low values of electric field and decreases at high values of electric field.
(D) increases linearly with electric field at low values of electric field and gradually saturates at higher values of electric field.

f. Avalanche photodiodes are preferred over PIN diodes in optical communication systems because of

(A) speed of operation. **(B)** higher sensitivity.
(C) larger bandwidth. **(D)** larger power handling capacity.

g. Gallium arsenide is preferred to silicon for use in Gunn diode because it has

(A) lower noise at high frequencies.
(B) high ion mobility.
(C) suitable empty energy band which silicon does not have.
(D) better frequency stability.

h. A solar cell operates in

(A) first quadrant of the junction I-V characteristics.
(B) third quadrant of the junction I-V characteristics.
(C) fourth quadrant of the junction I-V characteristics.

(D) second or third quadrant of the junction I-V characteristics.

i. In electronic grade silicon impurity level is of the order of

(A) $5\times10^{16}\ cm^{-3}$ **(B)** $5\times10^{13}\ cm^{-3}$
(C) $1\times10^{5} cm^{-3}$ **(D)** $1\times10^{25}\ cm^{-3}$

j. LASER in comparison to LED has

(A) lower emission efficiency. **(B)** tuning arrangement.
(C) wide spectral width. **(D)** none of these.

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Discuss how the characteristics of a semiconductor change with temperature? **(8)**

b. The relationship between energy of the electron and wavefactor k is given by following equation $E=\frac{h^2k^2}{2m}$. Show this equation graphically for free electrons. **(8)**

Q.3 a. "The net charge within the semiconductor is zero". Justify. **(8)**

b. Consider a silicon sample doped with donors at $1.0\times10^{17}\ cm^{-3}$. If the intrinsic concentration within silicon is $1.0\times10^{10}\ cm^{-3}$, determine the location of the Fermi level relative to the valence band. **(8)**

Q.4 a. Discuss carrier dynamics in semiconductors namely drift, diffusion and generation – recombination. **(8)**

b. Given, incident intensity $I_o = 5mW$, absorption coefficient $\alpha = 5\times10^{4} cm^{-1}$, thickness $\ell = 0.5\times10^{-4} cm$ photon energy h =2.0eV
(i) Find the total amount of power absorbed.
(ii) Assume perfect quantum efficiency and determine the number of electron-hole pairs produced per second. **(8)**

Q.5 a. State Shockley equation. Explain forward bias and reverse bias behaviour of diode quantitatively using this equation. **(8)**

b. Differentiate between avalanche and zener breakdown. How these breakdowns are different from secondary breakdown in diodes. **(8)**

Q.6 a. "Punch through is limiting situation of early effect". Discuss. **(8)**

b. Why band bending takes place in practical MOS structure? Explain the concept of flat band voltage. **(8)**

Q.7 a. Discuss subthreshold conduction in MOSFET? **(8)**

b. The reflection coefficients for a semi-conductor laser are equal and have the value 0.5. The cavity length is 1.0 μm. Assuming that there are no additional loss terms, calculate the gain of the laser. **(8)**

Q.8 a. What determines the peak tunneling voltage of a tunnel diode? Explain. **(8)**

b. Explain transferred electron effects. Name five materials which can be used for fabricating devices utilizing gunn effect. **(8)**

Q.9 Write short notes on any FOUR of the following:

(i) Crystal growth.
(ii) CMOS latchup.
(iii) Hall effect.
(iv) Schottky effect.
(v) Evolution of ICs.
(vi) Charge transfer devices. **($4 \times 4 = 16$)**