ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE - 2007

MICROELECTRONICS & OPTOELECTRONIC DEVICES

SEMESTER - 4

Time : 3 Hours] [Full Marks : 70

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Bulk Micromachining makes Micromechanical devices by etching deeply into

a) Germanium Wafer b) Carbon Wafer

c) Silicon Wafer d) Gallium Wafer. ☐

ii) In *P–I–N* Diode the *I* part refers to

a) extrinsic substrate b) intrinsic substrate

c) intrinsic semiconductor d) extrinsic semiconductor. ☐

iii) Electron Affinity depends on

a) semiconductor material

b) doping of the semiconductor

c) applied potential

d) none of these. ☐

iv) In photodiode, the light energy

a) is converted to electrical energy

b) is converted to mechanical energy

c) is converted to sound energy

d) is not converted into any other form. ☐

v) In a state of saturation a MOSFET acts as

a) a closed switch b) an open switch

c) an amplifier d) a pure resistor.

vi) When a transistor is used as switch its operation is confined to

a) cut-off regions b) saturation region

c) active region d) both (a) & (b) .

vii) If τ_{ps} and τ_{pb} denote the excess hole lifetimes at the surface and in the bulk material respectively, then

a) $\tau_{ps} > \tau_{pb}$ b) $\tau_{ps} < \tau_{pb}$

c) $\tau_{ps} = 2\tau_{pb}$ d) $\tau_{ps} = \tau_{pb}$

viii) Hall voltage is proportional to

a) velocity

b) magnetic field

c) both (a) & (b) and parallel to the velocity

d) both (a) & (b) and perpendicular to the magnetic field.

ix) In Schottky barrier diode, the current mechanism is due to

a) minority carrier b) majority carrier

c) both of (a) and (b) d) none of these.

x) Charge coupled devices are used to

a) store the charge b) transfer the charge

c) both (a) & (b) d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Derive the one-dimensional continuity equation for minority carriers in generation-recombination process, under low injection condition. G_n, G_p, R_n and R_p are generation and recombination rates for electron / hole. 5

3. What is population inversion in Laser ? What is external quantum efficiency in a semiconductor Laser ? What is the optical feedback & Laser oscillation by which the amplified coherent emission is obtained ? 1 + 2 + 2

4. An *n*-type semiconductor at thermal equilibrium ($T = 300$ K) has a linear variation in doping concentration given by $N_d(x) = 10^{16} - 10^{19} x$, $0 \le x \le 1$ μm.

   Determine induced electric field. (Volt equivalent temperature at room temperature = 0·02V) 5

5. Discuss the principle of operation of vertical power BJT. 5

6. With energy band diagram describe Schottky junction barrier formation. Describe its operation under external bias. 2 + 3

GROUP – C

(Long Answer Type Questions)

Answer any *three* questions of the following. 3 × 15 = 45

7. a) What is SCR ? Point out its major uses.

   b) By using two-transistor analogy, briefly describe the basic operation of two-terminal SCR.

   c) Is it possible to observe the purpose of SCR by connecting two separate transistors ? Explain.

   d) How does the presence of third terminal control the I-V response of SCR ? Explain with system diagram. 2 + 6 + 2 + 5

8. a) Sketch the ideal energy band diagram of a metal-semiconductor junction in which $\Phi_m < \Phi_s$. Explain why this is an Ohmic contact.

b) Discuss how 2D-electron gas is formed in semiconductor heterojuction.

c) The Schottky barrier height of a Si Schottky junction is $\Phi_{BN} = 0{\cdot}59V$, the effective Richardson constant is $A^* = 111\ A/K^2\text{-}cm^2$ and the cross-sectional area is $a = 10^{-4}\ cm^2$.

For $T = 100$ K, calculate

i) Ideal reverse saturation current

ii) The diode current for V (applied) = 0·30 V. (5 + 2) + 3 + 5

9. a) Illustrate the basic process flow in micromachining ? What do you mean by optical lithography ?

b) What do you mean by plasma etching ?

c) Explain one non-lithographic micro-fabrication technology. (6 + 3) + 2 + 4

10. a) What is the advantage of optical fibre over the copper wire system ?

b) What is the difference between step index and graded index fibres ?

c) Distinguish between non-radiative & radiative recombination processes in a semiconductor. Express the internal quantum efficiency in terms of the life times of the processes.

d) A silica optical fibre has a core refractive index of 1.5 and the cladding refractive index of 1.450. Calculate

i) the critical angle for the core cladding interface.

ii) the acceptance angle in air for the fibre.

iii) the Numerical aperture (NA) of the fibre. 3 + 1 + (2 + 3) + (3 × 2)

11. Write short notes on any *three* of the following : 3 × 5

a) Solar cell

b) Semiconductor laser

c) Insulated bipolar junction transistor

d) *P-I-N* photodiode

e) O.E.I.C.