



Name :

Roll No. :

Invigilator's Signature :

CS/B.Tech(ECE-O)/SEM-4/EC-405/2012

2012

**MICROELECTRONICS AND OPTO-ELECTRONIC
DEVICES**

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

10 × 1 = 10

- i) Electron affinity depends on
 - a) semiconductor material
 - b) doping of the semiconductor
 - c) applied potential
 - d) none of these.
- ii) 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) $\tau_{ps} < \tau_{ps}$
 - c) $\tau_{ps} = \tau_{pb}$
 - d) none of these.



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

- a) minority carrier
- b) majority carrier
- c) both (a) and (b)
- d) none of these.

iv) Fermi level of a heavily doped n type semiconductor may lie in the

- a) valence band
- b) conduction band
- c) trap
- d) middle of the band gap.

v) Which of the following is quaternary material ?

- | | |
|-----------|---------|
| a) Ge | b) GaAs |
| c) InGaAs | d) Si. |



vi) Which of the following pairs are suitable for semiconductor heterojunction ?

- a) Si & Ge
- b) Si & Ga
- c) GaAs & AlAs
- d) GaAs & GaAlAs.

vii) The condition for ohmic contact for metal & n-type semiconductor junction is

- a) $\phi_m > \phi_s$
- b) $\phi_m < \phi_s$
- c) $\phi_m = \phi_s$
- d) none of these.

viii) Rectifying contact is also called

- a) non-ohmic contact
- b) ohmic contact
- c) heterojunction
- d) homojunction.

ix) Accumulation layer of electrons contained in a potential well at a heterojunction interface are free to move in

- a) one direction
- b) two directions
- c) three directions
- d) all of these.



x) Condition for subthreshold condition is

a) $V_{GS} = V_{TH}$

b) $V_{GS} \leq V_{TH}$

c) $V_{GS} \geq V_{TH}$

d) $V_{DS} = V_{TH}$.

xi) The behaviour of excess holes under non-equilibrium condition depends on

a) time

b) space

c) time and space

d) none of these.

xii) Which two materials are used to form heterojunction ?

a) Metal & semiconductor

b) Semiconductor & semiconductor

c) Semiconductor & insulator

d) Metal & metal.



GROUP - B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. What is the ideal Schottky barrier height ? Indicate the Schottky barrier height on an energy band diagram. Sketch the energy band diagram of zero biased, reverse biased and forward biased Schottky barrier diodes. $1 + 1 + 1 + 1 + 1$
3. What is heterojunction ? Draw the energy band diagrams of nN and pN heterojunctions. What is graded heterojunction ? $1 + 2 + 2$
4. What do you mean by Thyristors ? Discuss the characteristics of power MOSFETS. $2 + 3$
5. a) What is SCR ? Point out its major uses.
b) By using two transistor analogy, briefly describe the basic operation of two-terminal SCR.
6. What is dynamic effects in MOS capacitors ? What are the applications of CCD ? $3 + 2$

GROUP - C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Define what is meant by constant field scaling in MOSFET device design and discuss how device parameters are changed in constant field scaling.
b) An NMOS transistor has the following parameters :
 $L = 1 \mu\text{m}$, $W = 10 \mu\text{m}$, $t_{ox} = 250 \text{\AA}$,
 $N_a = 5 \times 10^{15} \text{ cm}^{-3}$, $V_{app} = 3\text{V}$. If the device is to be scaled using constant field scaling, determine the new device parameters for a scaling factor of $K = 0.7$ and $K = 1.2$.



c) Describe briefly the following :

- i) Short channel effect
- ii) Subthreshold conduction of a submicron MOSFET.

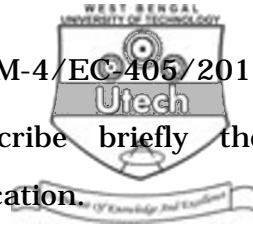
8. a) Derive the one dimensional continuity equation for excess carriers in generation recombination process, under low injection condition.

b) Excess electrons have been generated in a semiconductor to a concentration of

$\delta n(0) = 10^{15} \text{ cm}^{-3}$. The excess carrier lifetime is $\tau_{no} = 10^{-6} \text{ s}$. The forcing function generating the excess carriers turns off at $t = 0$ so the semiconductor is allowed to return to an equilibrium condition for $t > 0$. Calculate the excess electron concentration for

- i) $t = 0$
 - ii) $t = 1 \mu\text{s}$,
 - iii) $t = 4 \mu\text{s}$.
- c) What is ambipolar transport ? Why are carrier generation and recombination rate same in thermal equilibrium ?

5 + 5 + 5



9. a) What is photolithography ? Describe briefly the different etching used in MEMS fabrication.
- b) Illustrate with diagram the basic process flow in surface micromachining.
- c) What is MEMS pressure sensor ? Explain its working principle with diagram. $2 + 3 + 6 + 4$
10. a) Explain the operation of CMOS as an inverter with circuit diagram.
- b) How does CCD act practically in single phase and two-phase arrangements ?
- c) Describe the operation of insulated gate bipolar junction transistor (IGBT) with basic structure. $5 + (3 + 2) + 5$
11. Write short notes on any three of the following : 3×5
- a) MEMS pressure sensor
 - b) OEIC
 - c) 2D electron gas
 - d) Solar cell
 - e) MOSFET scaling.

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