INTRODUCTION TO MEMS
(AEIE 4244)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) In smart phone, the transducer measuring orientation of the screen is
(a) MEMS gyroscope (b) MEMS accelerometer
(c) MEMS capacitive sensor (d) MEMS inductive sensor

(ii) 'Stents' employed in angioplasty is an actuator of type
(a) electromechanical (b) electrostatic
(c) pneumatic (d) SMA

(iii) The main disadvantage of a MEMS pizeo-resistive type pressure sensor is
(a) suitable for high temperature applications
(b) its simplicity
(c) its low cost in production
(d) very strong temperature dependence

(iv) Sputtering is a form of
(a) Physical Vapour Deposition (b) Chemical Vapour Deposition
(c) Ionisation (d) Etching

(v) The most common Chemical vapour deposition (CVD) process is
(a) LPCVD (b) APCVD (c) PECVD (d) Sputtering

(vi) Spin coating is a form of
(a) Etching (b) Chemical Vapour Deposition
(c) Ionisation (d) Physical Vapour Deposition

(vii) The wet etching process is
(a) Isotropic (b) Anisotropic (c) Conformal (d) Planarization

(viii) Plasma enhancement is commonly used in
(a) CVD (b) Wet Etching
(c) Ion implantation (d) Oxidation

(ix) DRIE (deep reactive ion etching) process can produce
(a) Deep trenches (b) Slight trenches
(c) No trenches (d) Isotropic pattern

(x) The finite element method (FEM) is a viable analytical tool for micro-structures because of
(a) simple geometry
(b) complex geometry and loading/boundary conditions
(c) complex loading and boundary conditions
(d) simple loading with boundary conditions

Fill in the blanks with the correct word

(xi) *Scaling in geometry* means the scaling of _____size of the objects.

(xii) In sputtering, the carrier gas for metal vapour is _____.

(xiii) The concept used in "air bag" deployment system in automobile is _____.

(xiv) The physical process to dope silicon substrate is_____.

(xv) In surface bonding, only _____surface is required.

Group - B

2. (a) Which company manufactured the first surface micromachined accelerometer and when? *[(CO3)(Remember/LOCQ)]*
(b) State the part number of the said device. When the first Disposable blood pressure transducer was reported? *[(CO1)(Remember/LOCQ)]*
(c) List the popular MEMS based consumer health care products. *[(CO2)(Apply/IOCQ)]*
(d) Discuss briefly the importance of MEMS in medical domain. *[(CO2)(Analyse/IOCQ)]*

2 + 2 + 3 + 5 = 12

3. (a) What do you mean by MOEMS? *[(CO3)(Remember/LOCQ)]*
(b) Which type of material is preferred for such type of devices and why? *[(CO4)(Understand/LOCQ)]*
(c) Describe briefly any one type of optical sensor. *[(CO2)(Apply/IOCQ)]*

3 + 3 + 6 = 12

Group - C

4. (a) Describe the process of wet etching? What are the limitations of wet etching? *[(CO3)(Analyse/HOCQ)]*
(b) Make a distinction between deep reactive ion etching from Plasma etching. *[(CO4)(Remember/LOCQ)]*
(c) Distinguish isotropic etching from anisotropic etching. *[(CO2)(Apply/IOCQ)]*

(2 + 3) + 4 + 3 = 12

5. (a) What are the issues associated with deposition techniques? Explain with suitable diagram. *[(CO3)(Remember/LOCQ)]*

(b) Define the term lithography. Why is lithography associated with micro-fabrication? *[(CO2)(Apply/IOCQ)]*

(c) What is the use of mask in this process? *[(CO4)(Remember/LOCQ)]*

(3 + 3) + (2 + 2) + 2 = 12

Group - D

6. (a) State the differences between bulk and surface micro machining. *[(CO3)(Apply/IOCQ)]*

(b) What are the mechanical problems associated with surface micro machining? *[(CO4)(Remember/LOCQ)]*

(c) When will you prefer LIGA process? Define its advantages over the conventional micro machining technologies. *[(CO2)(Analyse/IOCQ)]*

4 + 3 + (2 + 3) = 12

7. (a) Describe the role of wafer bonding in MEMS based devices. Write down the names different wafer bonding methods. *[(CO4)(Analyse/IOCQ)]*

(b) What is the process required for bonding silicon to glass? Explain the process with a suitable diagram. *[(CO4)(Remember/LOCQ)]*

(c) Compare surface bonding technique with metallic interlayer bonding. *[(CO4)(Apply/IOCQ)]*

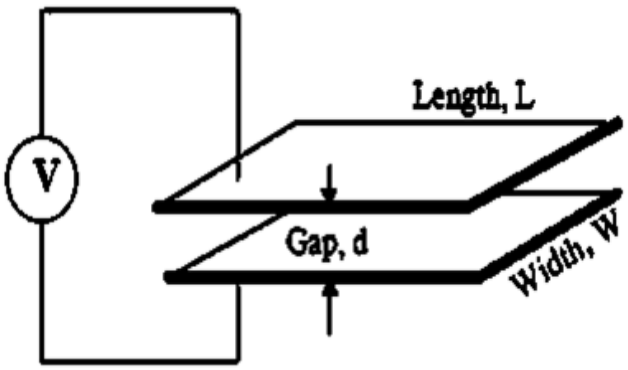
(2 + 2) + (1 + 4) + 3 = 12

Group - E

8. (a) Why does piezo-electric material so popular as a candidate material in micro-systems? *[(CO5)(Understand/LOCQ)]*

(b) State a few examples of natural and synthesized piezo electric crystals. *[(CO5)(Remember/LOCQ)]*

(c) A MEMS based parallel capacitor is made of two rectangular plates with the dimensions L = 100 μm and W = 50 μm as shown in Figure below. Evaluate the normal electrostatic force if the gap between these two plates is d= 4 μm. The plates are separated by static air with $\varepsilon_0 = 8.85 \times 10^{-12}$ Farad/m.



[(CO5)(Apply/IOCQ)]

3 + 4 + 5 = 12

9. (a) "Silicon-an ideal substrate material for MEMS fabrication" – Justify. *[(CO5)(Analyse/HOCQ)]*

(b) How to prepare SiO_2 in laboratory? *[(CO5)(Remember/LOCQ)]*

(c) Indentify the key chemical reactions involved in this. *[(CO5)(Apply/IOCQ)]*

5 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	42.70	46.89	10.41