

VALLIAMMAI ENGINEERING COLLEGE
S.R.M. Nagar Kattankulathur-603203
Department of Electronics and Instrumentation Engineering
M.E. CONTROL AND INSTRUMENTATION
Question Bank

Subject Code & Name: ET7014 - APPLICATION OF MEMS TECHNOLOGY
Class: III Semester M.E. (C&I)
Prepared by: P.Tamilmani, AP/EIE.

***UNIT – I MEMS: MICRO-FABRICATION, MATERIALS
AND ELECTRO-MECHANICAL CONEPTS***

PART - A

1. List the advantages and disadvantages of using piezoresistors?
2. What are the principle applications of micro sensors?
3. Write principle of optical sensors in MEMS.
4. Write the principle of thermal sensor in MEMS.
5. Write the principle of pressure sensor in MEMS.
6. What is the use of acoustic sensor?
7. Define resonant frequency.
8. Define thermal stress.
9. Differentiate CVD and PVD.
10. Define wet etching.
11. Define dry etching.
12. What is sputtering?
13. What is LIGA process?
14. Define oxidation.
15. Define diffusion.
16. Give the applications of MEMS in biomedical.
17. Compare the scaling law in miniaturization of devices based on electrostatic and electromagnetic principles.
18. State the materials that are used as piezoresistors.
19. Draw the steps showing photolithography process.
20. What is called deep reactive ion etching?
21. Give three examples of the objects that you are personally recognize to be of the size of approximately 1 mm.
22. Give at least four distinct advantages of miniaturization of machines and devices.
23. For order 1 scaling such as surface-to-volume scaling, the acceleration varies (1) linearly, (2) to the square power, (3) to the cubic power.
24. Heat flows (1) faster, (2) slower, (3) about the same in a smaller solid than in a larger solid.
25. What is a substrate?
26. Why silicon is an ideal material for MEMS?
27. What do you mean by scaling law in MEMS?
28. List the types of CVD.
29. Define etch rate.
30. Define stress and strain.
31. List types of beams.
32. Define intrinsic stress.
33. Define resonant frequency and quality factor.

PART - B

1. Discuss in detail the properties of silicon as a substrate material.
2. Compare and contrast MEMS technology and microelectronics.
3. Discuss in detail the MEMS fabrication processes:
 - (i) Oxidation.
 - (ii) Etching.
4. Discuss in detail the MEMS fabrication processes:
 - (i) Photolithography.
 - (ii) Ion Implantation.
5. What would happen to the required torque to turn a micro mirror With 50% reduction in size?
6. Estimate the associated changes in the acceleration **a** and the time **t** and the **power supply** to actuate a MEMS component if its weight is reduced by a factor of 10.
7. Find the reduction of electrostatic forces generated by a pair of parallel-Plate electrodes (having length **L**, width **W** and separated by a distance **d**) if both the length **L** and the width **W** of these plates are reduced by a factor of 10.
8. Use the scaling laws to estimate the variations of the volumetric flow and pressure drop in a circular tube if the radius of the tube is reduced by a factor of 10.
9. Derive equations for Mass, Acceleration, transient time and Power Density using Trimmer Force Vector.
10. Explain scaling of Electrostatic forces and Electromagnetic forces.
11. (i) Explain Czochralski method for growing single-crystal Silicon.
(ii) With neat diagram explain the structure of Silicon
12. Explain Silicon compounds used in MEMS.
13. Write short notes on Polymers and Packaging materials in MEMS.
14. Explain PECVD and APCVD with neat sketches.
15. Explain crystal planes and orientations.
16. Explain the methods for reducing bending induced by intrinsic stress.
17. Explain flexural beam bending analysis under simple loading conditions.

UNIT-II ELECTROSTATIC SENSORS AND ACTUATION

PART - A

1. Define pull-in effect.
2. Give the principle of electrostatic sensing devices.
3. Give the principle of electrostatic actuation devices.
4. List the applications of parallel plate capacitors.
5. What is the principle of inertia sensor?
6. List the applications of comb drive devices.
7. Define the sensitivity of accelerometer.
8. What is the principle of tactile sensor?

PART - B

1. With neat diagram explain two types of capacitive electrode configuration.
2. Explain different configurations of integrated finger capacitors and their relative pros and cons in terms of maximum displacement, linear/angular displacement and force output.

3. Consider an air gap capacitor made with two fixed parallel planar plates. At rest (zero bias), the distance between the two plates is air. The biasing voltage between two parallel plates is $x_0 = 100 \mu\text{m}$ and the areas of plates are $A = 400 \times 400 \mu\text{m}^2$. The media between the two plates is air. The biasing voltage between these two plates is $V = 5\text{volts}$. Calculate the numerical value if half of the area is filled with water(as an inter plate media)?
4. Explain equilibrium position of electrostatic actuator under bias.
5. With neat diagram explain parallel plate capacitive accelerometer.
6. With neat diagram explain torsional parallel plate capacitive accelerometer.
7. Explain the fabrication process of pressure sensor with sealed cavity.
8. Explain the fabrication process of condenser microphone.
9. With neat diagram explain the floating element shear stress sensor.
10. With schematic diagram explain bulk micro machined parallel plate capacitor serving as a differential mode tactile sensor.
11. With neat diagram explain the fabrication process of tactile sensor.
12. With neat diagram explain (a) comb drive, (b) transverse comb drive and (c) longitudinal comb drive.

UNIT-III THERMAL SENSING AND ACTUATION

PART - A

1. Define thermal resistance in the case of conduction, convection and radiation.
2. Write principle of thermal couples.
3. What do you mean by thermal sensors?
4. What do you mean by thermal actuators?
5. Define thermal conduction.
6. Define natural thermal convection.
7. Define forced thermal convection.
8. Define volumetric thermal expansion coefficient.
9. Define linear expansion coefficient.
10. Write the principle of thermal bimorph principle.
11. Define temperature coefficient of resistance.
12. Write the principle of hot wire anemometer.

PART - B

1. Explain thermal bimetallic bending and find vertical displacement at the free end of the cantilever beam.
2. With neat diagram explain bimetallic artificial cilia actuator.
3. With neat diagram explain polyimide thermal actuator.
4. With neat diagram explain lateral thermal actuator.
5. Explain thermal couple element with neat diagram and draw the I-V characteristic of a thermal resistor.
6. Explain thermal accelerometer with and without moving mass with neat diagram.
7. With schematic diagram explain single out-of-plane hot wire anemometer.
8. Explain the fabrication process of a surface micromachined hot-wire anemometer.
9. With schematic diagram explain thermal shear stress sensor and fabrication process.
10. With neat diagram explain infrared thermal sensor.
11. With schematic diagram explain the en-point sensor.

UNIT-IV PIEZOELECTRIC SENSING AND ACTUATION

PART - A

1. Define Piezo-electric effect.
2. Define electromechanical coupling coefficient.
3. Write the properties of Piezo electric materials.
4. What is the principle of acoustic sensor?
5. Write the governing equations of direct effect of piezoelectricity.
6. Write the governing equations of inverse effect of piezoelectricity.
7. List the commonly used Piezo electric materials.
8. Write the principle of surface elastic wave devices.

PART - B

1. Explain Piezo electric actuator model with neat diagram.
2. With neat diagram explain Piezo electric accelerometer.
3. With schematic diagram explain piezoelectric microphone and its fabrication process.
4. With schematic diagram explain cantilever type piezoelectric microphone.
5. Explain tactile sensor array with neat diagram.
6. Explain piezoelectric flow sensor with neat diagram.
7. Explain surface acoustic wave and flexural plate wave with neat diagram.

UNIT-V CASE STUDIES

PART - A

1. Define gauge factors for longitudinal and transverse cases for silica.
2. Differentiate longitudinal and transverse piezoresistors.
3. What do you mean by single crystal silicon?
4. List the applications of piezoresistive sensors.
5. Define magnetization.
6. Define Lorentz force on a current carrying wire.
7. List the micro fluidic applications of MEMS.
8. List the medical applications of MEMS.

PART - B

1. Explain piezoresistive sensor materials in detail.
2. With neat diagram explain stress in flexural cantilevers.
3. With neat diagram explain the fabrication of silicon proof mass with cantilever.
4. With schematic diagram explain artificial hair cell element with fabrication process.
5. Explain the process for electroplating of magnetic materials with neat diagram.
6. Explain design and fabrication process of magnetic coil.
7. Explain electrophoresis and dielectrophoresis with neat diagram.
8. With schematic diagram explain an integrated gas chromatography system.
9. Explain optical MEMS in detail.
10. Explain NEMS devices in detail.