(44)

Roll.No. | | | | | | | | |

B.E/B.Tech. (Full Time) DEGREE END SEMESTER EXAMINATIONS, APRIL/MAY 2012
MECHANICAL ENGINEERING BRANCH
EIGHTH SEMESTER (ELECTIVE)
ME 9033 MICRO ELECTRO MECHANICAL SYSTEMS
(REGULATIONS 2008)

Time: 3 hr **Max.Mark: 100**

Answer ALL Questions

Part – A (10 x 2 = 20 Marks)

1. Write down any one advantage of (100), (110) and (111) silicon planes with respect to Micro Electro Mechanical Systems (MEMS).
2. Why is there a 54.74° slope in the cavity of a silicon die for most of the MEMS?
3. What do you understand by the term "selectivity ratio" of etchant?
4. Define Fick's law with respect to diffusion of dopants.
5. Write down the advantages of shape memory alloy based MEMS actuator.
6. Write down the limitations of various signal conditioning circuits used for micropressure sensors.
7. What are the problems associated with micro fluidic system interface?
8. How does a microvalve work?
9. Write down the steps involved in the design of MEMS by using intellisuite.
10. What are the problems associated with microassembly in handling a sphere by a pair of flat plate gripping arms?

Part-B (5 x 16 = 80 Marks)

11. i. Explain the working principle of non-mechanical micropumps. **8**

ii. Evaluate the efficiency of the microchannels of three distinct cross sections circular, rectangle and V-channel of the same hydraulic diameter, based on the resistance offered to water flow. The circular capillary tube has an inside radius of 15 x 10^{-6} m. The height of the rectangular channel is 24 x 10^{-6} m. The angle and the length of a side of the valley of the V channel are 70.52° and 50.18 x 10^{-6} m, respectively. The dynamic viscosity of water at room temperature is 1001.65 x 10^{-6} N-s/m^2. **8**

12. a. i. Describe the world's top ten MEMS products along with their working principles. **8**

ii. Explain the multi-engineering disciplines involved in microsystems design and manufacture. **8**

(OR)

b. i. Explain with reference to context. **8**

1. "There's plenty of room at the bottom"
2. "Check out the world's lightest material"

ii. Describe the different materials used in the development of MEMS with two significant advantages of each and every material. **8**

13. a. i. Compare Bulk, Surface and LIGA micromanufacturing processes and **10**

also explain the methods of making microcantilever beam using the afore-said three manufacturing techniques.

ii. Explain ion implantation and ion sputtering. **6**

(OR)

b. i. Discuss the method of depositing silicon dioxide, silicon nitride, polycrystalline silicon and epitaxy growth over silicon substrate by chemical vapor deposition. **8**

ii. Explain the different methods of etching in detail. **8**

14. a. i. A microgripper is actuated by a capacitor made of two square plates (Area of the plate = 0.0625 m) with an intial gap of 4×10^{-6} m is attached at a distance of 2×10^{-4} m from the hinge. The length of the gripper arm is 6×10^{-4} m. The gripping arms are made of single-crystal silicon. The gripper is designed to pick up a rigid object weighing 4×10^{-5} N. The capacitor operates in an atmospheric environment. Determine the required electric voltage to pick up the weight. Assume a friction coefficient of 1.0 between the gripping points and the object surface. **8**

ii. Determine the electric voltage required to eject a droplet of ink from an inkjet printer head with a Lead Zirconate Titanate (PZT) piezoelectric crystal as pumping mechanism. The ejected ink will have a resolution of 350 dots per 2.54×10^{-2} m. The ink droplet is assumed to produce a dot with a film thickness of 1×10^{-6} m on the paper. The diameter and thickness of the PZT crystal are 2×10^{-3} m and 1×10^{-5} m respectively. Assume that the ink droplet takes the shape of a sphere and the inkwell is always refilled after ejection. The piezoelectric coefficient of PZT crystal is 480×10^{-12} m/V. **8**

(OR)

b. i. Two vehicles with respective masses 12,000 kg and 8,000 kg are travelling in opposite directions at equal velocities 14 m/s. Each vehicle is equipped with an inertia sensor built with a cantilever beam made of silicon. The length, breadth, height and seismic mass of the inertia sensor are 1×10^{-3} m, 1×10^{-5} m, 5×10^{-5} m and 1×10^{-5} kg, respectively. Estimate the deflection of the seismic mass in the sensor in vehicle 1 and also the strain in the two piezoresistors embedded underneath the top and bottom surfaces of the beam near the support after the two vehicles collide. Assume that the two vehicles will tangle together after the collision. **12**

ii. Estimate the reduction of torque required in turning a micro mirror with a reduction of 50% in the dimensions. **4**

15. a. i. Depict the various methods of testing for reliability of MEMS. **8**

ii. Describe the flow chart for integrated assembly, packaging and testing for mass production of MEMS. **8**

(OR)

b. i. Give details about the various techniques of bonding used in MEMS. **8**

ii. Explain the three levels of micropressure sensor packaging. **8**