Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – II • EXAMINATION – SUMMER • 2013

Subject code: 1724703 Date: 03-06-2013

Subject Name: Fundamentals of Micro Mechatronics Systems

Time: 10.30 am – 01.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Explain the importance of scaling laws in Miniaturization with reference to Geometry and Rigid body dynamics. **07**

(b) Differentiate Biomedical and Biosensors. List the major technical issues to be handled by BIOMEMS products. **07**

Q.2 **(a)** Describe the three principal signal transduction methods for micro pressure sensors. Provide atleast one advantage and disadvantage of all methods. **07**

(b) What is the role of Finite Element Analysis in the Design of MEMS? **07**

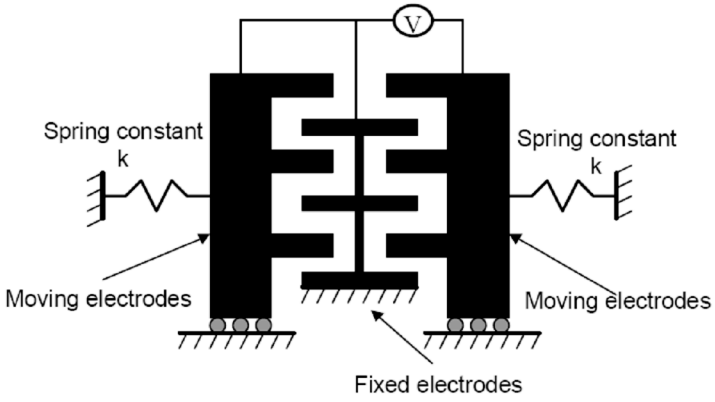
OR

(b) Explain the methods of constitutive relations: Hookean Elastic Solid and Greens elastic solid in brief. **07**

Q.3 **(a)** Silicon is an ideal material to be used as a substrate. Justify. **07**

(b) i. Discuss various applications of Micromotors with emphasis on working of linear micromotor. **03**

ii. Determine the voltage required to pull the moving electrode 10µm from the unstretched position of the spring for the comb driven actuator. The spring constant is 0.05 N/m. The comb drive is operated in air. The gap between the electrodes and the width of the electrodes are 2µm and 5µm respectively. **04**



OR

Q.3 **(a)** Explain the working and applications of different types of Micro accelerometers. **07**

(b) A silicon substrate is doped with boron ions at 100keV. Assume the maximum concentration after the doping is 30×10^{18} cm^3, Find (1) the dose Q, (2) dopant concentration at a depth of 0.15µm, and the depath at which the dopant concentration is 0.1 percent of the maximum value. **07**

R_p = 307nm, φR_p = 69E-7 cm

Q.4 **(a)** With a neat sketch explain the phenomenon of creep deformation and the three phases of fracture of a material. **07**

(b) Two vehicles with respective masses M_1 and M_2 are travelling in opposite directions at velocities V_1 and V_2. Each vehicle is equipped with an inertia sensor built with a cantilever beam of length 1000µm and a proof mass of 10mg. The beam has a cross section of 10 x 50 $_{\mu}$m and is made of silicon with a Youngôs Modulus of 190,000 MPa. Estimate the deflection of proof mass in the sensor in vehicle 1 with mass M_1 and also the strain in the two piezo resistors embedded underneath the top and bottom surfaces of the beam near the support after the two vehicles collide. The following data is given for consideration : **07**

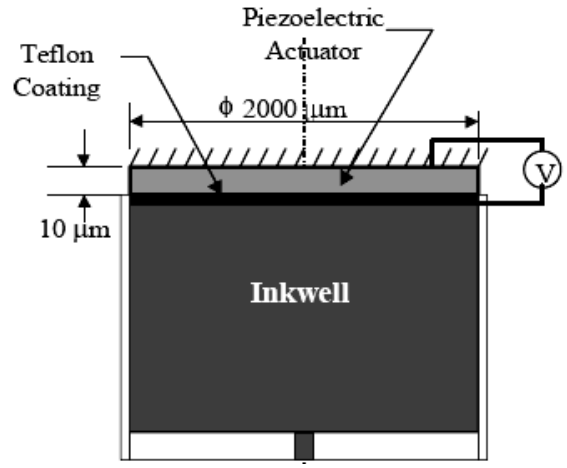
Mass M_1 = 12,000kg: M_2 = 8000kg, V_1= V_2 = 50km/hr.

Distance from outer surface to the centroid = 25E-6m.

OR

Q.4 **(a)** Discuss the similarities and differences between Ion Implantation and Diffusion processes **07**

(b) What would be the electric voltage required to eject a droplet of ink from an inkjet printer head with a PZT Piezoelectric crystal as a pumping mechanism? The ejected ink will have a resolution of 300 dots per inch. The droplet is assumed to produce a dot with a film thickness of 1µm on the paper. The geometry and dimension of the printer head is as per below figure. Assume that the droplet takes the shape of a sphere and the inkwell is always refilled after ejection. **07**



Q.5 **(a)** Explain the Czochralski method for growing silicon crystals. **07**

(b) Explain: Hamiltons principle, Fast Fourier Transformation when applied to MEMS. **07**

OR

Q.5 **(a)** Explain the concept of wave propagation in Micro Mechatronics structures. **07**

(b) List the microfabrication processes used for MEMS. Explain Photolithography and Chemical vapour Deposition techniques in detail. **07**

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