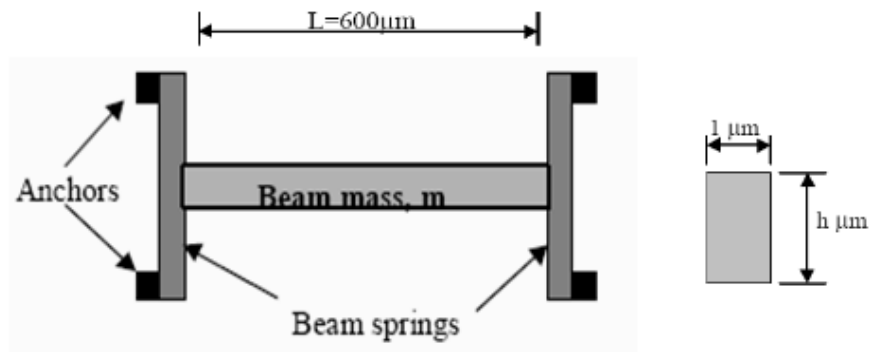


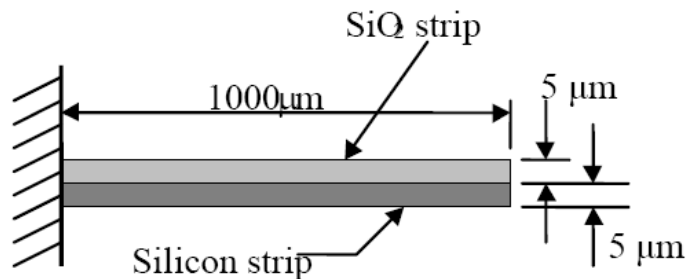
GUJARAT TECHNOLOGICAL UNIVERSITY**BE – SEMESTER–VIII • EXAMINATION – SUMMER • 2014****Subject Code: 182008****Date: 27-05-2014****Subject Name: MEMS & Nanotechnology****Time: 10:30 am - 01:00 pm****Total Marks: 70****Instructions:**

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

- Q.1 (a)** Describe the four main actuation techniques for micro devices with its pros and cons. **07**
- (b)** Determine the thickness of the beam spring shown below if the maximum allowable deflection of the beam mass is 5mm, one micro second after the deceleration from its initial velocity of 50km/hr to a standstill. The proof mass of the vibrating beam is 16×10^{-11} kg. The entire structure is assumed to be made of silicon with Young's modulus as 190GPa. **07**



- Q.2 (a)** Explain the conditions under which of Silicon and its compounds are used as Substrate materials for MEMS. **07**
- (b)** A micro actuator described below is expected to operate with a temperature rise from 10°C to 80°C . Plot the movements of the free end of the actuator with respect to the range of temperature rise. Use a temperature increment of 10°C . $E_{\text{SiO}_2} = 385 \text{ GPa}$, $E_{\text{Si}} = 190 \text{ GPa}$, $\text{CTE}_{\text{SiO}_2} = 5 \times 10^{-7}/^{\circ}\text{C}$, $\text{CTE}_{\text{Si}} = 2.33 \times 10^{-6}/^{\circ}\text{C}$. **07**

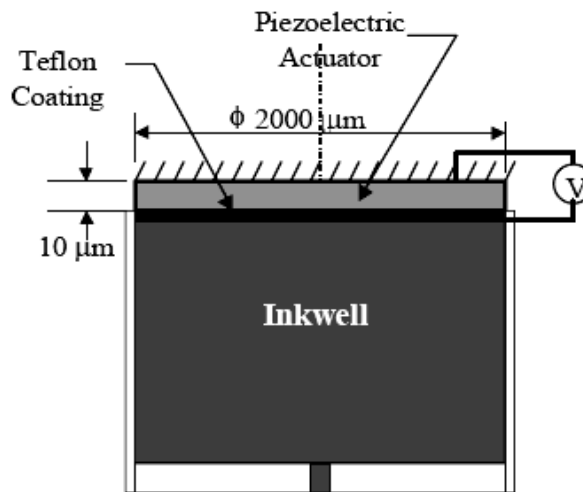
**OR**

- (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 $1000\mu\text{m}$ and a proof mass of 10mg . The beam has a cross section of $10 \times 50\mu\text{m}$ and is made of silicon with a Young's Modulus of $190,000\text{ MPa}$. 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 :

Mass $M_1 = 12,000\text{kg}$; $M_2 = 8000\text{kg}$, $V_1 = V_2 = 50\text{km/hr}$.

Distance from outer surface to the centroid = $25\text{E-}6\text{m}$.

- Q.3 (a) Differentiate 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 $1\mu\text{m}$ 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



OR

- Q.3 (a) Differentiate between squeeze film damping and damping in Shear from application point of view. 07
- (b) Explain the Czochralski method for growing silicon crystals. 07
- Q.4 (a) Discuss the effect of building up of the boundary layer during CVD process. 07
- (b) Sketch and explain the Three modes of fracture (in terms of the stress intensity factors) related to the fracture of a solid. With a neat sketch explain the three stages of creep deformation. 07

OR

- Q.4 (a) Discuss the tools available for measuring the nanostructures. Explain Scanning Electron Microscopy in detail. 07
- (b) Explain the importance of scaling laws in Miniaturization with reference to Geometry and Rigid body dynamics. What do you understand by Trimmer scaling factor? Explain giving a suitable example. 07
- Q.5 (a) Explain the process of molecular recognition applied to the field of Nanotechnology. 07
- (b) What is the role of Finite Element Analysis in the Design of MEMS? 07

OR

