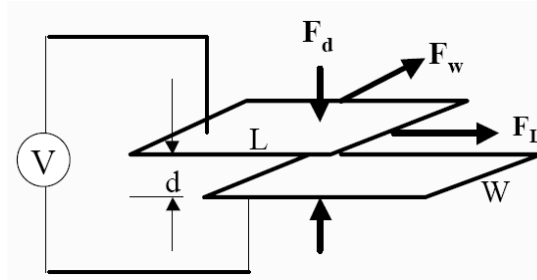


GUJARAT TECHNOLOGICAL UNIVERSITY**BE- VIIIth SEMESTER-EXAMINATION – MAY- 2012****Subject code: 182008****Date: 08/05/2012****Subject Name: MEMS & NANOTECHNOLOGY****Time: 10:30 am – 01:00 pm****Total Marks: 70****Instructions:**

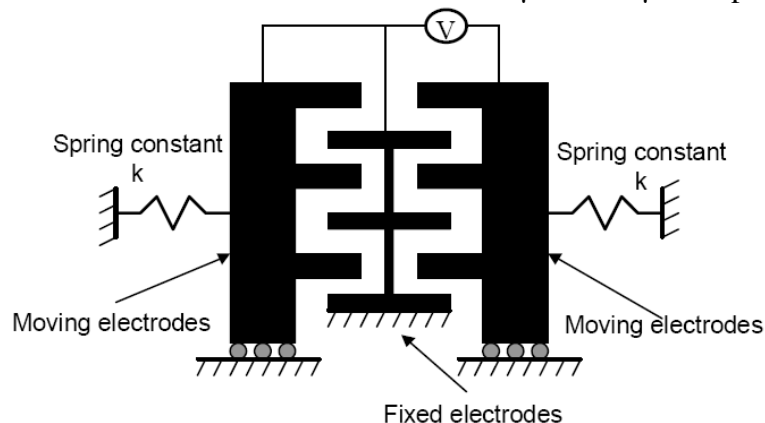
1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

- Q.1 (a)** Explain the working and applications of different types of Micro accelerometers. **07**
- (b)** i. What are the applications of Micromotors? Discuss the working of linear micromotor. **03**
- 04**

- ii. Calculate the electrostatic force on the plate electrodes with an applied dc voltage at 70V. Two square plates with the dimensions as $1000\mu\text{m}$ each are used. The plates are initially misaligned by 20 percent in both length and width directions. Pyrex glass is used as dielectric material.

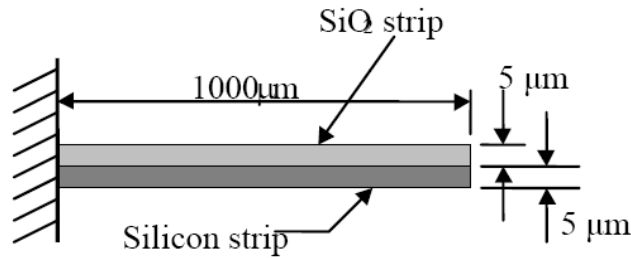


- Q.2 (a)** i. “Electrostatic forces are used to run micro motors rather than conventional electromagnetic forces.” Evaluate. **03**
- ii. For the comb driven actuator shown in Figure, determine the voltage required to pull the moving electrode $10\mu\text{m}$ from the unstretched position of the spring. 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 $2\mu\text{m}$ and $5\mu\text{m}$ respectively. **04**



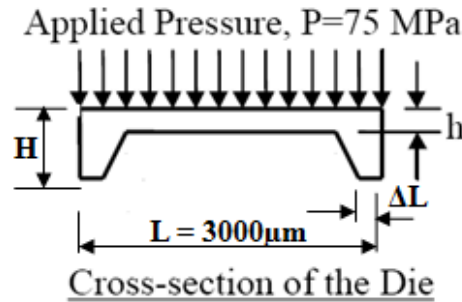
- (b) A micro actuator described below is expected to operate with a temperature rise from 10°C to 50°C . Plot the movements of the free end of the actuator with respect to the range of temperature rise. Use a temperature increment of 10°C .

$E_{\text{SiO}_2} = 385 \text{ GPa}$, $E_{\text{Si}} = 190 \text{ GPa}$, $\text{CTE}_{\text{SiO}_2} = 5 \times 10^{-7}/^{\circ}\text{C}$, $\text{CTE}_{\text{Si}} = 2.33 \times 10^{-6}/^{\circ}\text{C}$.

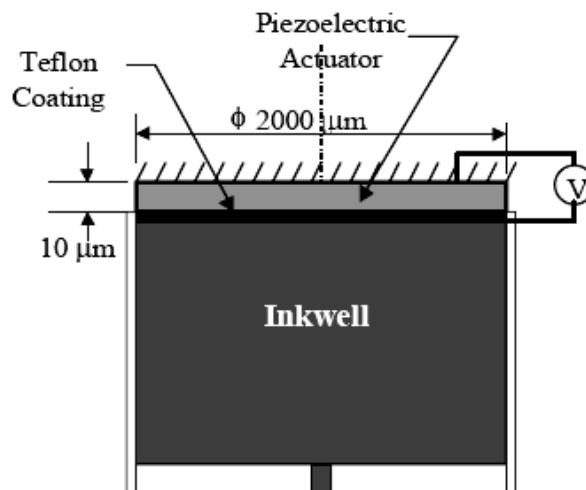


OR

- (b) A square diaphragm used in a pressure sensor is an integral part of a silicon die shaped from a wafer of 100mm diameter in the (100) plane (with a 54.74° degree slope from the bottom face into the cavity). The die has a plane area of $3 \text{ mm} \times 3 \text{ mm}$. A front side of the die is subjected to a pressure of 75 MPa . If the stress required to produce a measureable signal output is 350 MPa , find the required thickness of the diaphragm. $H = 500 \mu\text{m}$, $\Delta L = 250 \mu\text{m}$.



- Q.3** (a) What are the characteristics required for a material to be used as an ideal substrate? 07
- (b) Find 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) With a neat sketch explain the Czochralski method for growing silicon crystals. **07**
(b) List the microfabrication processes used for MEMS. Explain photolithography and Chemical vapour Deposition techniques in detail. **07**
- Q.4** (a) “At the nanometer scale, properties become size dependent”. Evaluate. **07**
(b) Why [surface area/volume] ratio is very large for nanoparticles compared to bulk materials? Explain with a simple example? Highlight any two problems associated with increase in surface area? **07**

OR

- Q.4** (a) “At the nanoscale, the job of "seeing" is done by molecular recognition.” Explain **07**
(b) What are the tools available to make the nanostructures? Discuss. **07**
- Q.5** (a) What are the types and possible applications of carbon nanotubes? Explain the use of carbon nanotubes as nano bio sensors. **07**
(b) What are the tools available for measuring the nanostructures? Differentiate between Scanning electron microscopy and Scanning probe microscopy. **07**

OR

- Q.5** (a) How can the concepts of molecular mechanics and structural mechanics be combined to model the carbon nanotubes? **07**
(b) Explain in brief **07**
i. Electronic Nose
ii. Application of Nanotechnology in Protein Engg
iii. Molecular motors
