

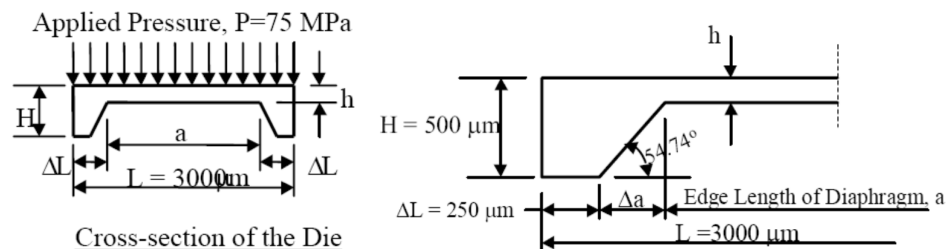
GUJARAT TECHNOLOGICAL UNIVERSITY**M. E. - SEMESTER – II • EXAMINATION – SUMMER • 2014****Subject code: 1724703****Date: 20-06-2014****Subject Name: Fundamentals of Micro Mechatronics Systems****Time: 02:30 pm - 05:00 pm****Total Marks: 70****Instructions:**

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

- Q.1** (a) Explain the following related to Micro Mechatronics systems: 07
 i. Chemical Sensors
 ii. Pressure Sensors
 iii. Thermal Sensors
 (b) What is the significance of a Micro Accelerometer in a MEMS system? Discuss its various types with applications. 07
- Q.2** (a) Describe the three principal signal transduction methods for micro pressure sensors. Differentiate between linear motors and rotary motors. 07
 (b) In a pressure sensor, the square diaphragm appears to be the least favored geometry. Discuss. 07

OR

- (b) Explain the methods of constitutive relations: Hookean Elastic Solid and Greens elastic solid in brief. 07
- Q.3** (a) What are the properties a material needs to possess to be considered as an ideal substrate material? Describe briefly. 07
 (b) If the stress required to produce a measurable signal output in a square diaphragm in a pressure sensors is 350 MPa, what will be the required thickness of the diaphragm? The diaphragm is an integral part of the silicon die that is shaped from a wafer of 100mm diameter in the 100 plane with a 54.74° angle in the slope from the bottom face into the cavity as illustrated in the below Figure. The die has a plane area of 3mm x 3mm. A pressurized medium is applied at the front side of the silicon die. 07

**OR**

- Q.3** (a) Explain the significance of Boundary layer related to the CVD process. 07
 (b) A silicon substrate is doped with phosphorus ions at 30keV. Assume the maximum concentration after the doping is $30 \times 10^{18} \text{ cm}^{-3}$, Find (1) the dose Q, (2) dopant concentration at a depth of $0.15 \mu\text{m}$, and the depth at which the dopant concentration is 0.1 percent of the maximum value. 07
 $R_p = 42 \text{ nm}$, $R_p = 19.5 \text{ nm}$
- Q.4** (a) δ Creep is a temperature dependent phenomenon. Evaluate. 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 $1000 \mu\text{m}$ and a proof mass of 07

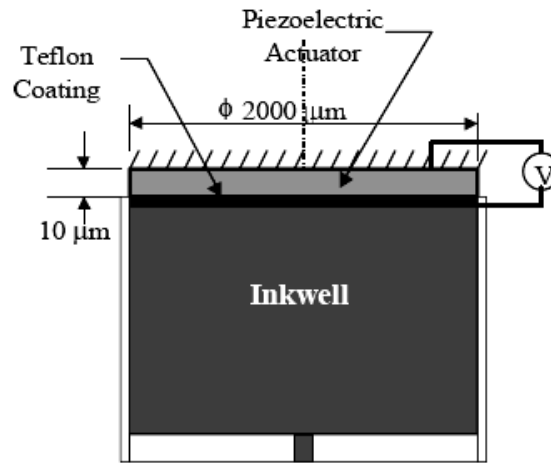
10mg. The beam has a cross section of $10 \times 50 \mu\text{m}$ and is made of silicon with a Young's Modulus of 190,000 MPa. Estimate the deflection of proof mass in the sensor in vehicle 1 with mass M_1 and also the strain in the two piezo resistors embedded underneath the top and bottom surfaces 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 = $25\text{E-}6\text{m}$.

OR

- Q.4 (a)** Discuss the importance of Finite Element Analysis in micro Mechatronics systems. **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**



- Q.5 (a)** Explain the Czochralski method for growing silicon crystals. **07**
- (b)** Explain the concept of wave propagation in Micro Mechatronics structures. **07**
- OR**
- Q.5 (a)** Explain: Hamiltons principle and Fast Fourier Transformation when applied to Micro Mechatronics systems. **07**
- (b)** List the microfabrication processes used for MEMS. Explain Ion Implantation and Diffusion techniques in detail. **07**
