

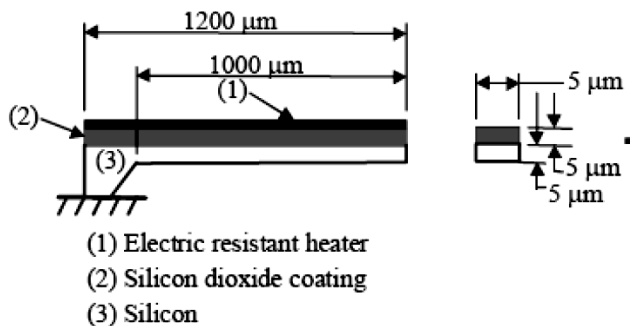
GUJARAT TECHNOLOGICAL UNIVERSITY**ME – SEMESTER II (NEW) – • EXAMINATION – SUMMER 2016****Subject Code: 2724703****Date: 27/05/2016****Subject Name: Fundamentals of Micro Mechatronics Systems****Time: 10:30 am to 01:00 pm****Total Marks: 70****Instructions:**

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

- Q.1** (a) Explain the significance and utility of micro mechatronics systems in several areas using appropriate examples. Also explain the interdisciplinary nature of microsystems engineering. **07**
- (b) Differentiate between microelectronics and micro systems. **07**
- Q.2** (a) Explain the working of an Acoustic wave sensor with a suitable illustration. With a neat schematic diagram explain the two types of Micro Pressure sensors. **07**
- (b) Explain the Czochralski method used for producing single crystal silicon ingots. Also explain the properties of silicon that makes it an ideal substrate material. **07**

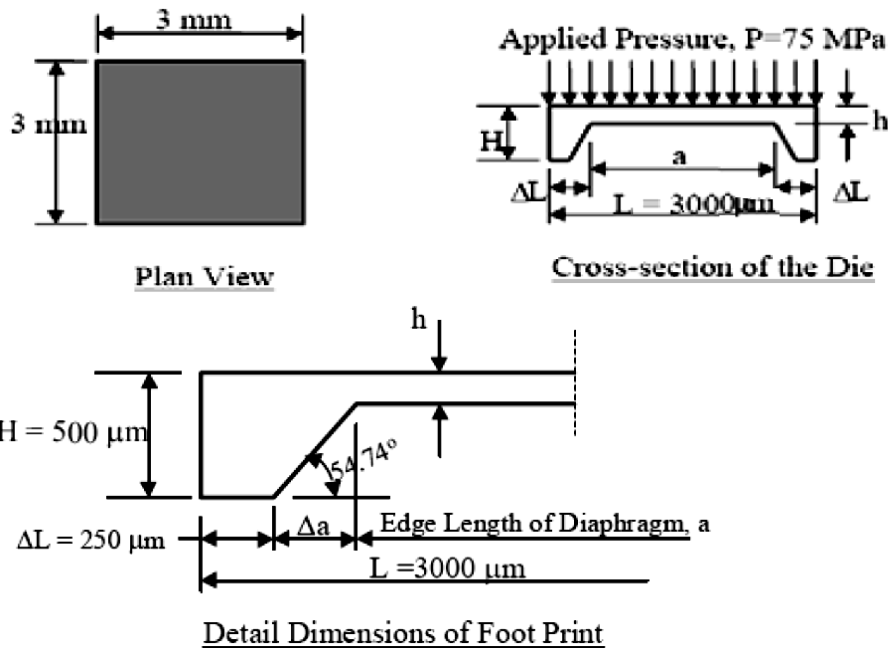
OR

- (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) Explain the steps to be followed in design a suitable micro accelerometer for a particular application. **07**
- (b) A micro actuator made up by a bilayered strip using oxidized silicon beam is shown below. A resistant heating strip is deposited on the top of the oxide layer. Estimate the interfacial force and the movement of the free end of the strip with a temperature rise of 10°C . $E_{\text{SiO}_2} = 385000\text{ MPa}$, $E_{\text{Si}} = 190000\text{ MPa}$, $\alpha_{\text{SiO}_2} = 0.5\text{E}-6/^\circ\text{C}$, $\alpha_{\text{Si}} = 2.33\text{E}-6/^\circ\text{C}$. **07**

**OR**

- Q.3** (a) Differentiate between squeeze film damping and damping in Shear from application point of view. **07**

- (b) If the stress required to produce a measurable signal output in a square diaphragm in a pressure sensor is 350 MPa, what will be the required thickness of the diaphragm? The diaphragm is an integral part of a silicon die that is shaped from a wafer of 100mm diameter with a 54.74° angle in the slope from the bottom face into the cavity. The die has a plane area of 3mm x 3mm. A pressurized medium is applied in the front side of the silicon die. The assigned die thickness $H=500\mu\text{m}$ is the standard thickness of 100mm diameter whereas the foot print $\Delta L=250\mu\text{m}$. 07



- Q.4** (a) Discuss the effect of building up of the boundary layer during CVD process. 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

OR

- Q.4** (a) Discuss photolithography and CVD as micro fabrication processes. 07
 (b) A silicon substrate is doped with Phosphorus ions at 100KeV. Assume the maximum concentration after doping is $30E18/\text{cc}$. Find the dose, dopant concentration at a depth of $0.15\mu\text{m}$, depth at which the concentration is 0.1% of the maximum value. $R_p=135\text{nm}$ and $\Delta R_p=53.5\text{nm}$. 07

- Q.5** (a) Explain the meaning and significance of a clean room. Differentiate the Ion implantation and Diffusion Micro fabrication techniques. 07

- (b) Explain the following 07
1. Hookean Elastic Solid
 2. Wave Propagation in Micro structures
 3. Use of FFT and DFT in Micro structures

OR

- Q.5** (a) 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

- (b) What is the role of Finite Element Analysis in the Design of Micro Mechatronics Systems? 07
