GUJARAT TECHNOLOGICAL UNIVERSITY ME SEMESTER II EXAMINATION – SUMMER 2017

Subject Code: 2724703Date: 29/05/2017Subject Name: Fundamentals of Micro Mechatronics SystemsTime:02:30 PM to 05:00 PMTotal 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 07 accelerometers. Also discuss the principles of damping used with their applications.
 - (b) Using a nest sketch explain the construction and working of a MEMS Pressure 07 sensor
- Q.2 (a) With a neat schematic diagram explain the Czochralski process of producing 07 silicon ingots.
 - (b) Discuss the various materials that can be used as substrate with their merits and 07 demerits.

OR

- (b) What are the characteristics required for a material to be classified as an ideal 07 substrate material?
- Q.3 (a) Two vehicles with respective masses M1 and M2 are travelling in opposite directions at velocities V1 and V2. Each vehicle is equipped with an inertia sensor built with a cantilever beam of length 1000 μ m and a proof mass of 10mg. The beam has a cross section of 10 x 50 μ 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 M1 and also the strain in the two piezoresistors 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 M1 = 12,000kg: M2 = 8000kg, V1= V2 = 50km/hr. Distance from outer surface to the centroid = 25E-6m.
 - (b) Explain the significance of scaling laws in MEMS structures with specific 07 application to rigid body dynamics.

OR

- Q.3 (a) A silicon substrate is doped with phosphorus ions at 30keV. Assume the maximum concentration after the doping is 30 x 1018 cm3, Find (1) the dose Q, (2) dopant concentration at a depth of 0.15µm, and the depth at which the dopant concentration is 0.1 percent of the maximum value. Rp = 42nm, Δ Rp = 19.5 nm
 - (b) Evaluate
 - 1. In a pressure sensor, the square diaphragm appears to be the least favored geometry.
 - 2. Electromagnetic force is not used for actuation in MEMS structures.
- Q.4 (a) Explain the concept of wave propagation in MEMS structures.

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(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 54.74⁰ 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.



OR

Q.4 (a) Differentiate between ion implantation and Diffusion processes.
(b) List the micro fabrication processes used for MEMS. Explain CVD technique in
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detail.

- Q.5 (a) "Quantitative assessment of induced stresses in thin films after they are produced on the top of base materials is a very difficult task". Evaluate. Also explain the significance of rate of buildup of boundary layer in a CVD process.
 - (b) Explain: Hamiltons principle and Fast Fourier Transformation when applied to 07 Micro Mechatronics systems.

OR

- **Q.5** (a) Explain the role of FEA in analyzing MEMS devices.
 - (b) Explain the methods of constitutive relations: Hookean Elastic Solid and 07 Greens elastic solid in brief.

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