

Roll No.:

National Institute of Technology, Hamirpur (HP)

Name of Examination: B.Tech., Dual Degree End Semester Examination, 2022

Branch: Open Elective I

Semester: 5th

Subject: MEMS Design

Subject Code: EC-370

Time: 3 Hours

Maximum Marks: 50

Note: Attempt all questions (There are 5 questions)

Q-1 (i) Figure Q-1(i) shows the two round plates of diameter (d) = 100 μm , directly overlap one-another. The upper plate is attached with three flexures as shown in figure Q1(i). The overall spring constant of the hanging structure = 19.2 N/m and the initial gap between two plates = 2 μm . The lower plate is fixed on the substrate.

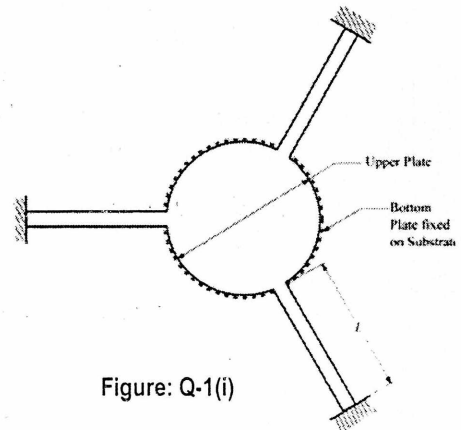


Figure: Q-1(i)

- (a) Find the value of pull-in voltage
- (b) What is the displacement of the upper plate if the applied voltage = 5V (between the plates) [6M]

Q-1(ii) Draw the cross-sectional view of an electrostatic actuator and define the term 'Pull-in voltage'. Also mention the gap at which the pull-in occurs. [4M]

Q-2(i) HF is used to etch SiO_2 isotropically at 100 nm/min. Further, assume that HF has infinite high selectivity against Si and photoresist (PR) such that it wouldn't etch them. **[Note PR stands for photoresist]**

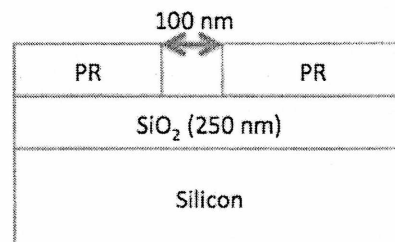


Figure -Q-2(i)

- (a) For the structure shown in the figure Q-2(i) below, how long should this wafer be placed in HF etchant to etch SiO_2 with 0% over-etch and 10% over-etch?
- (b) What is the width of SiO_2 removed at the top of the resulting trench (at the Photoresist/ SiO_2 interface), and what is the width of SiO_2 removed at the bottom of the trench (at the SiO_2/Si interface) at 0% over-etch and after the 10% over-etch? Also draw a schematic of the structure at 0% over-etch and after the 10% over-etch. [6M]

Q-2 (ii) Draw the cross-sectional view of an accelerometer having a proof mass and thermopiles. Explain the working principle of this device in detail. [4M]

Q-3 (i) Explain the LIGA process through an example and write the name of the few applications based on LIGA process. Also compare the LIGA process with SLIGA process. [6M]

Q-3(ii) Draw the block diagram of MEMS as a micro-actuator and explain each block. [4M]

Q-4 (i) Draw the diagram and explain the working of the in-plane and out-of-plane thermal actuators. [6M]

Q-4(ii) Explain the Bulk Micromachining process and write the process steps along with cross-sectional views to fabricate a cantilever using bulk micromachining process. [4M]

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245

Q-5 (i) Figure Q-5 (i) shows the full bridge circuit for sensing the pressure. There are 4 strain gauges in the circuit. Derive the expression for the V_{out} in terms of Gauge factor (GF), ϵ (strain), and V_{in} . [6M]

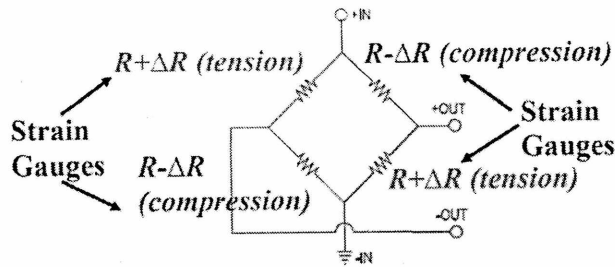


Figure: Q-5 (i)

Q-5 (ii) What is the direct and converse piezoelectric effect (write the equations). Discuss 1 application for direct and 1 application for converse piezoelectric effect. [4M]

****End of Question Paper****