Dr Saurabh Kumar (289) 8/12/2022 (E)

Roll No.:

# National Institute of Technology, Hamirpur (HP)

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

**Branch: B.Tech (Dual Degree)** **Semester: 7th**

**Subject: MEMS and Microsensor Design** **Subject Code: EC-731**

**Time: 3 Hours** **Maximum Marks: 50**

**Note:** ***Attempt all questions (There are 5 questions)***

**Q-1 (i)** A force moment diagram of the non-uniform cantilever is given below, If a = 150 µm, L =250 µm, W (width of beam) = 100 µm, y = 2, t = (thickness of the beam) = 2 µm and, g= initial gap between the cantilever and actuation electrode= 2 µm. The beam material is aluminum with young's modulus E=77 GPa, $M_0$ = moment working at the anchor position, $R_0$ = reaction force and q= uniform distributed force acting per unit length. Calculate the value of Pull-in voltage if the spring constant (k) of the hanging structure is = 9.5 N/m. **[6M]**

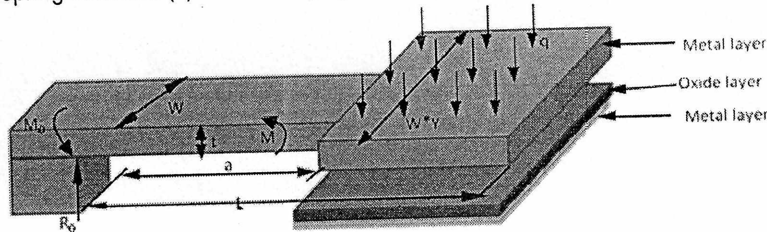


**Figure –Q -(i)**

**Q- 1(ii)** Figure Q-1(ii) shows the mechanical equivalent of the actuator. Derive the expression for the release time with b (damping coefficient) = 0 and V = 0 V. The release time is defines as the time taken by the movable structure to reach its neutral position (un-actuated position) from the down position (actuated state). **[4M]**

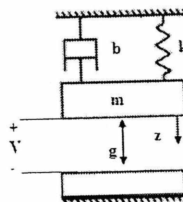


**Figure Q-1 (ii)**

**Q-2(i)** You are using KOH etching to define a 200 um thru-hole in a <100> oriented wafer. If you want to have a 200 µm wide opening at the bottom of the wafer, what size opening 'W' would you need on the top of the wafer (W = mask dimension), if you are using a) 400 um thick wafer b) 600 um thick wafer. What would be the dimensions of the thru-hole be if you used the mask intended for the 400 um thick wafer on the 600 um thick wafer. **[6M]**

**Q2-(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 Surface Micromachining process and write the process steps along with cross-sectional views to fabricate a cantilever using surface micromachining process. **[6M]**

**Q- 3 (ii)** If instead of rapid stirring, programmed growth (partial stirring) conditions are imposed such that stagnant layer thickness is 0.5 cm during growth of the crystal and dopant diffusivity in the melt (*D*) is $8\times10^{-4}$ $cm^2/sec$ and distribution coefficient of dopant is 0.27. What freezing rate is necessary to achieve an effective segregation coefficient of 0.99? **[4M]**

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**Q-4 (i)** Draw the diagram and explain the working of thermal bimorph actuator (bimetallic artificial cilia actuator) for object transport in VLSI fabrication lab. **[6M]**

**Q-4 (ii)** Explain the LIGA process through an example and write the name of the few applications based on LIGA process. **[4M]**

**Q-5 (i)** What is the direct and converse piezoelectric effect (write the equations). Discuss 1 application for direct and 1 application for converse piezoelectric effect. **[6M]**

**Q-5 (ii)** How do you classify MEMS devices? Give an example for each class. **[4M]**

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