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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL (A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS VII SEMESTER B.TECH. END SEMESTER EXAMINATIONS, NOV-DEC 2023 SUBJECT: MICROELECTROMECHANICAL SYSTEMS [MTE 4077] (Date: 07/12/2023)

Time: 3 Hours

MAX. MARKS: 50

Instructions for the Candidates:

- ✤ Answer ALL questions.
- ✤ Data not provided, may be suitably assumed.

Q. No		Μ	СО	РО	LO	BL
110						
1A.	A silicon substrate is subjected to diffusion of boron dopant at 1000°C with	05	4	2	2	3
	a dose of 10 ¹¹ /cm ² ·Find:					
	a. The expression for estimating the concentration of dopant in the					
	substrate.					
	b. The concentration at 0.15μ m beneath the surface after one hour into					
	the diffusion process. The substrate is initially free of impurity.					
1 B .	Explain the photolithography technique for creating 3D geometry for MEMS	03	4	1	1	2
	applications.					
1C.	After performing photolithography technique, a 3D silicon substrate is	02	4	2	2	2
	required to be doped. However, in order to maintain the structural integrity					
	of the substrate, it is required to dope it at low temperature without the					
	application of heat. Describe a suitable method to dope the substrate					
2A.	A PZT piezoelectric crystal film is used to transduce stress related	05	3	3	2	3
	information at a particular section of the cantilever beam where the induced					
	stress is 10% of the maximum stress. The beam is as shown in the figure					
	Q2A with a load of F=2000 μ N. The dimensions of the beam are: L=1000 μ m,					
	$b=12.5\mu m$ and $d=40\mu m$. Determine the electrical voltage output from the					
	PZT film for the given loading condition. Take $dPZT=480 \times 10^{-12}$ m/volt.					
	Length of PZT is 4μ m. Youngs modulus for silicon can be taken as					
	E _{silicon} =190000MPa					
	-1 .					
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	Fig. Q2A					
2B.	A clean silicon layer is subjected to oxidation to form a layer of silicon	03	4	2	2	3
	dioxide. The exposed silicon layer is in (111) plane. Both dry and wet					
	oxidation is being performed at 1200°C for 2 hours.					

2C.	Explain the factors affecting rate of deposition during a chemical vapor deposition process. Explain the effect of each factor on the deposition rate.	02	4	1	1	2
3A.	Determine the amplitude and frequency of vibration of an 8mg mass suspended from a spring constant $k=5 \times 10^{-5}$ N/m. Vibration of the mass is initiated by a small pull of the mass downwards by an amount 6µm	05	1	2	2	3
3B.	Explain the process of surface micromachining. How is it different from the standard photolithography technique?	03	4	1	1	2
3C.	List some disadvantages of the surface micromachining process.	02	4	1	1	2
4A.	A parallel plate capacitor is made with 2 square plates with dimensions $L=W=1000\mu m$. Determine the normal electrostatic force and electrostatic force in the direction of L and W if the gap between the 2 plates is $2\mu m$. The plates are separated by static air. Applied voltage is 100V.	05	1	2	2	3
4B.	Explain the LIGA process used for producing MEMS components	03	4	1	1	2
4C.	Compute the reduction in potential energy between 2 electrically conducting plates when charged by a voltage V and dimension reduced by 10 times	02	2	2	2	3
5A.	Derive the trimmers force scaling vector for force, acceleration, time, and power density.	05	2	2	2	3
5B.	Explain the deep reactive etching process and highlight its advantages against the regular etching process	03	4	1	1	2
5 .	Explain the electrochemical etch stop method used for controlling chemical etching.	02	4	1	1	2