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Analysis of U shaped MEMS Micro cantilever using COMSOL

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Abstract*: This paper explains about analysis of U shaped MEMS cantilever with silicon substrate using COMSOL Multiphysics software. This U shape cantilever structure is made of silicon and on that different layers are incorporated. U shape cantilever will have high beam length and this design can meet any requirements with allowable strain limits.

Keywords: MEMS, COMSOL, Simulation, U shape.

I. INTRODUCTION

Micro Electro Mechanical systems are the emerging technology for producing miniaturized products with low cost and high sensitivity. MEMS are of size in between 1 to 100 micrometers and generally range from 20 micrometers to a millimeter. MEMS cantilevers can be fabricated in different ways where multiple components can be fabricated on a single chip. The operation of MEMS mainly depends on the deformation. The deformation can be tensile and compressive which occurs at top and bottom of the cantilever. MEMS cantilevers give quick and exact response based on biomolecular activities when compared to conventional cantilever design.

II. DESIGN PARAMETERS

The cantilever basic structure is silicon with area of 10,000m and on that substrate various materials are incorporated as layers.

1. Dimensions

Dimensions	Value (µm)
Length	2000
Breadth	200
Thickness	1.5

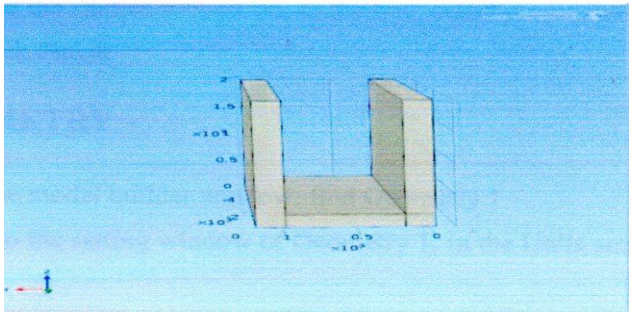

Diagram 1. U shape cantilever beam

The silicon structure has the following properties shown in 2.

2. Material Properties

Material property	Value
Young's Modulus	170E9pa
Density	2329kg/m^3
Poisson's Ratio	0.28

3. Different Material Properties as Layer

Material	Young's Modulus (GPA)	Density (kg/m^3)	Poisson's Ratio(υ)	Thickness (µm)
Graphene	10^{12}	2000	0.19	0.6
Quartz	$71.7*10^9$	2660	0.17	500
Nickel	$207*10^7$	8900	0.305	1520
Steel	$205*10^9$	7900	0.30	4760

Graphene has the best deflection property which can be easily deposited and etched

III. SIMULATION RESULTS

The U shaped cantilever simulated shape with force Applied = 250N is shown in diagram.2.

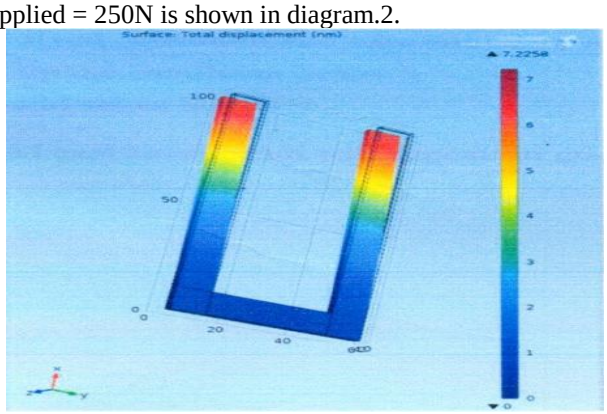

Diagram.2. Simulated Shape

The displacement vs arc length graph is shown in Diagram.3. for Graphene material. So we can observe clearly from the diagram that when the bending increases exponentially then the length of the cantilever also increases.

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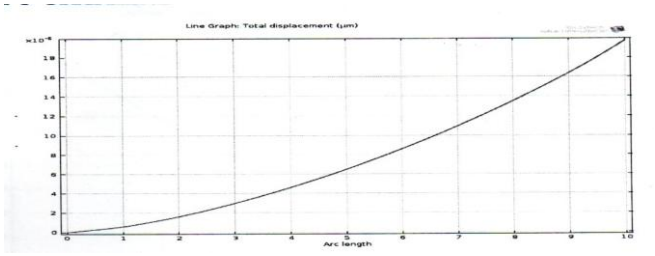

Diagram.3

The displacement vs arc length graph is shown in Diagram.4 for Quartz material. So we can observe clearly from the diagram that when bending is decreasing exponentially in this then the film thickness of the cantilever decreases.

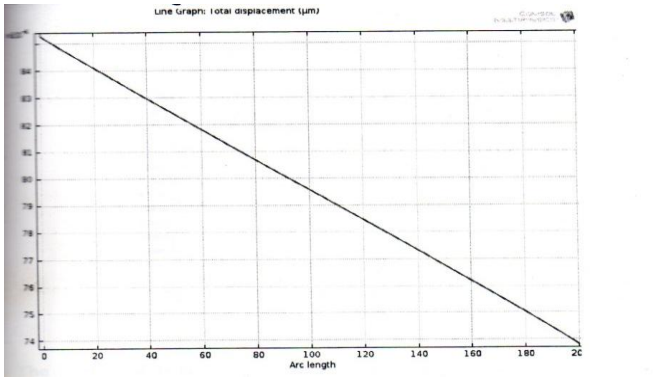

Diagram.4

The displacement vs arc length graph is shown in diagram.5. for Nickel material. So we can observe clearly form the graph that when the bending is increasing then length of the cantilever increases.

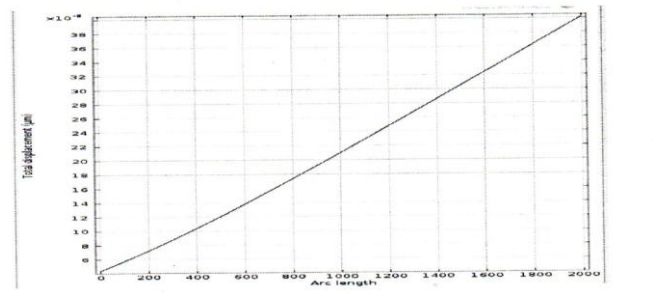

Diagram.5.

The displacement vs arc length graph is shown in diagram.6. for U shape steel material. So we can observe clearly from the graph that when bending is increasing exponentially then the length of the Cantilever increases.

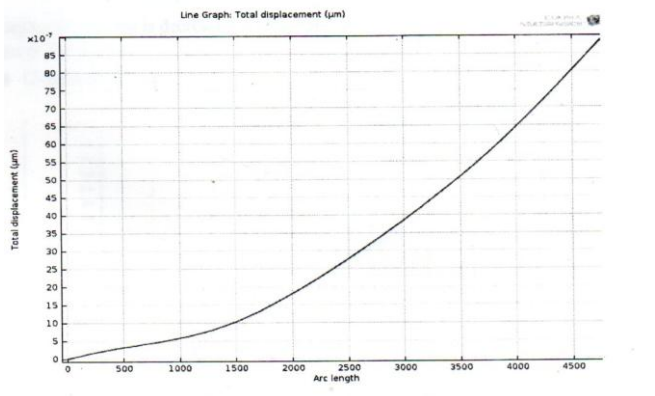

Diagram. 6

4. DEFLECTION OBTAINED

Material	Deflection (nm)	Force applied (Newtons)
Graphene	12.043	250
Quartz	2.443	250
Nickel	1.776	250
Steel	0.302	250

IV. CONCLUSION

The U shaped cantilever beam yields highest deflection for grapheme material which is most applicable in construction of bridges, energy harvesting and thermoplastic based products. This U shape will have a reduction in strain within the limits without reducing the cost and affecting the properties of cantilever.

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