Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

Design and Simulation of Cantilever Beams for Various Shapes and Materials

K. Durga Aparna[1]
Research Scholar
Department of Instrument Technology
Andhra University Visakhapatnam.

Rajesh Kanuganti[2]
Research Scholar, Department of ECE
Sri Satya Sai University of Technology and Medical Sciences
Shehore, Bhopal Madyapradesh India.

***Abstract*— This paper presents the various geometries of cantilever beams with different materials which are designed and simulated to get better sensitivity. The simulation analysis was performed using COMSOL Multiphysics. Among the E, Pi, P, W shapes considered P shaped cantilever beam shows greatest deflection.**

***Keywords*— COMSOL, Cantilever, Shapes.**

I.INTRODUCTION

A cantilever is a rigid structural element, such as a beam or a plate, anchored at only one end to a support from which it is protruding. When the cantilever is subjected to a load, deflection occurs at the tip of the cantilever. Basically MEMS cantilever sensor relies on the mechanical deformation of the structure, or in other words the deflection of membrane or beam structure. When the cantilever is loaded, its stressed elements deform. The MEMS cantilever will bend. As this deformation occur, the structure changes shape, and points on the structure displace. The concept is that deflection occurs when a disturbance or loading is applied to the cantilever is free end or along the MEMS cantilever surface. Normally the disturbance or loading is a force or mass that is attached to the MEMS cantilever in which it will make the MEMS cantilever bending. The sensing modes of cantilever could be broadly classified based on their principles in translating the recognition event into micro or nano mechanical motion. Two commonly used approaches for the operation of cantilever for sensing applications are *the adsorption-induced detection* and the *resonant frequency shift*. The continuous bending of a cantilever as a function of molecular coverage with the molecules is referred to as an operation in a static mode. Adsorption of the molecules onto the functional layer generates stress at the interface between the functional and the forming molecular layer. When the molecules are deposited on the surface of a cantilever they not only exert some mass but also generate a surface stress due to interaction between the molecules and the cantilever surface. To measure the deflection due to this surface stress stoney,s formula is generally used which is given by

$$\delta = \frac{3\sigma(1-v)}{E}\left(\frac{L}{t}\right)^2$$

Where,

σ is the maximum stress applied on beam,
v is the Poisson’s ratio of the material
L is the cantilever length,
E is the young’s modulus of the material
t is the thickness of the beam

Bending of cantilever is a direct result of the adsorption of the molecules on to the surface of the cantilever. But, here it is rather difficult to obtain the reliable information about the amount of molecules because surface coverage is not known, however mass change can be determined accurately by the resonant frequency shift method. By adding mass, this frequency shifts towards the lower value and mass change can be calculated. This approach is attractive to sense a small mass but this dynamic mode operation in a liquid environment poses problems such as high damping of cantilever oscillations due to high viscosity of the surrounding media. Due to change in stress of the cantilever concludes in a frequency change, which is then measured, thus when the cantilever oscillates at its natural frequency caused by external actuation, it is in dynamic state. The bending and resonant frequency shift of the micro cantilever can be measured with high precision using optical reflection, piezoresistive, capacitance and piezoelectric methods.

II.DESIGN PARAMETERS

Here we have taken the E, Pi, W, P shaped cantilever and silicon is taken as the base substrate at constant area of 10,000m and on that different materials are used as layers on the cantilever beams.

Table 1
Dimensions

Dimensions	Values (µm)
Length	2000
Breadth	200
Thickness	1.5

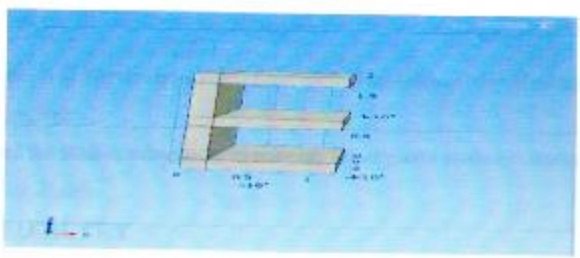

Fig.1. Design of E shape cantilever beam

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

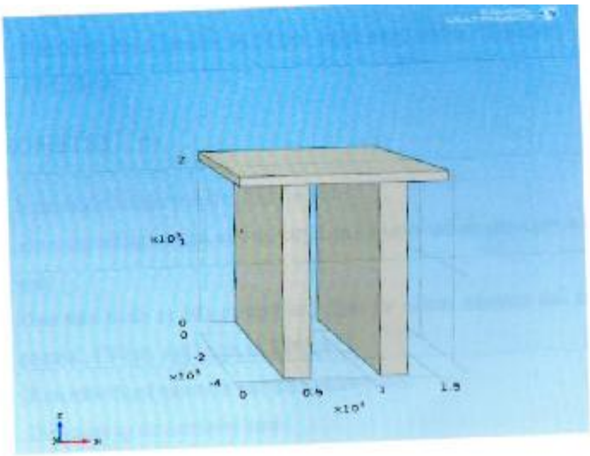

Fig.2. Design of PI shape cantilever beam

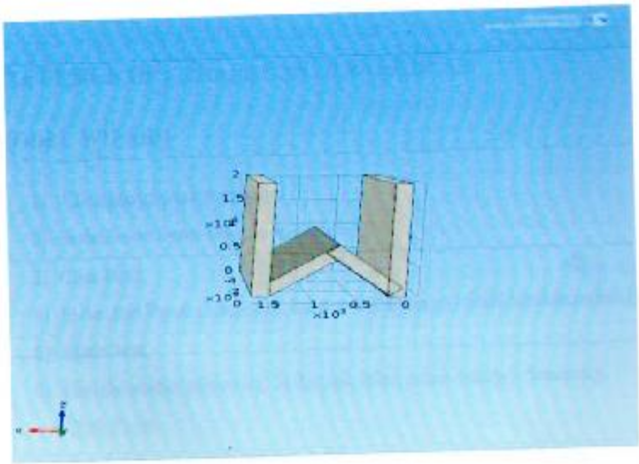

Fig.3.Design of W shape cantilever beam

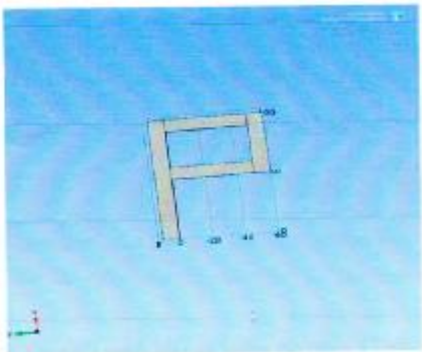

Fig.4. Design of P shape cantilever beam

The structure is made of silicon having the following material properties.

Table 2
Chosen Material Properties

Material property	Value
Young's Modulus	170E9Pa
Density	2329kg/m^3
Poisson's Ratio	0.28

Table 3
CHOOSEN MATERIAL PROPERTIES AS LAYER

Material	Density (kg/m^3)	Young's Modulus (GPA)	Poisson's Ratio (υ)	Thickness (μm)
GRAPHENE	2000	10^{12}	0.19	0.6
NICKEL	8900	207×10^7	0.305	1520
STEEL	7900	205×10^9	0.30	4760
QUARTZ	2660	71.7×10^9	0.17	500
DIAMOND	3510	35×10^9	0.2	310

From the given different material properties literature says Graphene is the best analysis layer for further simulation due to ease of deposition and etching processes available.

III.SIMULATION RESULTS

The schematic diagram of E shape cantilever when force applied=250N is shown in fig.5

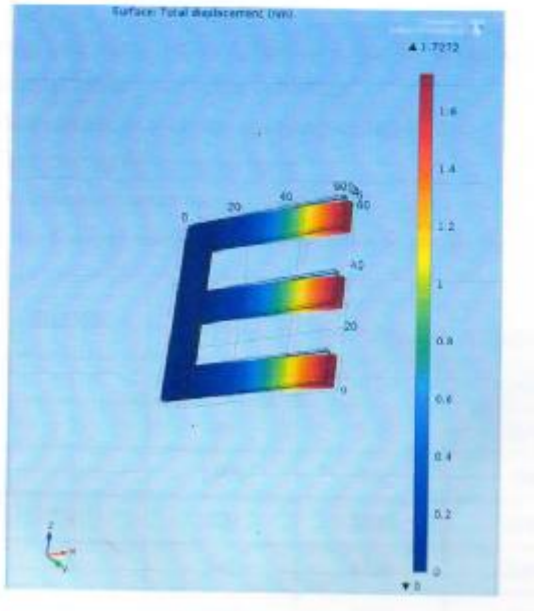

Fig.5. Deformed shape

The schematic diagram of PI shape cantilever when force applied=250N is shown in fig.6

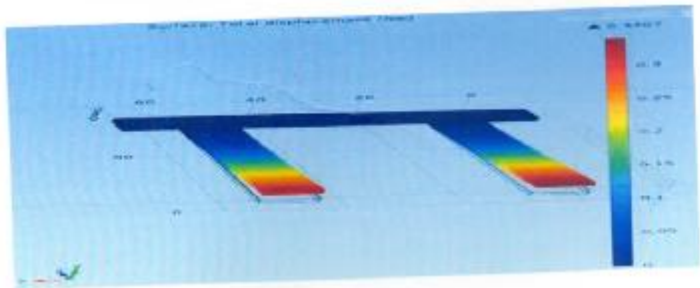

Fig.6. Deformed shape

The schematic diagram of W shape cantilever when force applied=250N is shown in fig.7

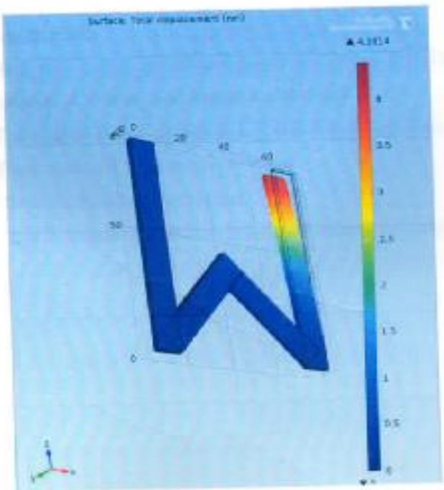

Fig.7. Deformed shape

The schematic diagram of P shape cantilever when force applied=250N is shown in fig.8

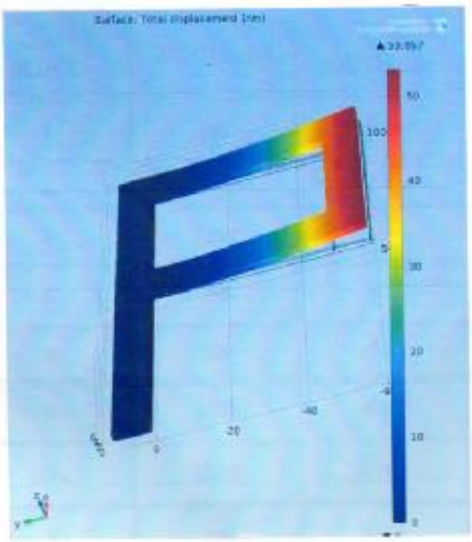

Fig.8 Deformed shape

Figure 9 shows the graph between total displacement vs arc length for E shape.The degree of bending is increasing exponentially in this case as the length of the cantilever is increasing.

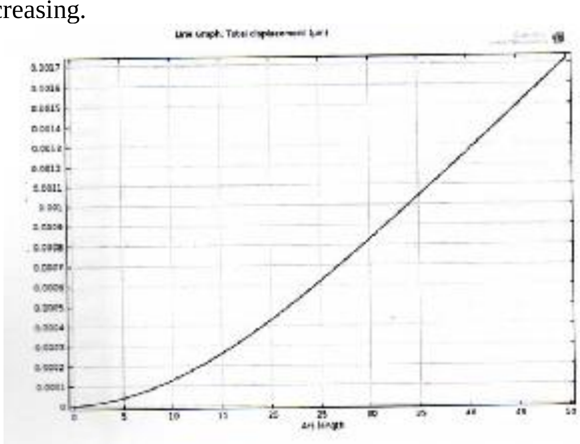

Fig.9

Figure 10 shows the graph between total displacement vs arc length for PI shape. The degree of bending is increasing exponentially in this case as the length of the cantilever is increasing.

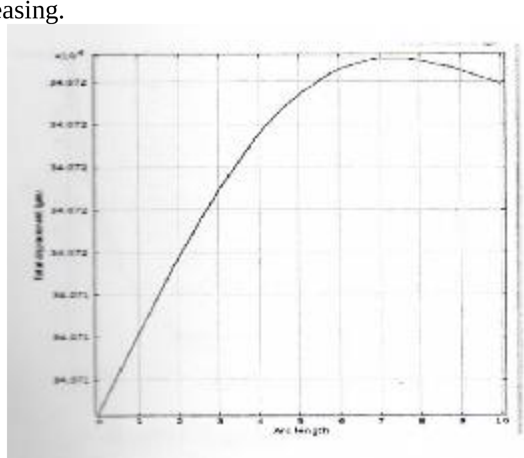

Fig.10

Figure 11 shows the graph between total displacement vs arc length for W shape. The degree of bending is increasing exponentially in this case as the length of the cantilever is increasing.

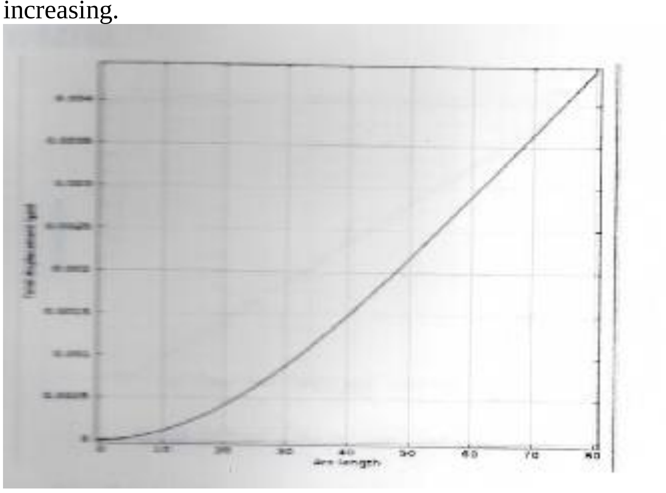

Fig.11

Figure 12 shows the graph between total displacement vs arc length for P shape. The degree of bending is increasing exponentially in this case as the length of the cantilever is increasing.

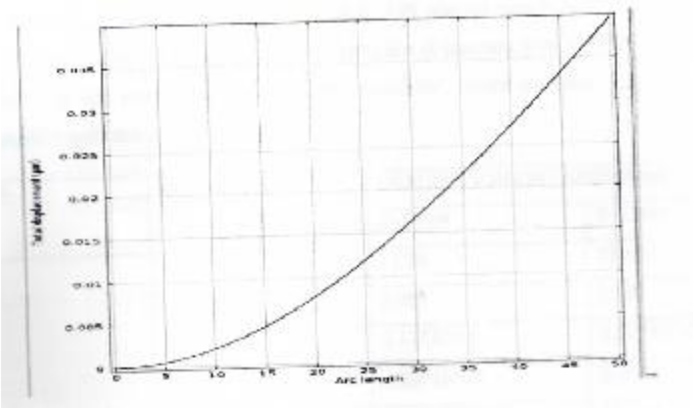

Fig.12

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

From the above results it is analysed that the microcantilever of P shape has more sensitivity than all other various shaped cantilever beams when same force is applied on all of them. It is more understood by seeing the comparison table 4.

TABLE 4
COMPARISON BETWEEN THE SENSITIVITY CANTILEVER BEAMS OF DIFFERENT SHAPES

STRUCTURE OF MICROCANTILEVER	DEFLECTION OF END IN(nm)	FORCE APPLIED in Newtons
P	22.107	250
W	4.391	250
Pi	3.407	250
E	0.785	250

IV.CONCLUSION

Cantilevers of different shapes have been designed and their sensitivity is analyzed under uniform conditions of stress and found that P shape cantilever has high sensitivity. The sensitivity of the material changes with change in geometry and material properties, so one can choose definite geometry and material based on the site of the application to be used. As the dimensions of the cantilever decreases sensitivity increases but fabrication of such smaller structures becomes complex. So by using cantilevers of different geometry complexity of fabrication can be reduced

V.REFERENCES

[1] Roberto Raiteri et al; Microcantilever cantilever based biosensors, J Elseveir, sensors and Actuators, B 4010, (2001),pp.112
[2] Monika Chaudary and Amia Gupta, Microcantilever based sensors, Defence Science Journal, Vol.59,No.6, November 2009,pp.634-641
[3] Suryansh Arora, Sumati, Arti Arora, P.J George, "Design of MEMS based Microcantilever using Comsol Multiphysics", Applied Engineering Research, Vol.7 No.11, 2012
[4] Sandeep Kumar Vashist,"A Review of Microcatilevers For Sensing Applications", 2007.
[5] Nitin S.Kale,V.Ramgopal Rao,"Design and Fabrication Issues in Affinity Cantilevers for bioMEMS Applications",Micro Electro Mechanical Systems,VOL.15,NO.6,2006
[6] www.azonano.com
[7] www.wikipedia.com