# Design of a Microcantilever for Biosensing Applications

Shilpa Nagod[#1], S.V Halse[*2]

[#] Research Scholar, Akkamahadevi Women's University, Department of Electronics, Vijayapura Karnataka, India

*Registrar, Davangere University, Davangere, Karnataka, India

***Abstract*** — *This paper presents the design and simulation of MEMS Microcantilever that is made up of Silicon Nitride coated with gold which is largely used for Biosensing applications. Here in, a simple microcantilever is designed and its simulation results are analysed to study stress, displacement, Eigen Frequency using Comsol Multiphysics.*

**Keywords** — *MEMS, Eigen Frequency, Microcantilever, Stress*

## I. Introduction

A microcantilever is a type of beam that is free to move at the one end and constrained at the other. Their dimensions are in the micrometres. These microcantilevers have a wide range of applications as chemical and biological sensors [1]. From the last decade microcantilevers have become very popular due to their high sensitivity and cost factor. Their ease of fabrication and flexibility in design make them fit into various integrated systems hassle free [2-4].Cantilever-based sensors are extremely versatile, they can be operated in air, vacuum and liquid environment, they can transduce a number of different signals, such as magnetic, stress, electric, thermal, chemical, mass, and flow, into a mechanical deflection [5]

The behaviour of a microcantilever as a sensor can be understood when we realize the process going on, on the surface of a microcantilever. The cantilever initially has to be surface coated with the bio-receptor material which has the uniqueness of binding only to the specific molecule of the target material. This leads to the increase in the weight over the cantilever and results in the deflection of the cantilever. It means there is proportional bending of the cantilever's free end and this bending or the displacement will make the cantilever to act as sensor.

## II. Design of Microcantilever

A microcantilever is best described using two equations, firstly Stoney's formula which relates cantilever's deflection 'δ' to the applied stress 'σ'

$$\delta = \frac{3\sigma(1-\nu)}{E}\frac{L^2}{t^2} \quad \text{------------ Eq(1)}$$

Where 'ν' is Poisson's ratio, 'E' is Young's modulus, 'L' is the beam length and 't' is the cantilever thickness.

The second is the formula relating the cantilever spring constant 'k' to the cantilever dimensions and material constants

$$k = \frac{F}{\delta} = \frac{Ewt^3}{4L^3} \quad \text{----------------Eq(2)}$$

Where, 'F' is force and 'w' is the cantilever width [6]

In this work, a microcantilever made up of Silicon Nitride coated with gold, as is best used as a biosensor was designed with following dimensions and simulated using Comsol Multiphysics.

Table 1: Dimensions

| Dimension | Value |
|---|---|
| Length | 300[um] |
| Width | 50[um] |
| Height | 7[um] |

The reason for selection of this dimension was that it is regarded as the standard dimension for fabrication considering the strength and mechanical properties of the material.

Table 2: Material Properties

| Material Properties | Values |
|---|---|
| Young's Modulus | 0.2Gpa |
| Density | 3100kg/m3 |
| Poisson's Ratio | 0.23 |

## III. SIMULATION ANALYSIS

The schematic diagram of microcantilever used for Biosensing applications is shown in Fig. 1

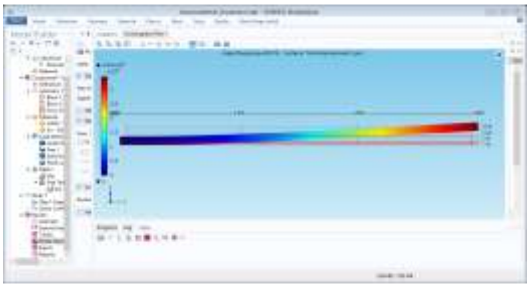

Fig. 1: Deformed Microcantilever

When there is a variable load applied on the microcantilever to realise its behavior as a sensor, there is displacement of microcantilever with the variable load. This basically shows that microcantilevers satisfy the Hooke's law which states that stress is directly proportional to strain.

$F= -kx$ ------------------ Eq (3)

Here 'F' is the restoring force, 'k'is the spring constant and 'x' is the cantilever displacement . This can be clearly understood through the figure below

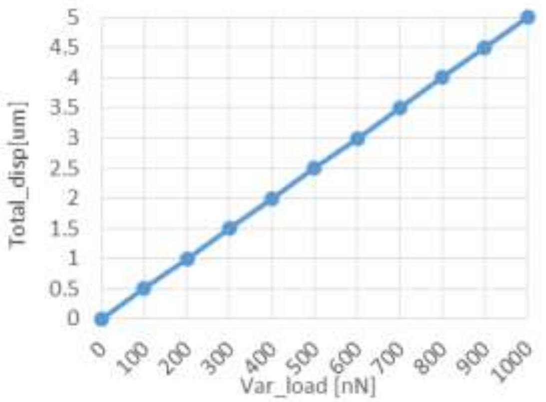


Fig.2 Microcantilever Displacement With Variable Load

The stress changes with the changes in load is understood from the follwing figure.

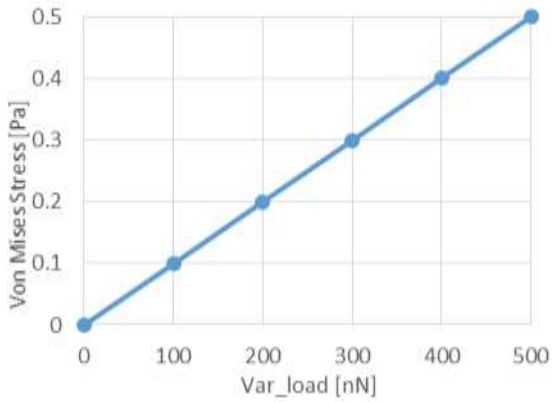


Fig. 3 Stress Changes of Microcantilever

Apart from the stress measurement the Eigen frequency analysis (as shown in Fig.4) was also done and the frequency response curve for microcantilever is as shown below in Figure 5. The calculated eigen frequency is 0.65Mhz

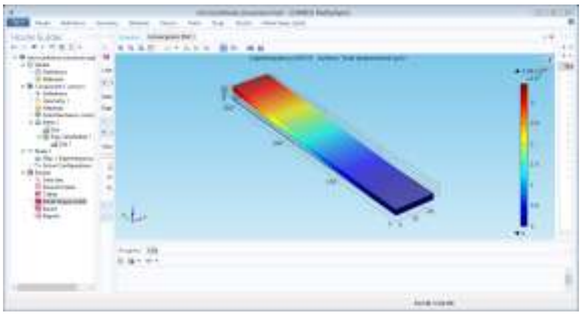

Fig.4 Eigen Frequency Study of Microcantilever

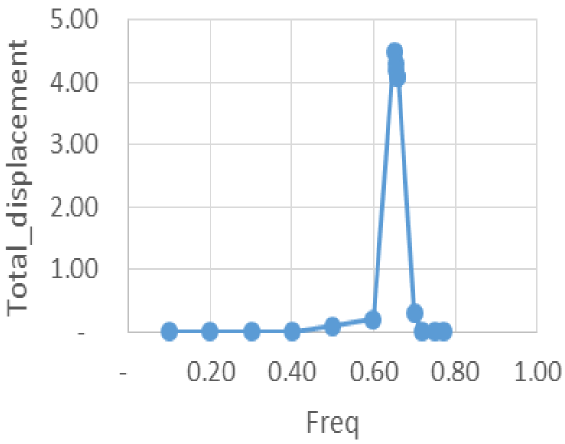


Fig.5 Frequency Response of Microcantilever

## IV. CONCLUSION

A simple MEMS based microcantilever is designed and simulated for stress and eigen frequency studies which shows that the microcantilevers can be best used as sensors since they are very sensitive to the change in stress that is caused when target material gets hooked up on the surface of cantilever. The displacement caused showed that presence of certain materials or viruses can be sensed, hence making them fit for biosensing applications.

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