# MEMS Microcantilevers: The Coming Generation Sensing Elements

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**Abstract-**MEMS is the integration of active and passive elements on a single chip, which combine electronics, electrical as well as mechanical elements to use in sensing and actuation. MEMS technology used the Microcantilevers as basic sensing elements. Microcantilevers are used to sense physical, chemical, biomedical and many other properties. In this paper different approaches are used to increase the sensitivity of sensors. Comparative analysis of simulated results of different microcantilevers is shown. Analytical approaches are also used to validate the design of microcantilevers.

***Keywords—*** *MEMS, Microcantilevers, Actuation, Sensing.*

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## I. Introduction

MEMS made microsensors are used for measuring physical parameters. The basic building block of a sensor is the transducer, which produces a measurable response to a change in a physical condition and transforms the response into the electrical signal, adopting various transduction principles.[1]

Microcantilevers and beams are very useful transducer elements, using which many physical changes can be measured. The main principle is the deflection of the beam and cantilever structures. The deflections are sensed either by capacitive or piezoresistive measurement. The difference between a beam and a cantilever is that a beam is fixed at both the ends whereas a cantilever is fixed at only one end.[2]

Thispaper shows the effects of variation in different physical parameters and compares the output simulation results. In order to increase the sensitivity of the microcantilevers, rectangular hole is formed on the fixed end of the microcantilevers. Comparative analysis of all the output simulated results is performed.

## II. Microcantilevers Equations

A cantilever is a beam in which one end is fixed and the other is free to deflect as per provided load. The cantilevers have more length as compare to width and have optimal thickness. Without load the cantilever is at the resting state and therefore initially it is horizontal and straight. When force is applied the horizontal axis of the beam is deformed into a curve. The deflection of the beam depends on its length, its cross-sectional shape, the material, the point at which the deflection force is applied and how the beam is supported. Two basic equations are used to study the behavior of cantilevers. [1]The first is Stoney's formula, which relates cantilever end deflection‘z’toappliedstress‘σ’:

$$z = \frac{3\sigma(1-\vartheta)}{E}$$

Where *d* and *L* are the cantilever beam thickness and length, respectively; *E* and υ are the elastic modulus and the Poisson ratio of the cantilever material.

The secondistheformularelating thecantileverspring constant k to the cantilever dimensions and material constants:

$$k = \frac{F}{z} = \frac{Ewd^3}{4L^3}$$

where *F* is the point load applied at the end of the cantilever, and *z* is the resulting end deflection, *E* is the Young’s modulus of elasticity for the cantilever material and *w*, *d*, *L* are the width, thickness, and length of the cantilever, respectively.

Equation for deflection of cantilever, when load is applied at the end,

$$d(x) = \frac{-Px^2(3L-x)}{6EJ}$$

$$d_{max} = d(L) = \frac{-PL^3}{3EJ}$$

Equation for deflection of cantilever, when point load is applied at the intermediate point:

$$d(x) = \frac{-Px^2}{6EJ} 0 \le x \le a$$

$$\frac{-Pa^2}{6EJ}(3x-a) a \le x \le L$$

$$d_{max} = d(L) = \frac{-Pa^2}{6EJ}(3L-a)$$

## III Design of Microcantilevers

First of all simple cantilevers beams are designed with specific dimensions as 100micrometer in length, 20micrometer in width and 2micrometer in height. The cantilever is simulated with applied boundary load at the free end i.e. force -1N/m2.

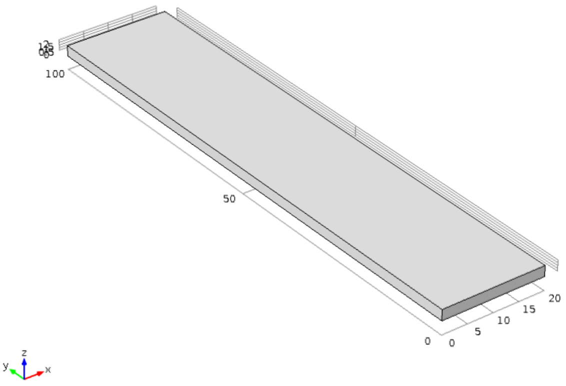

**Figure 1: Microcantilever model view.**

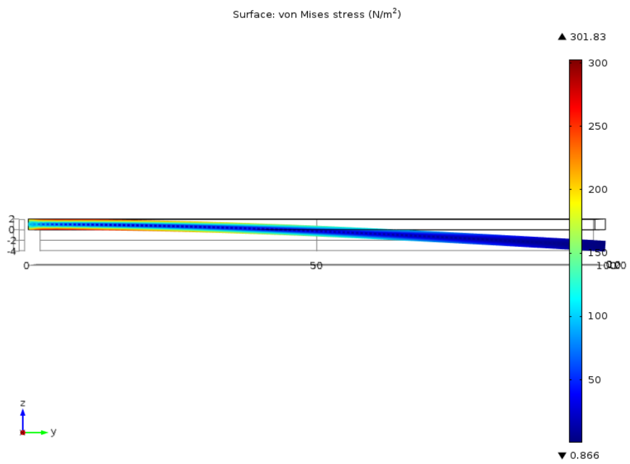


**Figure 2: Microcantilever with specified dimensions.**

Then comparative analysis of change in dimensions of the cantilevers is performed and the change in stress of cantilevers is formed, which proves the Stoney's formula.

**Table 1: Respective change in resultant stress with change in length of cantilevers.**

| S.No. | Material used | Dimensions | Resultant stress |
|---|---|---|---|
| 1. | Ploysilicon | Length-100um, width-20um, height-2um. | 301.83 |
| 2. | | Length-90um, width-20um, height-2um. | 271.56 |
| 3. | | Length-80um, width-20um, height-2um. | 237.93 |
| 4. | | Length-120um, width-20um, height-2um. | 360.88 |

With the change of cantilever materials, respective change in resultant stress is formed. Different materials used are polysilicon, silicon dioxide and silicon nitride. Table shows the respective change in stress with change of materials used.

**Table 2: Change in stress with respective change of cantilever materials.**

| S.No. | Material used | Dimensions | Resultant stress |
|---|---|---|---|
| 1. | Ploysilicon | Length-100um, width-20um, height-2um. | 301.83 |
| 2. | Silicon Dioxide | | 301.81 |
| 3. | Silicon Nitride | | 301.86 |

**IVDesign of Highly Sensitive Microcantilevers**

In order to increase the sensitivity of cantilevers, use of different holes is proposed on the fixed end of the cantilevers.

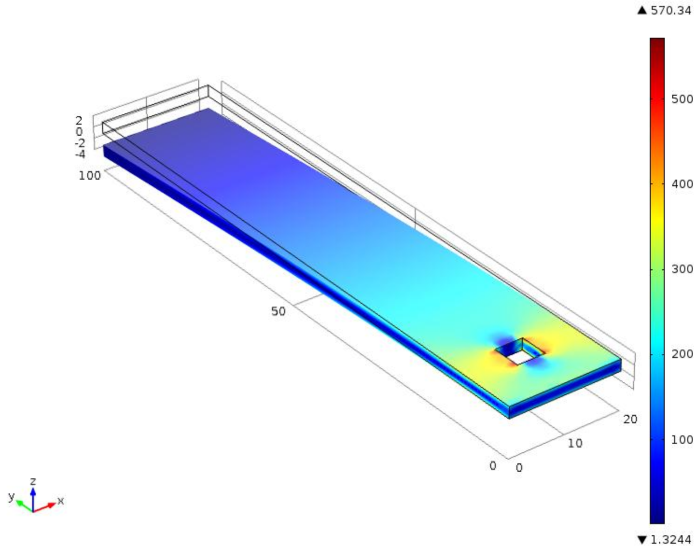


**Figure 3: Highly sensitive cantilevers with hole on fixed end.**

**Table 3: Resultant stress change with different type of cantilevers.**

| S. No. | Material used | Dimensions | Micro-cantilevers | Result-ant stress |
|---|---|---|---|---|
| 1. | Poly-silicon | Length-100um, width-20um, height-2um. | Simple Structure | 301.83 |
| 2. | | | Use of hole on fixed end | 570.34 |

## V Conclusion

With the change in dimension of cantilevers respective change in sensitivity is obtained. So an optimum dimension selection is required in design of the cantilevers. Further sensitivity of cantilevers is increased with use of different holes on the fixed end of the cantilevers.

## VI Future Scope

In thisresearch paper, highly sensitive microcantilevers are proposed. With the use of these microcantilevers, further the sensitivity of MEMS Devices can be increased.

## VII References


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