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Study of Enhanced Mass Detection Using Cantilever Beam

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Abstract: ***Cantilever, one of the most common forms of MEMS. Using Cantilever one can make highly sensitive sensor. Moreover to design a mass based sensor sensitivity plays a vital role. In this paper, micro-cantilever was designed whose sensitivity was enhanced. The strengthened sensor is now used to detect minimal changes in mass. Study was carried out in experimental and analytical analysis. Experimental analysis was executed using COMSOL MULTIPHYSICS (simulation software). This paper demonstrates the use of Stoney's formula for analyzing the analytical variations of micro-cantilever sensor. Obtained analytical and experimental outcomes of the sensor in both static and dynamic modes were compared.***

Keywords: Cantilever, COMSOL, Stoney's Formula, Sensitivity

1. Introduction

Working operation of MEMS sensors is generally based on mechanical motion and deformity of their micro machined components, such as single-clamped suspended beams like cantilevers, double clamped suspended beams like bridges. Cantilevered beams are the most present structures in the field of microelectro mechanical systems (MEMS). The use of cantilever based sensors is improving these days due to its high sensitivity and easy fabrication. The sensitive cantilever sensor can be used to detect minimum changes in the target molecule. Mass in micro range can be detected using micro cantilever so that they can be used for cancer cell detection, monitoring food supply etc. In this paper, the sensitivity of the sensor was enhanced and further the sensor was used to detect changes in applied mass in both static and dynamic mode.

2. Sensitivity Analysis

The sensitivity of a sensor always plays a key role in design parameter. To increase the overall sensitivity of micro cantilever biosensors, both the deflection and resonant frequency of the cantilever should be increased. The overall sensitivity of a micro cantilever biosensor depends on the design sensitivity of the cantilever and the measurement sensitivity of the deflection measurement system. A sensitive cantilever design should efficiently convert the bimolecular stimulus into a large cantilever deflection. The improvisation of sensitivity mainly depends on two factors. One is to increase the cantilever deflection by changing the shape of the cantilever. Therefore, dimensions and geometry have modified to increase the sensitivity. Deflection depends on length and thickness of the cantilever so the two parameters are varied to increase the sensitivity of the sensor. The other factor depends on the material taken in to consideration. As we change the material its young's modulus changes and sensitivity depends on it. In order to analyze it, three materials have taken in to consideration. They are Silicon, Silicon di-oxide, Silicon nitride.

Table 1: Chosen Materials

Sl. No	*Material*	*Young's Modulus(Gpa)*
1	Silicon Di-oxide(SiO_2)	70
2	Silicon(Si)	170
3	Silicon Nitride(Si_3Ni_4)	250

As different materials were applied corresponding deflection was calculated. The deflection for SiO_2 is more which implies it shows more sensitivity towards target molecule.

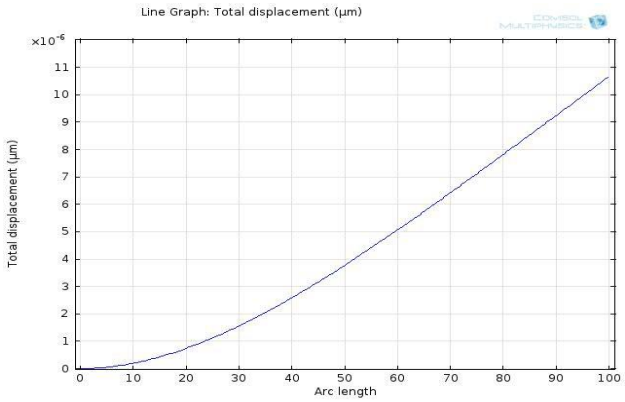

Figure 1: Deflection graph for Silicon Di-oxide Material

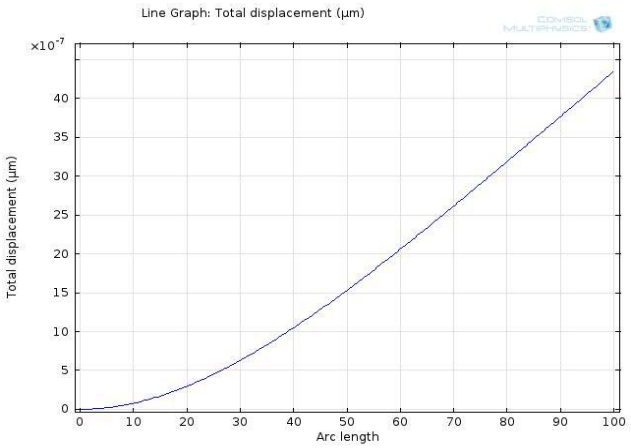

Figure 2: Deflection graph for Silicon Material