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MEMS Cantilever Sensor in Food Processing Industry

Beulah Sujan K[1], T Shanmuganantham[2]
[1] PG Scholar, Department of Electronics Engineering, Pondicherry University, Pondicherry, India
[2]Assistant Professor, Department of Electronics Engineering, Pondicherry University, Pondicherry, India
beulahsujanacademic@gmail.com[1], shanmugananthamster@gmail.com[2]

ABSTRACT

MEMS (Micro Electro Mechanical systems) cantilever sensor is designed which is used in food processing industry to detect toxic substances or bacteria present in the food which is packed. In this paper, MEMS cantilever sensor of dimensions 400 μm ×50 μm ×1μm is designed to detect the presence of bacteria in food obtained from cattle by using MZN (metronoidazole) molecules. The MEMS cantilever sensor designed by using the software INTELLISUITE version 8.7 and also the MEMS cantilever is designed with different sensing materials. The cantilever sensitivity is found for different sensing layer in order to find good sensor.

Keywords: MEMS, Cantilever, INTELLISUITE, MZN

I. INTRODUCTION

Now-a-days in this modern world we consume food which is packed such as milk, meat etc. In order to find any toxic substances or bacteria in food we use MEMS cantilever sensor as detectors in food processing industry. MEMS usually which are micro fabricated devices has wide area of applications. In medical field MEMS are used to detect diseases [2]. In Bio-medical field MEMS are used for drug discovery and drug development [3]. MEMS can be used as switches at Radio frequency range. This usage of MEMS has been extended to the food processing industries as detectors. In this paper, we detect the bacteria or toxic materials present in food obtained from cattle because of excessive feeding with additives which promote growth [1]. Usually MZN is used as antibody which reacts with bacteria and stops further growth.

The MEMS cantilever sensor works as detector based on adsorption phenomenon [4]. According to adsorption phenomenon, the surface of MEMS cantilever is coated with sensing layer. On the top of this sensing layer the molecules which react with the food sample is placed [1]. When food sample is added to the cantilever, the reaction takes places between food sample and molecules on the surface of cantilever. As reaction occurs, there is increase in mass due to which the cantilever beam deflects [5]. Thus the cantilever is used as a detector. The figure1 shows the adsorption phenomenon.

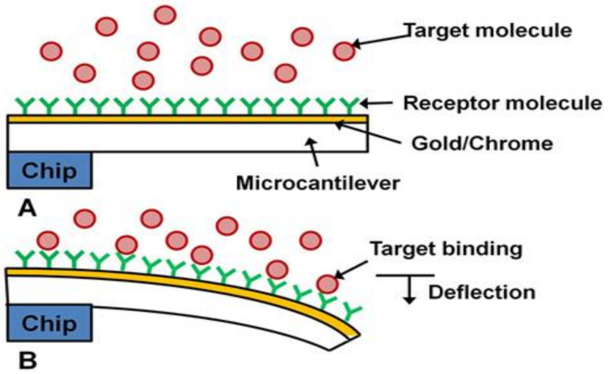

Figure 1. Adsorption Phenomenon

The analysis, which are carried for micro cantilever sensor, are:

1. Static analysis

2. Dynamic analysis

A. Static Analysis

Static analysis mainly determines the displacement undergone by MEMS cantilever sensor when it is subjected to pressure [4].

B. Dynamic Analysis

Dynamic analysis mainly determines the frequencies of cantilever when cantilever beam vibrates [4]

A.

The organization of this document is as follows. In Section 2, it discusses about design of cantilever. The section 3 presents the simulated results and discussions and Section 4 concludes the work.

II. MICROCANTILEVER DESIGN

A basic cantilever sensor which has one fixed end and other end is made free. A micro cantilever is designed with length of 400μmts, width of 50μmts and thickness of 1μmts. On the surface of this cantilever beam a sensing layer and antibody MZN of mass 1.45g/cm3 is considered. Food sample is considered for detection and food sample is added on the surface of cantilever. If there is presence of bacteria in food sample, the bacteria reacts with MZN molecule as a result the mass of cantilever beam increases and beam deflects. Thus we can detect the presence of bacteria in food which is packed [6].

The sensing layers, which are considered, are:

1. Tungsten
2. Tantalum
3. Chromium mono silicide
4. Glass pyrex sensor

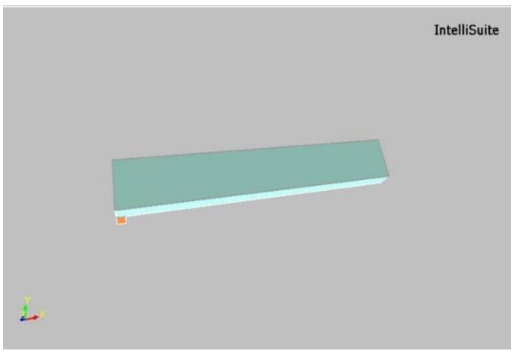

Figure 2. Design of Cantilever Sensor

III. SIMULATED RESULTS AND DISCUSSION

The cantilever is designed with different sensing layers

1. Tungsten
2. Tantalum
3. Chromium mono silicides
4. Glass pyrex

A. Simulation Result of Micro Cantilever Beam with Tungsten as Sensor

a. Static analysis

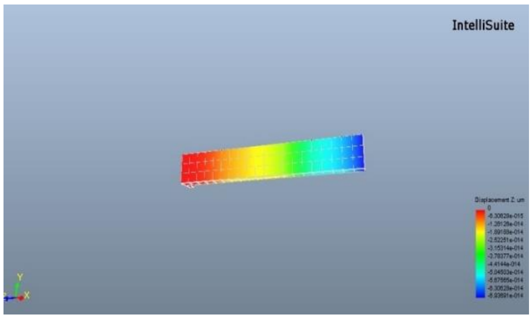

Figure 3. Static Analysis of Tungsten Sensor

B. Dynamic Analysis

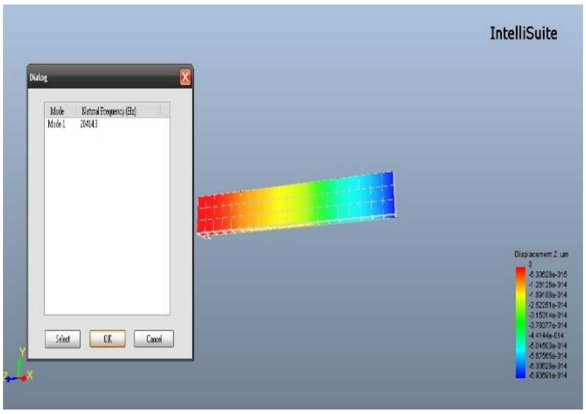

Figure 4. Dynamic Analysis of Tungsten Sensor

B. Simulation Result of Micro Cantilever Beam with Tantalum as Sensor

a. Static analysis

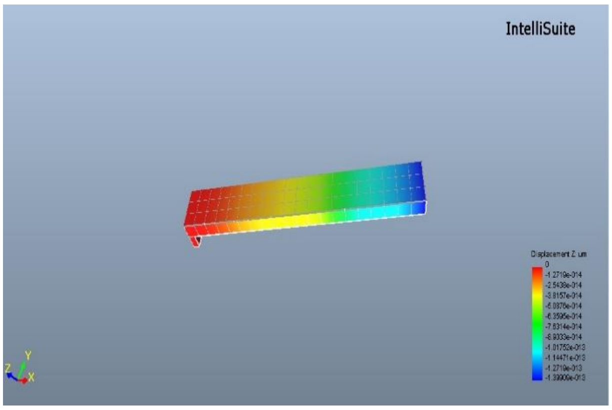

Figure 5. Static Analysis of Tantalum Sensor

b. Dynamic Analysis

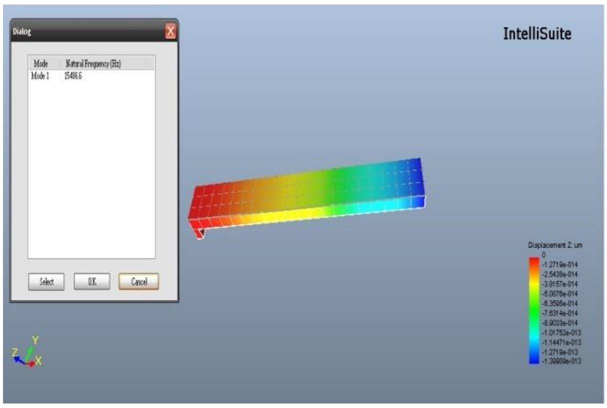

Figure 6. Dynamic Analysis of Tantalum Sensor

C. Simulation Result of Micro Cantilever Beam with Chromium Mono Silicide as Sensor

a. Static Analysis

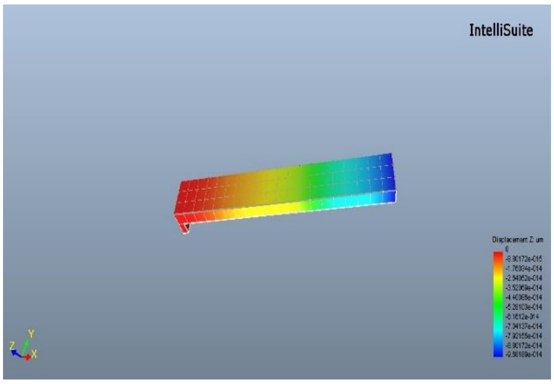

Figure 7. Static Analysis of Chromium Mono Silicide Sensor

b. Dynamic Analysis

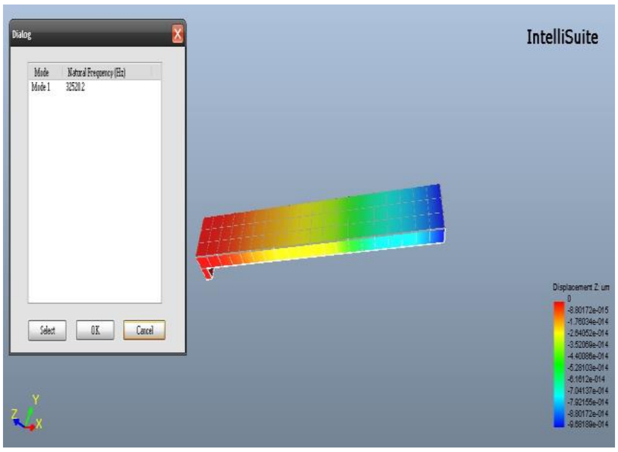

Figure 8. Dynamic Analysis of Chromium Mono Silicide Sensor

D. Simulation Result of Micro Cantilever Beam with Glass Pyrex as Sensor

a. Static analysis

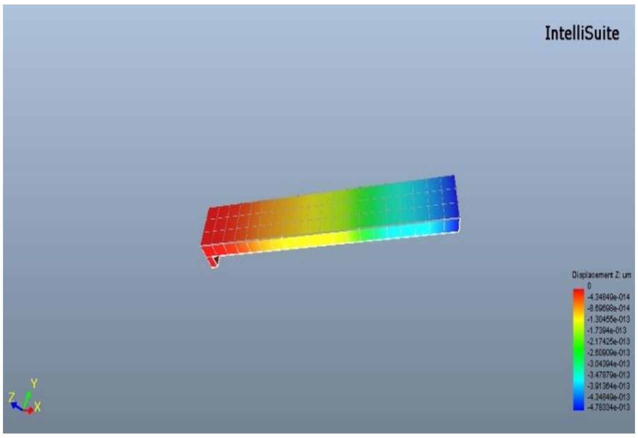

Figure 8. Static Analysis of Glass Pyrex Sensor

b. Dynamic analysis

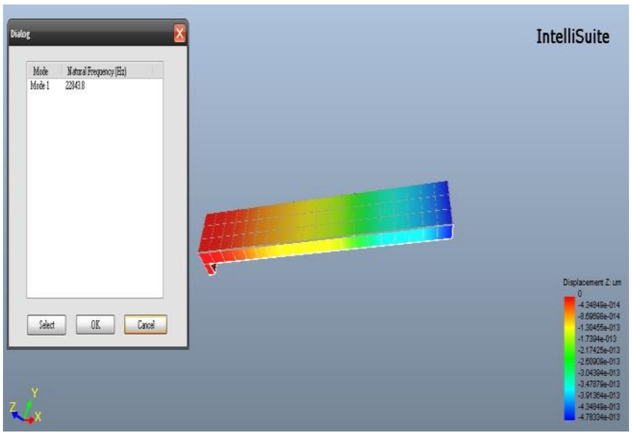

Fig.9 Dynamic Analysis of Glass Pyrex Sensor

TABLE I Frequency Response of Different Sensing Layers

Material	Density(kg/m3)	Frequency(kHz)
Tungsten(W)	19250	20.414
Tantalum(ta)	16600	15.486
Chromium mono silicide(crsi)	5440	32.5202
Glass pyrex	2230	22.8438

TABLE II Sensitivity of Different Sensing Layers

Material	Max. displacement (picomts)	Min. displacement (picomts)	Applied pressure (picopa)	Sensitivity (mts/pa)
W	0.069	0.00630	14.21	0.0044264
ta	0.1399	0.0127	14.21	0.008951
crsi	0.0981	0.0088	14.21	0.006284
Glass pyrex	0.47	0.0434	14.21	0.030021

IV. CONCLUSION

As four different sensing layers are used, the sensing layer with maximum frequency response is considered as fast detector if accuracy is not major concern. Therefore from values which are tabulated above we can conclude that chromium mono silicides (crsi) is fast detector with less delay response compared with other sensing layers considered. If accuracy is major concern then a layer with maximum sensitivity is considered as good sensor with accurate results. Therefore from values which are tabulated above glass pyrex is considered as good sensor compared with other sensing layers considered.

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