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Analysis of MEMS Based Capacitive Pressure Sensor

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Abstract:
This paper discusses about fundamental Analysis of MEMS based Capacitive pressure sensors. Recent times, capacitive pressure sensors had picked up favorable circumstances over piezo resistive pressure sensor because of high affectability, low power utilization, invariance of temperature impacts. The anatomy of Capacitive Pressure sensors was analysed in this paper. The COMSOL Multiphysics Tool is utilized for the structuring of MEMS based Capacitive Pressure sensors.

Keywords:*MEMS, COMSOL, Capacitive Pressure sensors.*

INTRODUCTION

The detectionof changes in electrical capacitance caused by the movement of a diaphragm gives the measure of pressure in a capacitive pressure sensor.Due to low power consumption, high sensitivity, IC compatibility etc, MEMS Capacitive Pressure Sensor exhibits more advantages than micromachinedpiezoresistive pressure sensor .Many designs were proposed in literature.[1] deals with MEMS Capacitive Pressure Sensor Design and Manufacturing.[2] Explains about how MEMS technology is used in sensors

applications.[3-4] Clarifies the review and recent development of capacitive pressure sensors.[5]Clarifies about Sensitivity Pressure Sensor by varying the geometry of the diaphragm that is for different circular radius for High Pressure Applications.[6] deals with how pressure sensor isused in bio medical applications. [7-8] Explains about the result of a silicon material which is directly bonded in to the pressure sensor and using a Graphene material for pressure sensor.[9]Explains about modelling of a Capacitive Pressure Sensor inComsolMultiphysics.[10-13]explores various capacitive pressure sensor designs.

Biomedical applications requires sensors with less size, low power utilization and high pressure affectability. Among various Pressure sensors parallel plate capacitive pressure sensors is the widespread one in physics execution. The sensor utilizes a couple of parallel plates which builds a capacitor.

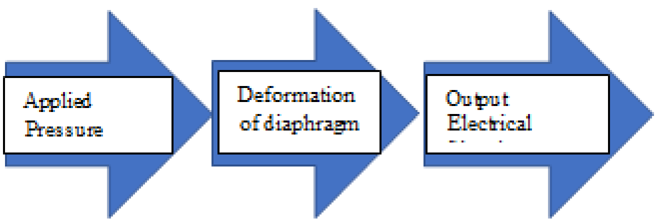

Fig 1. Principle of pressure sensor

The range of pressure is estimated through diaphragm which relies upon geometry, edge conditions ,materials utilized.

MATHEMATICAL EQUATIONS

Capacitive pressure sensor will change its capacitance relatively with applied pressure. A

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capacitive pressure sensor has two conductive plates, first one is known as estimating plate and second is reference plate. The estimating plate will be fixed when weight is applied, while the reference plate is fixed at suitable position so it goes about as reference to the estimating plate. When the estimating plate is flexed, the separation between these two conductive plates of capacitance is changed. By applying the condition of capacitance, C

$$C = \frac{\epsilon_r \epsilon A}{d}$$

where A =Area of each plate, ε= Relative Permittivity of a Vacuum, Relative Permittivity of Dielectric is ε_r, Distance in between the plates is d.

A circular plate having a deflection w with completely clamped edge of an element of w(r) is

$$w(r) = w_0\left[1-\left(\frac{r}{R}\right)^2\right]^2$$

TheRadius of plate R where 0< r <R , the displacementat center of the plate Wo is $w_0 = \frac{PR^4}{64D}$

The flexural rigidity D is given as,

$$D = \frac{Eh^3}{12(1-v^2)}$$

hereE is Young's modulus, h is diaphragm thickness,v is Poisson's ratio.

MODELLING USING COMSOL

COMSOL Multiphysics is a cross-stage limited component analysis, solver and multiphysics system software. It will permit material science which is traditional based UIs and also coupled frameworks of incomplete partial differential equation's.

MEMS design on Capacitive pressure sensors depend on change of the measured capacitance based position change due to the pressure. In this ,we model a capacitive pressure sensor in which the deflection can be calculated very accurately for a very small scale (nanoscale) by measuring the change in the capacitance between the two membranes of capacitor which of course depends on the separation distance. This model is completely self-contained in which the geometry of model built and the physics and boundary conditions are set then simulation is performed as a result capacitance is plotted.

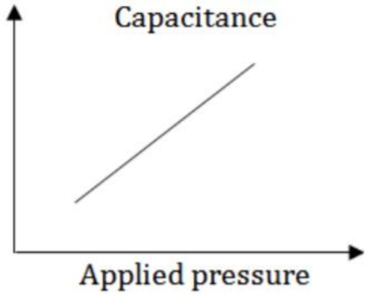

Fig3. Model graph of Applied pressure and the Capacitance.

MATERIALS USED

In COMSOL the physics used is electro mechanics and study is done using stationary study to build the sensor. The materials we have used are air (mat1), polymide (mat2), NI Nickel (mat3).By using these materials and giving the input through boundary load we have analysed the output of the capacitive pressure sensor.

Property	Value with unit
Young's modulus	3.1e9 [Pa]
Poisson's ratio	0.34
Density	1300[kg/m^3]
Relative permittivity	3.4

Table1:Material Properties of Polymide

Property	Value with unit
Young's modulus	219e9[Pa]
Poisson's ratio	0.31
Density	8900[kg/m^3]
Relative permittivity	110

Table2: Material properties of Nickel

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MODELLING OF CAPACITIVE PRESSURE SENSOR:

The device composed of FIDTs with several directly fragments, as appeared in Fig 4. The plan of the MEMS based shape contains characterizing the factors for the required geometry and preference of the parameters. The 3D geometryhas been built in the drawing mode of COMSOL Multiphysics.

The design of a capacitive pressure sensor using COMSOL Multiphysics. A block of size 3000x3000x120 and also a cylinder of radius 950 **µ**m is taken. By using difference parameter in the comsol , the block has been cut in to a cylindrical shape and placed the cylinder.

For 980 **µ**m:

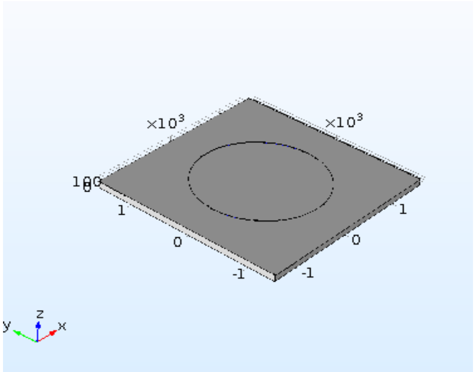

Fig.4(a)

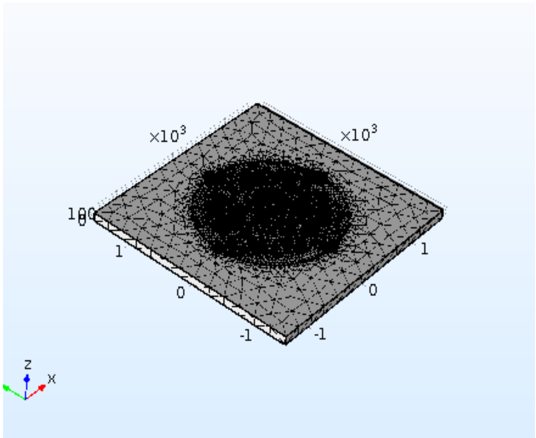

Fig.4(b)

For 500 µm:

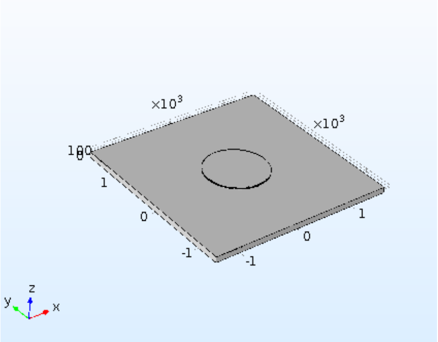

Fig.4(c)

For the materials taken, different parameter has been used as mentioned in the Table 1 and Table 2, for the capacitive pressure sensor Meshing is done. Meshing, like among the tools available in COMSOL Multiphysics, is customizable and interactive.

Customizing the meshing sequence can help lessen reminiscence requirements via controlling the variety, type, and first-rate of elements, thereby growing an green and correct simulation. The output of capacitive pressure sensor is observed by changing the radius of the cylinder and also the length, width and height of the rectangular block.

SIMULATION

We have done simulation using the COMSOL Multiphysics and checked the various output graphs by changing the parameters and also the materials of the design. We have obtained the graph between the capacitance and the pressure.

We have given the input as applied pressure and checked the output for capacitance and the pressure. We have also obtained the table for the pressure and the capacitance values and we have observed the change in capacitance value for different pressure values.

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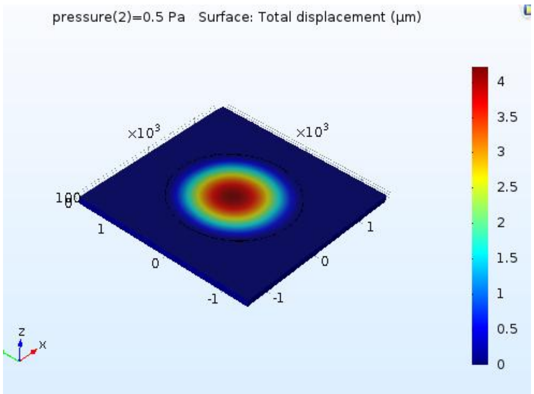

Fig.5(a).Output of 980 µm capacitive pressure sensor

	Pressure (Pa) In 10^6	Capacitance(pF)
For 980 µm	0.0000	1.518
	0.2	1.524
	0.4000	1.532
	0.6000	1.538
	1.0000	1.550
	1.2000	1.555

Table 3: Final values for 980 µm

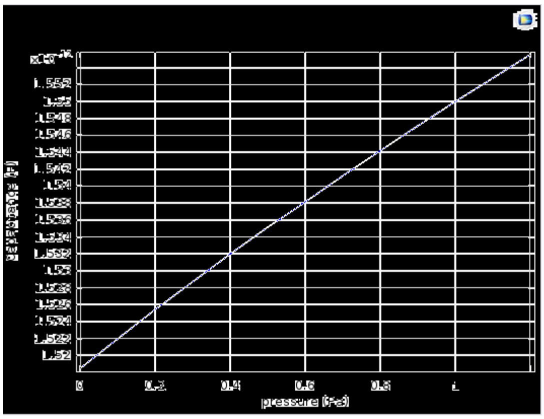

Fig.5(b)

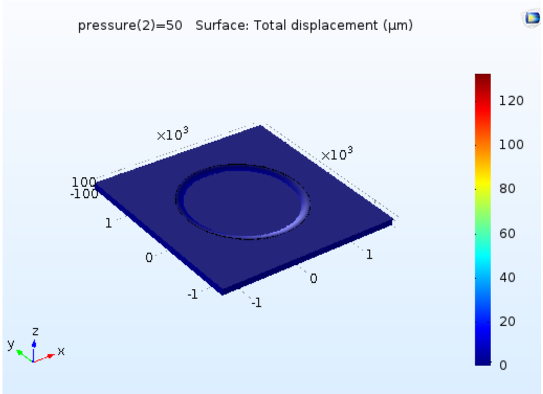

Fig.5(c).Output of 500µm capacitive pressure sensor

	Pressure (Pa) In 10^6	Capacitance(pF)
For 500 µm	0.0000	1.608
	0.2	1.614
	0.4000	1.622
	0.6000	1.634
	1.0000	1.650
	1.2000	1.654

Table 4: Final values 500 µm

RESULTS AND DISCUSSION

The observations on tables concludes that by varying the radius of the circle in the capacitive pressure sensor the capacitance will be varied. The capacitance for500 µm is more when compared with 980 µm.So,by decreasing the radius in the micrometer range we can increase the capacitance .So,by using comsol , design of the capacitive pressure sensor is easy when compared to other techniques.

CONCLUSION

In this paper we have investigated the working of capacitive pressure sensor by changing different parameters and also by changing the materials. We have analysed the output of capacitive pressure sensor for two dimensions in radius that is for 980µm and for 500µm and by giving pressure as input we observed the changing of the capacitive values for the different applied pressure inputs. The fabrication of capacitive pressure sensor is easy and

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has the minimal effort with most high exactness when contrasted with different sensors.

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