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A Review of Fabrication and Simulation of Piezoresisitive Pressure Sensor for Abdominal and Thoracic Pressure Measurement Based on Micro-Electro Mechanical System

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ABSTRACT*:* Highly sensitive observing and controlling processes require extremely effective and precise sensing device. The control and monitoring inputs for any structure totally rely upon the sensitivity of the sensors. MEMS technology has the ability to outline the complete detecting system on a chip. Single chip can detect temperature, pressureas well as humidity. Typical applications of MEMS are in physical, chemical and biochemical sensors, as well as in optical systems such as the digital micro mirror device of Texas Instruments. Further, MEMS device is a rising device in a few ranges of science and innovation, for example, material science, life science. MEMS based sensors are as of now being utilized as a part of different sensing applications. Pressure measurement is one of the most mature applications of MEMS. The execution of pressure sensor is on a very basic level contingent upon its different physical properties i.e. piezoresistive, piezoelectric, capacitive and resonating.

I. INTRODUCTION

This thesis work is focused on the design of piezoresistive pressure sensor based on MEMS technology. This pressure sensor is designed for the application of measurement of abdominal and thoracic pressure. The electronic industry has, since the beginning of integrated circuits (IC) technology, developed fabrication processes and machinery enabling two dimensional miniaturized structures of micrometer scales and smaller sizes. Siliconwas selected as a productive material for its excellent electrical properties. The fabrication technology used in IC production has been further developed into field ofMicro Electro Mechanical System. MEMS allude to an accumulation of micro sensors and actuators that can detect its condition and have the capacity to respond tochanges in that condition with the utilization of a microcircuit control. MEMS is theintegration of mechanical elements, sensors, actuators and electronics on a commonsubstrate through the application of micro fabrication technology.

MEMS are very small systems or systems made of very small components. MEMS concept has grown to encompass many other types of small things including thermal, magnetic, fluid dynamics, with or without moving parts. It includes both electronic and non-electronic components and perform functions that can include signal acquisition, signal processing, actuation, displayand control. MEMS devices range in size from 20 micrometre to a millimeter.

II. SYSTEM DESIGN AND WORKING PRINCIPLE

Pressure sensor is a device to measure pressure of gases or liquids. Pressure is an expression of the force required to stop a liquid from expanding. It is generally expressed in terms of force per unit area. A pressure sensor generally goes about as atransducer; it produces a signal as a function of pressure applied. Such type of signalis electrical signal. Pressure sensors are being used for control and monitoring in a large no. of everyday applications. Pressure sensors may also be used indirectly to evaluate other parameters such as gas flow, velocity and water level. Pressure sensors can differ radically in innovation, outline, execution, application and cost. A conservative estimate would be that there might be more than 50 technologies and atleast 300 organizations making pressure sensors around the world.

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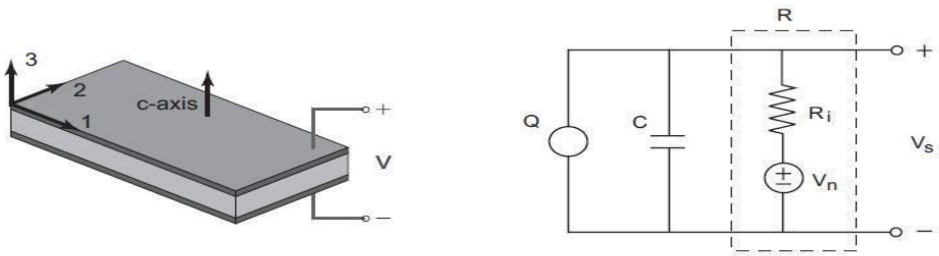

(a) (b)

Fig. (a) A conventional MEMS Piezoelectric Pressure sensor (b) the piezoelectric sensor model

The figure (a) shows the simple model of Piezoelectric pressure sensor which depicts the working of sensor. Piezoelectric material is placed between the two electrodes. As the pressure is applied between these two electrodes, voltage is developed which can be measured by voltmeter. Figure (b) describes the equivalent model of piezoelectric sensor model.

Abdominal and Thoracic Pressure Measurement

Abdominal and thoracic pressure are the parameter used in several diagnosis of body. These pressures are taken into consideration while checking the efficiency of respiratory and circulatory system [38]. Also the increasing thoracic and abdominal pressure can cause the spread of anaesthetics [39]. Hence, these pressures are important concern in health check-ups of human body. Figure 3.3 shows the measuring of respiratory flow using piezoelectric film belts.

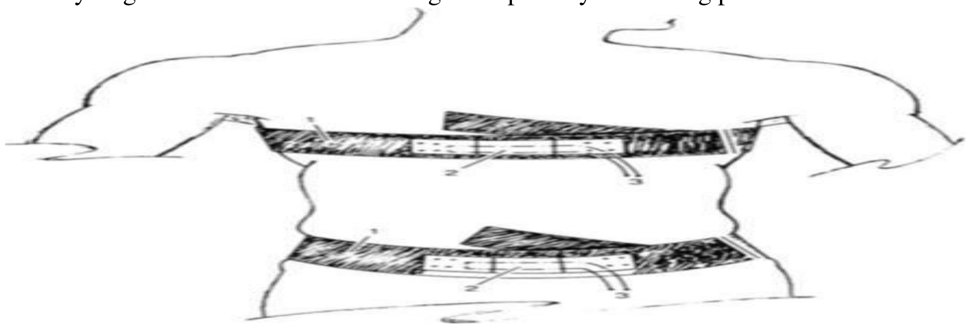

Figure :Piezoelectric belts to measure respiratory airflow 1=stretch Velcro (loops) 2=piezoelectric film sensor; 3=electrical connection

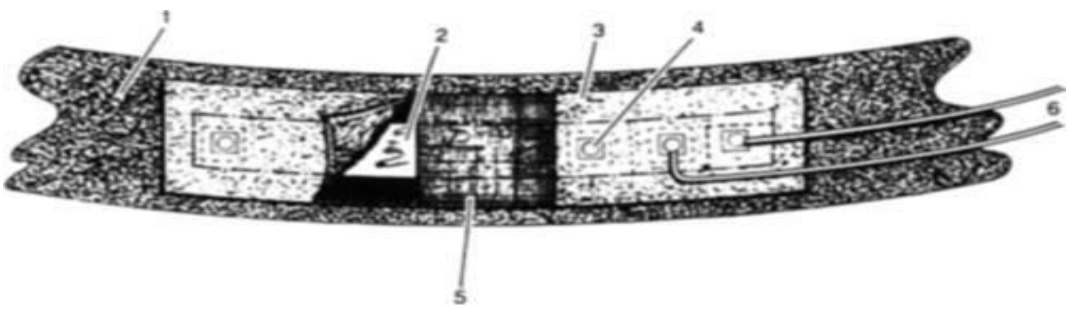

Figure : Detailed construction of piezoelectric sensor assembly

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1=stretch Velcro belt; 2 = piezoelectric film; 3= Velcro "hooks“; 4 = mechanical rivet attachment; 5=Lycra protective cover; 6=electrical connection

There is piezoelectric film placed on two belts. As the pressure exerted by abdomens and thorax, piezoelectric film is placed and the corresponding voltage is measured byelectrical connections.

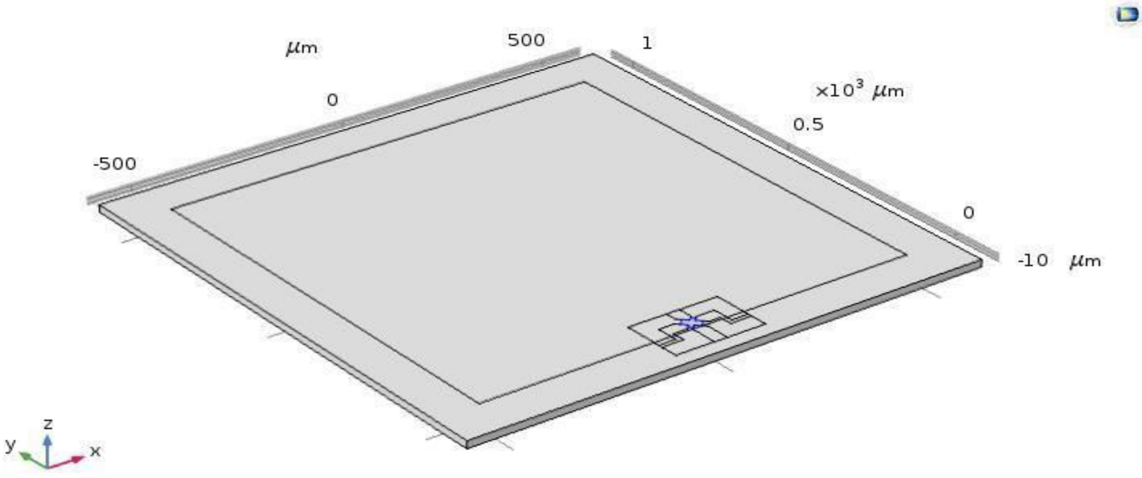
As discussed earlier, piezoelectric sensors shows non-linear variations. Also they are suitable only for high frequency signals. Pressure range of abdominal and thoracic pressure is 0-10 kPa. Piezoresistive sensor are suitable for the low range of pressure

III. DESIGN OF PIEZORESISTIVE PRESSURE SENSOR

This research is focused on finite element modelling of piezoresistive pressure sensor consisting of n-type and p-type silicon material. Simulation and analysis are completed with software package COMSOL Multiphysics version 5.3a using the MEMS module. The designed sensor measures the applied pressure and converts into the corresponding value of voltage. Working of this sensor is based on the principle of piezoresistance effect. On the application of pressure, stress is developed in the material due to which resistance of material is changed. The modelconsists of silicon substrate upon which diaphragm and piezoresistor are placed. This chapter will provide a detailed explanation of the approach to the design of piezoresistive pressure sensor including materials used and their properties, the geometry for 3-D model and how the solutions to the simulation are analyzed.

This research was conducted using the finite element software COMSOL Multiphysics . COMSOL Multiphysics is a cross-platform finite element analysis, solver and Multiphysics simulation software. . It is an adaptable platform that permits even beginners to model all pertinent physical aspects of their designs. Advanced users can go further and utilize their knowledge to create customized solutions, relevant to their special conditions.

The model comprises of square membrane with side 1000 µm and thickness 20 µm, supported around its edges by region 0.1 mm wide, which is proposed to show the remaining part of the wafer. The supporting region is settled on its underside (representing a connection to the thicker handle of the device die). Close to one edge of the membrane an X-shaped piezoresistor and part of its associated interconnects are noticeable.



Geometry of proposed design of piezoresistive pressure sensor

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IV. RESULTS AND DISCUSSION

Simulated Results

Displacement of Diaphragm on the Application of Pressure

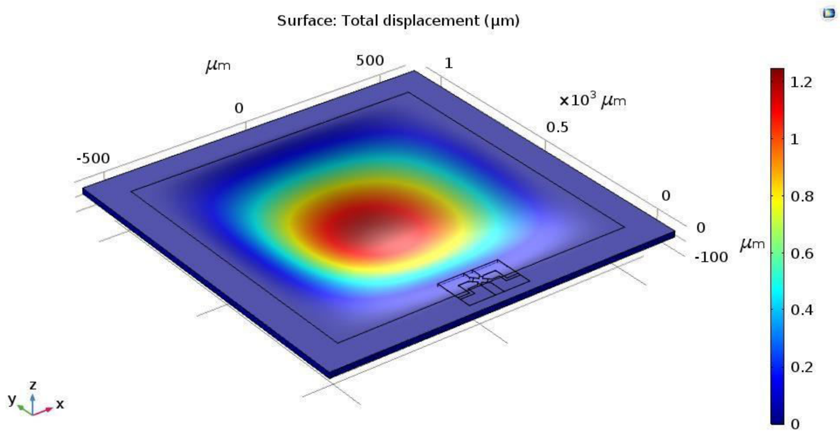

Fig 5.1 Diaphragm Displacement on the application of 100 kPa Pressure

Figure 5.1 shows the displacement of diaphragm when the pressure of 100 kPa is applied. As the contour plot shows that there is displacement of 1.2 µm at the centerof the diaphragm. Hence, the maximum displacement is found at the center of the diaphragm.

LOCAL SHEAR STRESS ALONG THE EDGES

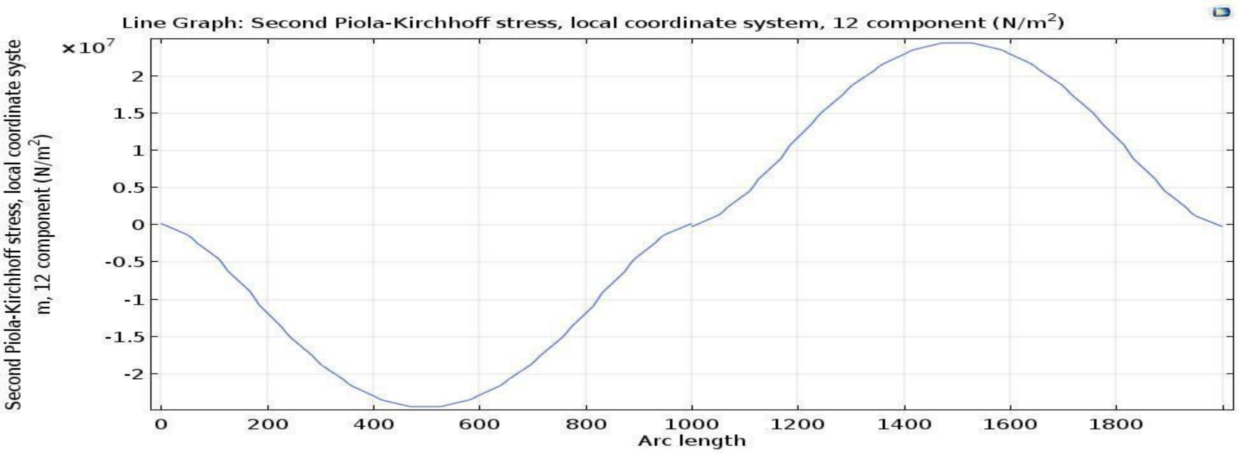

Fig 5.2 Graph of local shear stress on the application of 100 kPa pressure

V. CONCLUSION AND FUTURE SCOPE

In this thesis work a MEMS based Piezoresistor Pressure Sensor is designed for the measurement of abdominal and thoracic pressures. As it is shown by the previous research that abdominal and thoracic pressure ranges from 0 to 10 kPa. The designedsensor is simulated in the pressure range of 0-100 kPa and the results are concluded. The material used for the simulation is n-type annd p-type silicon of both single crystal and poly crystal type. Output Voltage is calculated for the different types ofcombinations of diaphragm and piezoresistor in the pressure range

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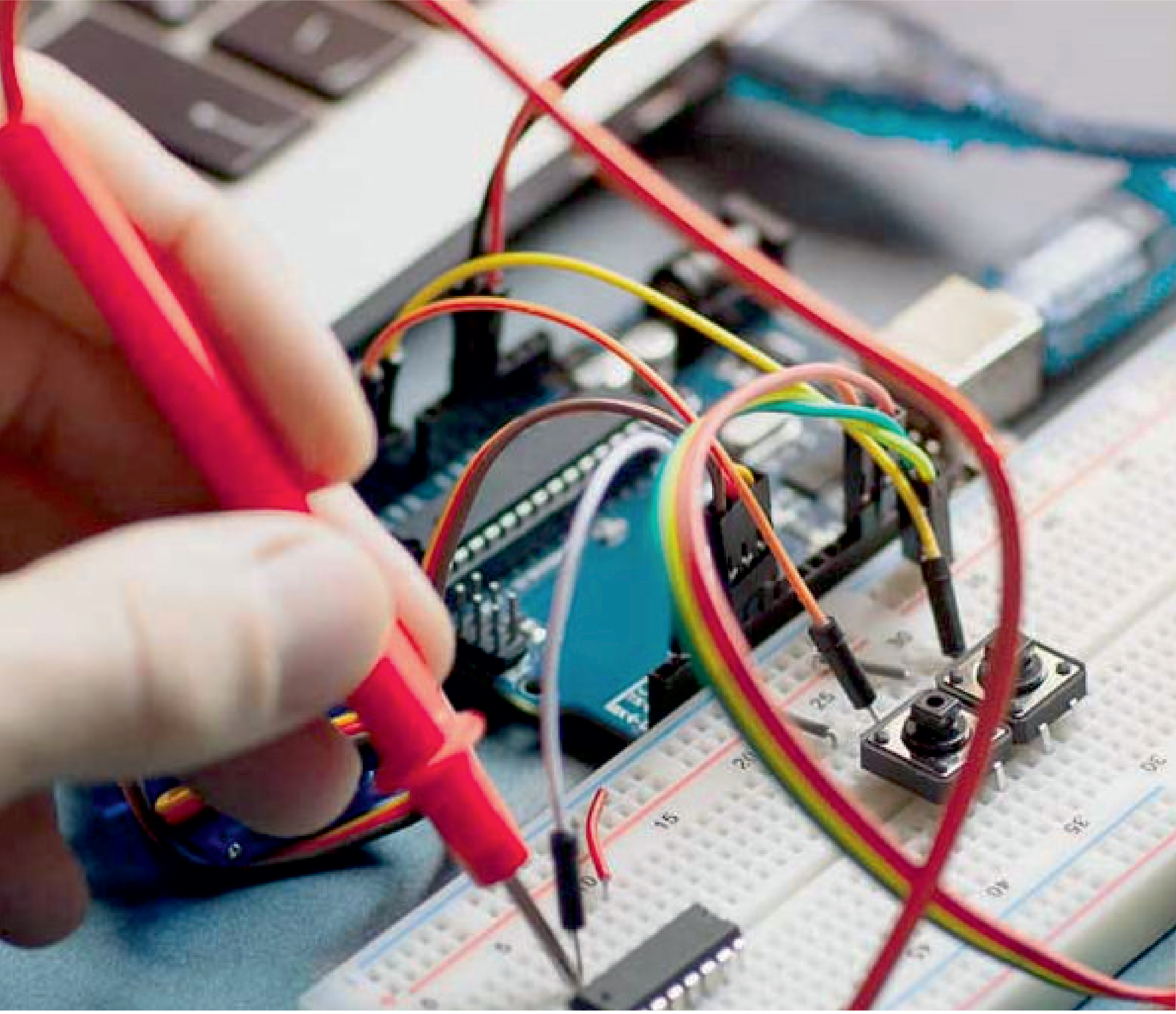
of 0-15 kPa and0-100 kPa. It has been observed that combination of n-type silicon single crystal fordiaphragm and p-type silicon single crystal for piezoresistor has better sensitivity among all the combinations. The graph shows linear variations which depicts that piezoresistive pressure sensor shows better linearity in comparison with capacitive and piezoelectric pressure sensor.

As the silicon material exhibits excellent piezoresistive property for the pressure sensor due to high sensitivity and better linearity. In future optimization of the devicecan be done by adding some other semiconducting materials to get the more enhanced results from the proposed design for small applied inputs.

REFERENCES

1.Fujita, H, (1998). 'Microactuators and micromachines,' Proc. IEEE, 86,(8),1721–1732
2.Madou, Marc J. Fundamentals of microfabrication: the science of miniaturization. CRC press, 2002.
3.Meijer, Gerard, ed. Smart sensor systems. John Wiley & Sons, 2008.
4.Gardner, Julian W., and Vijay K. Varadan. Microsensors, MEMS and smart devices. John Wiley & Sons, Inc., 2001.
5.Chen, Ying Jian. "Advantages of MEMS and Its Distinct New Applications." In Advanced Materials Research, vol. 813, pp. 205-209. Trans Tech Publications, 2013.
6.Eddy, David S., and Douglas R. Sparks. "Application of MEMS technologyin automotive sensors and actuators." Proceedings of the IEEE 86, no. 8 (1998): 1747-1755
7.Kraft, Michael, and Neil M. White, eds. MEMS for automotive and aerospace applications. Elsevier, 2013.
8.Yohtaro Yamazaki, "Application of MEMS technology to micro fuel cells" Electrochimica Acta Volume 50, Issues 2–3, 30 November 2004, Pages 663- 666
9.Pichonat, Tristan, and Bernard Gauthier-Manuel. "Recent developments in MEMS-based miniature fuel cells." Microsystem Technologies 13, no. 11-12 (2007): 1671-1678.
10.Bhansali, Shekhar, and Abhay Vasudev, eds. MEMS for biomedical applications. Elsevier, 2012.
11.https://www.engineersgarage.com/articles/mems-technology
12.Polla, Dennis L. "MEMS technology for biomedical applications." In Solid- State and Integrated-Circuit Technology, 2001. Proceedings. 6th InternationalConference on, vol. 1, pp. 19-22. IEEE, 2001.



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