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Micro-Electro-Mechanical-Systems (MEMS) based Device for Detecting Health & Environmental Variables

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ABSTRACT

An excessive buildup of cerebrospinal fluid (CSF), also known as "water in the brain," is a medical condition known as hydrocephalus that causes an unnatural increase in intracranial pressure (ICP). ICP side effects include headache, blood pressure increase, shallow breathing, nausea, and confusion. The sensitivity of a pressure sensor is purely reliant on the thickness of the silicon diaphragm used in a traditional MEMS piezoresistive pressure sensor, which uses silicon diaphragm with specific thicknesses. Therefore, in order to attain great sensitivity, a thin diaphragm is needed. Therefore, the thickness requirement can be met by making use of graphene's thinness, although non-linearity difficulties must still be taken into account.

Keywords: Cerebrospinal fluid, Intracranial pressure, MEMS pressure sensor, Piezoresistive, Sensor, Sensitivity.

INTRODUCTION

In this paper with the help of this research, a novel pressure sensor device that can measure intracranial pressure and identify ambient factors that are connected to health has been designed and examined[1]. The field of medical science is greatly impacted by contributions of this nature[2]. A tiny pressure sensor is used to assess the intracranial pressure (ICP)[3]. The sensor is based on the piezoresistive effect[4]. The piezoresistive pressure sensor is modelled and designed using finite element analysis (FEA) and nonlinear programming optimization tools[5]. There are two main sorts of sensor sizes for toddlers and adults. The sensors are made with Micro Electro Mechanical Systems (MEMS). Calculating intracranial pressure involves finding the cerebral pressure-standard ambient pressure difference (ICP).

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A sophisticated and flexible MEMS pressure sensor to solid state single particle sensor was made using graphene's electromechanical properties. Intracranial pressure, or ICP, is the force that substances like cerebrospinal fluid (CSF) apply to the brain tissue inside the skull[6]. High intracranial pressure can be caused by traumatic brain injury, major artery acute ischemic stroke, intracranial bleeding, intracranial neoplasms, diffuse cerebral illnesses such meningitis and encephalitis, and acute liver failure (ICP)[7]. In addition to being known as intracranial hypertension, elevated ICP over time is also referred to as sustained ICP[3]. From pressure sensors to solid state single particle sensors, complex and versatile MEMS sensors have been made using electromechanical properties of graphene[8].

The silicon diaphragm employed in MEMS piezoresistive pressure sensors, which have particular silicon diaphragm thicknesses, determines a pressure sensor's sensitivity only[1]. Traditional Methods and Fibreoptic Intracranial Pressure Monitors are the two basic categories into which intracranial pressure monitoring techniques fall[9]. There are several ICP monitoring techniques for traditional approaches[10]. A lumbar puncture, in which a catheter is inserted into the spinal subarachnoid space, is possibly the simplest procedure to carry out[11]. But this approach has technological and decal limitations that make it less appropriate for long-term medicinal use (for example, spinal CSF pressures often do not reflect intracranial pressure, and the method presents practical nursing problems).Clinically, the most common methods of ICP monitoring are intraventricular tubes and subarachnoid bolts[12].

By uniaxially stretching monolayer graphene membranes that are sealing air-filled cavities, the piezoresistive property of graphene has been proven[13]. Geometry, or thin rectangular cavities with suspended graphene membranes sealing the voids, was what caused the uniaxial strain[11]. Then, a pressure chamber was used to house these gadgets. The pressure differential between the air in the chamber and the air trapped beneath the graphene membrane changes as air is pumped out of the chamber[14]. The trapped air pushes up against the membrane, putting strain on it[2]. With values that are tens to hundreds of times more sensitive per membrane area than the sensitivity of traditional silicon pressure sensors, very high sensitivity has been attained for these devices[15].

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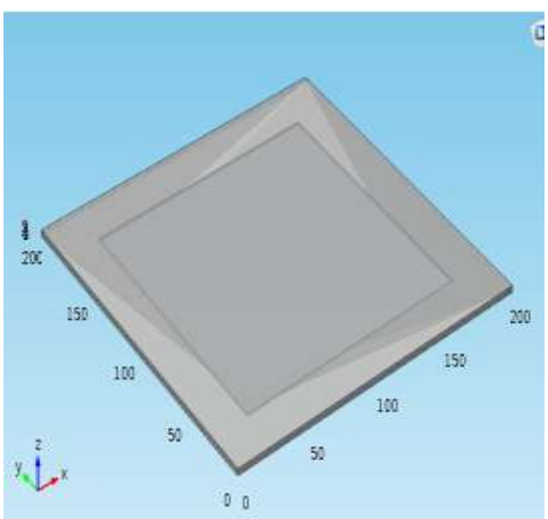
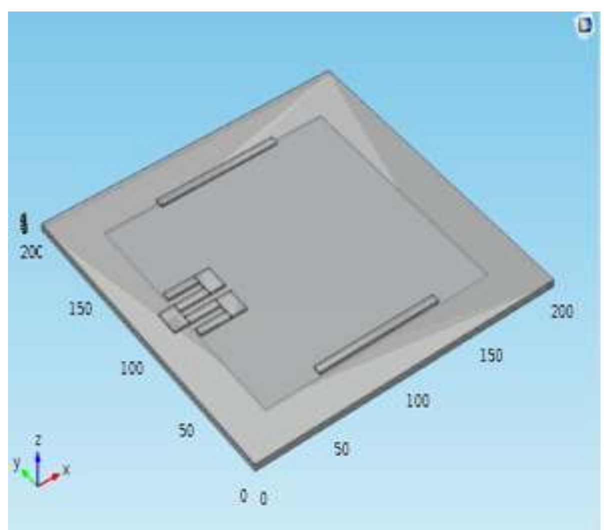
MATERIALS AND METHODS

Two components of the measuring assembly—the pipeline and the sensor—are responsible for the dynamic accuracy of pressure measurements. The sensor is connected to the location where pressure must be measured via a pipeline. According to the test signals employed for that purpose, the techniques for dynamic calibration of pressure sensors can be divided into two groups: frequency techniques that utilise the harmonic pressure signal and time techniques that use a step- or pulse-shaped signal. Because the step pressure signal is well realised using the time approach with a shock tube, it is strongly advised. However, the benefits of a shock tube are less obvious for piezoresistive silicon sensors, necessitating the search for other techniques.

RESULTS AND DISCUSSIONS

To understand the real outcomes by taking the references of the research objectives different models has been designed using COMSOL 5.3 a multiphysics software,which is shown in Table-1(Fig.-1 to Fig.-6) with the help of six different steps.These steps includes from substrate design to model design.

Table-1 Modeling and Design in Multiphysics environment using COMSOL 5.3a

Step-1 Design of a Substrate(Fig.-1)	Step-2 Resistor Implanted on Substrate(Fig.-2)
	

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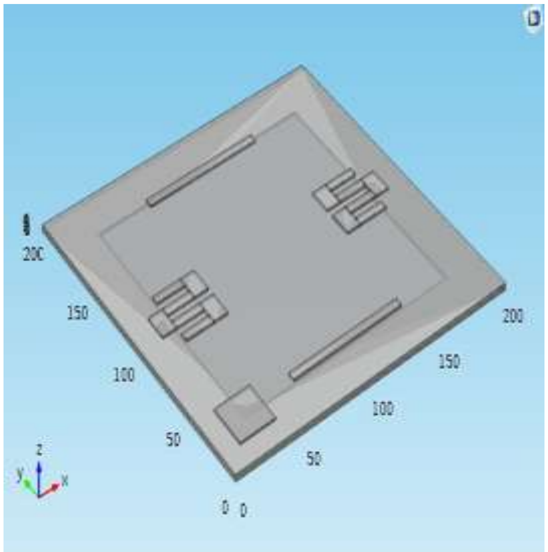
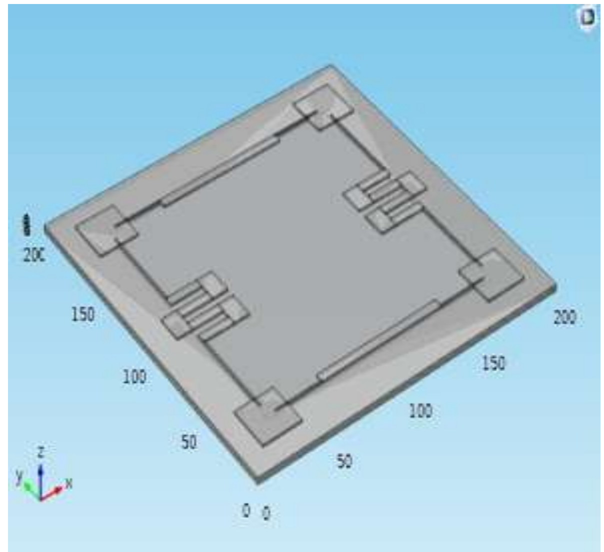
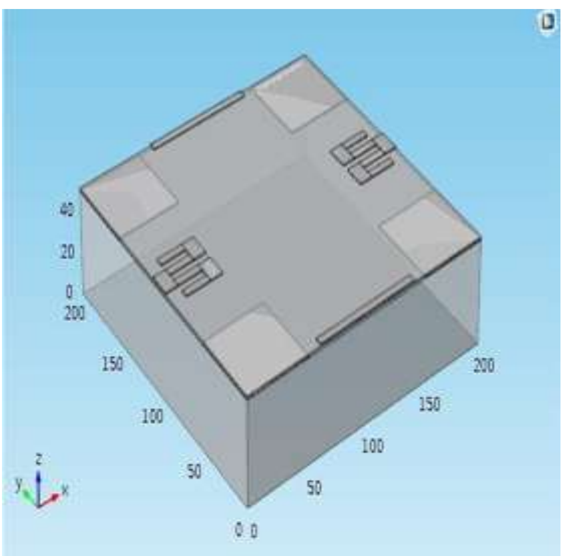
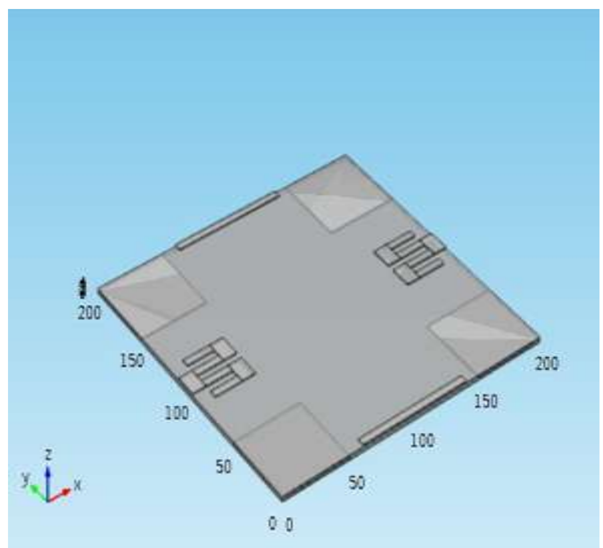
Step-3 Resistor Implanted at Edges(Fig.-3)	Step-4 Metal Connections(Fig.-4)
	
Step-5 Model-1(Fig.-5)	Step-6 Model-2(Fig.-6)
	

After analyzing the different models it has been simulated to obtain the maximum displacement. In Fig.-7 obtained displacement has been shown through the modeling and simulation.Additanily with the help of Table-2, Induced Strain through applied pressure has been highlighted.

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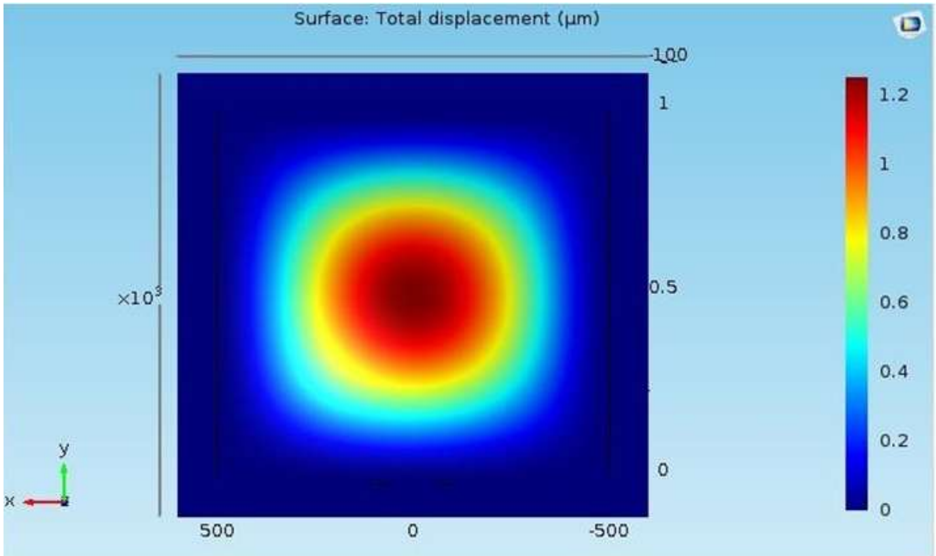

Fig.-7 Simulation of Piezoresistive Pressure Sensor

Table-2 shows that Piezoresistive is highly sensitivity at low pressure; hence it can be used in ICP invasive monitoring. Piezoresistive based ICP have much flexibility and lighter weight compare to other pressure sensors.

Table-2 Induced Strain through applied pressure

Type of Sensors	Pressure Applied	Strain Induced
Piezoresistive Pressure Sensor	100KPa	1.2

CONCLUSION

Piezoresistive pressure sensors have high stress, which increases sensitivity, according to this study and analysis. On the other hand, pressure is natural yet stress directly relates to sensitivity. In this study, a device structure that can detect pressure-induced strain at extremely low pressures is described. In addition, our study has shown that it is practical to use a piezoresistive MEMS intracranial pressure sensor. Graphene is also extremely sensitive at low pressure, making it suitable for ICP intrusive monitoring. ICP made of graphene is considerably more flexible and lightweight than traditional pressure sensors. As a result, it is suggested as useful significant equipment.

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