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SIMULATION OF PIEZO RESISTOR GAS PRESSURE SENSOR FOR EFFECT OF SHAKE OF THE AFM PROBE USING THE COMSOL SOFTWARE

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ABSTRACT

The amount of pressure on the surface perpendicular done using mechanical methods For measuring the force applied to the outer surface of reservoirs or pipes containing gas because the pressure exerted on all the walls and different levels, Is inefficient. In order to measure this kind of pressure, extensive studies have been conducted over the past decades and various methods have been proposed that some of the errors were associated advantages and disadvantages. In this study, the following issues raised by the use of piezoelectric structure, the design and simulation as a barometer Pisoresistor structure and to optimize its output linear displacement effects have been addressed probe. The results showed that apart from the physical parameters such as pressure screen dimensions, the County Laver, shape and dimensions of He, and made each of them a major role in the resistance again linearity of the output voltage to the probe.

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KEY WORDS

Simulation, pressure sensor, AFM

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INTRODUCTION

This paper discusses the design and simulation of piezo-resistor barometer in order to measure displacement of Afm probe. It is worth noting that all the obtained results of this paper which are studied and simulated in different voltage-ohmic frames and obtained from this structure are merely due to pressure on this structure and displacement of Afm probe. Displacement of the aperture is measured by changing the inductance (Hall effect). Induction pressure sensor has two coils that are coupled with a magnetic core. When the applied pressure moves the aperture, it moves the core. Induction feature is measured by electronic circuits such as resonance circuits.

Demand for low cost and small size of semiconductor pressure sensor has been increasing by technology development in various fields of engineering, including precision measurement, control and biomedical systems. Transferring from mechanical to the silicon type is the solution for this demand. Micro-sensors are widely used in today's devices and micro-pressure sensors are one of the most common Mems devices and have gained popularity in biomedical, aerospace and automotive industries. Such a sensor usually consists of a silicone membrane and four resistors located on the edges of the membrane along the crystal (110). When a pressure is applied to one side of the aperture, it bends and tension is appeared in the whole structure. Changes in stress represents a change in electrical resistance of piezo. To optimize voltage sensitivity of such a piezo-resistive sensor, Wheatstone bridge configuration is done using piezo resistors [1]. This paper aims to identify the properties of these micro-structures and simulate a new proposed structure to advance practical purposes. It should be added that simulation of this sensor is performed by powerful simulation software of COMSOL. The piezoelectric effect is used in certain materials, like quartz to measure the tensile due to stress. This technology is used to measure dynamic pressures. A variety of crystals called piezoelectric produce an electrical signal due to mechanical deformation. Voltage level of this signal is proportional to the deformation value.

Crystal is attached to a metal aperture. One side of the aperture is used for measuring pressure in contact with the process fluid and the other side of the aperture is mechanically connected to the crystal. Crystal's output voltage

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signal has a small amplitude (in mV range). Its operating modes are contact mode, non-contact mode and intermittent contact mode [2].

MATERIALS AND METHODS

In this section, first the structure and different parts and their relationships are investigated. Then, the nature and the need for mesh configuration have been raised.

The simulated structure consists of three part. The first part is the pressure-employing disk. In fact, pressure employed on the structure imports most of its power to this point. This part should be hard and dry to be able to convey the overall pressure. This part is positioned at the beginning of the second part [3].

The second part is the Cantilever with spiral-shaped structure and can start vibration once the pressure is employed. Cantilever, which is the connection between the first and third parts, conveys the vibration on itself to the third part causes important changes in electrical parameters such as frequency, voltage and the ohmic value of the structure. All this changes are appeared in maximum values in third part of the structure. In other words, all changes in Cantilever reach the greatest amount in third part.
Third part of the probe is Afm. This probe may have various sizes and shapes. Two aspects are of great importance in its design. First, it should be smaller than pressure-employing disk in order to convey all changes. Second, it should be hard and dry so as to convey Cantilever vibrations appropriately and avoid of damping nothing within itself.

RESULTS

All the mathematical relationships are related to mechanical and electrical modes [4-6]

Voltage Equation
V=abs(Rl_v)
Mechanical Power Equation
0.5*intop1(realdot(solid.rho*g_const*acc,solid.u_tY))*w_plate

Electrical Power Equation
0.5*realdot(cir.R1_i,cir.R1_v)
The reason why the structure is designed as shown in **Figure- 1** is that the Cantilever can easily moves toward different frequencies by employing various pressures.

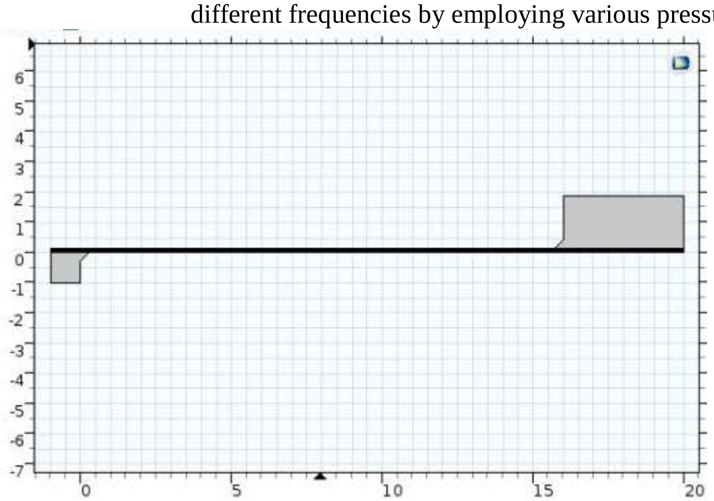

Fig: 1. simulation structure

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As seen in **Figure- 2,** the best performance obtained is in the frequency of 75.5 Hz. Thus, to get appropriate output, it is required to employ frequency of 75.5 Hz to the structure called frequency response curve. This is shown in **Figure- 3and 4**.

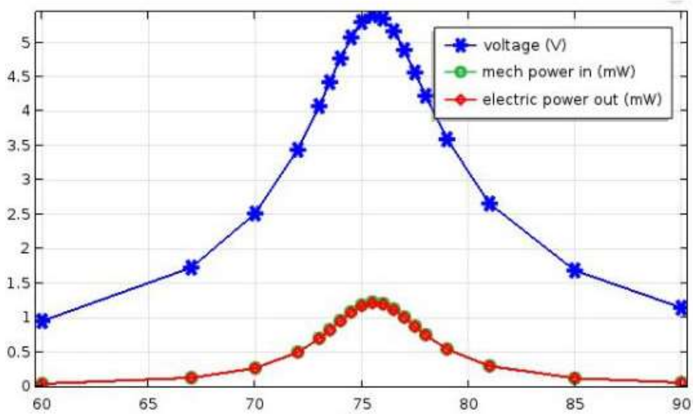

Fig: 2. Frequency response

In the next step, the created changes of pressure is adressed properly and with higher quality which cause variotions in voltage, mechnical pressure, and electrical pressure in frequency of 75.5 Hz.

Thus, it can be stated that simulations and ohmic value measurement and its placement in Wheatstone bridge and Afm measurement probes (12 possible modes) are done by employing pressure on piezo-resistor structure which leads to find optimal point of performance.

One of the important parameters in this paper is to investigate pressure variation, resulting in variations in voltage, mechanical pressure and electrical pressure.

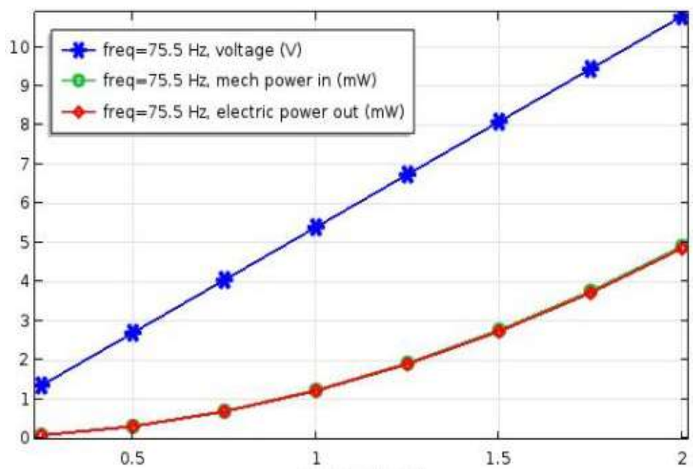

Fig:3. Pressure structure

The employed pressure on the structure is addressed in **Figure- 3.** The pressure employed on the structure not only causes initial acceleration on sesnsor plate, but also leads to oscillations in the Cantilever. This, in turn, results directly and practically in Afm probe displacement. In tjis figure, the reason why accelartaion is evaluated is that the pressure employed on the structure on vertical axis leads to initial acceleration. Blue, red and green lines depicted in the fisgure denote voltage in V, output electrical power in mW, and mechanical power employed in mW, respectively. It should be mentioned that two electrical and mechanical power curves are overlapped when transformation value is 1.

Another important parameter evaluated was 1 kΩ's load resistor which had linear growth in lower pressures; however, it was not the case in higher pressures **[Figure- 4]**. Despite the fact that this increase is of exponential type, it is continuous and permanent. Thus, 10 kΩ's load resistor is the appropriate load resistor. In order to ensure appropriate operating point, i.e. selection of 1 kΩ's load resistor, the output of the structure is also given for 100 kΩ's load resistor. As it is clear from its figure, this resistor provides no appropriate and linear performance for the system.

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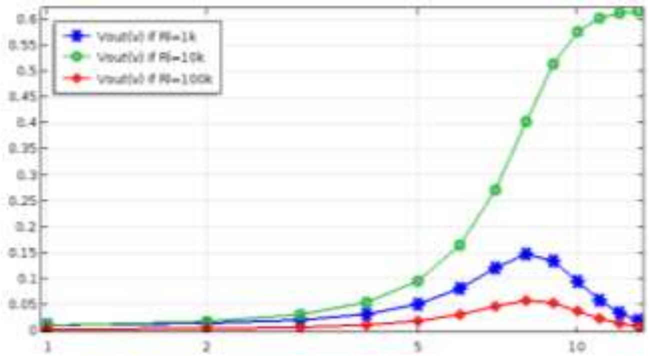

Fig: 4. Load resistor

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As seen in **[Figure- 4]**, the output value is in V. this voltage is due to employing pressure on pressure sensor region which caused displacement of Afm proble and changed the values.

CONCLUSION

Since piezos have more appropriate performance in alternative currents, it is recommended to operate them in alternative voltages.

Voltage changes in piezo structures are low. Thus, it is required to use amplifiers. These changes occur in different directions such as measurement of pressure, vibration, tempreature, and audio production, etc. Ohmic changes of piezos have non-uniform Impednace matching in various load conditions. That is, for example, a structure with load resistor of K 2.2 has better performance than its k 22 counterpart. This structure with a resistor of k220 supplies no proper output. Therefore, finding exact load resistor is of paramount importance in detecting ohmic variations of piezo structure.

Finding the best frequency is another important parameters in piezo structures, Because the performance of piezo structures is different in various freqncies.

CONFLICT OF INTEREST

Authors declare no conflict of interest

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None

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None

REFERENCES

[1] CH C. C.-T. L. K.-N. C. T.-L. Chou,[2009] Sensitivity analysis of packaging effect of silicon-based piezoresistive," ELSEVIER Sensors and Actuators A: Physical, 29-38,

[2] M-q. Z. B.-h. MW.-z. YS. Chen.[2008] Design and Optimization of a Micro Piezoresistive Pressure, in Proceedings of the 3rd IEEE Int. Conf. on Nano/Micro Engineered and Molecular Systems, Sanya,, pp. 50-62.

[3] BCS Chaurasia.[2012] Design and Simulation of Low Pressure," IEEE, pp. 20-35,.

[4] KT PHC. K. a. KC JH. Kim. [2009] "FABRICATION OF A PIEZORESISTIVE PRESSURE SENSOR FOR ENHANCING SENSITIVITY USING SILICON NANOWIRE," *IEEE*, pp. 1936-1939.

[5] BC Saloni Chaurasia.[2013]Design and Simulation of Low Pressure Piezoresistive NEMS Sensor Using Analytical Models for Biomedical Applications," IEEE, pp. 1-5

[6] AK Mateusz Gęca.[2013]"Design, modeling and simulation of MEMS pressure sensors," Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics, pp. 1-10.