An Experimental Approach to Sensors Silicon Forced

[1]Hara prasad Tripathy, [2]Priyabrata Pattanaik, [3]Susanta Kumar Kamilla

Abstract--- *According to this literature, a silicon forced sensors is offered by which the measurement of the force is calculated by means of force exerted on the gauge made up of polysilicon. Particular gauge is stressed by a metallic plate on which the maximum force of 500 kN is applied. The total force is calibrated with the change in resistance. Our model is constructed for the temperature change and the plane sketching and the bending of the stresses into the chip. Piezo-resistive module made up of the "Comsol Multiphysics 4.3" is employed for the simulation purposes.*

Index Terms*— Force sensor, Comsol Multiphysics, piezo-resistor*.

I. INTRODUCTION

The basic circuit diagram of the silicon forced sensor is illustrated in Fig.1. Force based sensor is embedded in between two blocks[1]. The force required to be calculated should be applied on these two blocks. These two polysilicon strain gauges are mounted on the top of the 8mm through 8 mm siliconic chips[2]. First gauge is directly loaded. Second gauge is mounted at 15 µm deep trench and it is indirectly loaded.

1,2,3 Department of Engineering, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar

haraprasadtripathy@soa.ac.in, priyabratapattanaik@soa.ac.in, sushantakamilla@soa.ac.in

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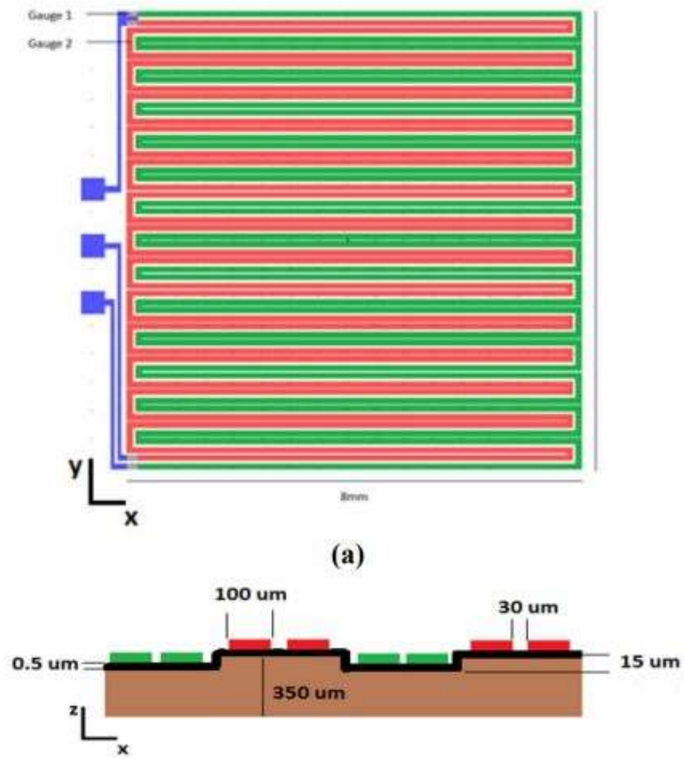

(a)

(b)

Fig. 1.1 (a) Geometric details of load cell (top of load cell), (b) Cross-sectional view

The piezo-resistive forced sensor are suggested just because of its "high sensitivity", "low noise", "better scaling characteristics" and wide range of the measuring force etc. also it has simple and effective circuit[3].

II. CHARACTERISTICS

The relative change of resistance for gage 1 and 2 can be written as

$$\frac{\Delta R_1}{R} = \pi_l(K_1\sigma_z) + \pi_t(K_2\sigma_z + \sigma_z) + \alpha T \qquad (2.1)$$

$$\frac{\Delta R_2}{R} = \pi_l(K_3\sigma_z) + \pi_t(K_4\sigma_z) + \alpha T \qquad (2.2)$$

Here $K_1 = \sigma_x^1/\sigma_z$, $K_2 = \sigma_y^1/\sigma_z$, $K_3 = \sigma_x^2/\sigma_z$ and $K_4 = \sigma_y^2/\sigma_z$,

depends on Poison's ratio and geometry. π_l and π_t are piezoresistance coefficients. σ is stress.

By subtracting both (2.1) and (2.2) relative changes of resistance is the result

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$$\frac{R_1 - R_2}{R} = \pi_l(K_1 - K_3) + \pi_t(1 + K_2 + K_4)\sigma_z \qquad (2.3)$$

The change in resistance under applied load and corresponding stress along the z-axis is $\sigma_1 = {}^{F}/_{WL}$, Where F is the applied force, W is the width of the Piezoresistor and L is the total length of Piezoresistor.

$$\frac{R_1 - R_2}{R} = K\frac{F}{WL} \qquad (2.4)$$

Where $K = \pi_l(K_1 - K_3) + \pi_t(1 + K_2 + K_4)$.

The value of ΔV_{out} (change in output voltage) can be accurately determined using a voltage divider arrangement (Fig. 2.1). V_s is supply voltage.

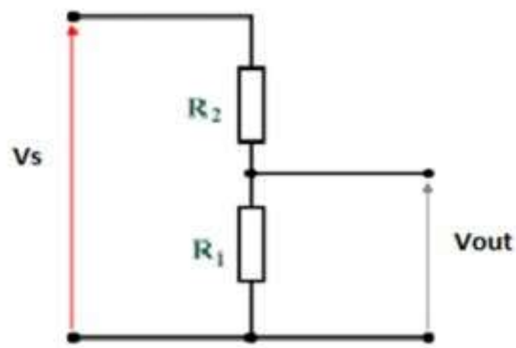

Fig. 2.1 Voltage divider circuit

$$\Delta V_{out} = V_s - \frac{R_2}{R_1 + R_2} \qquad (2.5)$$

III. STRUCTURE

This model is simulated on the Comsol Multiphysics 4.3a. the Piezoresistivity, current boundary physics on the basis of structural mechanism and module is employed for designing and simulating its load cell model[4].

The structure is constructed by employing blocks of the required values such as height, depth and width. A 2-Dimensional working plane is defined by the top blocks on which the structure of the piezoresistors and connections are defined. Aluminium is employed as metallic interconnections in between Piezoresistors[5]. The default property values of the material provided in Comsol Multiphysics [6]are employed for the simulation purpose. Next step deals

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with structural defining, electrical and piezoresistive property of the sensing model. For designing the sensor design 1 is has fixed constraint is applied on the bottom of the block i.e. the blocks lower side is fixed and load is applied on the top side of the block as of load boundary. Second gauge is placed under 15μm deep grooves therefore only first gauge is loaded. The "COMSOL" model of the forced sensor is illustrated in Fig.3.1[7].

Design simulation is performed by employing parametric sweep ranges 0N to 3kN into the steps of the 500N as applied.

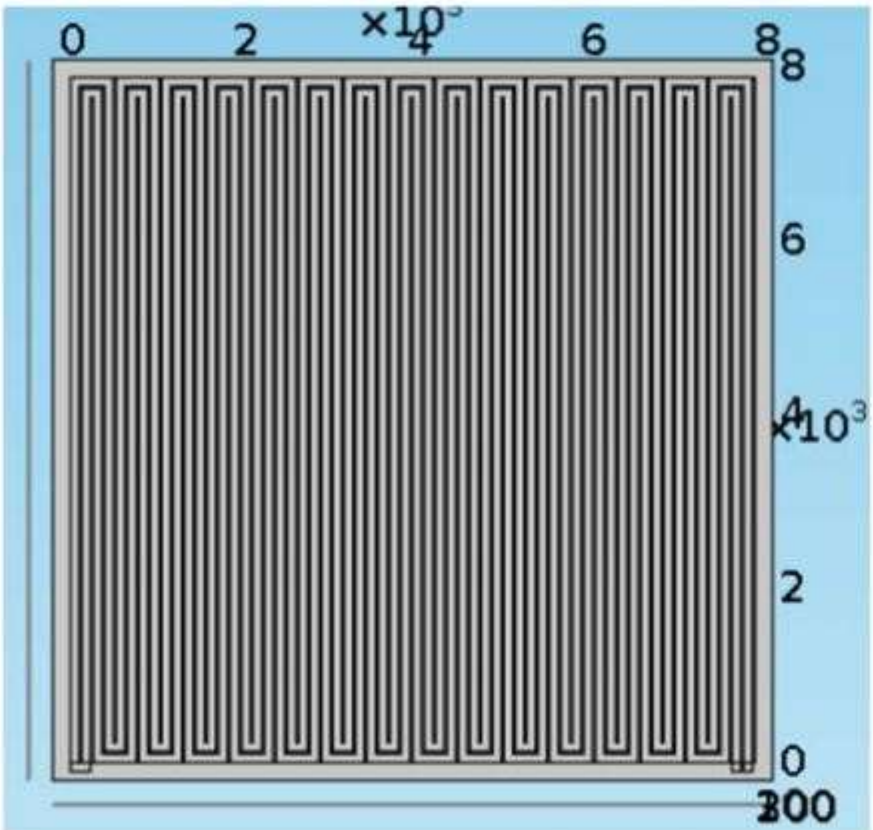

Fig. 3.1: Comsol model of force sensor

IV. RESULTS

The profile of distribution, distributed stress, distributed potential of the forced sensor is illustrated in Fig.4.1 and Fig.4.2 that illustrates the characteristic output.

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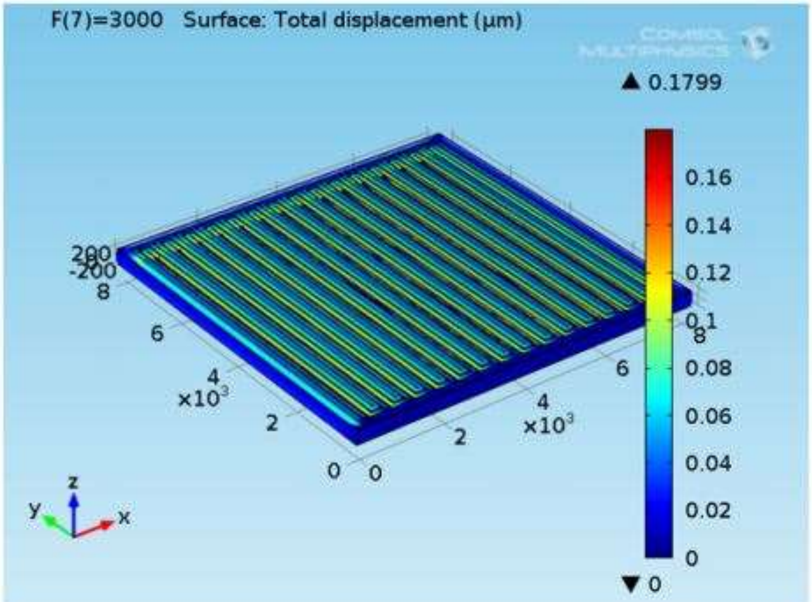
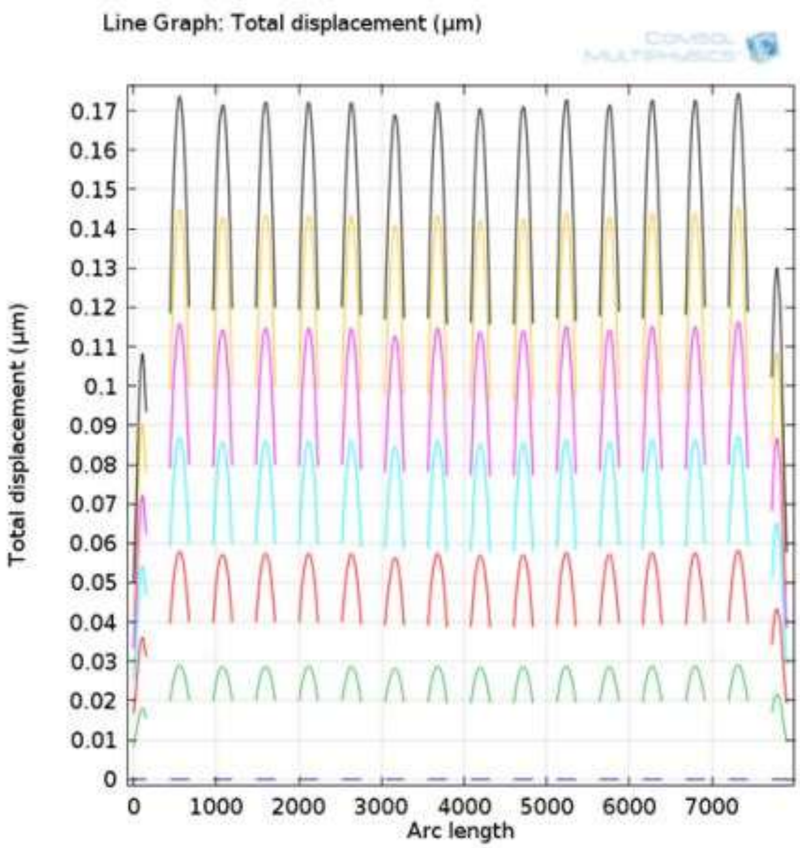


(a)



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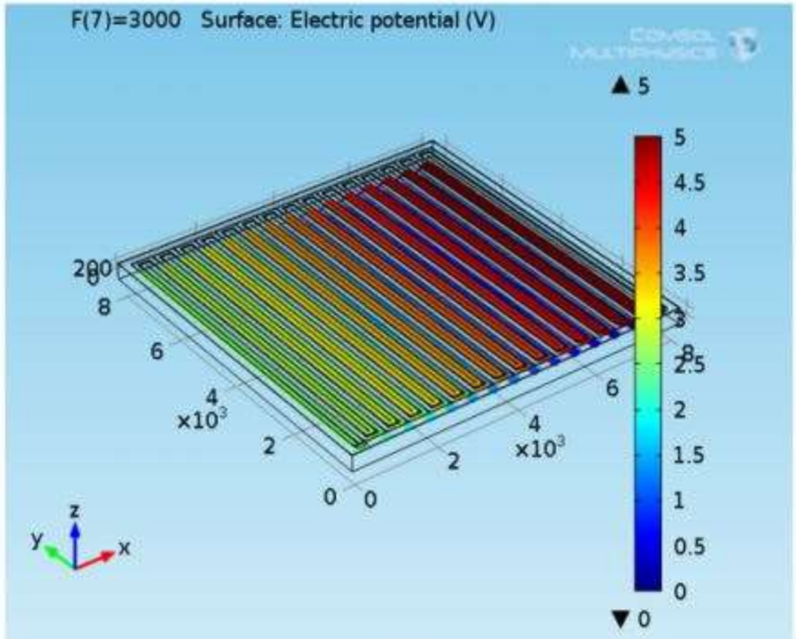

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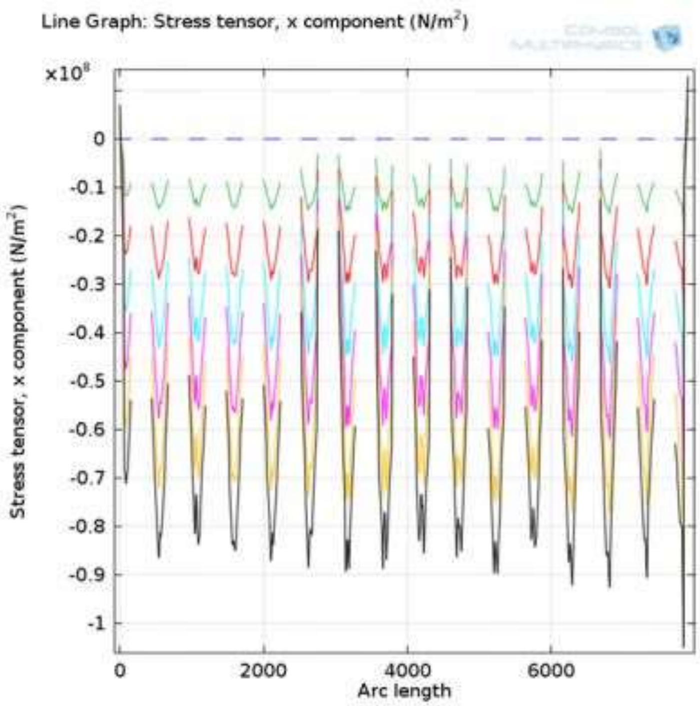

(d)

Fig. 4.1. (a) Displacement profile, (b) Total displacement along the length of sensor under applied loads and (c) Potential distribution for sensor design 1 and (d) Stress along the surface of load cell.

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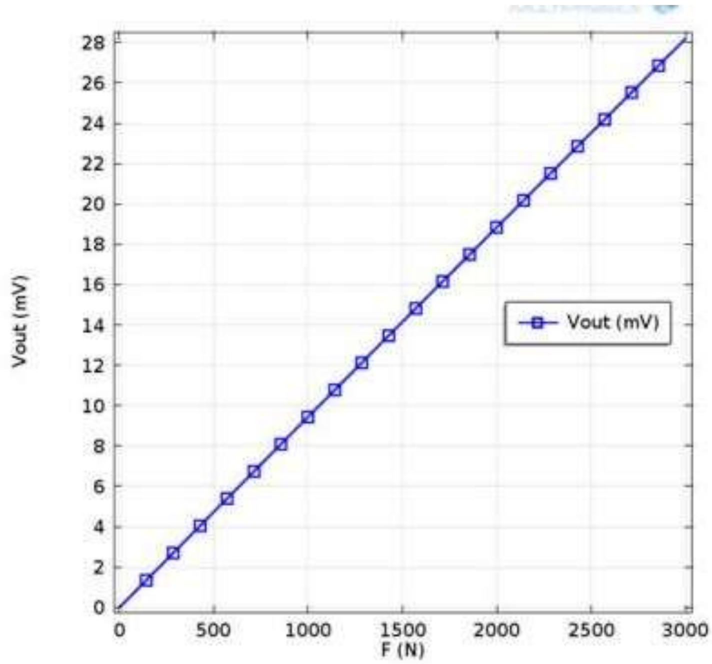

Fig. 4.2. Output characteristics

V. CONCLUSION

The simulation of force sensor for 3kN and maximum change in an output voltage by employing arrangement of potential divider of ~28 mV at 3kN. The output sensitivity to be 1.880 µV/V/N.

The model sensitivity can be increased further by employing Wheatstone bridge that determines the change in voltage output under applied stress that has to be calculated.

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