MEMS Based Silicon Load Cell for Weighing Applications

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Introduction: Load cells are force sensors, which are used in weighing equipment. First design is based on compressing a meander like polysilicon strain gage for the measurement of high forces up to 10kN. Second design is based on MEMS pressure sensor consisting of membrane, on which force (up to 500N) is applied keeping the surrounding frame fixed. The simulation results shows the sensitivity and range of output voltage for both load cells measured over range of applied forces.

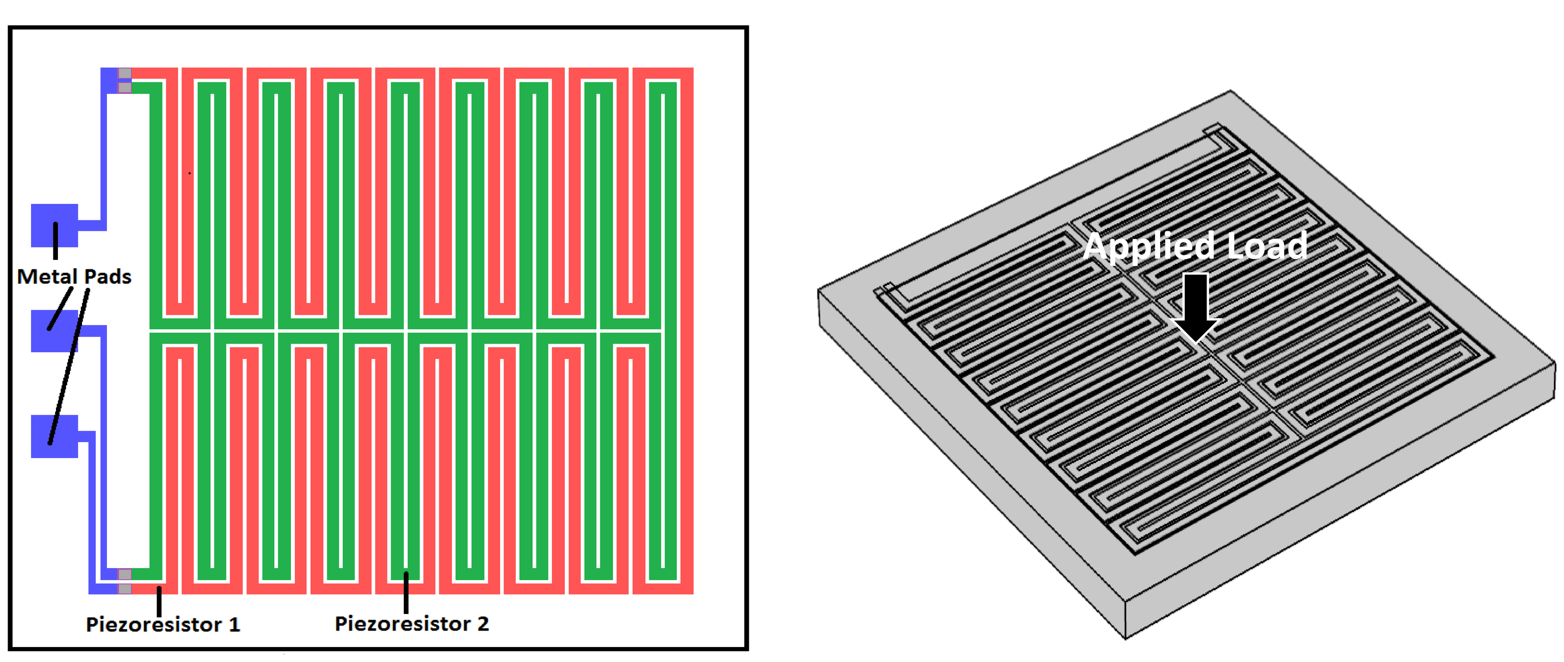
Characterisation: The change in relative resistance in silicon piezoresistor is given as

$$\frac{\Delta R}{R} = \pi_l\sigma_l + \pi_t\sigma_t$$

R can be calculated by length l, area of cross section A and resistivity of material ρ as

$$R = \rho\frac{l}{A}$$

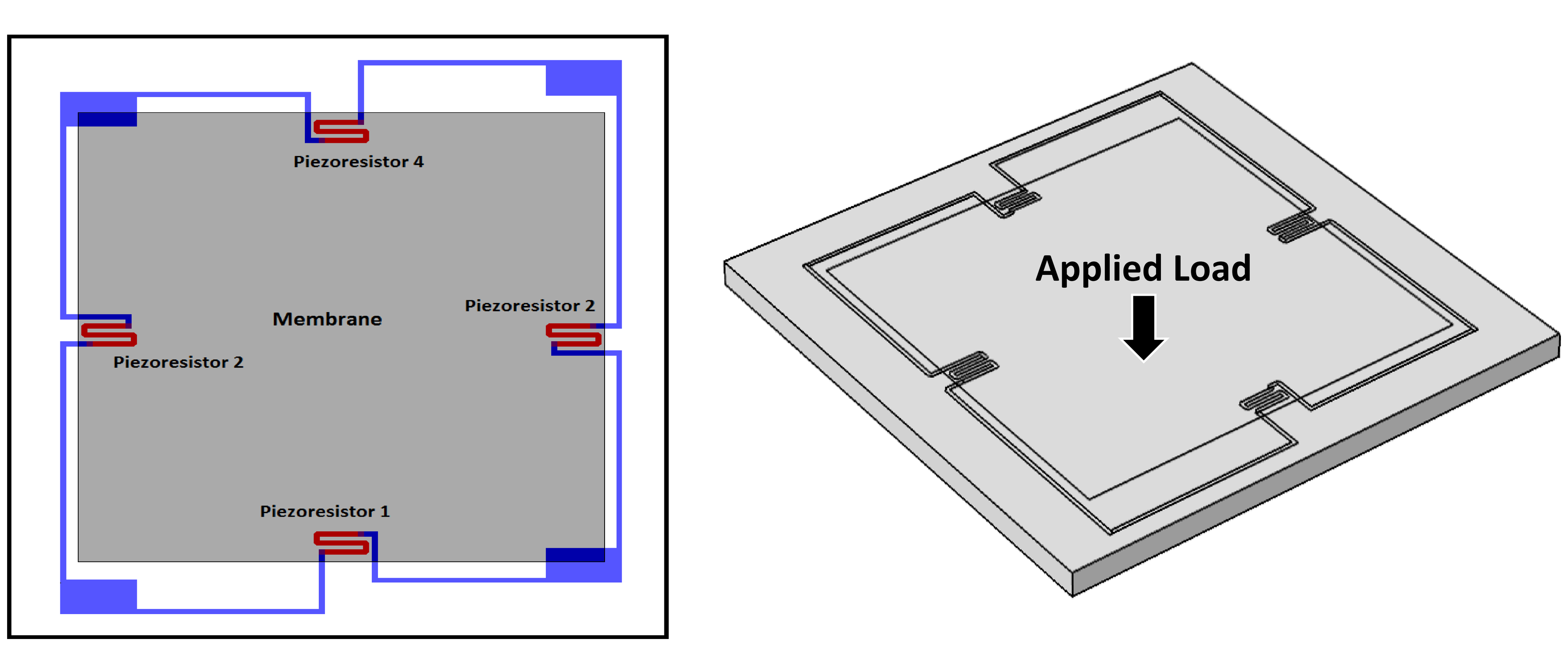
Design 1: Meander Shaped Polysilicon Piezoresistive Silicon Load Cell:



(a) (b)

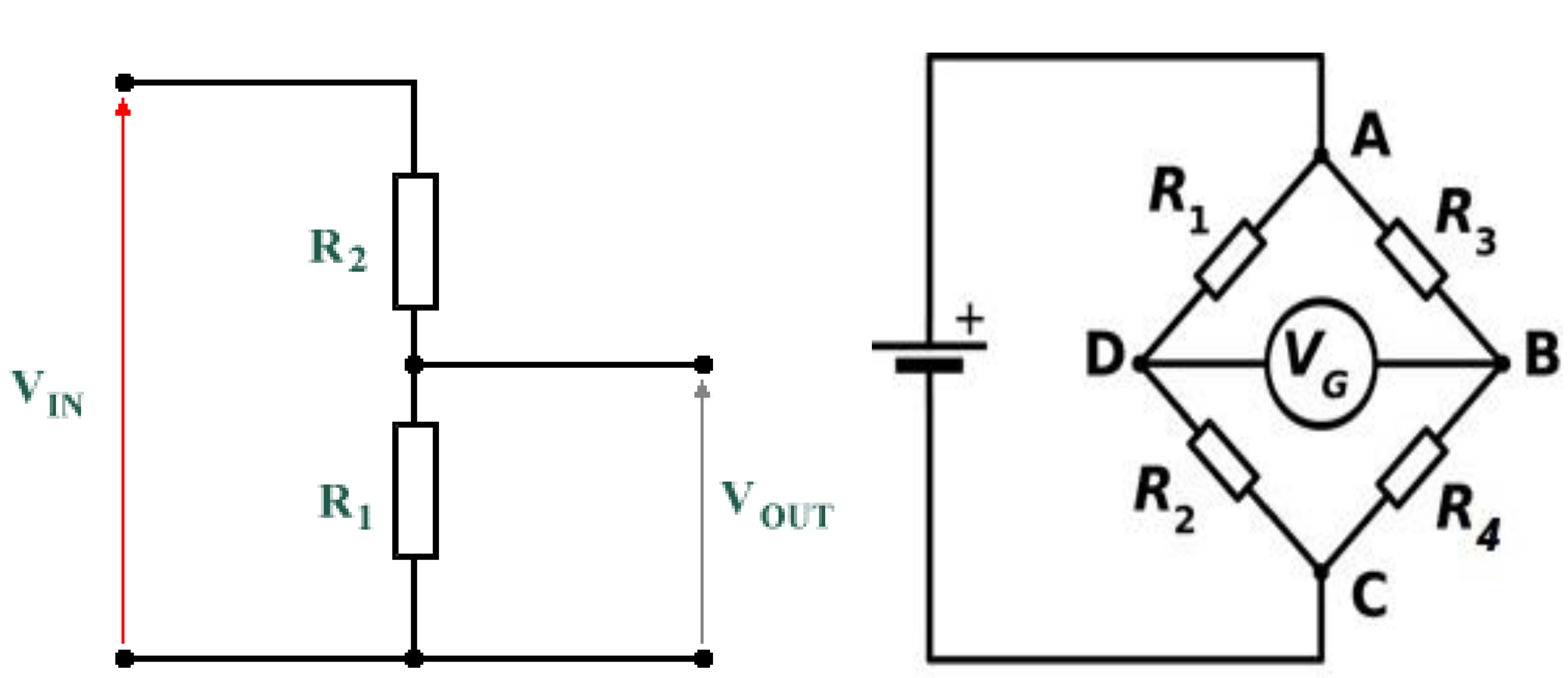
Figure 1. (a) Top view of Meander shaped polysilicon Piezoresistive silicon load cell and (b) its Comsol Model

Design 2: Pressure sensor based Piezoresistive Silicon Load Cell:



(a) (b)

Figure 2. (a) Top view of Pressure sensor based shaped polysilicon Piezoresistive silicon load cell and (b) its Comsol Model

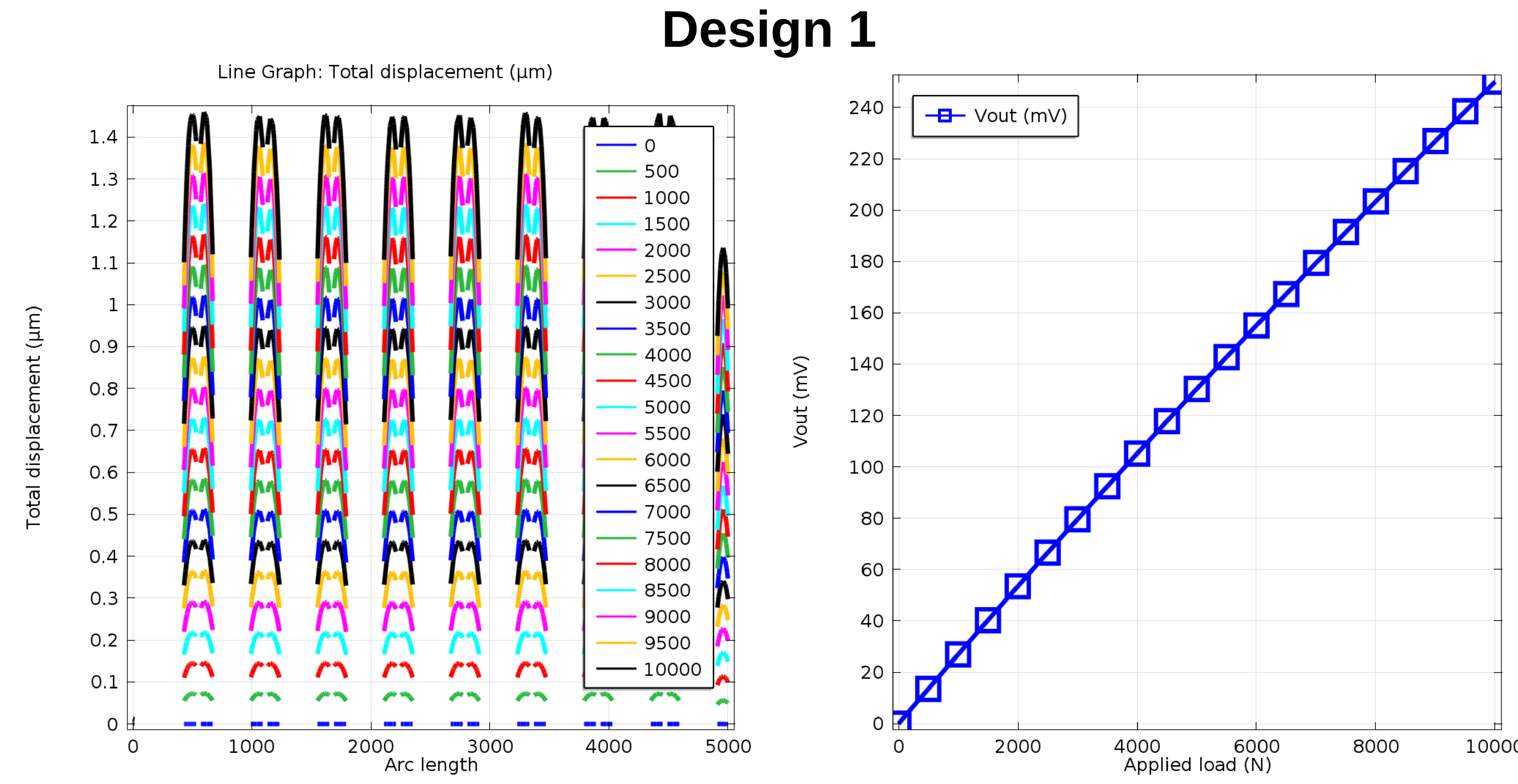


(a) (b)

Figure 3. Circuits used for the measurement of change in output voltage under applied load(a) Potential divider arrangement (design 1) (b) Wheatstone bridge circuit (design 2)

Results:

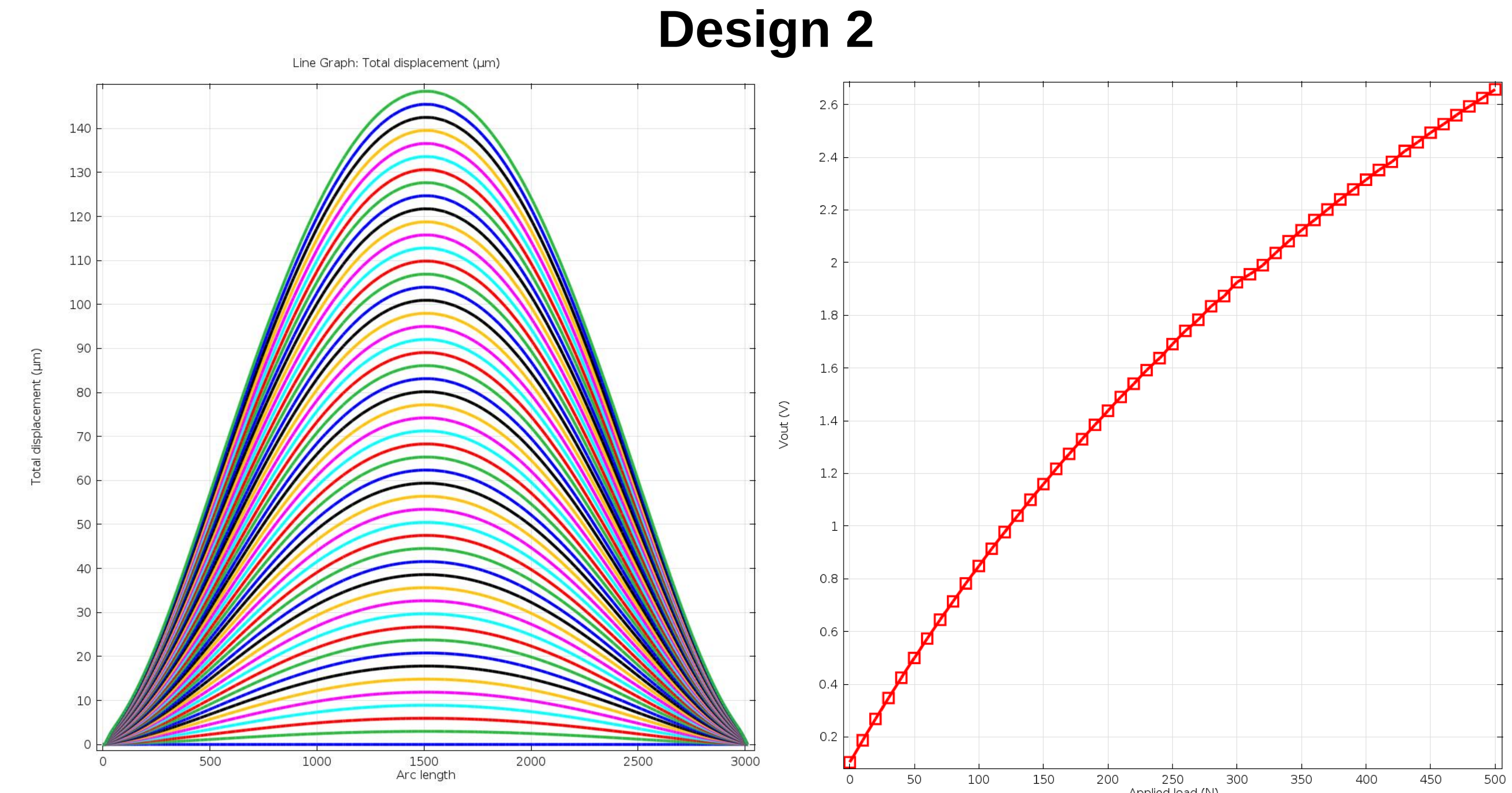
Design 1



(a) (b)

Figure 4. (a) Displacement along the length of sensor and (b) Output characteristics

Design 2



(a) (b)

Figure 5. (a) Displacement along the length of sensor and (b) Output characteristics

Conclusion:

Sensor design 1 is simulated for loads up to 10kN and maximum change in output voltage obtained using Potential divider arrangement is 250.03 mV at 10kN. Maximum output voltage obtained with sensor design 2 under maximum load of 500 N is 2.65 V. Sensitivity of design 1 comes out to be 49.06µV/V/Kg and that of design 2 is 0.29mV/V/Kg.
It is observed that Model 2 has higher sensitivity. The output of model 2 tends to become nonlinear for higher load values and hence drop in the sensitivity occurs. For better results and accuracy it is recommended to used model 2 for the measurement of loads up to 250-300N. On the other hand Model 1 has a very low sensitivity as compared to model 2, which makes this model applicable only for measuring of high forces up to 10kN.

References:

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