Design and Simulation of Underwater Acoustic MEMS sensor

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INTRODUCTION: — Silicon based MEMS have wide applications in under water sensors. This work aims one such applications, hydrophone. Hydrophone detects the pressure variations of acoustic signals and noise in the water and produces an output voltage proportional to the pressure. Here the attempt is made to design and simulate MEMS based underwater acoustic sensor whose working is based on piezoresistive physics. Piezoresistive transducers translate a force in to a change in the value electrical resistance, which is then converted into voltage output by a Wheatstone bridge circuit and thus realizes vector detection of underwater acoustic signal .

COMPUTATIONAL APPROACH:

When the material of the resistor is stressed , the resistivity of the material, ρ' is a tensor of the second rank relating the electric field tensor and the current density tensor. The resistance is stress dependent and the relative change of the resistance is $\Delta R/R_0=(\rho_1'-\rho_0)/\rho_0 = \pi_l T_l+\pi_t T_t+\pi_s T_s$ …(1). Where T_I, T_t, T_s are longitudinal, traverse and shear stresses respectively. $\pi_l = \pi_{11}'$ is often referred to as the longitudinal piezoresistive coefficient, $\pi_t=\pi_{12}'$ is the transversal piezoresistive coefficient and $\pi_s=\pi_{16}'$ is the shearing piezoresistive coefficient. If the resistors are parallel to the beam direction i.e., along x plane then

$\pi_{11}'=1/2\pi_{44}$ and $T_t=T_s=0$. $\Delta R/R=(\pi_{44}/2)T_l$ ------(2)

DESIGN SPECIFICATION: Models were designed and simulated using COMSOL tool.

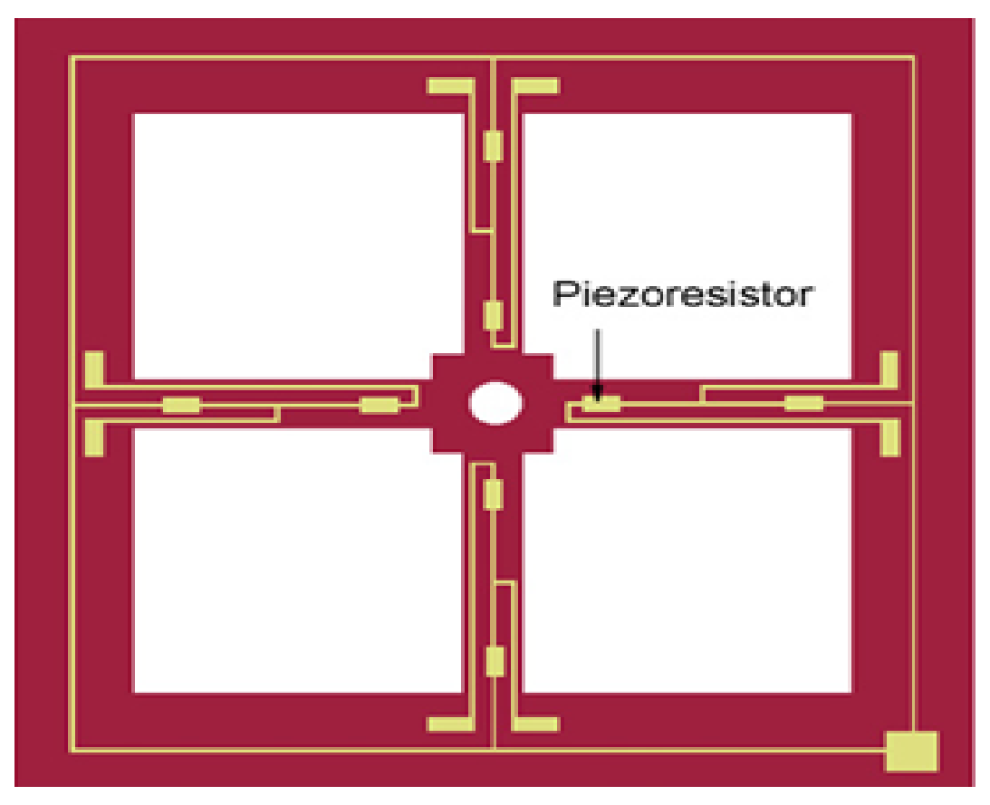

Figure 1. 4 Beam Microstructure

SOFTWARE REQUIRED:

- COMSOL MULTIPhYSICS
- SIMULATION TOOL VERSION 5.0

DIMENSIONS:

Parameters	Length	Width	Thickness	Unit
Cantilever	1000	120	10	µm
Central Block	500	500	10	µm
Piezoresistor	45	2	1	µm

SIMULATION RESULTS: When the center block is subjected to axial force due to an acceleration in the x direction, axial deformation of the beams take place and results in change in resistivity as shown in fig 2&3 and produces equivalent electrical output voltage. We could also observe linear relationship between change in resistivity and applied pressure in Fig4.

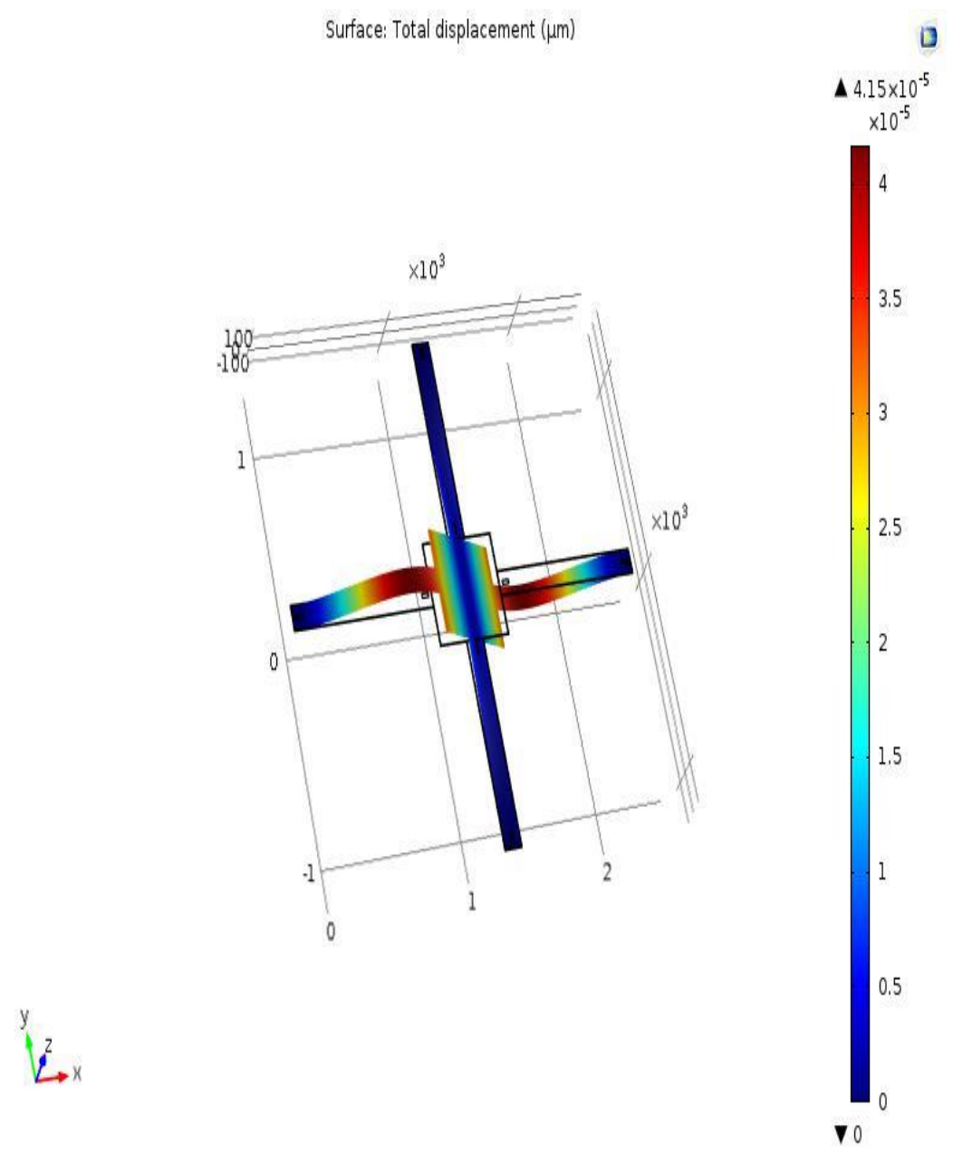

Figure 2: Axial deformation when subjected to 25N force

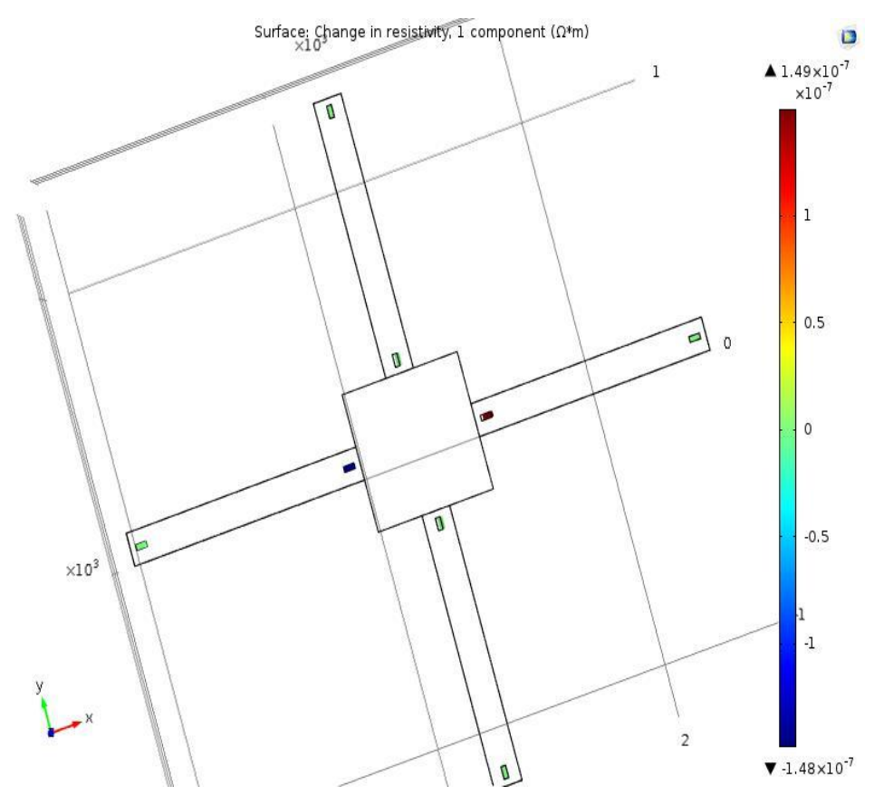

Figure 3: Change in resistivity plot to 25 N force in +x direction

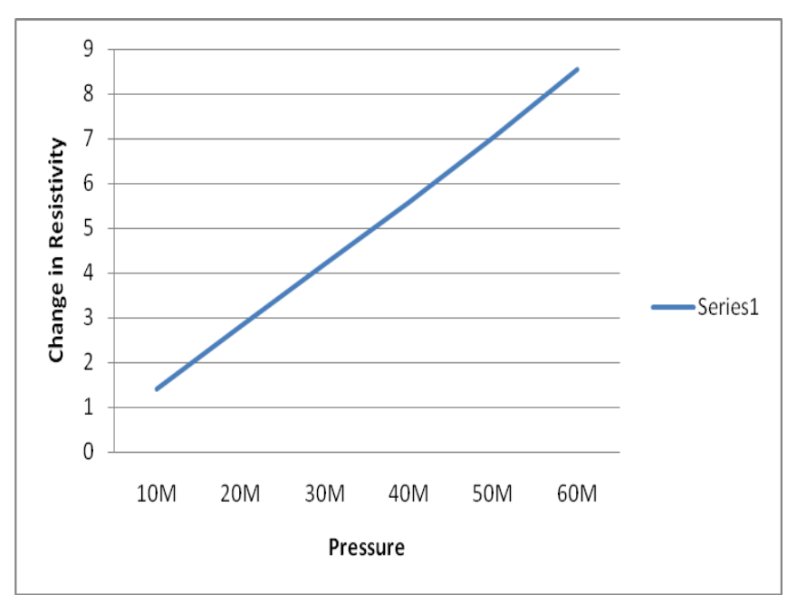

Figure 4: Linear relationship between change in resistivity and pressure

CONCLUSIONS:

COMSOL Multiphysics was used and simulation results demonstrate a linear relationship between the resistance change and stress for various pressures loading. The radial and tangential resistance changes due to the radial and tangential strains corresponding to the acoustic particle motion along axial and radial direction. When there is a incentive direct current, the bridge output will be detected as per flow direction and hence the structure is used to detect the vector underwater acoustic signal.

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