Design and Simulation of Underwater Acoustic MEMS Sensor

S. Prabhu[1], Nagbhushan[1]

[1]Nitte Meenakshi Institute of Technology, Bengaluru, Karnataka, India

Abstract

The MEMS technology is a new attempt to design a hydrophone. The structure of the hydrophone consists of two parts: high precision four-beam micro-structure and rigidity plastic cylinder which has the same density of water and is fixed at the center of the microstructure. When the plastic cylinder is stimulated by sound, the strain gets generated the piezoresistor transforms the resultant strain into an electrical output signal.

In this paper, the intension is to simulate a MEMS based high precision 4 beam microstructure which can be used for under water applications for detection of the flow direction and flow rate of the medium surrounding the structure using COMSOL Multyphysics software based on the piezoresestivity domain currents physics. The four beam microstructure consists of 4 vertical cantilever beams which are attached to the center block on one side and other ends are fixed at the support as shown in figure 1. Both the center block and the beams have same thickness and the whole structure has complete axial symmetry. The microstructure consists of N type silicon cantilever on which p type silicon piezoresistors are integrated. The center block material is silicon with the dimensions being 500 µm long, 500 µm thick and 10 µm thick. The cantilever is 1000µm long, 120µm wide and 10µm thick. When the center block is subjected to various pressures and forces in various directions which correspond to the acoustic particle motion, the center block will have a horizontal displacement and an angular rotation. Therefore the structure will be subjected to deformation, because of which an amplified and concentrated strain is generated on the slim sensing beams. On the sensing beams, piezoresistors are located at the maximum stress regions which are used to sense the deformation of the beams. The resistance of the piezoresistor implanted in the structure is changed when the signal is transmitted to it. In this study authors could observe results as shown in figure 2, 3, 4. The results obtained shown that the structure behaves in a linear manner for the applied various pressures and force in different directions.

Reference

1. Shang Chen et.al., A Novel MEMS based piezoresistive Vector Hydrophone for low frequency detection, Proceedings of the 2007 IEEE , International Conference on Mechatronics and Automation, 1839-1844 (2007).

2. Chenyang Xue et.al., Design,Fabrication and Preliminary characterization of a novel MEMS bionic Vector Hydrophone, Microelectronics Journal 38,1021-1026(2007).

3. T Chu Duc., et.al., Lateral nano-Newton force-sensing piezoresistive cantilever for microparticle handling,Journal of Micromechanics and Microengineering, S102-S106(2006).

Figures used in the abstract

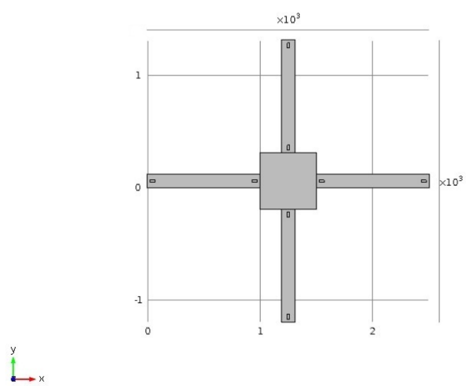

Figure 1: Four beam microstructure.

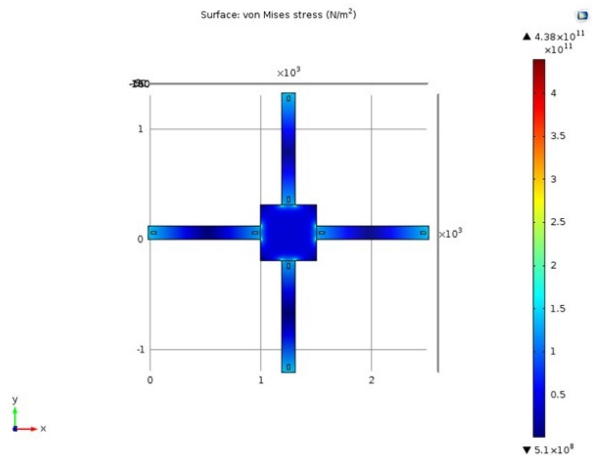

Figure 2: Von Mises Stress(N/m2) when pressure 10 MPa is applied on the center block.

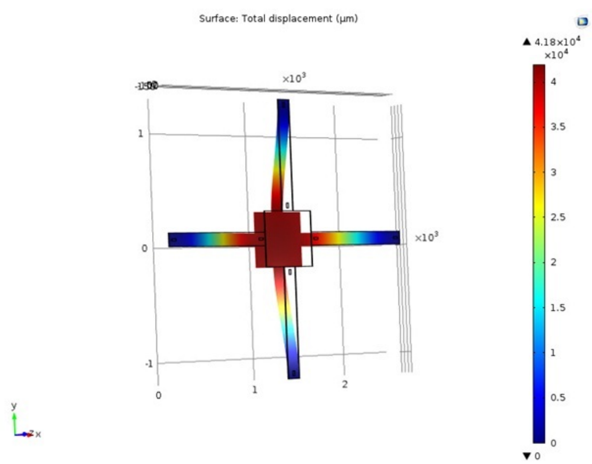

Figure 3: Total displacement of the structure.

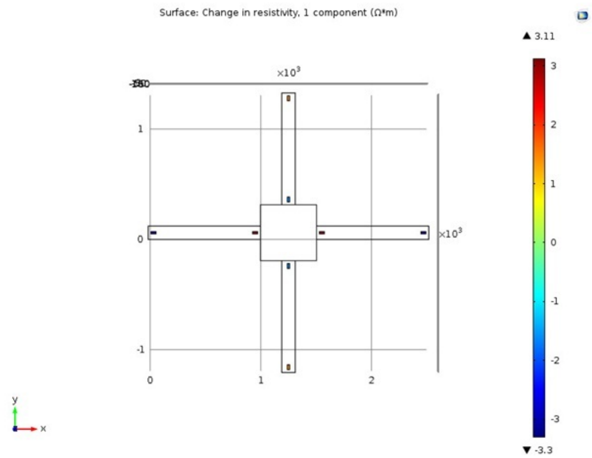

Figure 4: Change in resistivity for the pressure of 10MPa.