Modeling and Simulation of High Sensitivity Pressure Sensor with Current Mirror Sensing Based Ring Channel Shaped Bridge Structure Embedded on a Circular Diaphragm

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Introduction: The integration of CMOS-MEMS technology in developing pressure sensors helps in reduction of area and improvement of sensitivity especially in biomedical applications . This paper reports on the design and simulation of CMOS-MEMS integrated current mirror sensing based MOSFET ring shaped channel bridge structure embedded on a circular diaphragm with free edges.

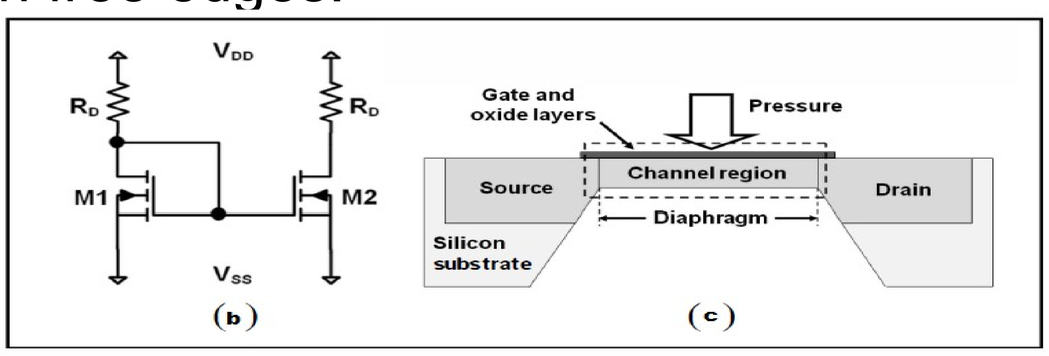

Figure 1. Structure of the MOSFET embedded pressure sensor.

Computational Methods: Modeled the MOSFET embedded pressure sensor using COMSOL Multiphysics 4.4 Structural Mechanics Module. The basic theoretical model has :

1.Mechanical Sensing Element

2.Electrical Transduction: MOSFET as a piezoresistor.

$$\frac{\Delta\mu}{\mu} = -\frac{\Delta R}{R} = (\pi_l \sigma_l + \pi_t \sigma_t)$$

$$I_{D(sat)p} = (\mu_n \pm \Delta\mu_n) C_{ox} \frac{w}{L} \frac{(V_{GS} - V_{tn})^2}{2}$$

Geometry: Current mirror sensing based MOSFET ring shaped channel bridge structure embedded on a circular diaphragm with free edges is shown.

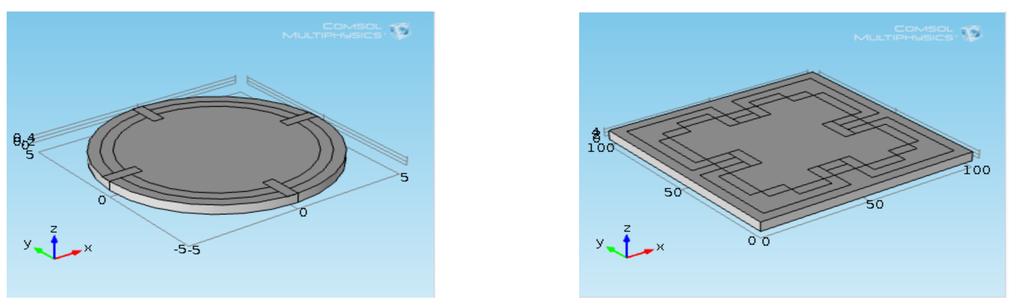

Figure 2. Geometry of ring channel and square channel bridge embedded Pressure sensor.

Results: Using the 3D,Structural mechanics module , stationary analysis, the structural behaviour of the MOSFET embedded pressure sensor and the piezoresistive effect in n-MOS equivalent piezoresistor were observed.

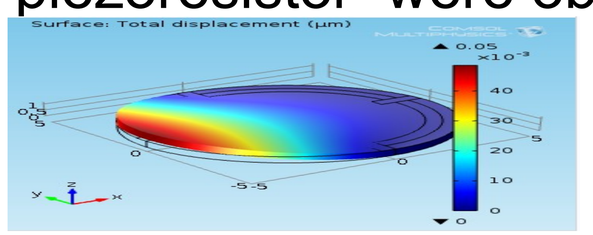

Figure 3. Displacement profile for pressure=1MPa

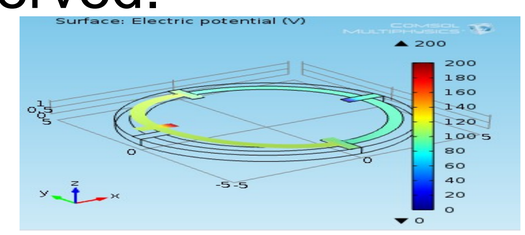

Figure4.Electrical conductivity profile for p=1MPa and V=200V

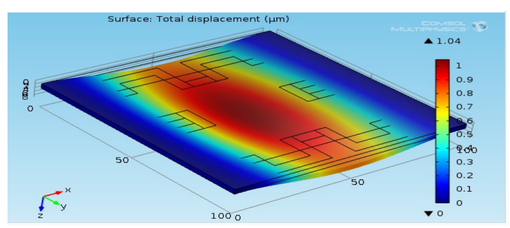

Figure 5. Displacement profile for pressure=1MPa

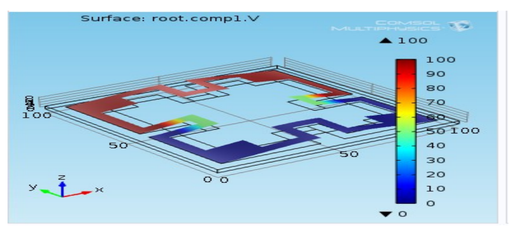

Figure6.Electrical conductivity profile for p=1MPa and V=200V

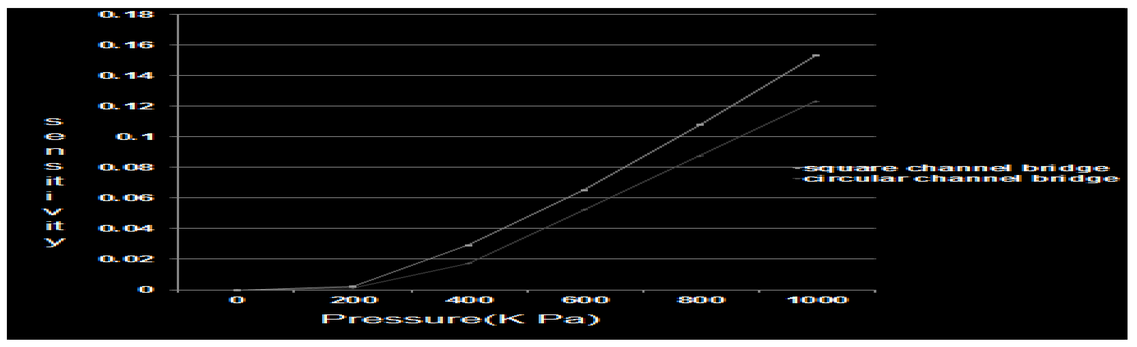

Figure 7. Sensitivity versus pressure

Conclusions: CMOS-MEMS integrated current mirror sensing based MOSFET ring shaped channel bridge structure embedded on a circular diaphragm with free edges has been simulated and its performance is compared with square channel shaped bridge structure. These ring shaped pressure sensing structures have enhanced sensor sensitivity and is widely used in biomedical applications.

References:

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2.Pradeep Kumar Rathore, Brishbhan Singh Panwar, “High Sensitivity CMOS Pressure Sensor Using Ring Channel Shaped MOSFET Embedded Sensing”, IEEE CONECCT2014 1569823903.

3. Z.H. Zhang, Y.H. Zhang, L. T. Liu, and T.L. Ren, "A novel MEMS pressure sensor with MOSFET on chip", IEEE Sensors 2008, pp. 1 564-1567, 2008.

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