Modeling and Simulation of High Sensitivity CMOS Pressure Sensor Using Free Boundary Circular Diaphragm Embedded on Ring Channel Shaped MOSFET

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Abstract

Sensors have diverse applications ranging from medical field to space explorations. They convert physical parameters such as temperature, pressure, humidity etc: - into an electrical output. The discovery of piezoresistivity property of silicon and germanium led to miniaturization of pressure sensors. Improvement in the sensitivity is the major factor to be considered while designing pressure sensors. In this paper our effort is to design and simulate current mirror sensing based MOSFET with ring shaped channel embedded on a circular diaphragm with free edges which provides high sensitivity. The integration of CMOS-MEMS technology in developing pressure sensors helps in reduction of area and improvement of sensitivity especially in biomedical applications such as intracranial pressure sensors. Finite element method COMSOL Multiphysics® is used for modeling n-channel MOSFET equivalent resistor which is used to modeling the channel. (Figure 1). In the MOSFET pressure sensor, the channel region of the MOSFET acts as piezoresistive material as well as diaphragm that deflect under applied pressure. Stress developed due to applied pressure changes the drain current and hence the output voltage produced.

COMSOL Multiphysics® is utilized for the simulation of MOSFET embedded pressure sensor. The Structural Mechanics module in COMSOL Multiphysics® is used for modeling the proposed high sensitivity pressure sensor. Different models such as block and cylinder models are used for modeling circular and square diaphragm. Piezoelectric resistor models are used for modeling MOSFET.

In this paper, a conventional square diaphragm with all edges fixed is modeled (Figure 2) and the sensitivity is compared with the sensitivity of a circular diaphragm with fixed boundaries. Similarly a square diaphragm with two free ends is modeled. The sensitivity of circular diaphragm is also compared with this structure. A three dimensional FEM including fixed edge circular and square diaphragm integrated with circular and square (Figure 3) ring channel shaped structure is to be modeled and simulated. The circular diaphragm (Figure 4) is modeled and simulated and is found to have sensitivity than square diaphragm.

Bridge structured diaphragm and ring structured diaphragms are embedded on MOSFET and

sensitivity is calculated by making both edges of the channel fixed. Then the sensitivity is measured by making one edge fixed and other end free for improving the sensitivity. Comparison between MOSFET embedded bridge structure having one free end and the MOSFET embedded ring structure with free boundary is done. This paper mainly aims at modeling a high sensitivity pressure sensor with free boundary circular diaphragm integrated with circular ring channel shaped structure.

A free boundary ring channel shaped MOSFET embedded MEMS pressure sensor is simulated and a model is proposed to describe the behavior of this structure. This proposed model has high sensitivity and consumes less area than existing pressure sensors.

Reference

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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.
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Figures used in the abstract

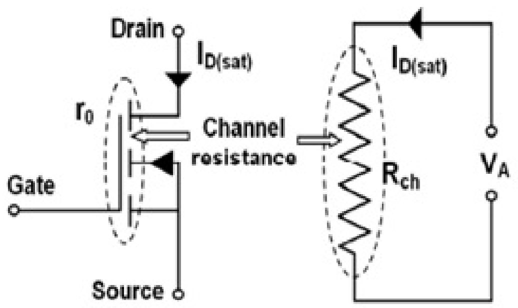

Figure 2: MOSFET equivalent resistor

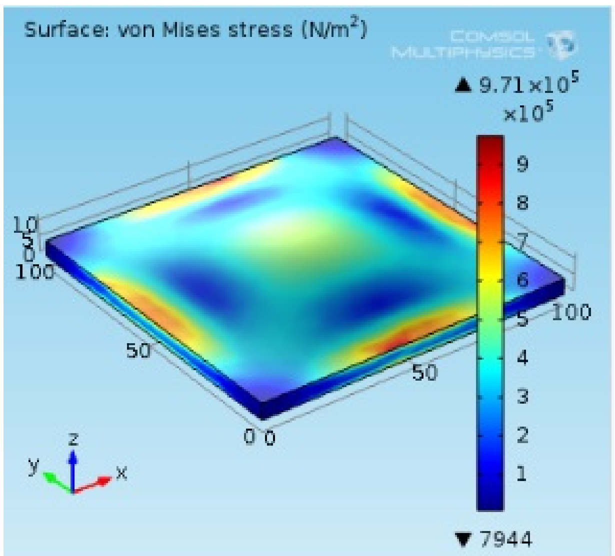

Figure 2: Stress developed on the top surface of the diaphragm for an applied pressure of 10KPa

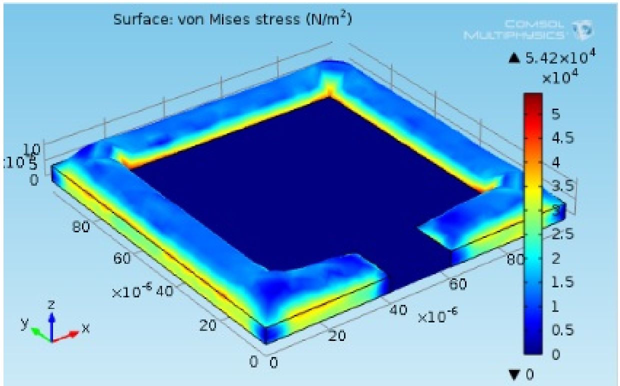

Figure 4: square ring channel shaped nmos equivalent piezoresistor

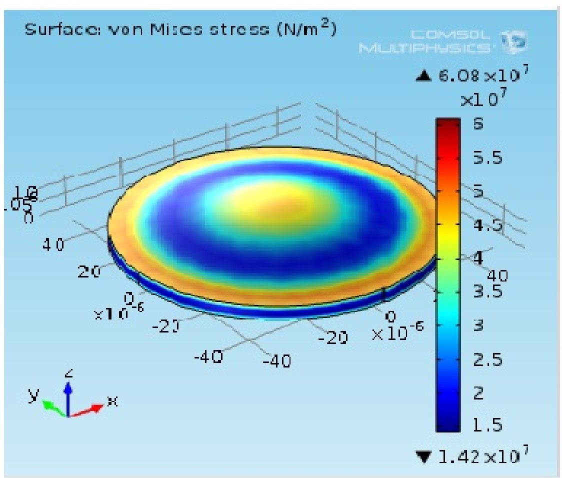

Figure 4: Stress developed on the top surface of the circular diaphragm for an applied pressure of 10KPa