Influence of the Silicon Membrane Geometry on the Mechanical Behaviour for a Piezoresistive Pressure Sensor

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Pressure sensor is one of the most famous microsystems in the world. Otherwise, his expansion now is depending of a good optimization, to improve his capabilities and conquest other markets. Different technologies exist to sense the pressure: capacitive, piezoresistive [1] or piezoelectric transductions are well-known and others more innovative like optical, RF [2] or acoustic are appearing. A common element for all these technologies is still the same: a membrane able to deflect itself by the application of the pressure. An optimisation of the membrane geometry has been analysed in this article.

SOI Piezoresistive pressure sensor

The pressure sensor that we are simulating is based on a SOI technology.

The piezoresistive pressure sensor working principle is explained in figure 1. Four piezoresistors in a full Wheatstone bridge configuration allows detecting the membrane deflection with the variation of the resistivity of a piezoresistive gauge. The mechanical optimization comes from the localisation of the gauges and/or the membrane geometry. In our application, the gauges are in a full Wheatstone bridge configuration showed in figure 2.

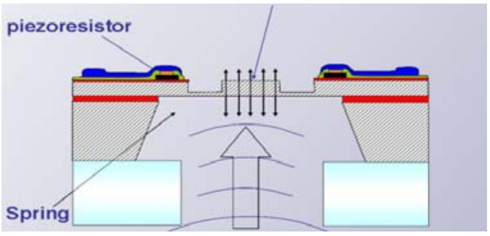

Figure 1: Sensor working principle

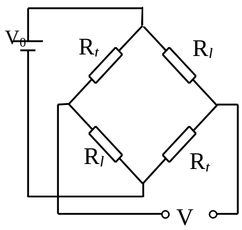

Figure 2: Full Wheatstone bridge configuration

The silicon membrane shape used for in our device is a square one, anisotropically etched in a KOH water solution. KOH wet etching, following the crystalline plans, makes squared shapes in a silicon <100> wafer. Other shapes are allowed with deep RIE process, but this technique is not convenient and more expensive.

Localisation of the gauges

To optimize the pressure sensor the location of the resistors on the membrane has to be in the region where the stress is at the maximum level.

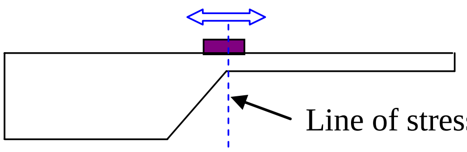

Figure 3: Position of gauge with membrane

Front side design

Another possibility to optimize the pressure sensor sensitivity and pressure linearity is to take off material on the front side of the membrane to concentrate the stress near the gauge.

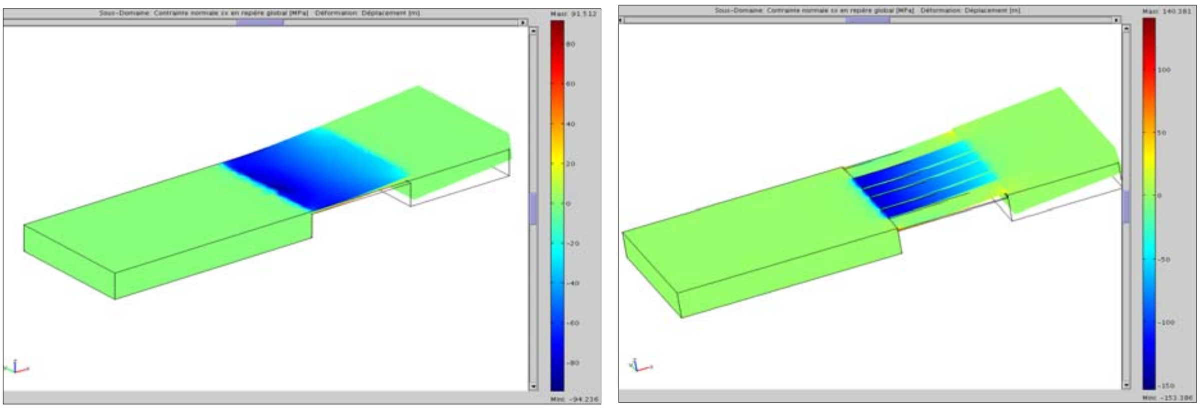

Fig.4: Comparison between membranes without front side structure with membrane with front side structure

In our case, for a pressure of 1 bar, we have an increase of 45% of the stress (Fig.4). Other simulations and experimental results had shown a good opportunity to increase the sensor sensitivity in all the studied temperature range.

How the Pressure is applied

In special applications, it is important to confirm if the membrane has the same behaviour when the pressure is applied from the front side or from the backside of the membrane.

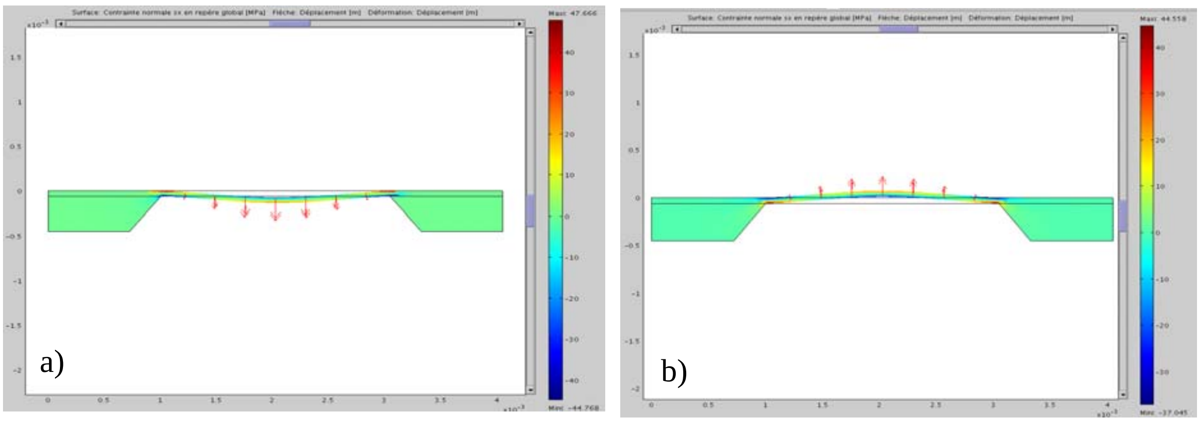

Fig.5: a) Pressure (1bar) applied on the front side b) Pressure (1bar) applied on the backside

The FEM results (Fig.5) shows that for pressure applied from the backside, the stress level is almost the same that what we found if the pressure is applied from the front side. This fact can be very useful for packaging reasons, in harsh environment for instance.

REFERENCES

[1] A.BOUKABACHE, P.MENINI, P.PONS, *Micro-capteurs de pression*, Techniques de l'Ingénieur, pp. R2 070.1-R2 07.10, 2001

[2] M. M.JATLAOUI , P.PONS , H.AUBERT, *Radio frequency pressure transducer*, 37th European Microwave Conference, Munich (Germany), 8-12 October 2007, pp.736-739