Modeling of Silicon Piezoresistive Pressure Sensor: Application to Prevent some Diabetes Complications

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Introduction: Several analytical solutions describing the mechanical behavior of a silicon micro membrane deflection, perfectly embedded and subjected to a uniform and constant pressure have been proposed. The obtained results are compared with those obtained by using COMSOL software for a rectangular diaphragm deflection. The model presented in this work, allows measuring the pressure at any point of the membrane. This pressure allows us to have information on the status of a diabetic's foot. This simple system is a very effective prevention tool.

Computational Methods:

1. Membrane Geometry

The Silicon membrane of rectangular or square form is described in Figs.1 and 2.

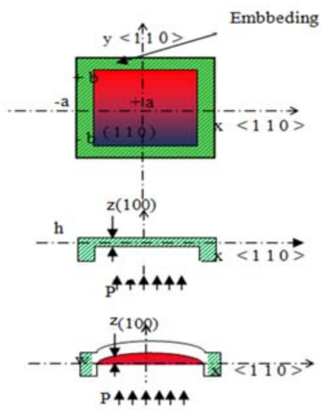

Fig. 1. Schematic top-view of the membrane.

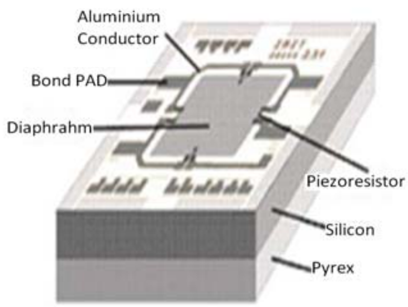

Fig. 2. Schematic top-view of the diaphragm with piezoresistive gages.

2 Proposed solutions the mechanical behaviour of a membrane subjected to a uniform and static pressure P in the case of the weak disturbances, w << h, is governed by the following Lagrange equation of the fourth order:

$$\frac{\partial^4 w(x,y)}{\partial x^4} + 2\alpha_{Si}\frac{\partial^4 w(x,y)}{\partial x^2 \partial y^2} + \frac{\partial^4 w(x,y)}{\partial y^4} = \frac{P}{D} \quad (1)$$

with $\alpha_{Si} = \nu + \frac{2G}{E}(1-\nu^2)$ and $D = \frac{Eh^3}{12(1-\nu^2)}$

Results: Using the 3D, MEMS module, Structural mechanics, solid stress-strain, static analysis, the equation 1 has been resolved, taking into account thermal stresses generated by the manufacturing process of the device.

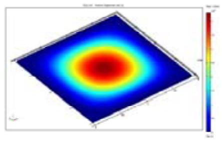

Fig. 3. 3D-visualized deflection w(x,y) for P=100kPa

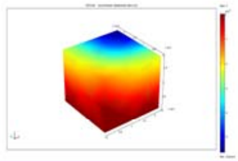

Fig. 5. deflection variation vs temperature at rest P=0

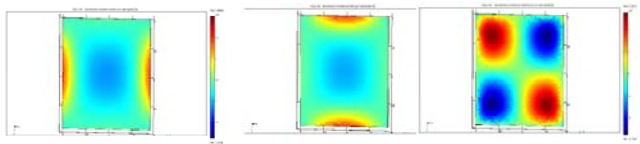

Fig. 4. Variation of normal stress sxx, syy and shear stress sxy for 100kPa pressure load

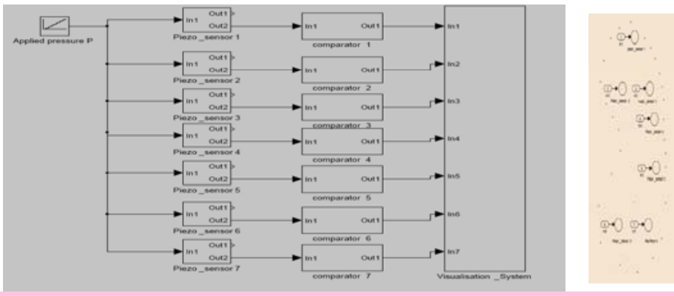

Figure 6. schema block visualisation system of pressure sensor using as application to measure diabetic foot pressure

Conclusions: COMSOL Multiphysics is a powerful software for solving problems based on partial differential equations and provides the advantage of allowing the simulation of the entire device. As application, this sensor has been used to measure the value of plantar pressure in particular points. This pressure allows us to have information on the status of a diabetic's foot.

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