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FEM Simulation of Influence of Protective Encapsulation on MEMS Pressure Sensor

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ABSTRACT

The objective of the work is to evaluate the feasibility of packaging a MEMS silicon pressure sensor by using either a polymer encapsulation or a combination of a polymer encapsulation and a metallic protection Membrane (fig. 1). The potential application of the protected sensor is for harsh environments. Several steps of simulation are carried out:

1) Comparisons of the sensitivities are made among the non-encapsulated silicon sensor, the polymer encapsulated and polymer with metal encapsulated sensor. This is for evaluating whether the encapsulating materials reduce the pressure sensitivity compared to the conventionally exposed sensor.

2) Stress concentration calculations are performed to investigate if the encapsulation could lead to increased stress concentration in the silicon structure. The reliability of the adhesion of the metallic encapsulating membrane is assessed by investigating whether the metallic membrane / coating will peel off when applying the maximum pressure, which is 4000 bar leading to high shear stress between the metallic membrane and the polymer encapsulation material.

3) Thermal calculations are made to evaluate the influence of the environment on the packaged sensor.

Sensitivity related conclusion remarks:

- The polymer and the metallic encapsulation would not lead to a significant reduction of the sensitivity of the silicon sensor.
- Metallic encapsulation has a negligible influence on the sensitivity compared to the polymer-encapsulated design without the metal protection membrane.

Stress concentration related conclusion remarks:

- The coating leads to larger stresses on the interface between the two silicon parts of the sensor die.
- The coating leads to larger stresses in the junction region between the silicon sensor die and the mounting material.
- Whether the stress concentration on the interface between the metallic membrane and the polymer lead to a reliability risk depends on the adhesion of the membrane.
- The polymer encapsulation leads to much larger vertical displacement of the silicon sensor, which might harm the reliability of the mounting of the sensor die to the substrate.

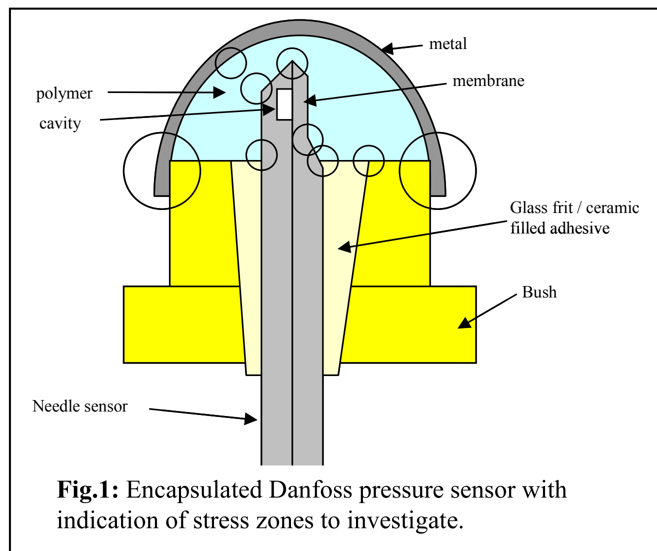

Fig.1: Encapsulated Danfoss pressure sensor with indication of stress zones to investigate.

Thermal related conclusion remarks:

• For the currently selected polymer encapsulation material with a thermal expansion coefficient of $5 \cdot 10^{-5}$, the temperature-induced deformation has significant influence on the sensitivity. A temperature change of 15 °C will give a signal as a pressure of 40 bars.

Acknowledgement

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