High Precision Alignment and Packaging of Silicon Microsystems

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1 Introduction

One of the most difficult and cost-intensive process in sensor development is packaging [1]. It is currently challenging to ensure adequate packaging of micro-electromechanical systems for in vitro applications (bio-MEMS), particularly when there are interfacing connections (e.g. fluidic, electric) and direct contact between analytes and the sensor. Packaging can be realized by different approaches as summarized in [2]. With the availability of precision injection moulding machines [3-5] more and more polymer based injection moulded packaging solutions apply either polymer overmoulding [6,7] or gluing [8] solutions.

The motivation of this work is to develop a novel packaging concept for silicon sensor chips. The current state-of the art of using special components for each function (e.g. sealing with an O-Ring) is expensive and assembly costs can be dramatically reduced by decreasing the number of part that have to be handled and placed. In this research the presented concept, is intended to increase the level of integration between the part production and packaging.

With an aim of future mass reproduction, the proposed packaging concept is based on precision injection moulded polymer parts providing the precision alignment of a silicon sensor within a polymeric carrier part. This feature is essential to guarantee the functionality and improve the interface between to the micro and macro world. To realize this challenge, several additional functions needed to be integrated. These
include the compensation of stress induced by different coefficients of thermal expansion or fluidic sealing functions.

2 Outline and design

For the proposed alignment function to be implemented in the packaging concept, a combination of different polymers is mandatory. The material choice for the sensor carrier part, which is shown in fig. 1(left), is polypropylene (PP; Moplen HH 315 MO). Its green appearance is due to an enrichment of the polymer pellets with a laser absorbent pigment (Gentex A225). Using a thermoplastic elastomeric rubber (TPE; Santoprene 8281-65 MED), a multi-functional sealing gasket is produced (fig.1). It provides multiple functionalities such as biological barrier functions, microfluidics and fluidic sealing. The alignment of the sensor within its carrier part is achieved by utilizing the flexibility, and consequently the compression of the TPE with reference to the reference planes.

![Fig. 1: Injection moulded parts: Sensor carrier part showing fluidic i/o ports, the alignment gap and the sensor position (left); Sealing gasket with fluidic i/o-ports towards the sensor, septa reinforcement structure and sketched fluidic channels (right)](image)

Beneath the mechanical precision alignment this concept also acts as a functional element to compensate the mechanical stress induced by different coefficients of thermal expansion of the used materials. Moreover, vibrations and shock are absorbed. The sealing gasket provides fluidic functions, like sealing functions and fluidic routing, as well as an included septum acting as biological and fluidic barrier.
After assembling of all components the joining is done by laser transmission laser contour welding (fig.3).

![Image](image.jpg)

**Fig. 3:** Assembly consistent of carrier part, sealing gasket, silicon sensor chip and capping foil joined by laser contour welding

### 3 Proof of concept

After fabrication of several thousand single components, a small series of complete systems is assembled and examined. The measurements are carried out under a controlled environment (humidity of 60%, temperature 25°C) using a Werth HA multi-sensor coordinate measuring system in combination with a Renishaw touch trigger probe. To reduce the measurement uncertainty as well as to examine the process deviations, all parts are characterized by ten measurement cycles. As a result, it can be claimed that the lateral precision of the alignment is less than 5 µm with respect to a reference distance of 5.91 mm. The vertical alignment precision is measured to be 2 µm in relation to 1 mm.

### 4 Conclusion

In summary, this work presents a packaging principle for silicon bio-MEMS, enabling precision alignment within only a few microns. Based on injection moulded polymer components, a proof of concept is presented, featuring integrated microfluidic routing, sealing and biological barrier functions. The system is designed for usage in pick-and-place assembly lines, which enables small batch production of analytical systems with highest flexibility, hence enabling biologists and developers of biosensors to focus on the interaction between the sensors and the biologic assay.
References:


