DOI 10.5162/SMSI2020/P2.10

# Validation of high temperature stable sensor packaging materials and methods

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## Summary:

Many modern sensor concepts are only limited in their operating temperature because of insufficient packaging solutions. Therefore, novel-packaging concepts needs to be evaluated on all interconnection levels. This work summarizes possible materials, technologies and characterization methods for reaching high temperature stable packages. Especially materials for sensor chips mounting inside ceramic packages and package connector mounting up to 600 °C were focused and discussed.

**Keywords:** high temperature, packaging, ceramic, interconnection, resistance welding

## Motivation

Modern technology trends like big data need reliable data sources. Sensors in all kind of fields are the basic elements of these technologies. Generated sensor signals are needed for process simulation or controlling especially during challenging production processes of materials or electronic components. Challenging for most kind of sensors is, that many of this processes take place at very harsh environments, like high pressures, acid atmospheres or simply high temperatures. Existing packaging technologies are based on integrating a sensor element in a metallic or ceramic package and hermetically sealing it. All therefore needed process steps needs to be further developed to fulfill requirements of higher environmental temperatures. The complete sensor packaging process can be splitted into five separate steps according Fig. 1.

*Fig. 1. Process flow of sensor element packaging.*

Packaging process is divided into package material selection (step 1), package connection if needed (step 2), assembling of the sensor element inside the package (step 3), interconnection between package and sensor element (step 4) and hermetical package enclosing (step 5). Influence of high temperatures on ceramic packages and their electrical characteristics is already discussed in [1]. Long time stability of of welded interconnection joints at high temperatures was evaluated in [2].

Present study is focusing on connection and assembling technologies. Main aim is demonstrate methods for brazing pins on ceramic packages and developing mechanical characterization methods for assembling materials up to 600 °C.

## Technology development and characterization method up to 600 °C

Technology for generating high temperature stable brazing connections to ceramic packages were developed. Outstanding achievement of the underlying project is the development of a shear test method up to 600 °C, which is compatible to commercially available shear test tools. Degradation mechanisms of different interconnection materials could be inspected in that way insitu during the real conditions.

## Characterization of brazed package joints

Kovar pins with ENIG finish were brazed using mainly silver-based brazing solders on different kind of metallization. Materials and process conditions have been widely variated to generate a better understanding of their influence on the mechanical joint characteristics.

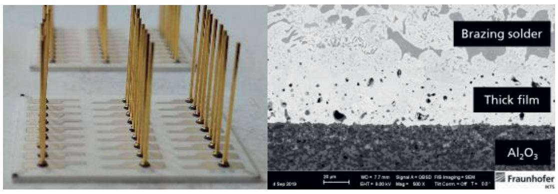

*Fig. 2. Brazing of Kovar connectors on ceramic substrates. Left: brazing samples, right: cross section of brazed contact*

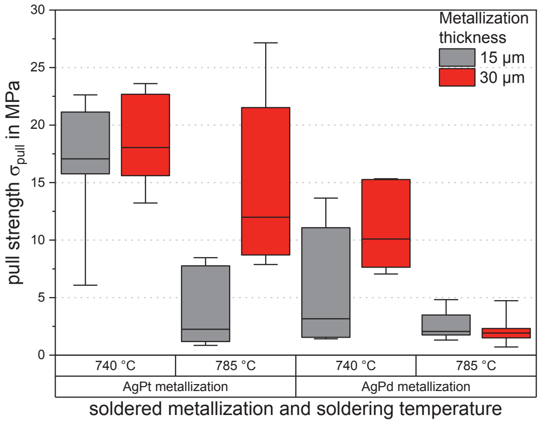

*Fig. 3. Mechanical characteristics of brazed high temperature connection joints und various conditions*

High temperature stable brazing joints could be generated and correlations between process conditions, material selection and resulting mechanical characteristics could be given.

## Characterization of assembling joints up to 600 °C

Active solders, sintering materials or ceramic adhesives, could be used to realize high temperature stable sensor assembling inside a ceramic package. Ceramic adhesives should be preferred because they show nearly comparable thermal expansion to the package itself. Mechanical stability of these kind of joints could in most cases only be inspected before and after a high temperature storage but not under real condictions. Therefore, a high temperature shear-strength measurement setup has been developed (Fig. 4).

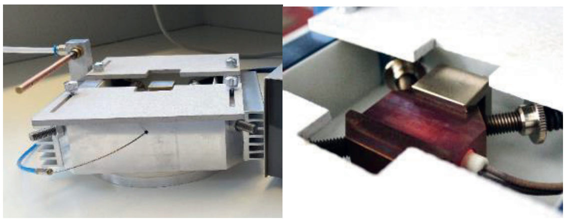

*Fig. 4. High temperature shear test rig. left: complete rig with cooling airflow and temperature control, right: core heating table heated up to 600 °C.*

The developed test rig was mounted on a Dage Series 4000 shear-force measurement tool and different high temperature adhesives were evaluated. It could be found that all kind of ceramic adhesives show completely different mechanical joint characteristics und different test temperatures (Fig. 5). Even promising materials, which should whitstand temperatures up to over 900 °C, could show enormous interface degradations und real conditions (Fig. 5 $SiO_2$).

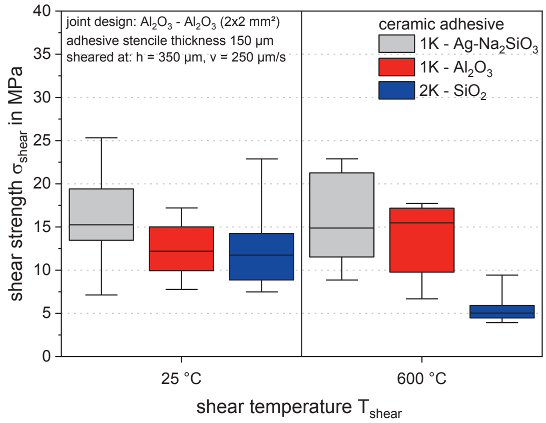

*Fig. 5. Comparison of assembling adhesive joint strength at different test temperatures*

This method is highly recommended for initial material screening before expansive long time storages at high temperatures takes place. For example, a degradation trend of the $SiO_2$ adhesive and an increasing cross-linking trend of the $Al_2O_3$ conductive as shown in Fig 6 could already be postulated by the initial measurement at 600 °C (compare Fig 5).

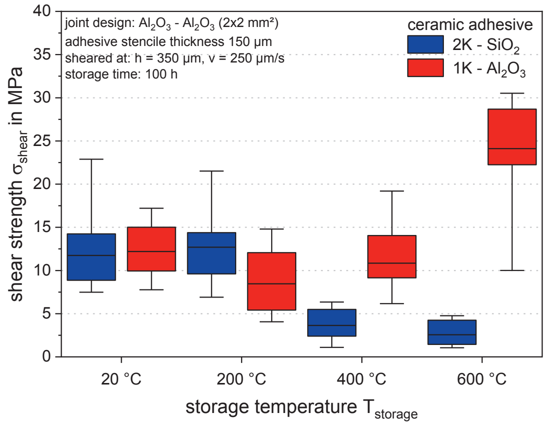

*Fig. 6. Changing in assembling adhesive joint strength after high temperature storage for 100 h*

## References

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