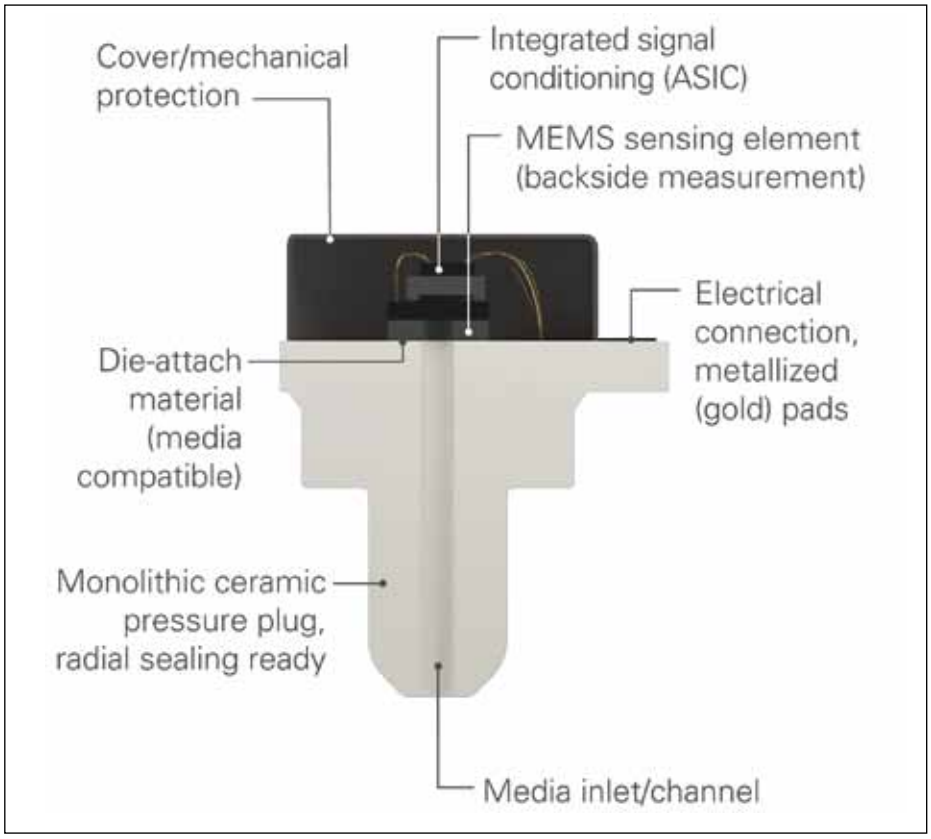
A Fully Compensated, Monolithic Pressure-Sensing Plug for Easy Integration

In today's sensor-related industries, the trend is toward smaller sensors that are easier to integrate into various applications. Demand in automotive and consumer industries is especially high, which is great for the future of MEMS pressure sensors. Furthermore, with the internet of things becoming more common, MEMS pressure sensors will need to accommodate the volume, cost, and efficiency of smaller end products with more functionality. Merit Sensor's concept of the Monolithic Metallized Plug addresses applications that require wide pressure ranges, wide-ranging media compatibility, direct-temperature measurement, compensated ASIC functionality, and easy integration into increasingly smaller secondary packaging.

Efficient Design

The main concept behind Merit Sensor's Monolithic Metallized Plug has been efficiency, i.e., smaller parts and more functionality. The Monolithic Metallized Plug is, in its essence, one single unit of ceramic that includes gold contact pads. On the topside of the ceramic, directly above the backside media inlet sits the MEMS sensing element. On top of the sensing element sits the ASIC, which performs the signal conversion and supplies the calibrated output signal, both analog and digital (see Fig. 1).



▲ **Fig. 1: Monolithic Metallized Plug Cross Section.**

Compensated ASIC Integration

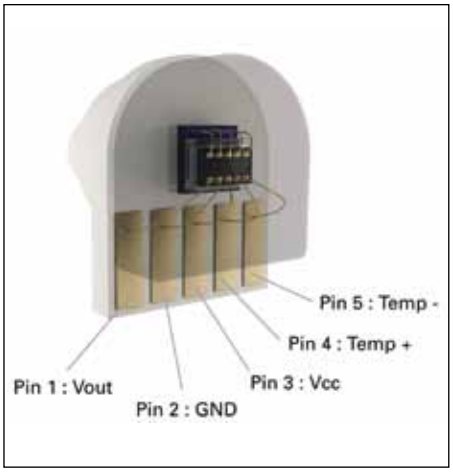
The device has options for various electrical connections, depending on the type of final device. The pads (see Fig. 2) can be soldered to pins or cables or wire bonded to other contacts. Any specific requirements in terms of ESD or EMI can be satisfied through the addition of the necessary passive components on the topside of the ceramic. Extra components can also be added externally with an additional circuit. However, the most common ESD and EMI requirements are satisfied within the ASIC.

Easy Integration into Packaging

The Monolithic Metallized Plug is intended for simple integration into secondary packaging. Part of the design is a pressure port, which is ideal for radial sealing. This sealing method enables an O-ring to seal around the pressure port, eliminating the need for face sealing, which can cause unwanted stress on the device and, ultimately, sensing errors. But the Monolithic Metallized Plug can also be sealed via injection molding. The material of the Monolithic Metallized Plug enables the device to withstand the temporary hot temperature that accompanies the injection molding process. Additionally, the roughness of the material enables a strong bond with the injection-molding material.

Backside Pressure Sensing & Media Compatibility

The Monolithic Metallized Plug has been designed to measure pressure from the backside. One of the notable features of this product concept is the monolithic ceramic design, i.e., one unit of ceramic constitutes the media-inlet port as well as the surface for the die-attach material. The ceramic material offers high compatibility and reliability in various media. Backside measurement isolates the wire-bonded



▲ **Fig. 2: Electrical Connection Options.**

electrical connections and ASIC from the media that enters through the ceramic pressure port. The die is attached via glass-frit bonding, which is also highly resistant to harsh media. The topside can be protected with conformal coatings or other compounds to enhance the sensor's capability to withstand the application requirements without influencing the MEMS membrane's behavior.
Ultimately, backside-pressure measurement means high compatibility with various media. Merit Sensor can advise regarding media compatibility, pressure range, and temperature range (see Tab. 1).

Wide Pressure Range

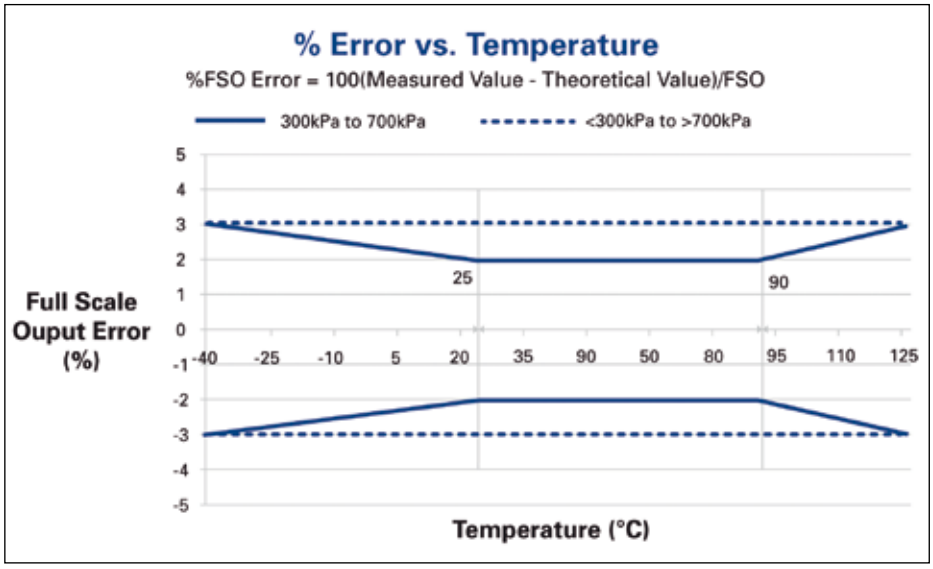
The radial-sealing method on the Monolithic Metallized Plug is intended to mitigate undesired pressure effects that could be transferred directly to the thin and sensitive silicon membrane. As a result, this design allows for a wide range of pressure. The design has been conceived with the HM Series die in mind; however,

Type of Die-Attach	Type of Media	Cost	Burst pressure (MPa)
Glue / Adhesive	Air, non-aggressive gases	$	> 8,5
Glass	Fuel, fuel vapor, oil	$$	> 10

▲ **Tab. 1: Media Compatibility and Burst Pressure.**

MEMS Pressure Sensor Package Type	Pressure Range	Sealing	Temp Range	MEMS (die-attach)	Media compatibility	Integration function/size ratio	Copy
Backside pressure with eutectic die attach to ceramic	Medium 100kPa to 3.5MPa	Face	Excellent (-40...+150°C)	Eutectic soldering	Excellent	Medium	$$$
Backside pressure with eutectic/glass/adhesive to ceramic port	Low to Medium 7kPa to 3.5MPa	Radial	Medium (-40...+125°C and -40°C...+150°C if eutectic)	Glass / adhesive	Good	Medium	$$$
Backside pressure with glass/adhesive to ceramic pressure plug	Low to Medium 7kPa to 3.5MPa	Radial	Medium (-40...+125°C)	Glass / adhesive	Good	Excellent	$$

▲ **Tab. 2: Sensing Modules Comparison.**



▲ **Fig. 3: Output Signal Error vs. Temperature.**

the option to integrate any of the various Merit Sensor die increases the design's capabilities. The HM Series, for example, allows a pressure range between 100 kPa and 3,5 MPa for both gage and absolute configurations. A custom, dedicated design could bring the maximum pressure range up to 7 MPa and guarantee a backside burst of 3x.

Direct Temperature Measurement

In addition to the temperature measurement on the ASIC, temperature measurement can be done via a temperature diode integrated in the MEMS die. This enables a quicker, more accurate temperature reading of media than the temperature reading on the ASIC. The reading can be output via digital or analog.

Conclusion

The Monolithic Metallized Plug is a small, efficient design that can be fully calibrated and ready for easy integration in a final package.

It is designed to be compatible with most harsh and wet media. Backside pressure can be assured between 100 kPa and 3,5 MPa and an output of 2.5 FS % can easily be obtained between -40 °C and 125 °C (see Fig. 3). The configuration does not require adjustment after the integration, so there is no need for dedicated calibration equipment. The Monolithic Metallized Plug is an all-in-one solution to the growing demand for smaller sensors that can do more things.

Have a look at the Monolithic Metallized Plug online:
meritsensor.com/products/mmp

► INFO

Contact:
Merit Sensor Systems, Inc.
1600 West Merit Parkway
South Jordan, UT 84095, USA
Phone: +1 801 208 4700
Fax: +1 801 208 4798
Email: sales@meritsensors.com
www.meritsensor.com