

Glass-ceramics revolutionize exhaust gas sensors

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First published on: www.all-electronics.de



Sensors in the exhaust gas system must meet the highest demands, especially in terms of temperature resistance. So far, ceramics have been used as insulation material. Glass would be more suitable but does not withstand the high temperatures. Glass-ceramics combine the benefits of both. They also allow for the number of parts in a sensor and costs to be reduced. With HEATAN™, SCHOTT has developed the right material and a method for processing.

Temperature, pressure and the concentration of various pollutants are among the information that sensors in the exhaust gas tract provide to the engine management system. More and more accurate and up-to-date data is necessary to meet current or planned emission limits. Often five or more sensors are used. Since the rules are expected to be tightened further, this number is likely to go up even more in future. To achieve fast control loops, it's beneficial to install them near the engine. This means it can get quite tight and hot at the installation points. So far, ceramics, which house the actual sensors, have been used as insulation material. But the lack of space makes them reach their limits.

While ceramic components have an essential quality for use in exhaust systems – they can withstand temperatures of more than 1000 degrees – they are not that suitable when it comes to sealing. The interfaces between the materials used for sensors and the sensor housings are critical. Glass would be better suited because it can be directly fused with the metal parts to provide a hermetic seal. However, glass cannot cope with more than 300 degrees. Ceramic seals, on the other hand, require more space and additional parts for fixing.

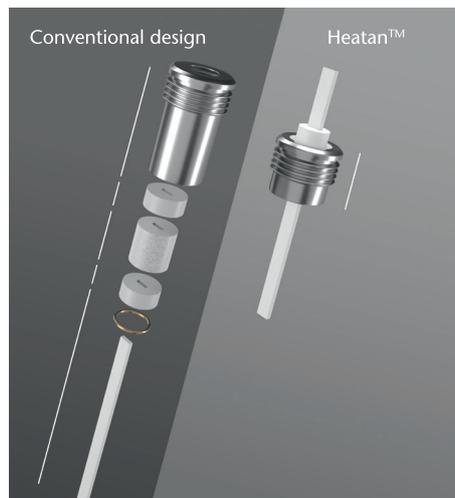
This is where glass-ceramics come in. Under the brand name of Heatan™, SCHOTT has developed a material and a production

process for complete sensor components which are specially designed for use in exhaust systems.

The benefits of ceramics and glass come together to create an ideal end product. Glass-ceramics are also heat-resistant to well over 1000 degrees, but it's the difference in packaging that is significant. "All in all, axial space required for sensors is reduced by more than 50 percent," says Mark Stroncsek, Sales Manager Automotive in the Electronic Packaging business unit at SCHOTT.

No additional fixing

Small sensors offer a major advantage for OEMs. Increasingly stringent emission control regulations, for example in connection with the Euro 7 standard, usually require them to have additional or different sensors. This means that components need more space – both in the engine compartment and along the exhaust tract. In the confined space around catalysts, particulate filters and selective catalytic reduction (SCR) units, saving even the smallest amount of space makes a huge difference. After all, cables also need to be accommodated around the actual sensor units and their bending radius taken into account.



There are two reasons why Heatan™ is so compact: on the one hand, the robust elements are smaller than their ceramic counterparts. And on the other hand, SCHOTT's glass-ceramic seals do not require metal springs or rings to secure the insulator in the sensor housing. Instead, the new insulators are hermetically sealed with the other parts.

The connection between the materials is one of the great advantages of glass-ceramics. The result is short insulation distances for axial sensors. This is particularly evident in the sealing of gas sensors, where SCHOTT sees the first major potential for the new product.

From 20 down to two steps

Short insulation distances also have advantages for other sensor types. For example, thermal capacity is lower thanks to reduced mass which improves decoupling during temperature measurement. The sensor adapts more quickly to the temperature in the exhaust gas system. Response times are shorter and changes can be detected more quickly, which has a positive impact on the quality of control by the engine management and therefore on emissions.

Even in the case of welded sensors, which are now often used by OEMs and suppliers of exhaust systems, the smaller contact surfaces show advantages. The high temperatures of the welding process have a lower impact on the actual sensor element. Bolted sensor units, on the other hand, can not only become smaller in the axial direction. "The thread diameter can also be kept much smaller than the usual M14," explains Stroncsek.



Sensors in exhaust applications must reliably withstand temperatures over 1.000°C (1.800°F).

These technical benefits for OEMs and suppliers go hand in hand with cost benefits. They are the result of dramatically simplifying the production of the sensors.

"The number of steps is reduced from about 20 to two," says Stroncsek. There is also a significant decrease in the number of parts required. Only the connection cable and a protective cap are added to the component. By comparison, conventional designs require up to a dozen components. And their purchasing, logistics and warehousing generate costs of course.

Hermetically sealed

Glass is in SCHOTT's DNA. The company has been known for special high-quality glass for 130 years. Products such as the famous Jena glass and the widely used Ceran ceramic cooktops are from SCHOTT.

The company is highly skilled in combining glass with metal. Heatan™ is based on a specially developed glass-ceramic material which starts out as a sintered preform. It contains one or more axial openings in which sensor elements are inserted. Once the preform including the inserted sensor has been placed in the outer metal part, it is put into the melting furnace. In a precisely controlled thermal process, glass-ceramics and metal components are combined. By sealing the glass with the metal, a hermetic seal is created. In the subsequent ceramization process, the material changes into a ceramic and dimensionally stable state.

According to SCHOTT's experts, the thermal load on the sensor's electrical parts during heating is within the range that these parts must, by definition, resist anyway. The glass-ceramic itself withstands 1000 degrees as well as low temperatures down to minus 40 without any problems.

Processing at SCHOTT results in a single part, the original components of which are firmly joined together. By comparison, in ceramic insulation, the sensor element and insulator are often only held in the housing by springs and rings. However, fewer parts always reduce complexity. In times of increasingly elaborate exhaust gas treatment systems, sensors with glass-ceramics are supporting the trend.

SCHOTT supplies Heatan™ components as subcomponents to sensor manufacturers, or – depending on the supply chain – back to them. Only a few final steps remain before they are delivered to OEMs or exhaust system suppliers. During one of these steps, the cable and plug are connected to the sensor element. Then a cap is added in most cases to protect the connection from environmental influences.

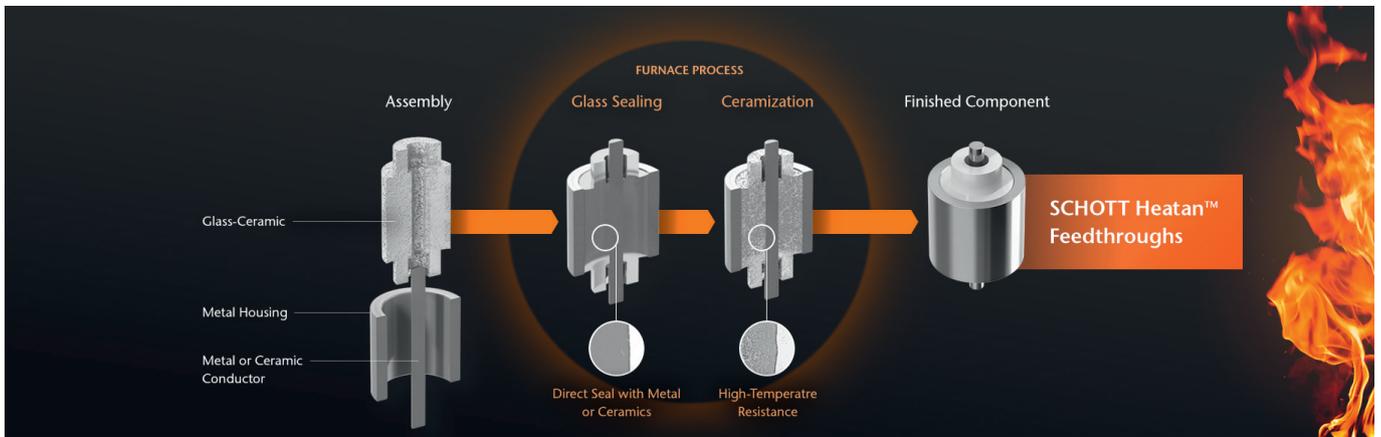
Know-how in glass

Decades of Schott's experience have gone into the process. A great deal of know-how is required to deal with Heatan™. "We only process the glass ourselves," confirms Mark Stroncsek.

One reason is the high demands on the processes. Temperatures and other parameters have to be accurate. Changes in the size of the glass parts that occur during processing in the furnace must be taken into account beforehand. In practice, only one part out of three is produced in SCHOTT's factories. Two of them are supplied by other companies: the actual sensor element or connecting conductor and, if necessary, the outer cover. SCHOTT contributes the glass-ceramic material from its own production. Heatan™ can also be described as a process that goes beyond the material, with both the material and its processing being patented.

The traditional company has a lot of experience in the automotive sector and also in the aviation industry for such orders. Feedthroughs for airbag igniters are developed in Germany and produced in millions at locations worldwide. Production is possible in close geographical proximity to customers, for example in Asia.

SCHOTT is a company owned by the Carl Zeiss Foundation. Such corporate forms are considered to be particularly stable and robust in the industry.



To produce Heatan™ feedthroughs, SCHOTT combines the best of both material worlds: glass and ceramics

Cost benefits

Outsourcing parts of sensor production to SCHOTT is generally a good answer when considering whether to make or buy. In addition to steps for assembly, individual quality assurance measures are also eliminated. It is no longer necessary to check whether the sensor element is properly sealed in the insulator. Glass-ceramic compounds with metals are hermetically sealed. The reduced number of components and steps also minimizes possible errors in production. “‘Fit & forget’ is one of the key benefits of our product,” says Stronczek.

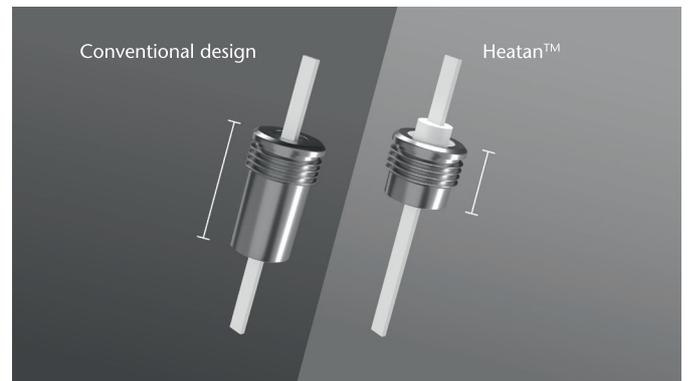
Of course, Heatan™ meets all the usual requirements for use in the automotive sector. Resistance to all fuels, including their additives and lubricants, has been tested, as has resistance to environmental influences, for example salt and other substances from the roads and surroundings. After all, exhaust gas sensors are installed in corrosive environments. Of course, the material is also immune to everything that occurs in exhaust gases. This includes AdBlue, a urea solution for selective catalytic reduction, which will be crucial for the future of diesel. As is mandatory in the automotive sector, Heatan does not contain any problematic substances. It meets RoHS regulations. What’s more, the starting materials for glass are ecologically sound and available in abundance. An essential one is sand.

The options for combining glass-ceramics with other materials are basically the same as in customary sensor technology practice. In addition to corrosion-resistant steel, various stainless-steel grades and nickel-based metals have been successfully tested for the outer casing. Even ceramics are possible, which also applies to the sensor element itself.

Further applications possible

Statutory regulations and OEM requirements call for high long-term stability of components that are relevant to exhaust gas behavior. In North America, they have to perform a very high mileage without replacement or maintenance. With Heatan™ you can expect up to 300,000 kilometers, according to Stronczek. The decisive factor is its extraordinary resistance to loads caused by thermal cycles.

The technology can be used practically immediately and is suitable for large-scale production. Glass-ceramic technology offers potential for further applications in cars. It is not just suitable for newly developed sensors. Production lines for sensors with ceramic insulators can be changed and benefit from considerable simplification in terms of part numbers and steps.



Smaller and more simple than conventional designs: Heatan™ feedthroughs enable next-generation high temperature sensors.

This means that Heatan™ could also become economically viable for manufacturers of lambda probes. The original equipment market and aftermarket require a large number of these parts, and cost pressures are high. The potential savings resulting from the drastic reduction in the number of parts and the steps involved should attract interest. In future, the market will also demand a higher quantity of sensors for new emission control systems. Manufacturers who rely on the new technology from SCHOTT for new developments right from the start will be well prepared.

For more information, please visit:

www.schott.com/heatan