Heat-resistant ultrasonic transducers

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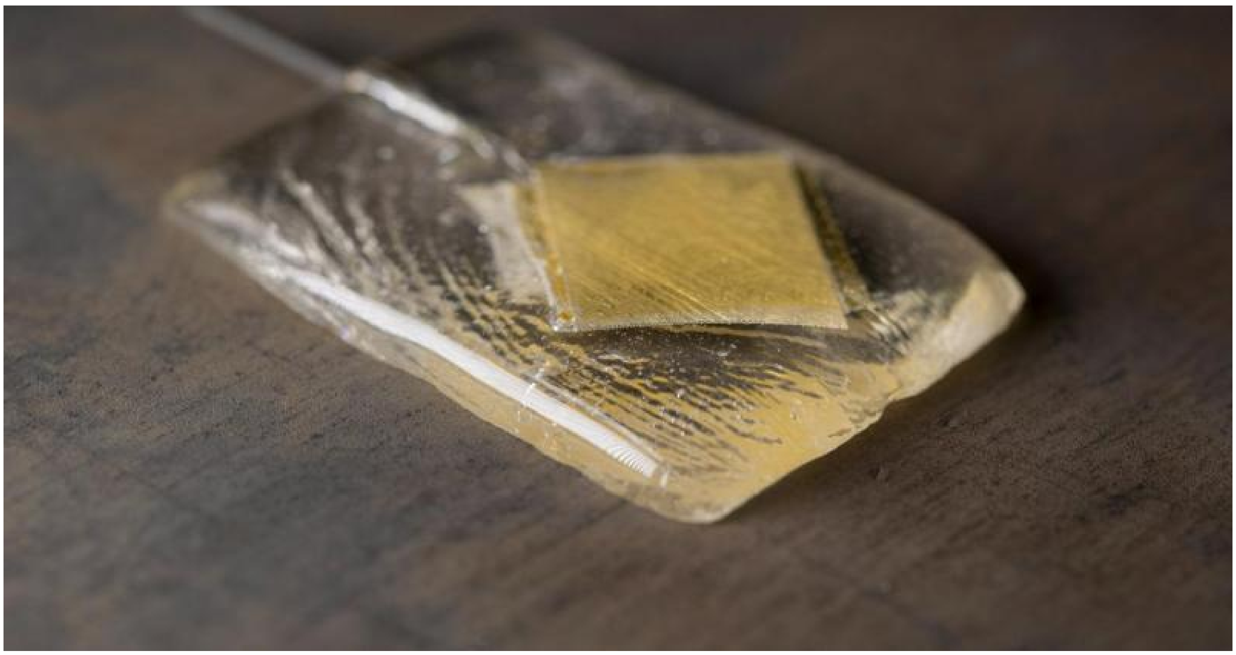

High-temperature ultrasonic transducer. Credit: Fraunhofer ISC

Technical systems must be regularly checked for defects, such as cracks. Up to now, piezo sensors measuring pressure, force or voltage have been used to reliably detect such faults – but only to around 200 degrees Celsius. Now, special high-temperature piezo sensors can continuously monitor components that are as hot as 900 degrees Celsius. Fraunhofer researchers will present their development at the SENSOR+TEST measurement fair in Nürnberg, May 30 to June 1, 2017.

If a component such as a steam pipe in a coal-fired power station has a crack, corrosion or other flaw, repairing it is imperative. Ultrasonic sensors mounted externally can detect flaws like these, but only when the component does not heat up to more than around 200 degrees Celsius. Above that temperature, conventional piezoelectric materials can no longer determine pressure, force, voltage or acceleration or act as a gas sensor. Furthermore, at these temperatures any plastic encapsulations that are not heat-resistant will fail.

First sensors for high-temperature applications

Researchers at the Fraunhofer Institute for Silicate Research ISC have now successfully realized piezo sensors for high-temperature applications. "We have already implemented our sensors at temperatures of up to 600 degrees Celsius. Generally speaking, temperatures of up to 900 degrees Celsius are possible," says Dr. Bernhard Brunner, head of the Application Technology department at Fraunhofer ISC's Center Smart Materials. Additionally, the ultrasonic sensors remain stable over long periods – at least two years in any use case – and for many applications, researchers expect a service life of several decades. The principle is the same as for other piezo sensors: they are mounted externally on the component, for instance on a hot steel pipe. When an alternating voltage is applied to the piezoelectric crystal, it mechanically deforms and sends an ultrasonic wave into the material. After the sound wave, the sensor switches to receive and detects the signal reflected by the component. In most cases, it receives the same original signal it sent. However, if the component is cracked or has a corroded spot, the defect alters the reflected signal and indicates the defect's location. When several transducers are used that serve as transmitter and receiver, the location of the flaw can be pinpointed exactly to within a few millimeters. Depending on the component's material, the sensor's range covers a few meters.

The challenge lies in constructing standard piezoelectric crystals that can withstand long-term use as sound transducers on hot components. Especially problematic is the adhesive that coats the sensors and attaches them to the component: it can't withstand very high temperatures. "That's why we use glass solder as both a glue and a housing material," explains Brunner. This means the glass belonging to this group of adhesives must withstand not only heat, but in particular the several hundred degrees Celsius difference between the ambient temperature in the room and the operating temperature of the component. While the steel in the component expands significantly when it is heated, the dimensions of the crystal change only marginally. The glass solder in which the sensor is embedded has to endure these deformations without shattering. To this end, the researchers coat the sensor with multiple layers consisting of different glass solders that are perfectly compatible with each other as well as with the component's material specifications. The corresponding glass solders as well as the process technology and processing technique all come from Fraunhofer ISC. To ensure that the electric signaling lines do not corrode in high temperatures, the feed lines are made of precious metals such as platinum.

Broad range of applications

There are numerous possible applications for the high-temperature ultrasonic transducer: for example, the researchers can also use their sensors for contactless measurements of how much of a hot liquid – such as oil – flows through a pipe or of the temperature of a gas or a liquid. While a probe takes a few seconds to ascertain the exact temperature, the ultrasonic transducer can provide a result within a few milliseconds. It measures temperature based on sound velocity, which is temperature dependent. The scientists will present prototypes of their sturdy sensor sleuths at the SENSOR+TEST measurement fair in Nürnberg, May 30 to June 1, 2017 (Hall 5, Booth 248).

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