RESEARCH NEWS

Hydrogen economy

Sensors for Safe Use of Hydrogen

Fraunhofer researchers have developed sensor systems and measuring equipment that detect leaks in hydrogen lines and tanks. Applications for the new technology include continuous monitoring of hydrogen shipments and facilities in the chemical industry. The researchers use multiple sensor technologies to provide safety equipment covering as many scenarios of the future hydrogen economy as possible.

When it comes to building hydrogen infrastructure, the safety of pipelines, tanks and connectors is crucial, as the invisible, odorless gas is highly flammable and explosive. The Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg has developed sensor and measurement systems that reliably detect even the slightest amount of hydrogen. This makes it quick and easy to detect leaks of all kinds.

The research work was part of the TransHyDE hydrogen flagship project initiated by the German Federal Ministry of Education and Research (BMBF) and project management organization Projektträger Jülich (PtJ). Partners from the research sector and industry are working together in the project to develop solutions for transporting and storing gaseous hydrogen. Dr. Carolin Pannek and the team at Fraunhofer IPM were in charge of the subproject on safe infrastructure.

Hydrogen is used across a wide range of different scenarios and applications, so the Fraunhofer researchers developed three different sensor systems.

Ultrasonic sensor with photoacoustic effect
Light can cause a gas to vibrate, thereby generating sound waves. The researchers use this photoacoustic effect for their ultrasonic sensor. In this technology, light is beamed into the device from a light source, generating resonant sound waves in the gas at a frequency in the ultrasonic range. When hydrogen enters the container through a membrane, there is a shift in resonance, which changes the tone. MEMS (micro-electromechanical systems) microphones register the change in tone. This method can be used to detect hydrogen leaking out of tanks or pipelines, for example. “This sensor could be used to check containers, pipelines or connectors. It would also be possible to place multiple devices around a room like smoke detectors and combine them into a sensor network,” explains Pannek, the project manager at Fraunhofer.

But the ultrasonic sensor can do even more. It is so accurate and precise that it even registers when molecules of other substances are present in the hydrogen as minimal

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levels of contamination. Fuel cells like those used to generate electricity in trucks require high-purity hydrogen. The slightest contamination could damage the sensitive membranes. The sensor can be used in these applications to check whether the hydrogen is truly pure.

Laser spectrometer
One alternative to laborious storage of hydrogen in high-pressure tanks in gaseous form or at negative 253 degrees Celsius in cryotanks in liquid form is the use of ammonia (NH_3) as a carrier matrix. This method considerably simplifies both storage and transportation. But because ammonia is highly toxic, rapid and reliable leak detection is vital. Fraunhofer IPM developed a laser spectrometer for remote detection of ammonia. It absorbs the wavelength of ammonia, so it reacts immediately. The system then shows the result on a display. "Specialists can hold our compact device in their hand to check pipelines or tanks from a safe distance of as much as 50 meters. Mounted on a robot or drone, it can be used to check industrial facilities or fly over pipelines," Pannek says.

Raman spectroscopy
The third measurement system builds on the principle of Raman spectroscopy. The Raman effect, named for scientist C. V. Raman, is produced by interactions between light and matter. The light reflected off the matter has a different wavelength than the light emitted at the source. This means that every kind of matter has its own spectroscopic "fingerprint."

Fraunhofer IPM has years of experience in designing and configuring Raman systems. For the TransHyDE project, the researchers developed a filter-based Raman sensor that selectively detects hydrogen in complex media. The device works with low-cost components including an inexpensive CMOS camera, plus it is portable, so it can be used as a mobile testing station for quantifying hydrogen. The system is used in applications including production of hydrogen in the energy sector.

Versatile systems, advice on hydrogen projects
All of the sensor systems are designed to be versatile so they can be adapted for a wide range of different scenarios. The Fraunhofer experts step in as needed to provide advice to industry customers, energy suppliers and operators of hydrogen projects on all kinds of issues surrounding safe use.

Pannek is a firm believer in the future of hydrogen: "The expansion of the hydrogen economy can start now."

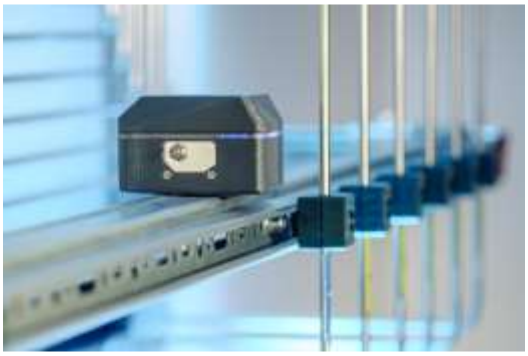

Fig. 1 The ultrasonic sensor can be used to monitor hydrogen tanks, pipelines or connectors. The sensors can also be placed around a room like smoke detectors to form a network.

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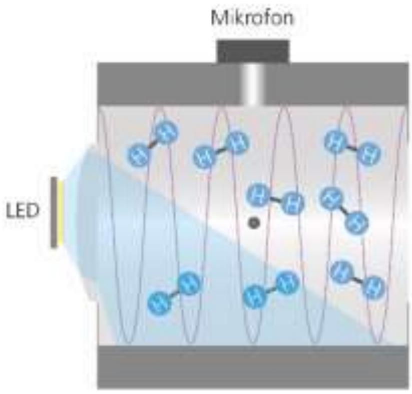

Fig. 2 How the ultrasonic sensor works: The LED light generates sound waves in the gas. If hydrogen enters the container, the resonance changes. A MEMS microphone registers the shift.

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Fig. 3 Hydrogen can be stored and transported in the form of ammonia (NH_3). The laser spectrometer from Fraunhofer IPM absorbs the wavelength of ammonia, so it reacts immediately. The system then shows the result on a display.

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