DISRUPTIVE NANOPLASMONIC SENSOR SET TO SUPPORT SAFETY IN THE HYDROGEN ECONOMY

Gas detection relies on sensors that sniff the air and generate electronic signals that can be processed to indicate the concentration of the gas they are looking for. These signals can be further analysed to trigger alarms or invoke other safety functions.

The ideal sensor is quick to respond, accurate and able to detect the target gas amongst a matrix of other gases. Repeatability over a long lifetime with minimal maintenance and low purchase costs round off the selection criteria for the perfect sensor.

For a leak to air, hydrogen has an LEL (lower explosive limit) of 4% and a UEL (upper explosive limit) of 75% - that is an extremely wide range. And in many locations where hydrogen is used, spark ignition from electrical components or maintenance activities is an ever-present risk. But, with appropriate measures such as risk assessment, HAZOP, and the implementation of appropriate mitigating actions, like gas detection, the risks associated with hydrogen production, storage, distribution, and utilisation can be minimized. Safety across the full hydrogen value chain can be improved with appropriate gas detection sensors.

Ready for lift-off

David Nilebo, Business Area Manager for Gas Sensors at Insplorion AB in Göteborg, Sweden says that "we have been developing and applying a disruptive technology to gas analysers for the past decade. It is called NanoPlasmonic Sensing, or NPS."

The sensor works based on an optical phenomenon – a plasmon. This occurs when metal nanoparticles capture visible light and become illuminated. The sensor changes colour based on the amount of hydrogen in the air and the colour is detected by sophisticated opto-electronics.

Insplorion spun off from the Chalmers University of Technology in Gothenburg a decade ago to commercialise their technology in a range of market-ready products for the lab and industrial gas detection applications.

Nilebo and his team are now ready to test their new hydrogen sensor in the field and are actively seeking gas detection systems integrators and end users for collaboration. The next step will be to use their NPS technology in parallel with an established gas sensing technique to generate independent field data and demonstrate its performance. "We are convinced that our sensor will become the industry standard in the next generation of hydrogen sensors. Our goal at present is to find suitable partners to work with us to validate this hypothesis. Then, we will be ready for commercialisation and our products will become available to support the safe development of the emerging hydrogen economy.", says Nilebo.

Hydrogen specific measurement means selective sensors are required

In crude oil and biofuels refining, hydrogen is used for the desulphurization and hydrogenation of fuels. At present, most refinery hydrogen is produced from natural gas, refinery gas or naphtha to produce hydrogen on a steam methane reformer (SMR).

Around each SMR, there is a fuel gas pipeline feeding the plant and a hydrogen pipeline to deliver hydrogen to the refinery. The SMR also produces carbon monoxide, which is also flammable.

"To selectively detect a hydrogen leak on the SMR or nearby downstream hydrogen processing equipment, a gas detection system fitted with a sensor that is specific to hydrogen is required", says Nilebo. "And our NPS technology is highly specific to hydrogen."

Using a conventional gas detection system that sniffs for a broad range of flammable gases means that the precise cause of the leak is difficult to identify because there are so many flammable gases present around SMRs and in refineries.

Hydrogen electrolyser gas detection

Electrolysers are set to join SMRs as large-scale hydrogen producers in the refining sector, as the 10MW PEM electrolyser from ITM power now operating at Shell's Rhineland Refinery near Cologne in Germany demonstrates. Hydrogen electrolysers are also making inroads into hydrogen refuelling stations and other small to mid-scale hydrogen consumers such as float glass makers, where hydrogen is used for annealing

There are various international technical standards that must be followed when considering the safety of hydrogen electrolyser installations, for example the 'ISO 22734-1: Hydrogen generators using water electrolysis process'. This standard identifies the first lines of defence as good ventilation and the installation of a hydrogen gas detector. Automated safety control systems driven by the gas detector should invoke the appropriate actions in the event of a gas leakage alarm. For example, a severe alarm at a high concentration of hydrogen in the air would trigger a full emergency shutdown of the electrolyser. Additional measures may be required, and generic international standards must be used in combination with a detailed risk assessment that is specific to the installation.

Gas detection works very well in enclosed buildings but in outdoor spaces a leak can quickly be diluted to very low levels by the wind. Flanges and valves in the pipework are potential gas leak points and the plant risk assessment may have determined that each one should have a hydrogen gas detector close by.

Allowing for the wind dispersion, the level of hydrogen at the sensor is likely to be low, even if it is located very close to the potential leak point. For this reason, a low detection limit is essential to identify an outdoor hydrogen gas leak. Nilebo adds that "NPS technology is able to sense hydrogen in air at only 5 parts per million. That's means it really can find the needle in the haystack."

Avoiding gas detection sensor calibration saves money and improves reliability

Operating procedures will generally specify that fixed gas detectors are 'bump-tested' at regular intervals to demonstrate system functionality. Some standards and company policies also mandate that the sensors must also be removed periodically for servicing and recalibration. These activities consume operator time, incur cost, and remove the sensor from service for a short duration. Reliable sensors are both safer and cheaper to own than ones that suffer from drift and require frequent maintenance.

"Our NPS sensors have a high level of stability require less frequent calibration which maximises their availability and minimises costs of ownership", confirms Nilebo. "Another advantage is that our sensors do not suffer from a problem known as 'saturation'. This means that their responsiveness and accuracy are not adversely impacted after exposure to a high level of hydrogen."

Able to handle the pressure

Handling hydrogen demands specific attention due to the danger of fire and explosion. Hydrogen is also stored and distributed at high pressure, meaning that a small leak can quickly escalate to a major hazard. For example, in the automotive sector hydrogen is stored on board cars at 700 bar. Although there is no confirmed standard in this area yet, it is understood that FCEV automotive OEMs expect leak detectors to be sensitive enough to detect hydrogen at concentrations of 0.1% or less with a response time of less than one second to achieve 90% of full-scale deflection.

In the refuelling stations for the cars, the pressure exceeds 900 bar. Testing of stationary hydrogen gas detection systems is covered by ISO26142:2010 Hydrogen detection apparatus — Stationary applications. Performance requirements are not explicitly stated, but the consensus is that a detection limit of 100ppm would be suitable at a response time of less than 30 seconds to achieve 90% of full-scale deflection.

Nilebo summarises the situation by saying that "gas detection of hydrogen at low concentrations with a rapid responding sensor is clearly the best way to nip hydrogen leak in the bud before it gets out of control." He adds that "our NPS technology has a faster response time than any other hydrogen sensor that we are aware of, and we believe that are in line with the rigorous expectations of the automotive sector for onboard mobile hydrogen storage and stationary hydrogen refuelling stations."

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