Fraunhofer
IPM

Hydrogen sensor
Plug & Measure

Compact in size – low in energy needs

This compact sensor detects H_2 quickly and with a high degree of sensitivity. Thanks to MEMS technology, it uses very little energy.

Hydrogen (H_2) is set to become a future energy source in industry, heating supply and transportation. Storage tanks, pipelines and supply points must be continuously monitored for leaks to ensure this gas is used safely. Fraunhofer IPM has developed a particularly energy efficient hydrogen sensor, which detects the gas quickly and with a high degree of sensitivity.

Hydrogen is highly flammable and, when mixed with air, it becomes explosive over a wide concentration range. The lower explosion limit of the hydrogen in air stands at 4 percent. A dangerous oxyhydrogen gas explosion can occur if a mixture such as this comes into contact with an ignition source. Even the smallest leaks in tanks or pipelines therefore represent a high safety risk. Hydrogen is temporarily stored in high pressure containers during transportation. Systems that carry hydrogen must be particularly well secured and permanently monitored by means of sensor technology.

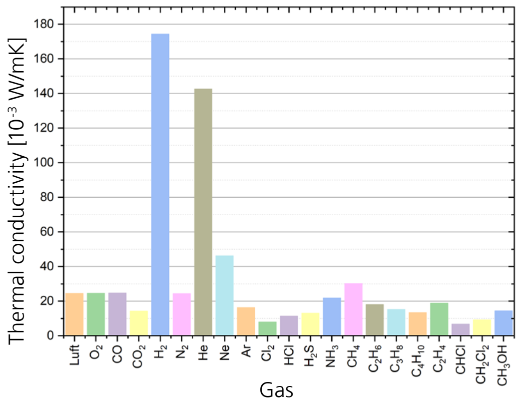
Using thermal conductivity for H_2 detection

The specific thermal conductivity of H_2 can be used to detect the gas. Along with helium (He), H_2 is one of the gases with the highest thermal conductivity. This is what clearly differentiates it from other gases, and from air in particular. Hydrogen conducts heat seven times better than air. This means that even the smallest concentration of this gas can be detected in air, or in other gases, by measuring thermal conductivity levels.

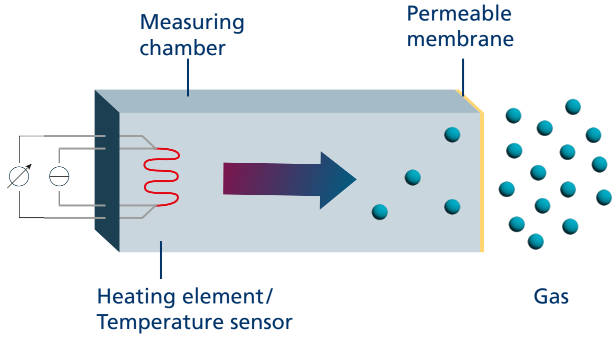
Thermal conduction in gases is based on the movement of molecules, which transfer part of their kinetic energy to each other when they collide. This results in energy being transported from a place of higher temperature (i.e. higher average energy) to places of lower temperature. Thermal conduction mechanisms differ between gases, liquids and solids. In a solid, for example, atoms are bound to a stable equilibrium, while in gases they can move freely.

Obtaining H_2 from water

Through electrolysis, water can be split into its atomic elements of oxygen and hydrogen in an emission-free and therefore climate-neutral way. Unlike the pyrolysis of methane, this process does not lead to an accumulation of CO_2.
With the help of fuel cells, a reverse reaction is possible. Oxygen from the atmosphere reacts with hydrogen to form water. The energy stored during electrolysis is then released.



The thermal conductivity of gases differs widely. The high thermal conductivity of H_2 can be used to detect this gas.



The heating element in the thermal conductivity detector serves as a temperature sensor.

Operating temperature under 100 °C

Fraunhofer IPM develops cost-effective, self-testing thermal conductivity detectors (TCD) and integrates them within compact sensor systems. The operating principle behind a TCD has been proven to be effective and is already used in many applications. The sensors essentially consist of a heating element, which also serves as a temperature sensor. The heat output of the sensing element is proportional to the temperature and therefore to the gas concentration level. If the sensor is exposed to only a mixture of hydrogen and air, with any cross-influence from helium ruled out, it is possible to determine the hydrogen concentration.

The TCD consists of a gas-permeable membrane, a measuring chamber and a heat resistor. Measurements are taken at sensor temperatures of 100 °C or less. This means that the operating temperature remains well below the ignition temperature of hydrogen (585 °C). A thermal conductivity sensor covers a wide measuring range from < 1 percent to 100 percent hydrogen in the air.

Lower energy use thanks to MEMS technology

Commercially available sensors generally react very sensitively to interferences such as high humidity or warm and cold drafts. By combining the TCD principle with smart signal processing, as is currently being researched at Fraunhofer IPM, it is possible to compensate for these interferences to the greatest possible extent.

In addition to promising control software, Fraunhofer IPM is also developing TCD sensors using MEMS technology. This requires even less energy than previous solutions and means that these sensors can also be used for building battery-driven systems. Sensor systems developed by Fraunhofer IPM operate with a power consumption of less than 120 mA at 3.3 V and detect an H_2 concentration of 0.4 percent in the air in less than 1 minute.

Technial Specifications

Power consumption	Approx. 120 mA at 3.3 V
Measuring range	0.16 % to 10 % H_2 in the air
Measuring speed	42 seconds
Sensor temperature	< 100 °C
Size	Thumb drive (59 × 20 mm²)
Graphic interface	Traffic light warning system for non-critical and critical concentration levels

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