HYDROGEN H2 SS SOLID ELECTROCHEMICAL SENSOR

1. Description of Technology

The Hydrogen Sensor is based on the electrochemical gas detection principle. This technology can be used to detect chemicals or gases that can be oxidised or reduced in chemical reactions.

Hydrogen:

The following reaction takes place when Hydrogen diffuses into the sensor:

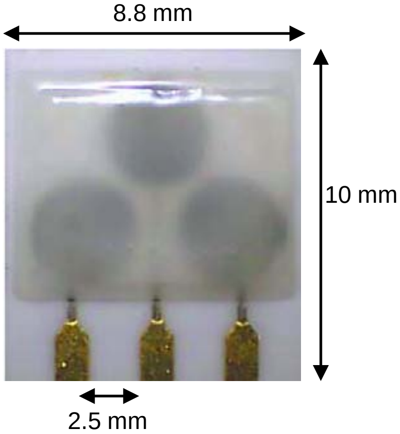
• H_2 diffuses into the working electrode, which holds free places for Hydrogen molecules.

• At the point where the Hydrogen and Electrolyte mix, H_2 will break up into 2H+ and 2 electrons. The amount of electrons (Current) is directly proportional to the concentration of Hydrogen. Protons (H+) move through the electrolyte to the Counter Electrode where H+ and Oxygen form water.

The Reference Electrode is isolated and maintains the base potential to stabilise the sensor output, even when the sensor is exposed to high concentrations of Hydrogen. Three electrode sensors have a wider detection range with good direct linearity.

Oxygen is not required for the chemical reaction but this does not mean that the sensor can work in environments without Oxygen. An atmosphere without Oxygen will cause the free Oxygen inside the electrolyte to disappear slowly. This process absorbs only the Hydrogen and since the H_2 is the fuel for the reaction, the life expectancy of the sensor is over five years.

2. Design – Raw Sensor Dimensions:



- *Size:* 8mm wide x 10mm high x 1mm thick.
- *Contact separation:* 2.5mm between pads
- *Contact size:* 2mm x 1mm.
- *Material:* Gold - can be soldered or bonded

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STOKE ROAD, NOSS MAYO, PLYMOUTH, DEVON PL8 1EY, UK
☎: +44 (0)1752 872222 Fax: +44 (0)1752 872223
euro-gas@btconnect.com www.euro-gasman.com

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Operation:

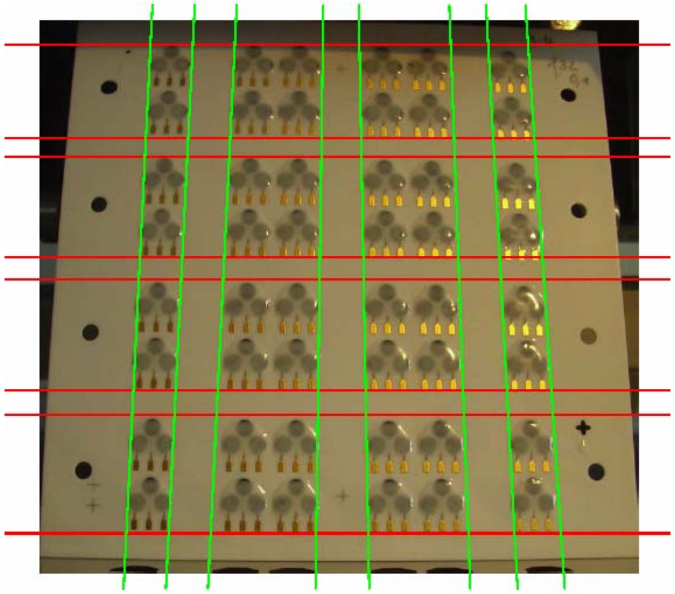
Gas enters through a diffusion and protection filter from the back. This filter protects the sensor from dust and water, allowing the gas to flow through. It is nearly impossible to keep gas from entering into the sensor unless the filter is completely blocked.

Composition:

The left electrode is the Reference electrode (R).
The middle electrode is the Measurement Electrode (M).
The right electrode is the Counter Electrode (C).
The final layers are electrolyte and a protective skin.

A RAW single sensor is part of a wafer which contains 48 RAW Sensors. Single RAW sensors or a complete wafer can be purchased. Every wafer is gas tested prior to shipment.

The sensors are separated through pre-manufactured break lines as shown on the illustration below.



If ordering a wafer of 48 RAW sensors, it is important to break the sensors away from the wafer in the following order. The separation process is very easy if this order is followed:

1. Break the wafer at the **RED** lines first. It is not important which one is used first.
2. Next break the wafer at the **GREEN** lines.

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3. DIFFERENCES TO STANDARD ELECTROCHEMICAL SENSORS

a) Acid electrolyte like H_2SO_4 is replaced by a solid electrolyte.

What happens with the previous system?

- ✕ Standard sensors require a sealed housing to protect the surrounding from the aggressive acidic electrolyte.
- ✕ As acid takes in and releases water, there is a risk of leakage in humid atmospheres or a drying out effect in dry atmospheres. Therefore, the biggest part of such a sensor is a reservoir for the acid electrolyte. Acid based sensors are therefore larger due to the need for a large electrolyte reservoir.
- ✕ There is a potential for damage to electronic circuits should the sensor leak.
- ✕ Production of acid based sensors is complicated.
- ✕ Acid is dangerous.

Benefits of the new system:

- ✓ The solid electrolyte is not dangerous and much easier to handle.
- ✓ No housing is needed.
- ✓ No reservoir is needed.
- ✓ The reading is very fast and promptly reacts to gas leaks in the environment.
- ✓ Adjustment to humidity and temperature variation is immediate.

b) Plastic housing is not required - the sensor is built on a ceramic wafer.

What does this mean in the old system?

- ✕ Plastic housing needed to be sealed or glued together. Acid and change of temperature may cause damage to the plastic over time.
- ✕ Sensor construction is more complex, with contacts and pins connected via wires to the electrodes through the housing. The process is risky and can reduce sensor life and quality.

Benefits of the new system:

- ✓ Sensors can be produced in parallel in one production step.
- ✓ Ceramic electrodes and electrolytes can be built up in layers.
- ✓ Production is fully automated, increasing quality and stability.

c) Differences in connection

What happens with the old system?

- ✕ Electrodes are produced separately.
- ✕ The connection is made with a platinum wire, which needs to be connected to contact pins.
- ✕ Contact pins must be protected from the acid electrolyte.

Benefits of the new system:

- ✓ The wire and the electrode are printed on layers.
- ✓ The last layer is gold, which can be soldered to directly.

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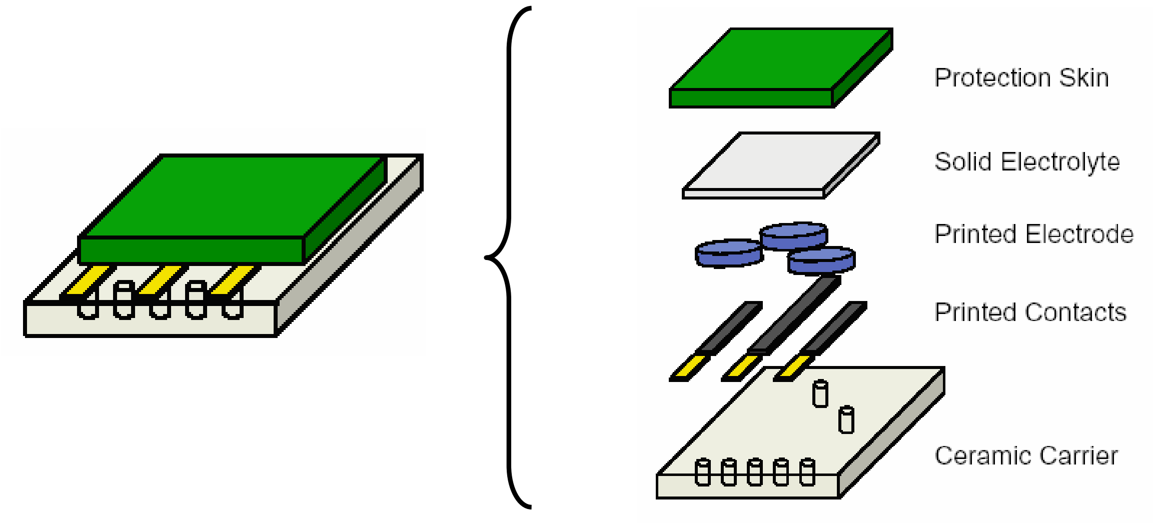
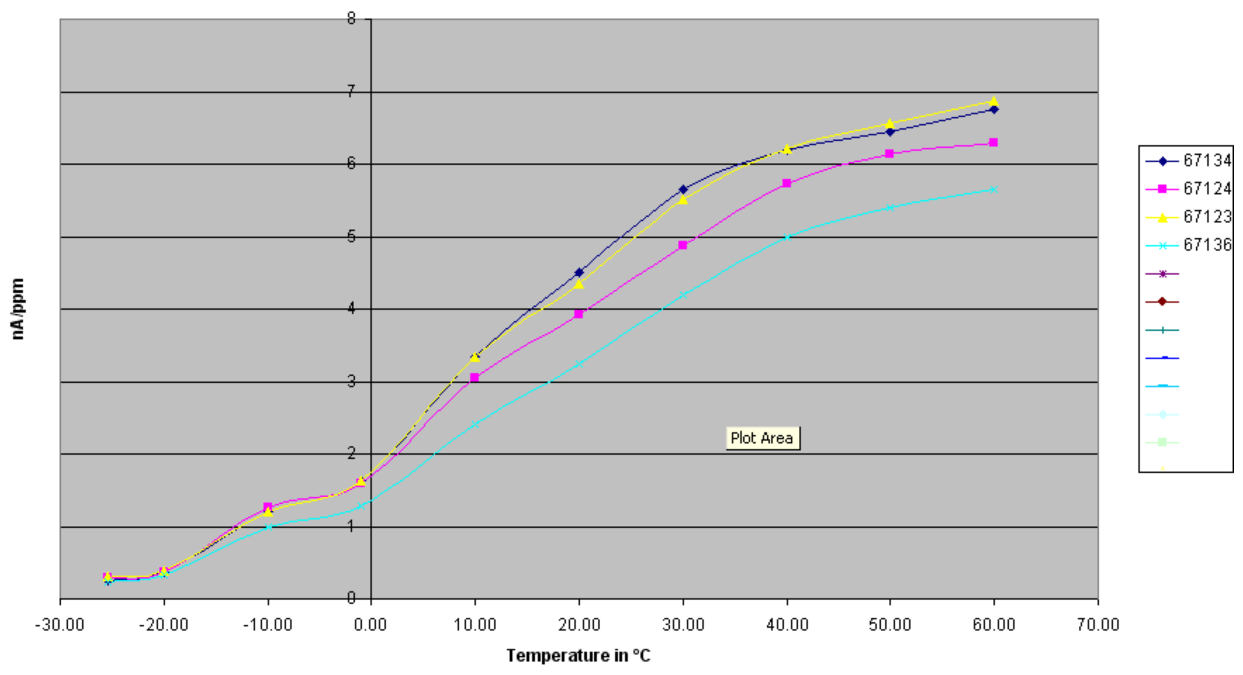


3. Temperature and Humidity Dependence

Temperature dependence differs from the common electrochemical sensor. Normally temperature changes also cause changes in relative humidity in ambient air. Solid electrolyte sensors adjust immediately to humidity changes and will adapt to the new temperature in minutes.

All materials used for the H_2 sensors are suitable for use in temperatures up to 80ºC and down to -20ºC. However, 80ºC and very dry air reduce the humidity inside the electrolyte and may result in less sensitivity.



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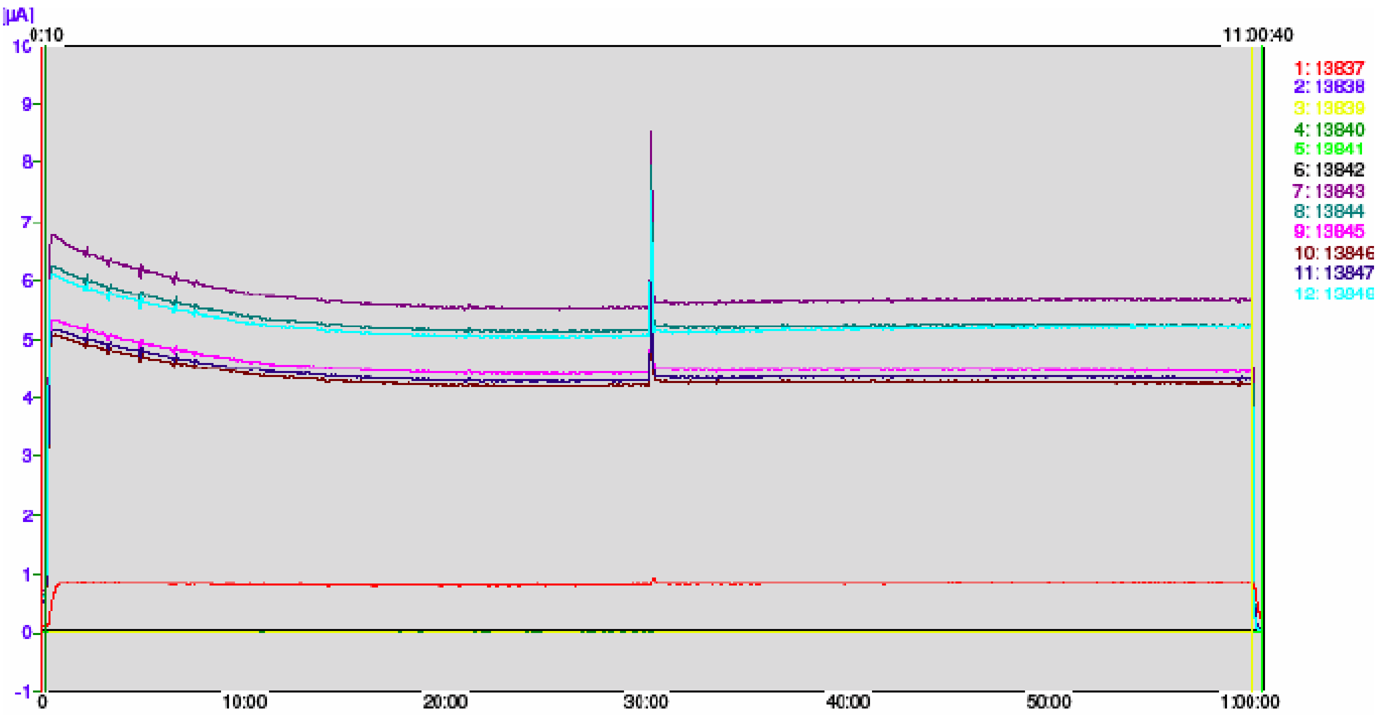
The standard humidity range for the solid electrolyte sensor is between 15% RH and 90% RH non-condensing. Water drops cannot block the diffusion opening but may cause a momentary change in the behaviour of the sensor.

The graph below shows no change in the sensor output when the humidity changes from 15% RH to 90% RH at minute 30. The spike is a result of a high gas concentration during mass flow adjustments from dry air to wet air.



The gas concentration was 1300ppm H_2 and the test was conducted at room temperature of ~23^{o}C. There is a drop of signal during the first 10 minutes due to stabilisation to the dry air. The switch to 90% RH shows no change.

The red line at 1µA represents a standard electrochemical style sensor used for reference. These types of sensors will not normally show a large change due to different humidity caused internally by the acid reservoir. They will dry out very slowly but consistently. If they dry out completely, the sensors will no longer react to gas.

Our solid electrolyte sensor may change behaviour but it will quickly adapt to the changed environment. In addition, it will not show further drying out problems.

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4. Lifetime of the Hydrogen Sensor

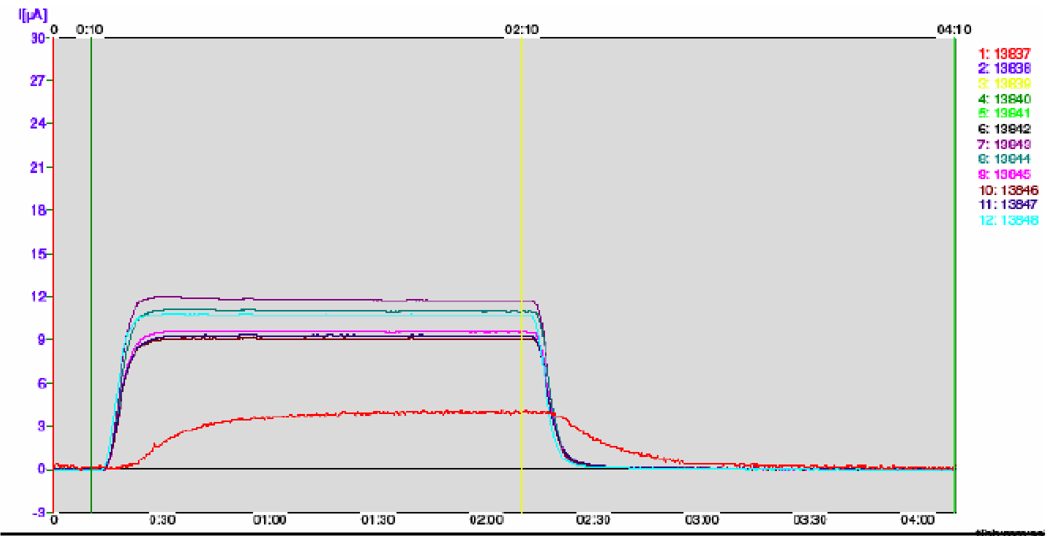
The Sensor is made of materials that do not have a limited lifetime. There is no poisoning from silicon materials and no consumable materials. Due to the long lasting materials used for the construction of the sensors, aging is not a significant factor.

The sensor warranty is 2 years from despatch of order, which is soon to be extended.

5. Sensitivity and Response Time From newest Sensor Generation

The latest revision has a much bigger dynamic range and performs faster than the prior generation. The graph below shows sensors from a production run from December 2008. The revision level can be identified from the gold contacts and the hole on the counter electrode.

NOTE: The red sensor with no. 999 at 3µA is the reference sensor and the first six were sealed and protected sensors.



Span gas:	Hydrogen	**SPC:**	2
Concentration [ppm]:	1900,00	**Quantity:**	13
Temp. coeff. [%/grd]:	0,00	**Aging factor:**	1,00
PV-No.:	11	**Exposing procedure No.:**	7
Comment:		**Span gas Exposing[sec]:**	120

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Label No.	R	P	Sensor-Bez.	PC	I Start µA	T 50 sec	T 90 sec	I max µA	Empf. nA/ppm	NennE. nA/ppm	CE-Wert ppm/nA	I Ende µA	Status A	Status M
PC100	2	1	13843	-	0,062	8,8	12	11,99	6,134	6,134	1630	11,72	1	1
PC100	2	2	13844	-	0,043	9,2	12,8	11,1	5,75	5,75	1739	10,97	1	1
PC100	2	3	13845	-	0	9,2	13,2	9,578	4,999	4,999	2001	9,497	1	1
PC100	2	4	13846	-	0	9,2	13,6	9,125	4,768	4,768	2097	9,059	1	1
PC100	2	5	13847	-	0,047	9,2	13,6	9,312	4,845	4,845	2064	9,254	1	1
PC100	2	6	13848	-	0	8	11,6	10,8	5,639	5,639	1773	10,71	1	1
PC100	3	6	999	-	0,169	22,4	45,6	4,125	1,997	1,997	5008	3,963	1	1

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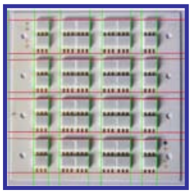
6. SENSOR OPTIONS AND HOUSING

The H_2 SS is available in different options. The sensor can be purchased as Raw, Micro and 4 Series sensors or with integrated circuitry:

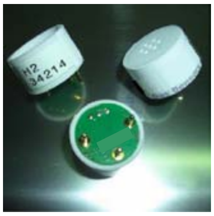
RAW sensor
part no. 2112B010210



Micro sensor
part no. 2112B012710

5V transmitter
part no. 2112B013410

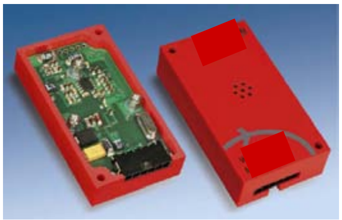
For standard pin requirements, the H_2 SS sensor is available as a standard 4 series size sensor with 3 pins:



4 Series
part no. 2112B010410

For H_2 transmitter and housing requirements, there are a number of different options available:

H_2 Gas measuring system in PVC housing:
part no. 2112B0090



H_2 Gas measuring system in aluminium housing: part no. 2112B24420

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