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Innovative hydrogen sensors in fuel cell vehicles

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Summary:

For the measurement of H_2 concentrations in the exhaust gas of automotive fuel cells and in its vehicle environment an active diversified-redundant hydrogen gas sensor system will be developed. The combination of a selective metal oxide semiconductor gas sensor and a thermal conductivity detector as well as suitable signal preprocessing enables an application-specific H_2 sensor system with high sensitivity, selectivity, stability and safety. Based on updated application specific sensor requirements the work status and current results of the project focused on the current development state of the ambient gas sensor including measurement results will be presented.

Keywords: H_2-sensor, fuel cell, monitoring, ambient, exhaust gas, automotive, diversified-redundant

Used gas sensor principle for H_2 measurement

Technical objectives, requirements and basics for the development of a highly integrated miniaturized humidity compensated H_2 sensor systems for the use in exhaust gas and ambient monitoring systems of automotive fuel cells are described in [1]. The gas sensor systems to be realized are based on an innovative combination of a H_2 selective metal oxide semiconductor gas sensor and a thermal conductivity detector as well as a suitable signal preprocessing [2]. Based on this patented Semicon® principle application-specific H_2 sensor systems with high sensitivity, selectivity, stability and safety for various applications are realizable [3]. Following up [1] in this paper the current development state of the ambient gas sensor is described.

Application specific sensor requirements

For the intended automotive application of H_2 sensors various properties and technical parameters of the sensors must be realized. These are in particular, additional to the described active diversified-redundance [1] [2], integrated safety related functions (e.g. errors will be signaled during the measurement procedure), icing resistance (ready for operation after defrosting), resistance to deionized water (as condensate of the fuel cell), certifiability for use in safety-critical systems, perspective suitability of the sensor concept for large series production, the validatability for automotive applications up to compliance with the target costs. Tab 1 shows target parameters for both the H_2 sensor types to be developed.

Tab. 1: Selected technical target parameters for the H_2 Sensors (Ambient and Exhaust)

Parameter	H_2 Sensor Ambient	H_2 Sensor Exhaust
H_2 measurement range	1 ppm - 10 Vol%	
Accuracy	± 30 % from measured value (≤ 1 % H_2), ± 10 % from measured value (> 1 % H_2)	
Operating hours	≥ 8.000 h	≥ 6.000 h
Lifetime	≥ 15 Years	≥ 10 Years
On/Off cycles	≥ 45.000	≥ 30.000
Mileage	≥ 300.000 km	
Resistances to chemical substances	CO, C_6H_6, C_7H_8, NH_3, NO, NO_2, O_3, SO_2, ammonium sulphates/nitrates, HMDS, …	
Ready for operation after defrosting	≤ 5 s	
Operating temperature	-40°C - +85 °C/+125°C	
Dew point	≤ 40°C	≤ 80°C – 95°C
Power supply U_b	12 V DC – 16 V DC	

Laboratory sample of the ambient H_2 sensor

Fig.1 shows the block diagram of a first laboratory sample of an integrated H_2 sensor system for ambient monitoring. In the sensor is an ceramic one-chip H_2 MOX/TCD gas sensor element and a platinum thin-film temperature sensor element as reference sensor as well the sensor electronics for sensor control, signal preprocessing, communication, I^2C-interface and power supply integrated. The sensor elements are realized in hybrid-technology: ceramic carrier substrate (Al_2O_3) with a micro-structured platinum thin-film layer, covered with a passivation layer, specific layers for contacts and locking as well as a gas-sensitive metal oxide (MOX) layer (H_2-selective) for the MOX gas sensor element [1] [2] [4].

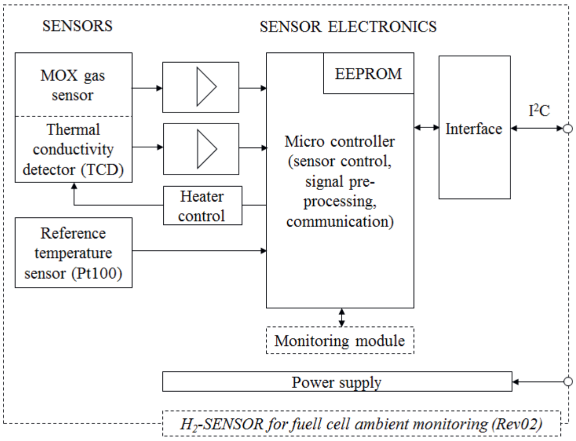


Fig. 1 H_2 Semicon® sensor for ambient monitoring of an automotive fuel cell – block diagramm

Fig. 2 shows an exploded view of the first laboratory sample of the H_2 sensor for ambient measurement, Fig. 3 shows the PCB with the sensor elements and the capped sensor sample (LxWxH ca. 17x13x7 mm).

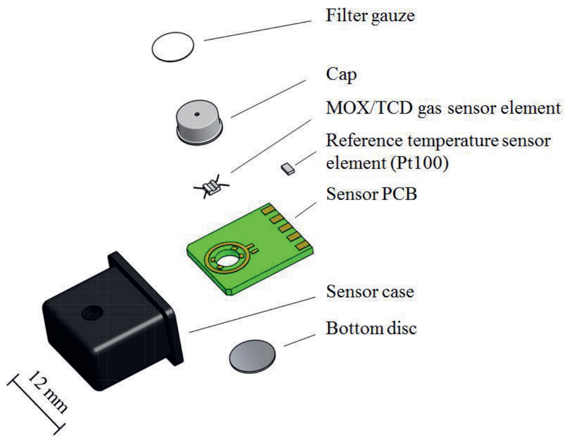
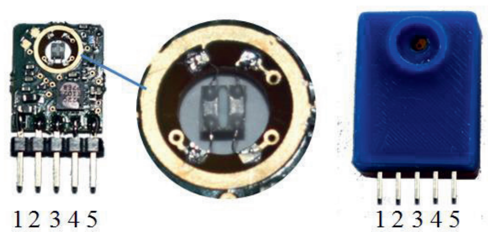


Fig. 2 H_2 Semicon® sensor for ambient monitoring of an automotive fuel cell – exploded view



1: GND, 2: VCC (operating voltage), 3: SDA (I^2C), 4: SCL (I^2C), 5: Hz (heater)

Fig. 3 H_2 Semicon® sensor for ambient monitoring of an automotive fuel cell – left: PCB with gas sensor element; right: sample H_2 sensor capped

During measurements in the laboratory test environment the H_2 sensor system was exposed to various H_2 concentrations. Fig. 4 shows the reactions of the MOX gas sensor and the TCD as raw signals. These raw signals can be application specific further processed.

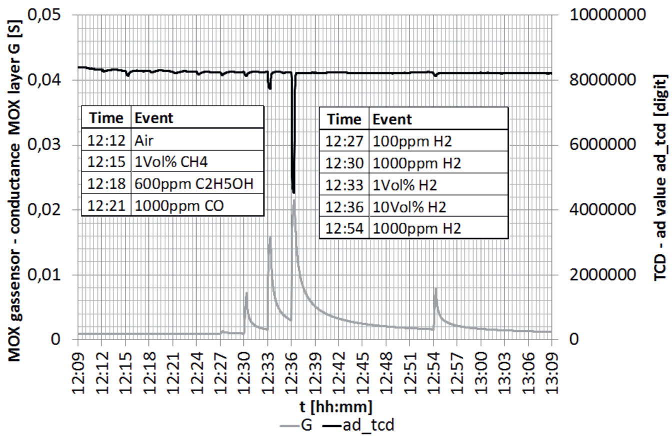


Fig. 4 Laboratory measurement of H_2 Semicon® sensor sample for ambient monitoring

Results and outlook

The presented results show that the realized and tested ambient H_2 gas sensor sample is promising for further development. Sensor concept and design as well in particular the possibility of an easy sensor gas calibration are basically for a successful future development as serial product and the following transfer in serial production. Furthermore some results will be suitable for the ongoing development of the H_2 gas sensor for exhaust gas monitoring systems of automotive fuel cells.

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