H_2 Sensor Workshop

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Overview of Fuel Cell Technologies: Hydrogen Sensor Activities

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June 8, 2011

H_2 Sensor Overview

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Significant progress towards meeting some targets has been made; however no H_2 Sensor meets all DOE targets

Hydrogen can be used as a clean and renewable alternative to carbon-based fuels in a variety of markets and applications. Hydrogen sensors must be available for the safe and successful deployment of this fuel.

H_2 Sensors are needed and required for:

1. Equipment used for
   - Compression
   - Processing
   - Dispensing
   - Storage
   - Hydrogen generation
2. Fuel cell vehicles
3. Indoor refuelings
4. Garages
5. Stationary fuel cell installations

Sensor Types

- Electrochemical sensors
- Metal Oxide sensors
- "Pellistor"-type combustible gas sensors
- Thermal conductivity sensors
- Optical device sensors
- Pd-firm & Pd-alloy film sensors

Issues in Sensor Technology

- Sensitivity
- Selectivity issues (e.g., CO interference)
- Temperature range response
- Response and recovery times
- Environmental affects
- Chemical poisoning
- Durability

2007 H_2 Sensor Workshop

The 2007 H_2 sensor workshop brought together experts from industry, government, national labs, and universities to asses the current H_2 sensor landscape and draft technical and performance requirements to guide the development of H_2 sensors. The table below summarizes the proposed targets.

Parameter	Target
Sensitivity	25% LFL (1 vol% H_2)
Range and Accuracy	0.04-4%, ±1% of full scale over the lifetime of the sensor
Cross Sensitivity	RH, H2S (<10 ppm), CH4 (<1%), CO (<50 ppm), VOCs (0.5%)
Lifetime	5 years
Response Time	<1 min at 25%LFL (1 vol%) <1 sec at 100% LFL (4 vol%)
Recovery Time	<1 min
Reliability	100%, no false positive
Drift	No calibration required for life of the sensor
Temperature	-40ºC to +60ºC
Operational	Alarm for sensor failure
Listing	Listed by nationally-recognized testing laboratory (i.e., UL, CE)
Cost (mass production)	≤$40 for packaged device

2011 H_2 Sensor Workshop

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Assess H_2 Sensor Landscape and Refine Technical and Performance Targets

Great progress in the commercialization of H_2 and fuel cell technologies has been made since 2007 when applications and targets were more general. Specific products and early-markets are more clearly defined and several OEMs have confirmed their commitment to commercial FCEVs by 2015. **As technology has advanced, now is the opportunity to define requirements for applications and assess current H_2 sensor capabilities.**

Tentative Topic Areas
Technology Update
Safety, Codes & Standards
Industry Perspectives
Barriers to sensor deployment
International Perspectives

Workshop Goals

1. **Review Sensor Technologies**
2. **Identify Sensor Specific Applications**
3. **Update Sensor Performance Metrics**
4. **Identify Research Areas**

FCT Funded H_2 Sensor Highlights

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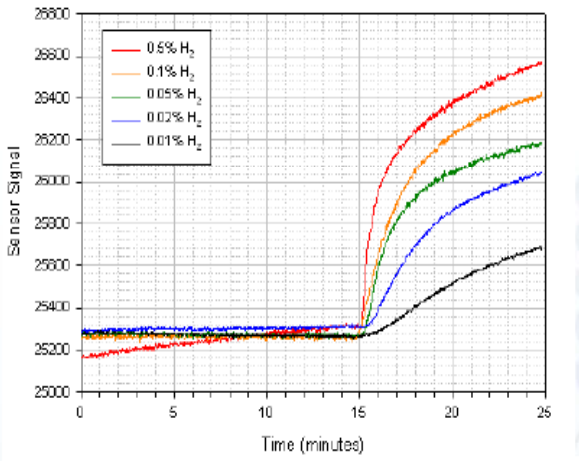
Safe Detector System for Hydrogen Leaks – Intelligent Optical Systems

Optical Waveguide Hydrogen Sensing

- Immobilize H_2-sensitive indicator where the intensity of indicator color changes yields H_2 concentration.
- Comes in optrode, integrated optic waveguide, and distributed sensing fiber formats.
- Verify sensor repeatability/reversibility



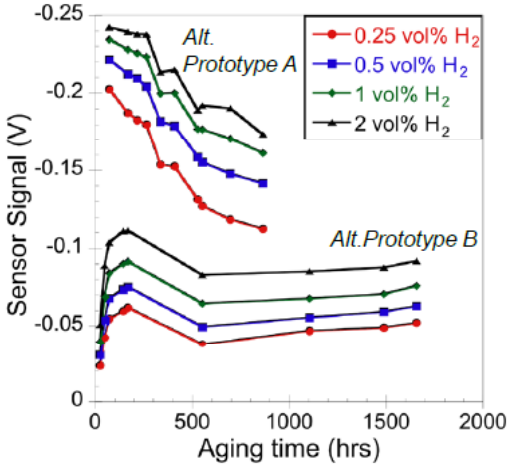
H_2 (%)	Detection Time
4.0	3 s
1.0	3 s
0.5	3 s
0.1	10 s
0.02	30 s
0.01	120 s

High sensitivity and rapid alarm capability demonstrated

Hydrogen Safety Sensors – LANL/LLNL

Controlled Interfaces for Sensor Design and Development

- Develop a sensor fabrication process and perform long term testing (minimum of 500 hrs) of pre-commercial hydrogen safety sensor prototypes.
- Stable and reproducible three phase interfaces with exceptional sensitivity and stability



Completed long-term testing (over 1,500 hrs)

DOE – NREL Safety Sensor Laboratory

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NREL works with sensor manufacturers to validate sensor technology and independently tests sensors and prototypes to provide quantitative performance specifications.

The NREL hydrogen safety sensor test facility (Robert Burgess/NREL) PIX 18240

Test Apparatus: The apparatus can simultaneously test multiple sensors and can handle all common electronic interfaces. The lab is set up for 24-hour operation, and all tests can be run and monitored remotely.

Test Plan: An NREL-developed test plan with well defined protocols in which sensor performance metrics are measured under prescribed gas composition and environmental stresses (temperature, pressure, and humidity extremes).

International Collaboration: NREL and the European Joint Research Centre's (JRC's) Institute for Energy are collaborating via round-robin testing of representative commercial hydrogen detectors. (SINTERCOM)

Manufacturer Support: The Sensor Laboratory provides manufacturers access to a state-of-the-art test facility for an independent, unbiased evaluation of their technologies. Data and an expert critique of performance metrics are shared with manufacturers.

H_2 Safety Sensor Apparatus: Designed and built at IIT.

Thank you

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DOE – Intelligent Optical Systems

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Safe Detector System for Hydrogen Leaks

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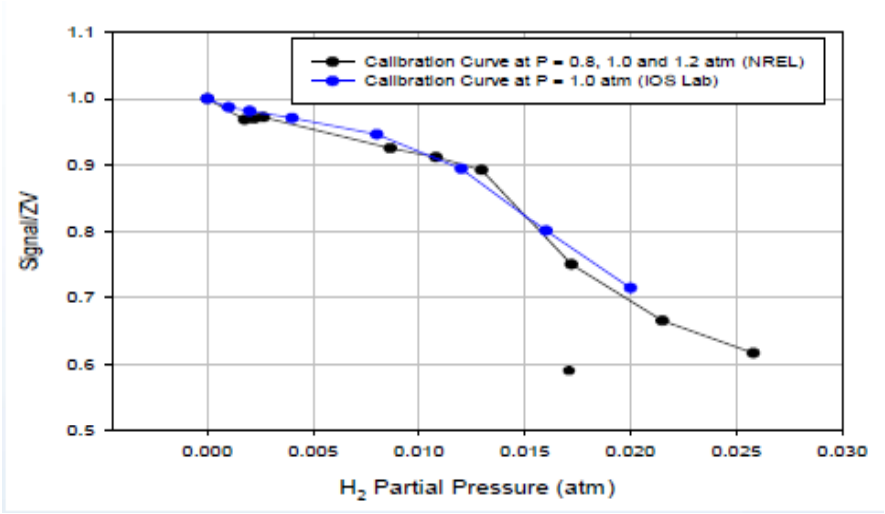
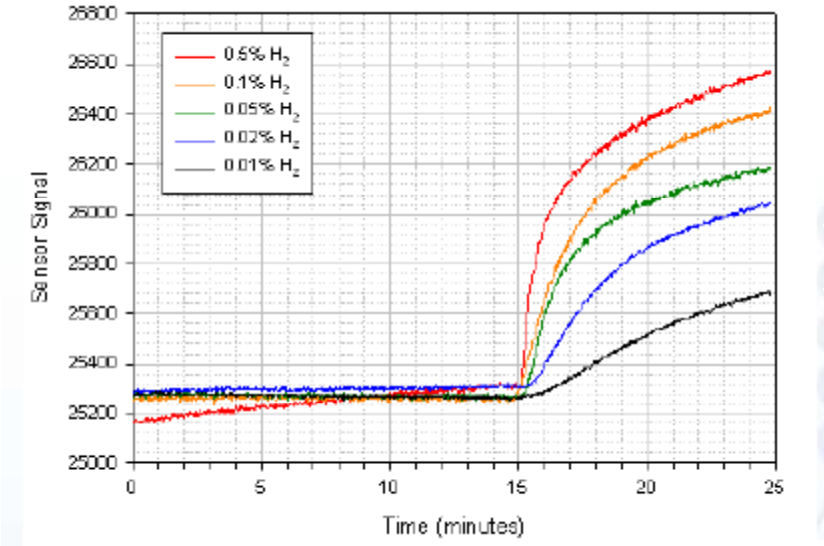
- Comes in optrode, integrated optic waveguide, and distributed sensing fiber formats.



Verify sensor repeatability/reversibility



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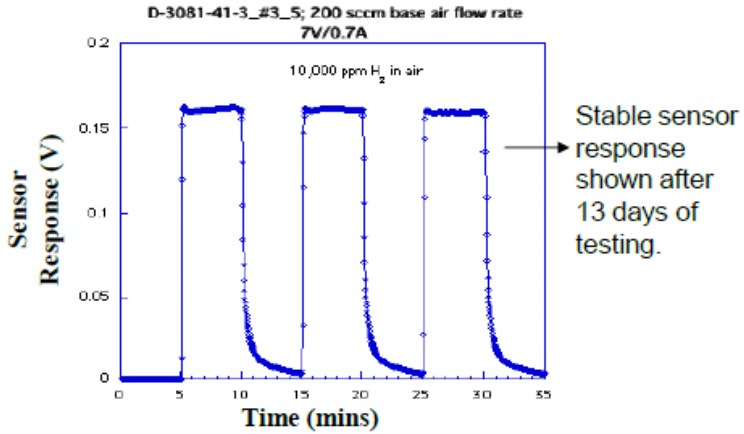
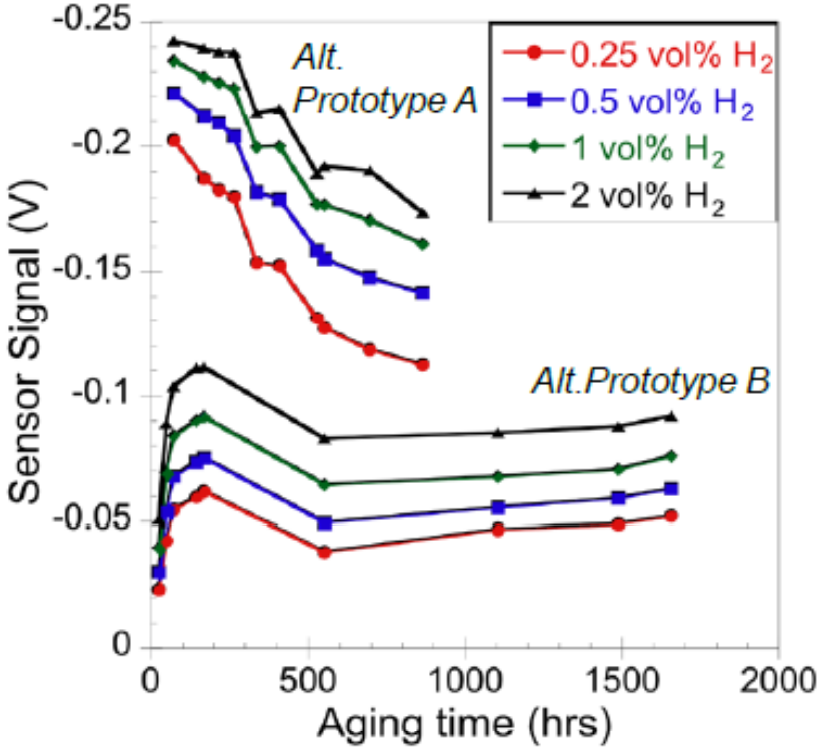


Stable sensor response shown after 13 days of testing.

Completed long-term testing (over 1,500 hrs)



Prototype that is conducive to commercialization, has low power consumption, is compact, has a simple transduction mechanism, and a fast response time.