Florida Solar Energy Center

Creating Energy Independence Since 1975

FSEC's Irreversible Chemochromic Hydrogen Sensor Overview

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Florida Solar Energy Center

Creating Energy Independence Since 1975

A Research Institute of the University of Central Florida

Florida Solar Energy Center

- Created in 1975 by the Florida Legislature
- **The** energy research institute of the state of Florida
- Mission is research, testing and education
- More than $9 - 12 million annually in external contracts and grants
- The experience, staff (>140) and capabilities to help solve our energy problems and help meet our energy needs
- Began as a “solar energy” center, but grew into many new research and development areas
- Housed in one of the world’s most energy-efficient buildings.

FSEC Program Areas

- **Hydrogen and Fuel Cells** (the future's fuels and engines)
- **Alternative Fuels & Transportation** (an agricultural opportunity for Florida)
- **High-Performance Buildings** (energy efficiency)
- **Solar Thermal Systems** (today's cost-effective solution)
- **Photovoltaics** (solar electricity)
- **Testing & Certification** (protecting Florida's citizens)
- **Education and Training** (Florida's workforce for today and the future)

Objectives

- The aim of this project is to research, develop, and demonstrate a new generation of versatile chemochromic hydrogen detector that employ "smart" materials that:
  - ***Cost less***
  - ***Are user-friendly and reliable***
  - ***Have superior field worthiness***

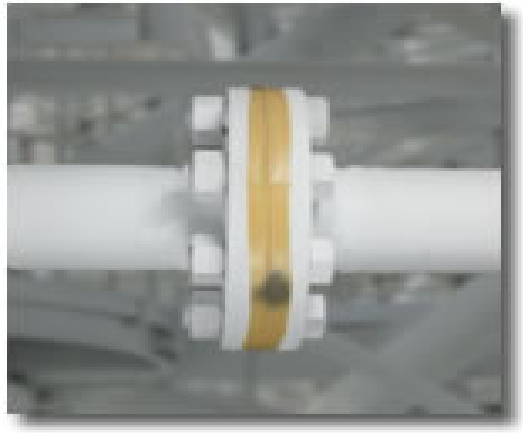
DOE-Sponsored Workshop in 2007 Fuel Producer/Supplier Environment

- A leak sensor that is to be installed every mile or so (or at every weld/joint) on a long pipeline, then the response time can be slow (perhaps in the 5 min range) but the cost per sensor has to be very low.
- If it is a leak checker carried by an operator looking for fugitive gases from small leaks, then you want a very rapid response and recovery time (on the order of 1 s), but you can take a bigger hit on the cost (say $500).
- For something like an electrolyzer installed in a remote location and possibly producing significant quantities of hydrogen you may want something in between those two cases.

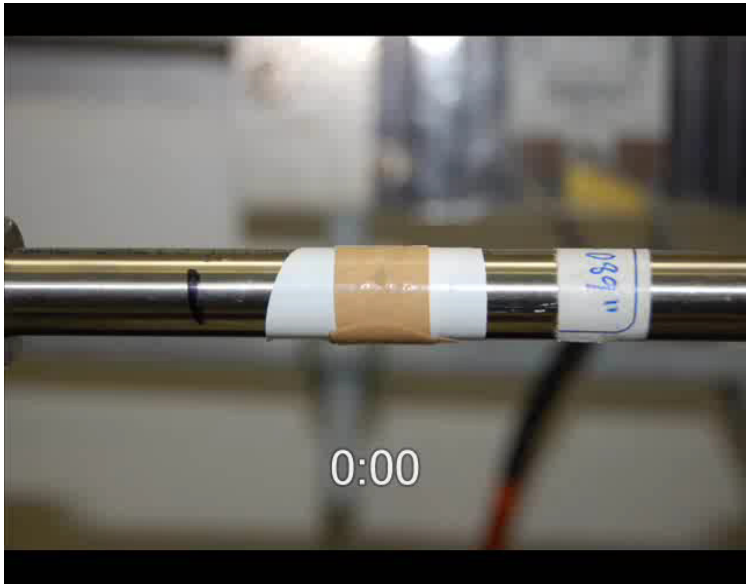
Applications

- Hydrogen Generation
  - *Ammonia plants*
  - *Oil refineries*
  - *Water electrolyzers*
- Hydrogen Storage/Distribution
  - *NASA – Kennedy Space Center*
  - *Hydrogen pipelines*
- Hydrogen Utilization
  - *Combustion Systems*
  - *Fuel Cell Applications*

FSEC's Chemochromic H_2 Sensing Materials (1st Generation)



- Team members:
  - Dr. Ali Raissi (FSEC)
  - Dr. Gary Bokerman (FSEC)
  - Dr. Janine Captain (NASA-KSC)
  - Dr. Barbara Peterson (ASRC)
  - Dr. Mary Whitten (ASRC)
- Funding:
  - NASA-GRC
  - DLA/ONR
- Commercialization
  - In talk with 3M



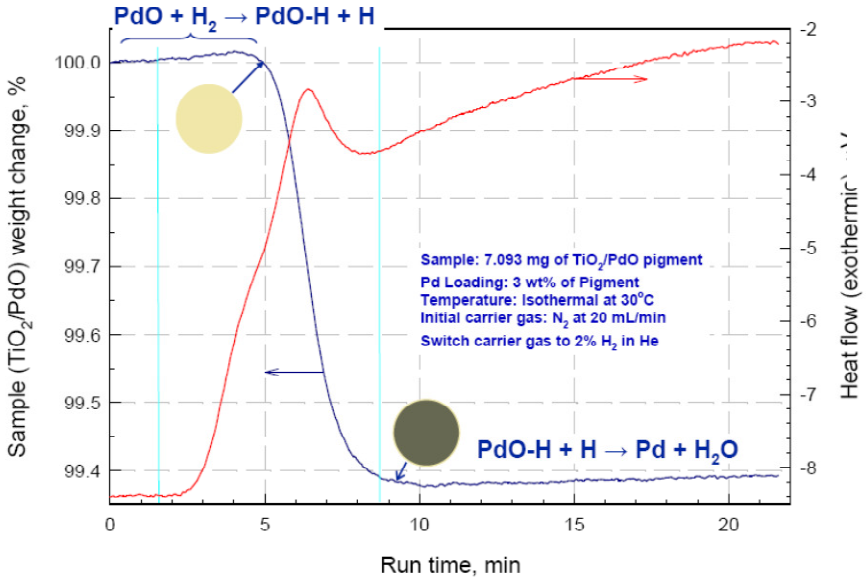
Material Costs

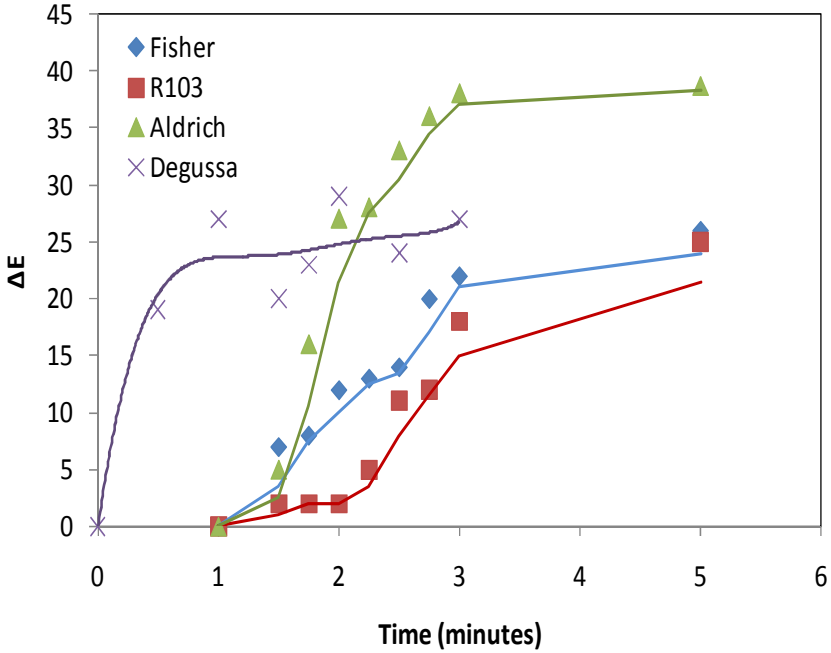
1″ Wide Chemochromic Tape

	Reagents & Chemicals ($/Yd)	Matrix ($/Yd)	Total ($/Yd)
1st Generation	0.05	0.87	0.92

1st Generation Drawback

- The main drawback of pigment used for 1st GEN H_2 sensor is its slow response time (~1.5min for a visible color change) which is believed to be due to an induction period associated with PdO reduction mechanism by H_2 gas.





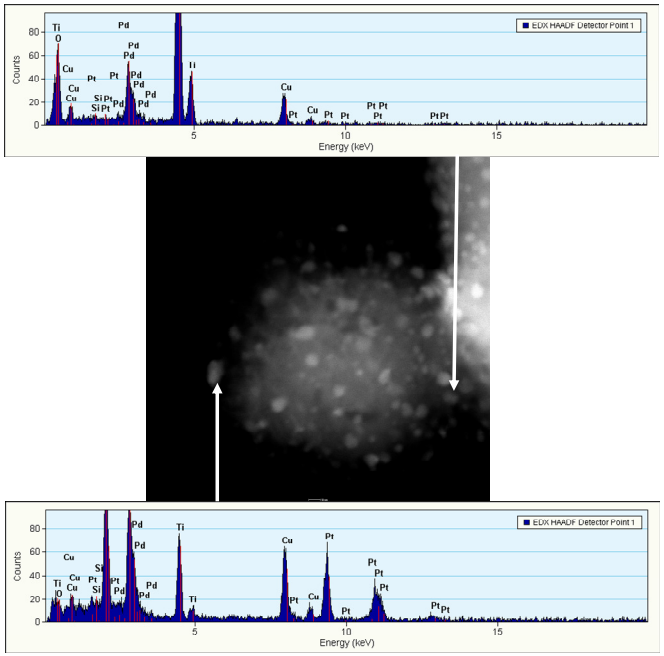
1) N. Mohajeri *et al.*, *Sens Actuators B* (2010),144,208
2) N. Mohajeri *et al.*, *Thermochim Acta* (2011), 518,119
3) G. Bokerman *et al., U.S. Patent Utility Application* 11/414,900

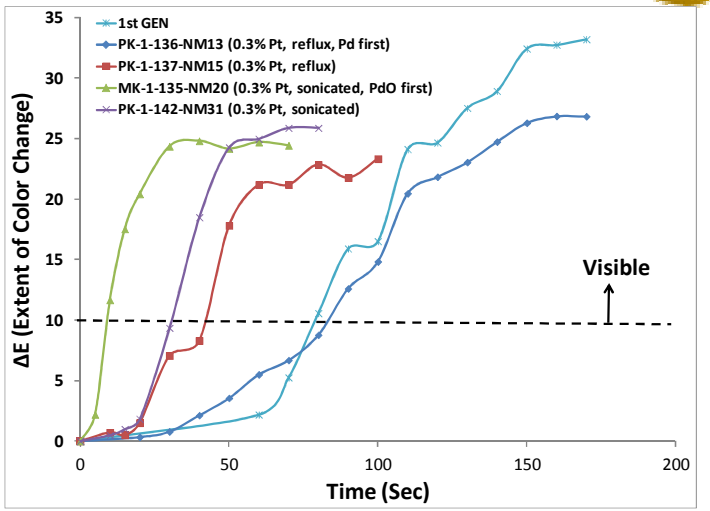
2nd Generation

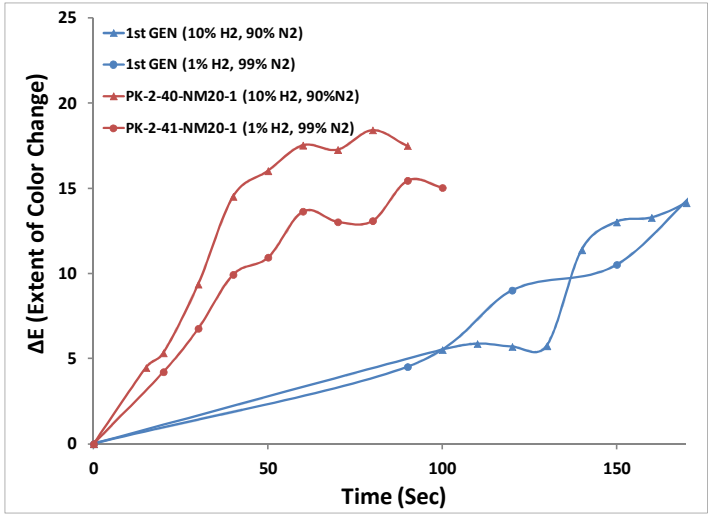
To optimize the sensor performance by Pt doping (3 wt% Pd, 0.3 wt% Pt) using two techniques:

A) Reflux

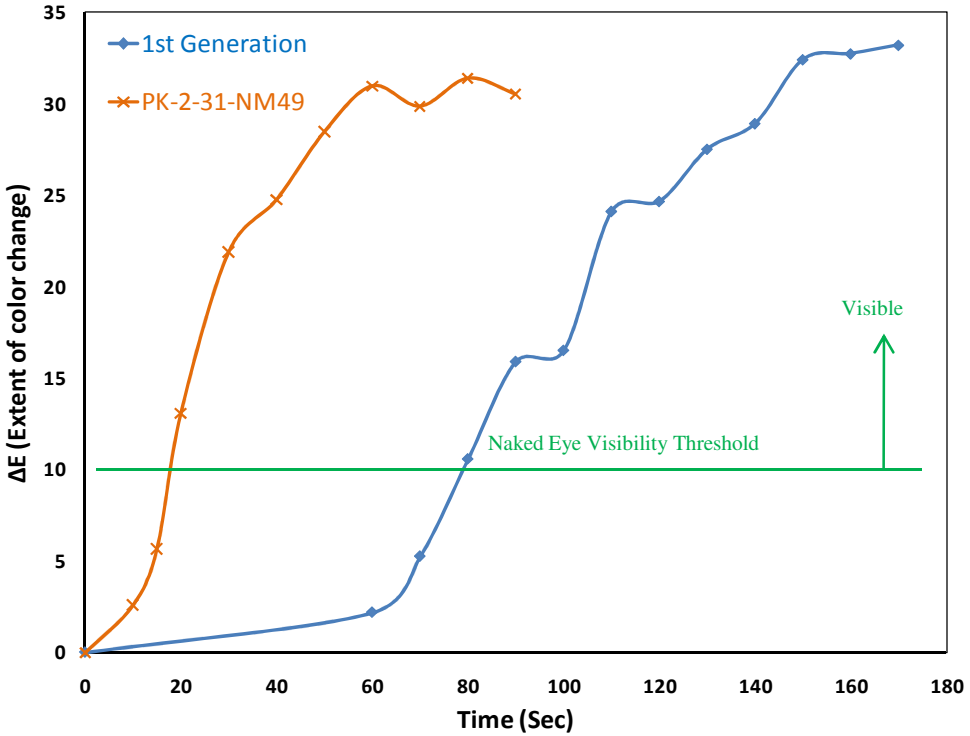
B) Sonochemistry





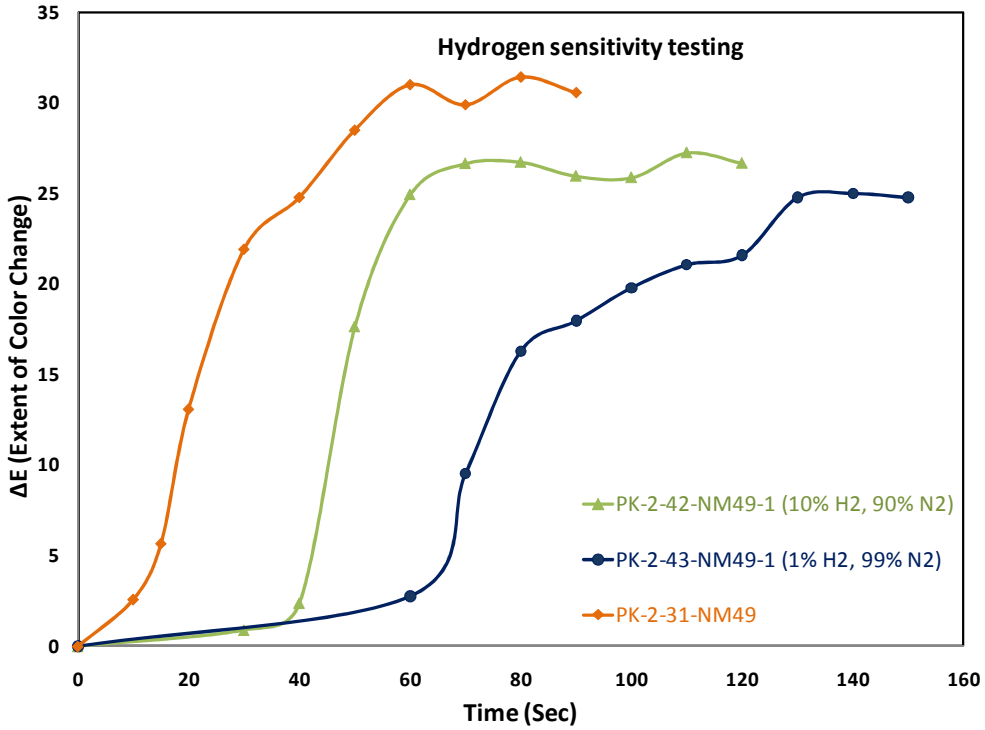


3rd Generation



- The response time for PK-2-31-NM49 chemochromic sensor is 20% of the FSEC's 1st Generation sensor.
- The extent of color change (ΔE), in saturation, for PK-2-31-NM49 is almost the same as FSEC's 1st Generation

3rd Generation- H_2 Sensitivity



- PK-2-31-NM49 Chemochromic Sensor shows a great sensitivity and response to 10% and 1% H_2 gas mixture (1% curve exposure kinetics are as good as FSEC's 1st Generation sensor).
- No reaction with CH_4, CO, and H_2S was noticed after one hour at room temperature.

Acknowledgement

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