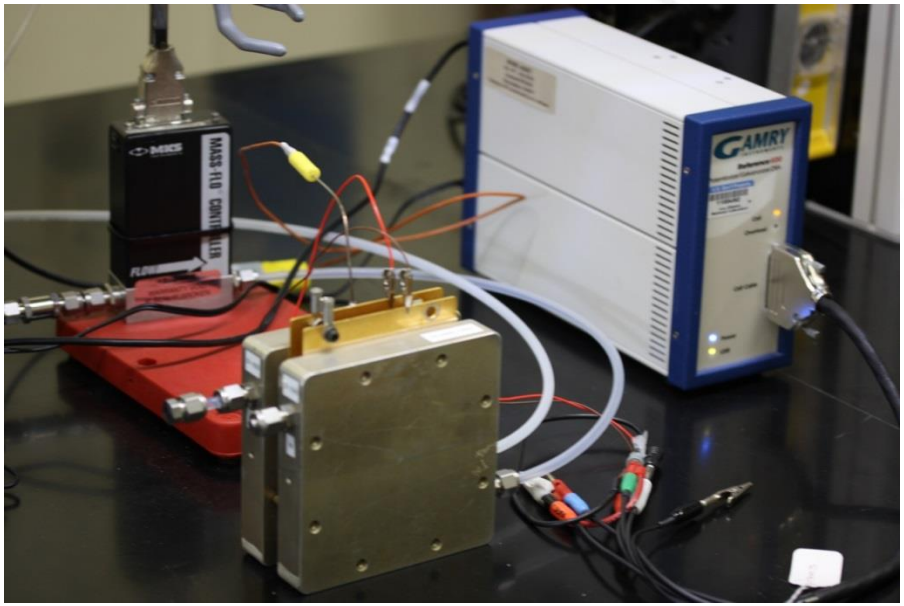
Electrochemical Approaches to Hydrogen Contaminant Detection



Team:

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Outline

- Problem Statement
- Potential Solutions
  - SKYRE, Southwest Sciences Inc., LANL
- Prototype development at LANL
- Field Testing at H2Frontier
- Future Work/Summary

Problem Statement

Problem:

Certain contaminants in the hydrogen fuel steam can cause irreversible damage to Fuel Cell systems and therefore should be avoided. Stations required to do expensive certification (≈ $3500) periodically (6 months) to meet SAE J2719 standard. An in-line fuel quality analyzer can significantly improve the reliability of the Hydrogen Infrastructure and alert station operators to problems in a timely manner

Requirements:

1. A low cost (< $1000) fast response (< 5 minutes) device (analyzer) to measure impurities in a dry hydrogen fuel stream at or above the SAE J2719 levels.

SAE J2719 impurities	Allowed levels
Carbon Monoxide (CO)	200 ppb
Hydrogen Sulfide (H_2S)	4 ppb
Ammonia (NH_3)	100 ppb
Water (H_2O)	5 ppm

DOE funded Solutions

SCS program (Project Manager: Laura Hill)

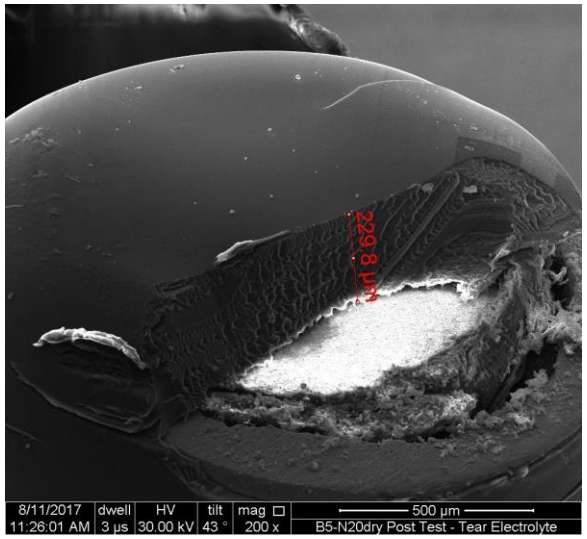
SKYRE (SBIR) : High pressure electrochemical sensor

Southwest Sciences Inc (SBIR) : Diode Laser Sensor

LANL : Electrochemical H_2 fuel quality analyzer

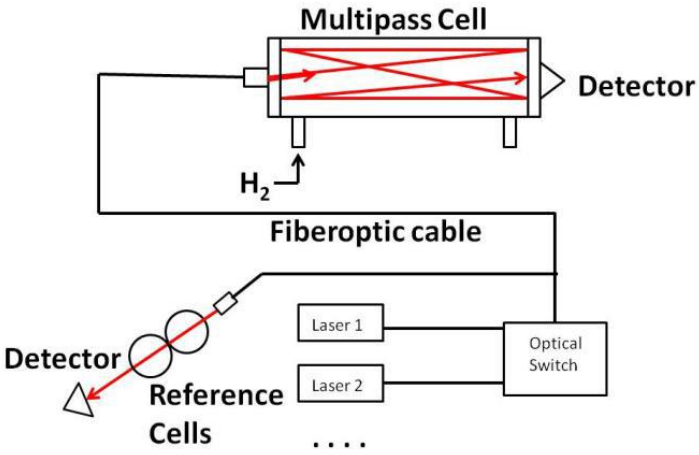
SKYRE and University of Connecticut

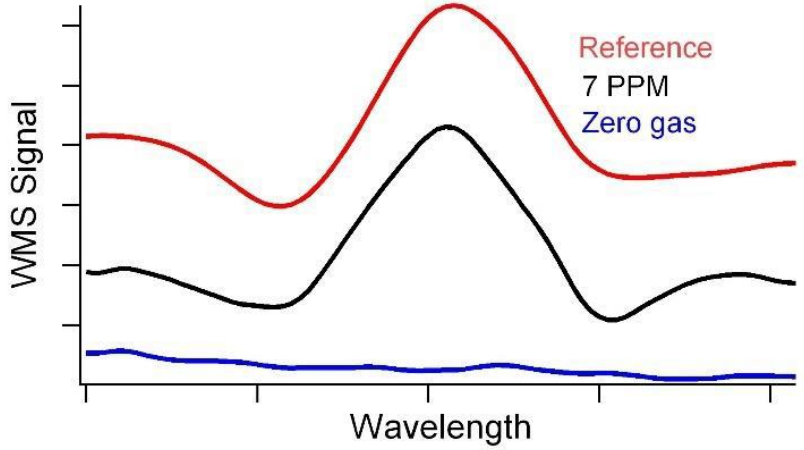
- High pressure test system designed/built at SKYRE to evaluate sensors upto 4500 psi
- Thermocouple type device with wire electrodes covered with Nafion® electrolyte
- High pressure humidifier bottle is part of system



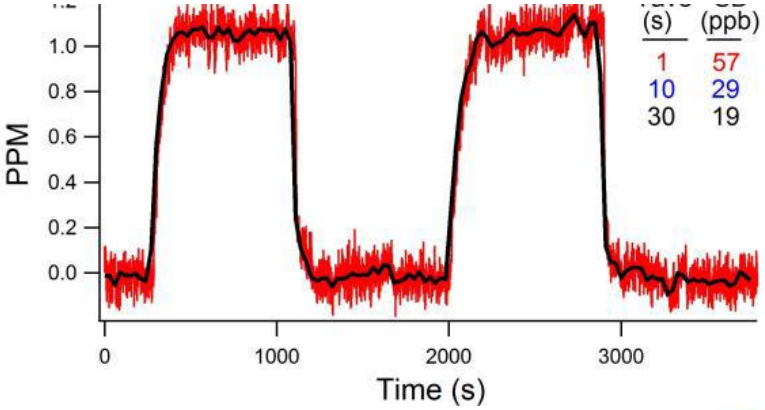
DOE funded Solutions

Southwest Sciences, Inc



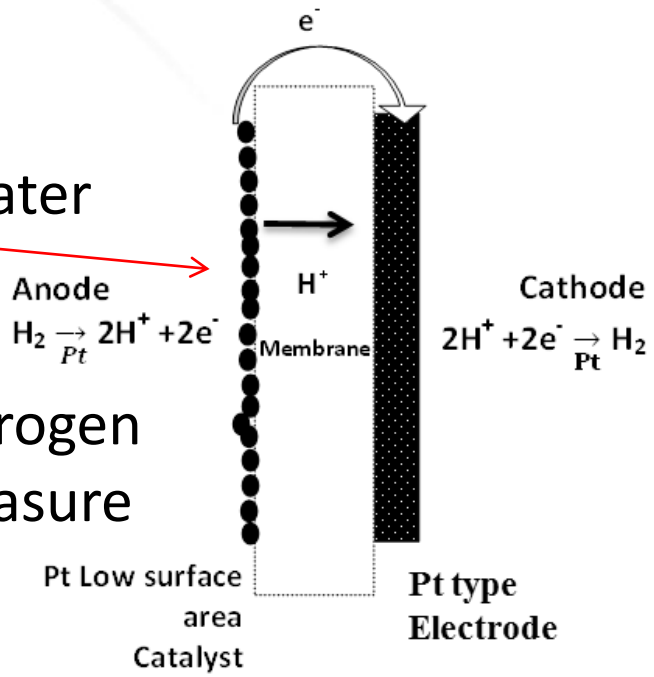


- Developed different lasers for detection of CO, H_2S, NH_3 and water
- Technology originally developed for atmospheric monitoring
- In laboratory testing to be validated at LANL

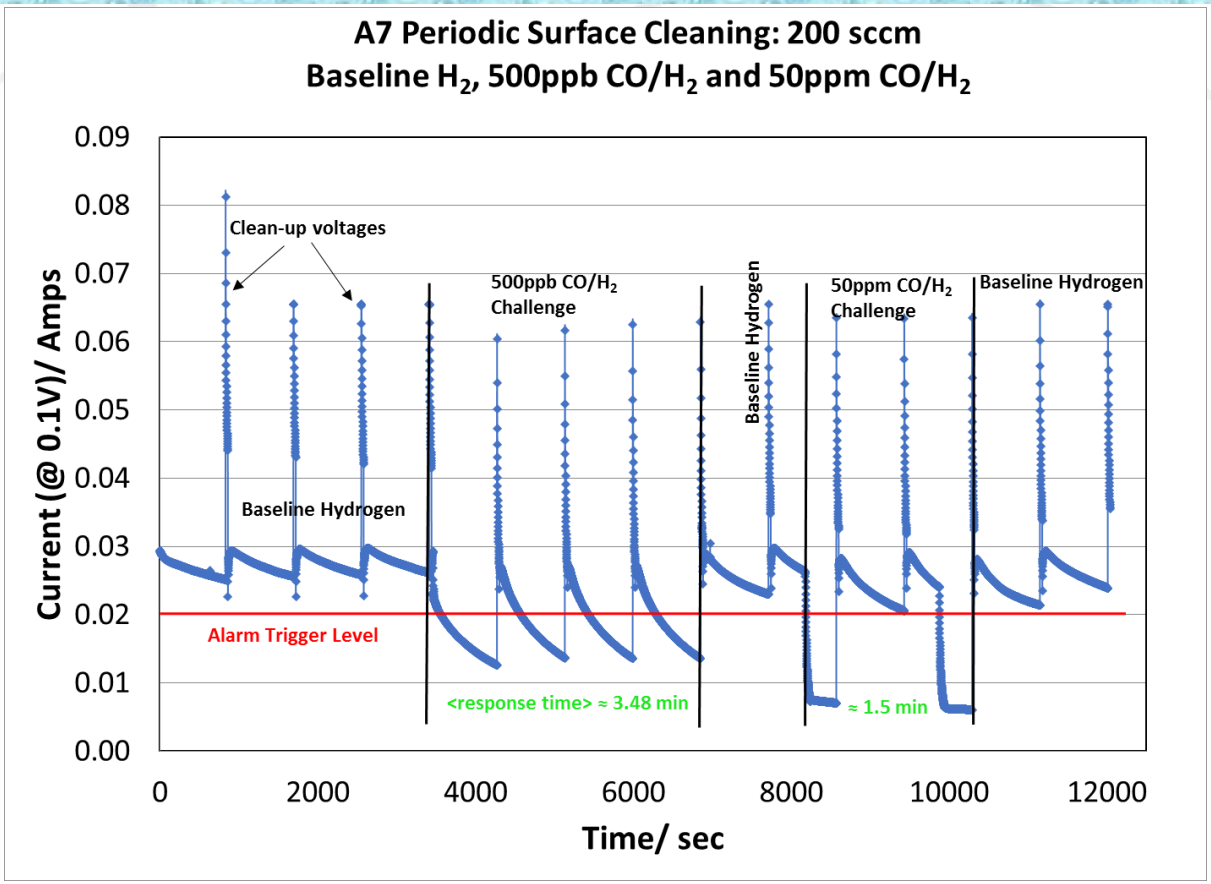


LANL Approach

- A miniature fuel cell can be used in the hydrogen stream to detect impurities that can be harmful to the fuel cell stack
- However, no continuous source of air or water available at the filling station
- Device operates as an electrochemical hydrogen pump using a MEA-type configuration. Measure pumping current before, during and after contaminant exposure**. (No Air required)**
- Provide hydration via a ***Wicking Scheme***



Pulsed Operating Mode Demonstrated



Ave. Response Time:

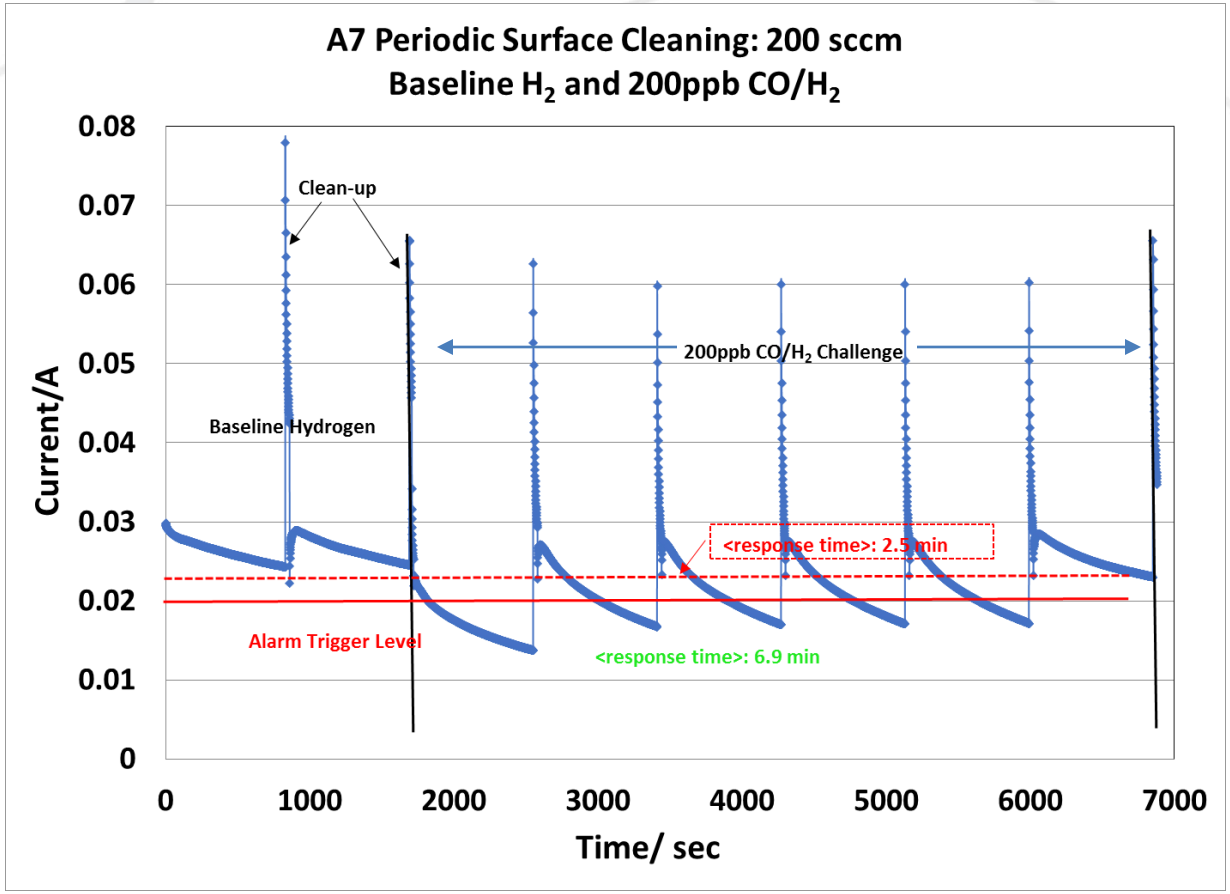
500ppb CO: **3.48 min**

50ppm CO: **1.5 min**

1.5V, 30s clean up pulses between 15 minute measurements at 0.1V

Response time < 5 min (filling up 1 car)

CO detected at SAE J2719 Level



Ave Response Time: **6.9 min**

Adjusted Trigger Level
Ave Response Time: **2.5 min**

Sensitivity to 200ppb CO in < 5 minutes demonstrated

Collaborator: Testing Partner for Analyzer Field Trials

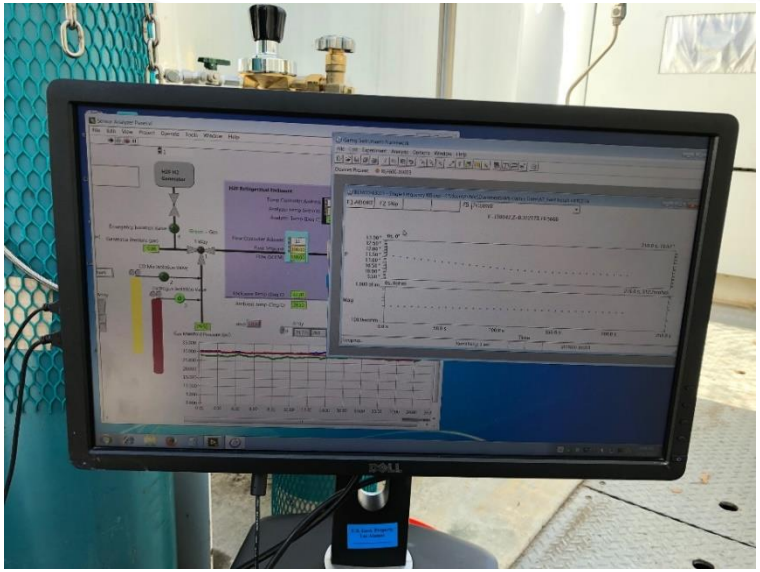
H2 Frontier Inc
Hydrogen Generation, Storage & Delivery Systems

- Dan Poppe at H2Frontier volunteered access to the Burbank CA station for Analyzer Field Trials experiments.
- Collaboration established in 2014
- Experiments conducted remotely from LANL.

2017 R&D 100 WINNER

LANL, LLNL, and H2F capture R&D 100 award for hydrogen safety sensor work (previous SCS project)

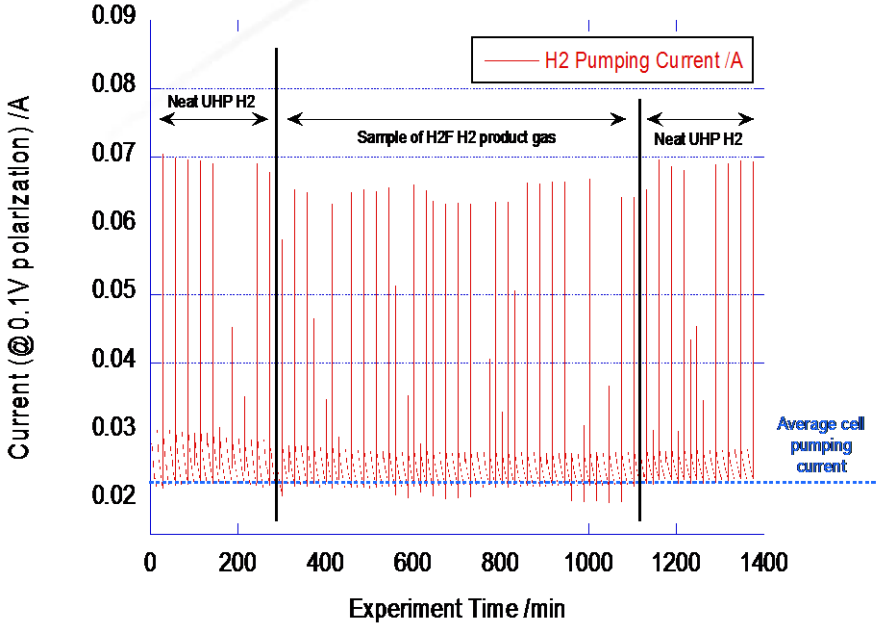
Analyzer Installed and Tested in Field (March 18)



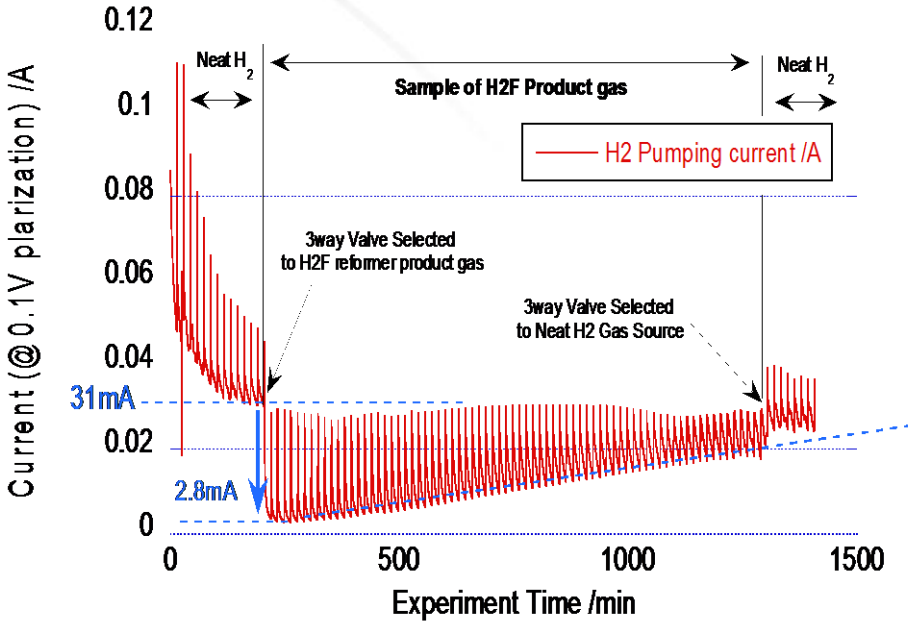
- Installed analyzer and potentiostat in temp controlled enclosure
- Remote access software used to monitor and control experiments from Los Alamos

Field Data

Clean H_2



Contaminated H_2 during reformer start up



- Extensive baseline data obtained
- Demonstrated ability to detect low levels of impurities in H_2 with fast response time using a low cost instrument

Remaining R&D needs

- Long term stability, drift and calibration
- Package analyzer with lower cost electronics
- Differentiate/Quantify CO, H_2S with clean up voltage
- Eliminate MFCs and control flow with orifices
- Ability to operate under pressure at various locations within the H_2 fueling infrastructure

  - Eliminate wicking system
    - Decreases flow rate dependence of baseline
    - Decreases RH dependence of baseline
    - Decreases maintenance and calibration
    - Provides flexibility with packaging to position at various locations with in H_2 fueling infrastructure

Future Work / Summary

- A miniature fuel cell with an external wicking system can be used to detect impurities in a dry H_2 stream.
  - Ambient pressure
  - Fixed flow rate of H_2
- Ability to detect SAE J2719 levels of CO in ≈ 2.5 minutes
- Developing system with alternative electrolyte
  - Ability to operate without water source
  - Ability to operate under pressure
- Developing Impedance capability
  - Ability to operate at different temperatures
- Long term goal : Inline operation within refueling system
- Collaborating with SKYRE and Southwest Sciences