

# Optical Hydrogen Sensor for Inert Environments

Jerald A. Cole

Alexander Trunov

Robert A. Lieberman



INTELLIGENT OPTICAL  
SYSTEMS, INC.

# Acknowledgements

- NASA Contracts
  - NAS13-01038
  - NAS10-02039
- DOE Contract
  - DE-FC36-06G086057

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# Optical Hydrogen Sensors

- No copper wire!
- Key safety consideration in certain applications
- Low power requirements
- Easily multiplexed over long distances
- e.g. Benson-Tracy detector

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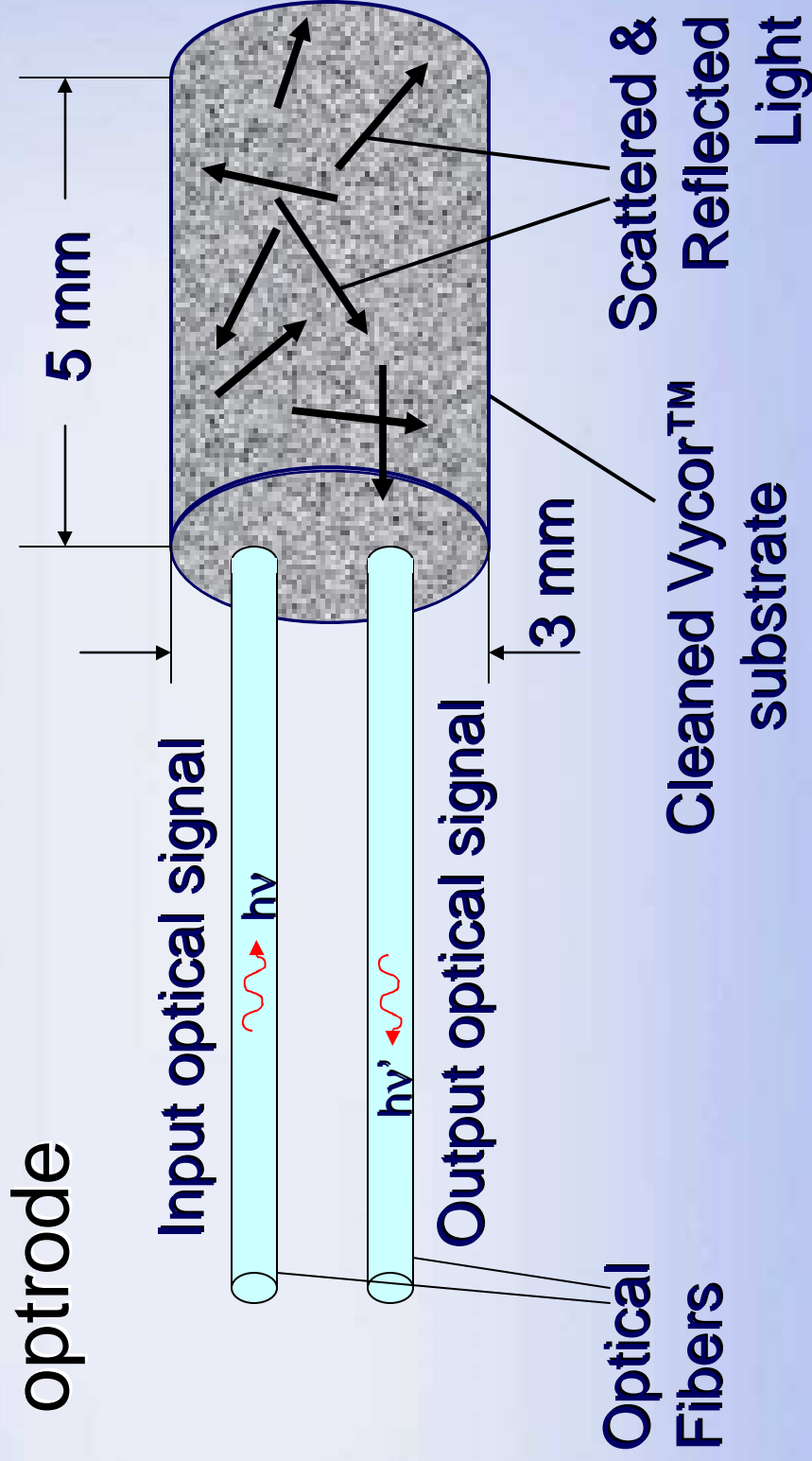
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# Optical Hydrogen Sensors

- Thin film sensors
  - 10 nm Pd film over 1  $\mu\text{m}$  layer of  $\text{WO}_3$
  - ~ 20 s response time
  - Color change from yellow to blue
- Porous matrix sensors
  - Chemistry deposited as nanocrystals in 4 nm pores
  - ~ 1 – 3 s response time
  - Change in extinction coefficient

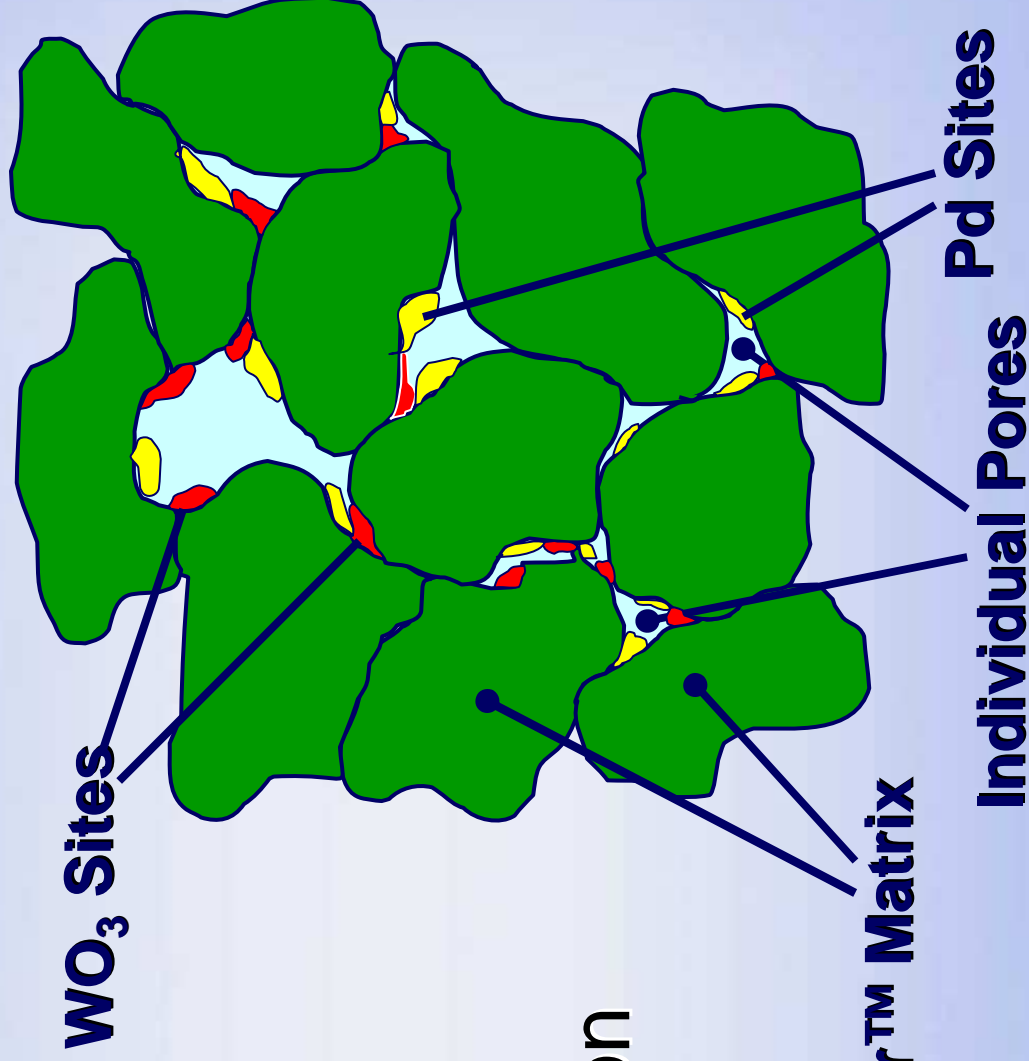
# Porous Matrix Optrode

- Replace thin film with porous optrode



# Porous Matrix Optrode

- Distributed active sites
- Open pore structure for rapid diffusion
- Nano-scale structure



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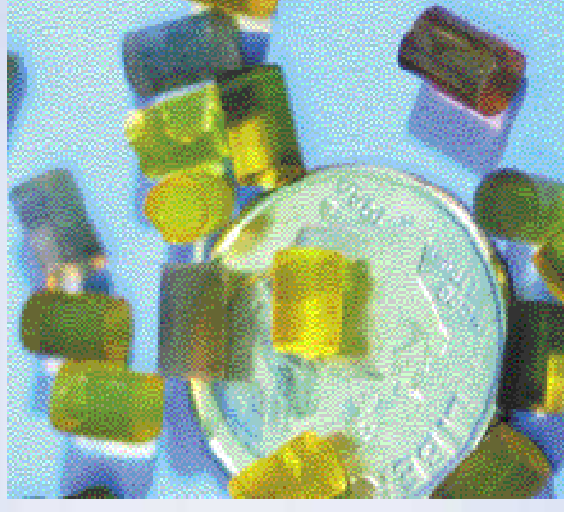
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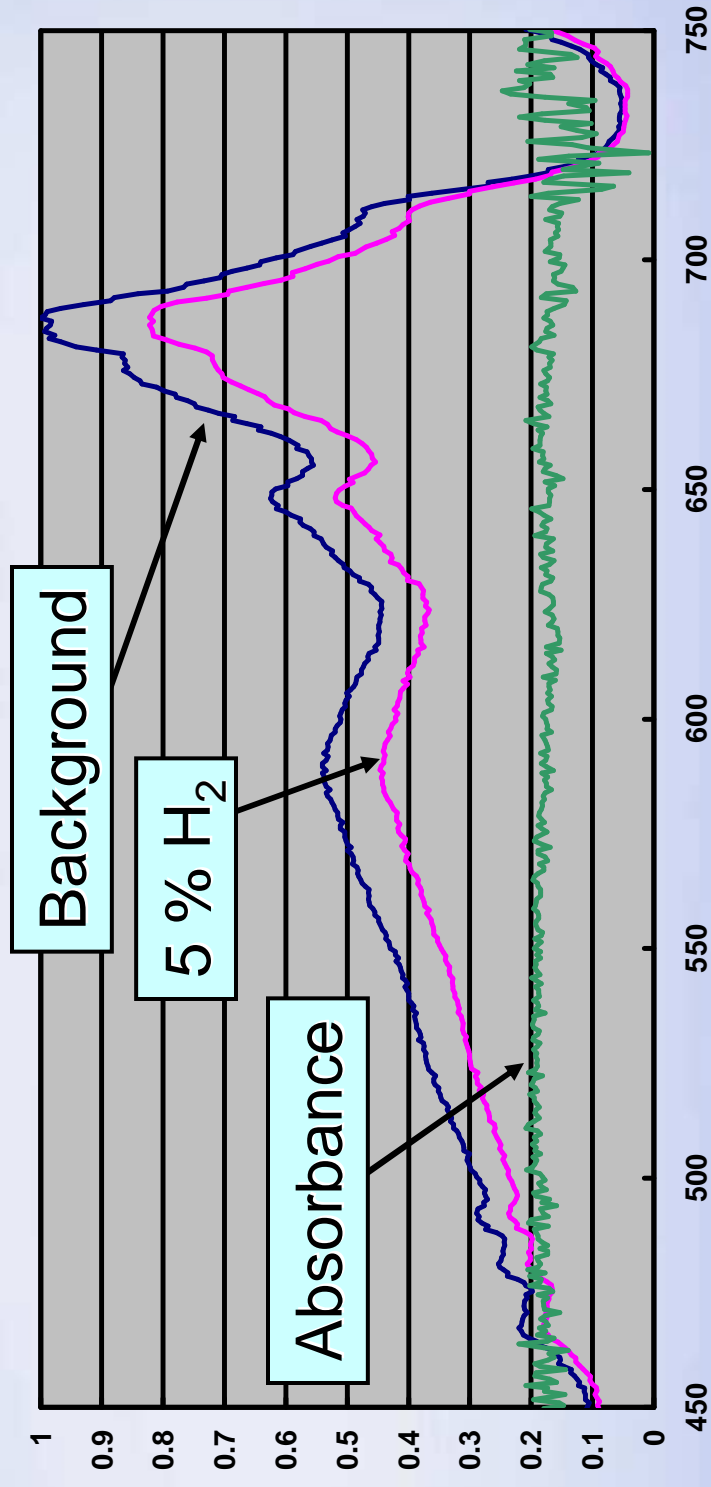
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# Porous Matrix Optrode

- Advantages
  - Rapid Response Time
  - Low -cost mfg
  - Long optical path
  - Variable geometry
- Challenges
  - Oxygen effect
  - Moisture/humidity
  - Temperature/Pressure effects



# Optical Characteristics

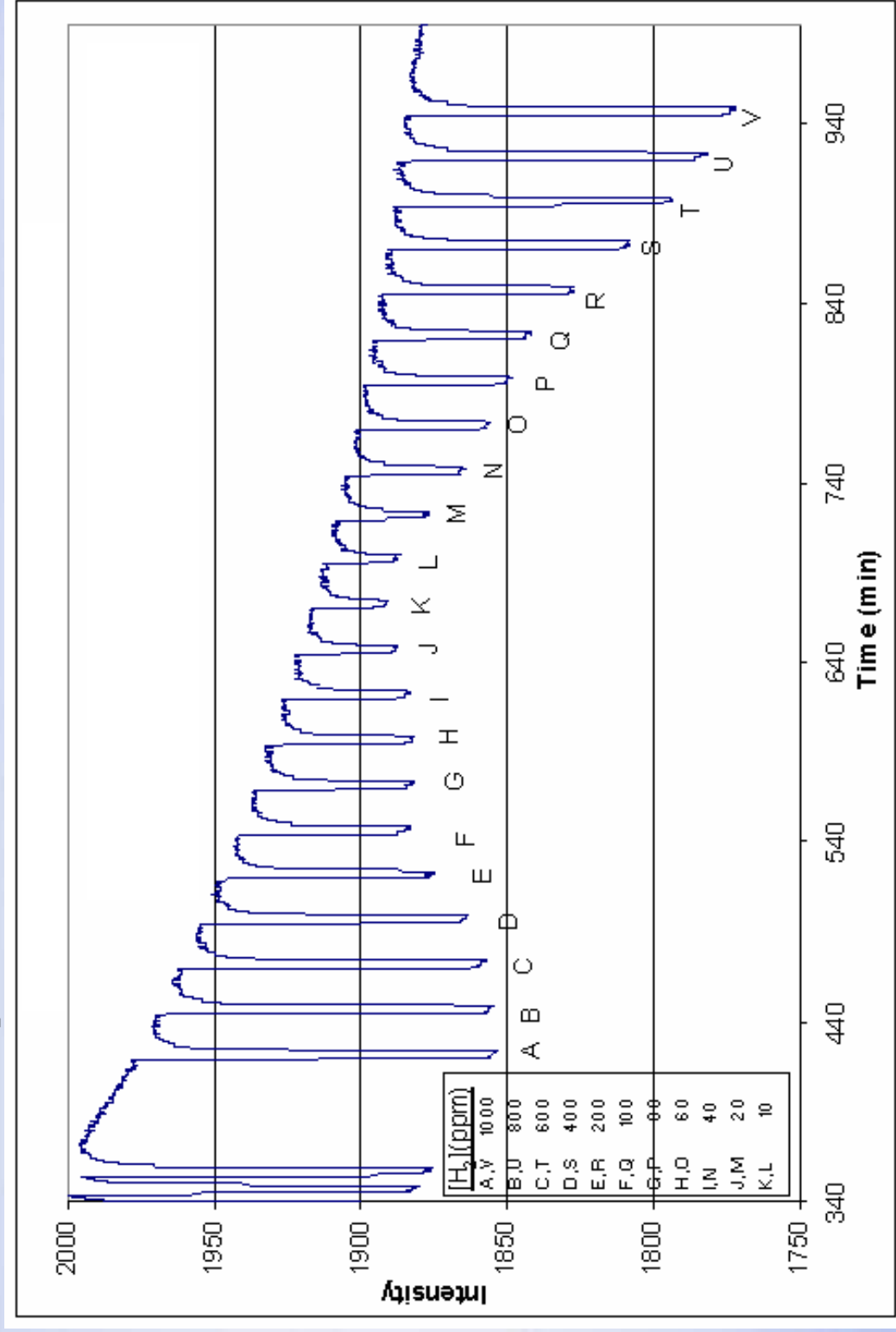


➤ No change in absorbance across visible spectrum

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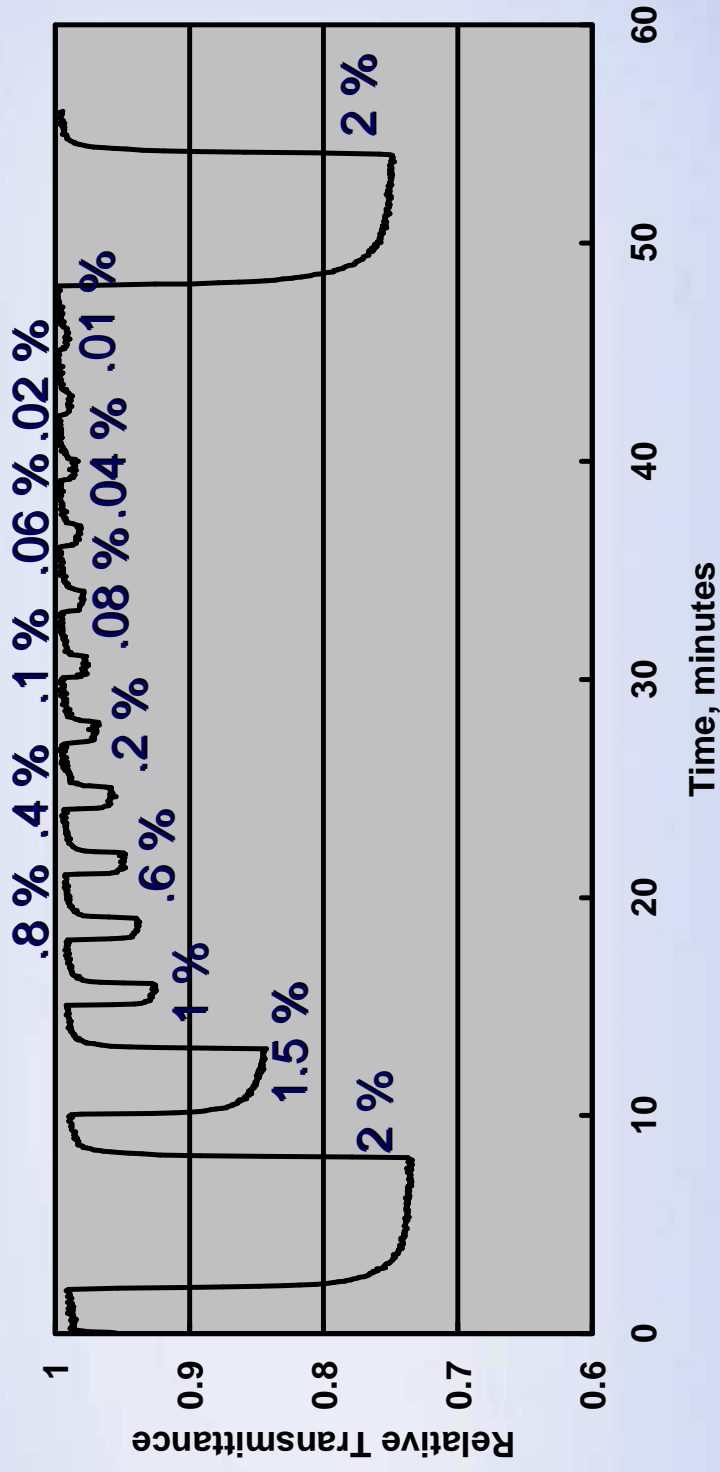
# Response Characteristics



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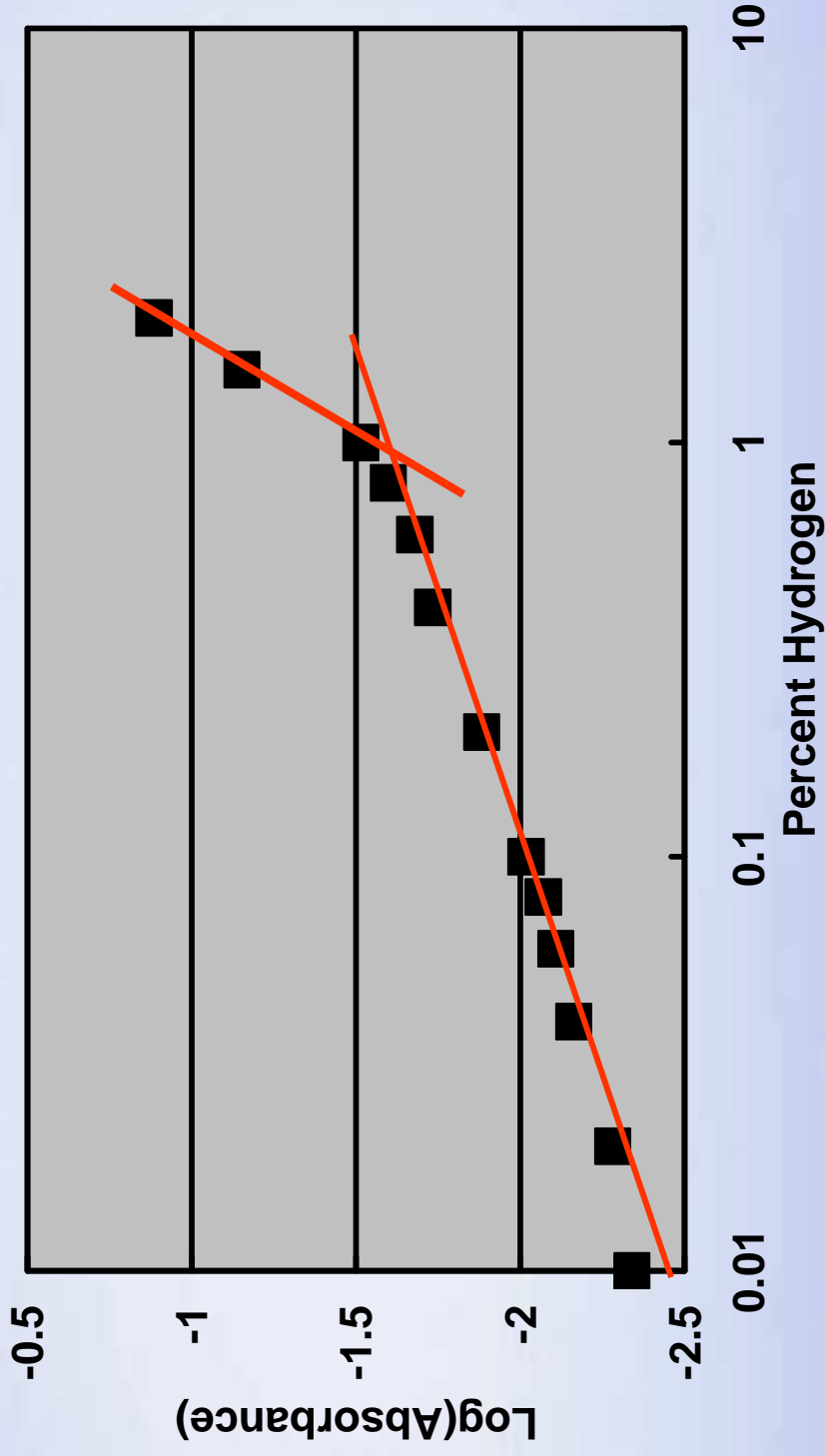
# Response Characteristics



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# Response Characteristics

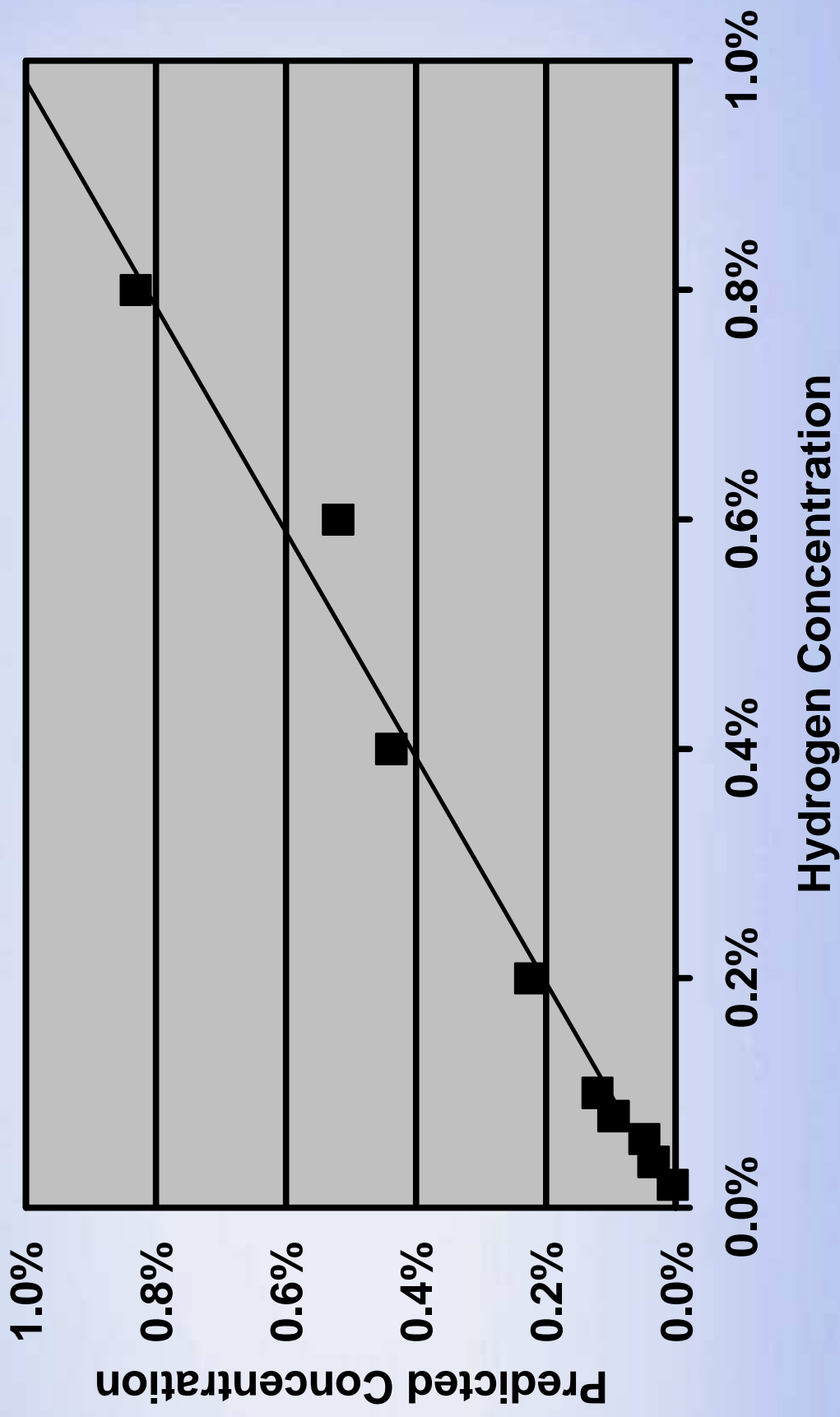


➤ Two linear regions correspond to  $\text{Pd(H)}^{\alpha \rightarrow \beta}$  transition

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# Response Characteristics



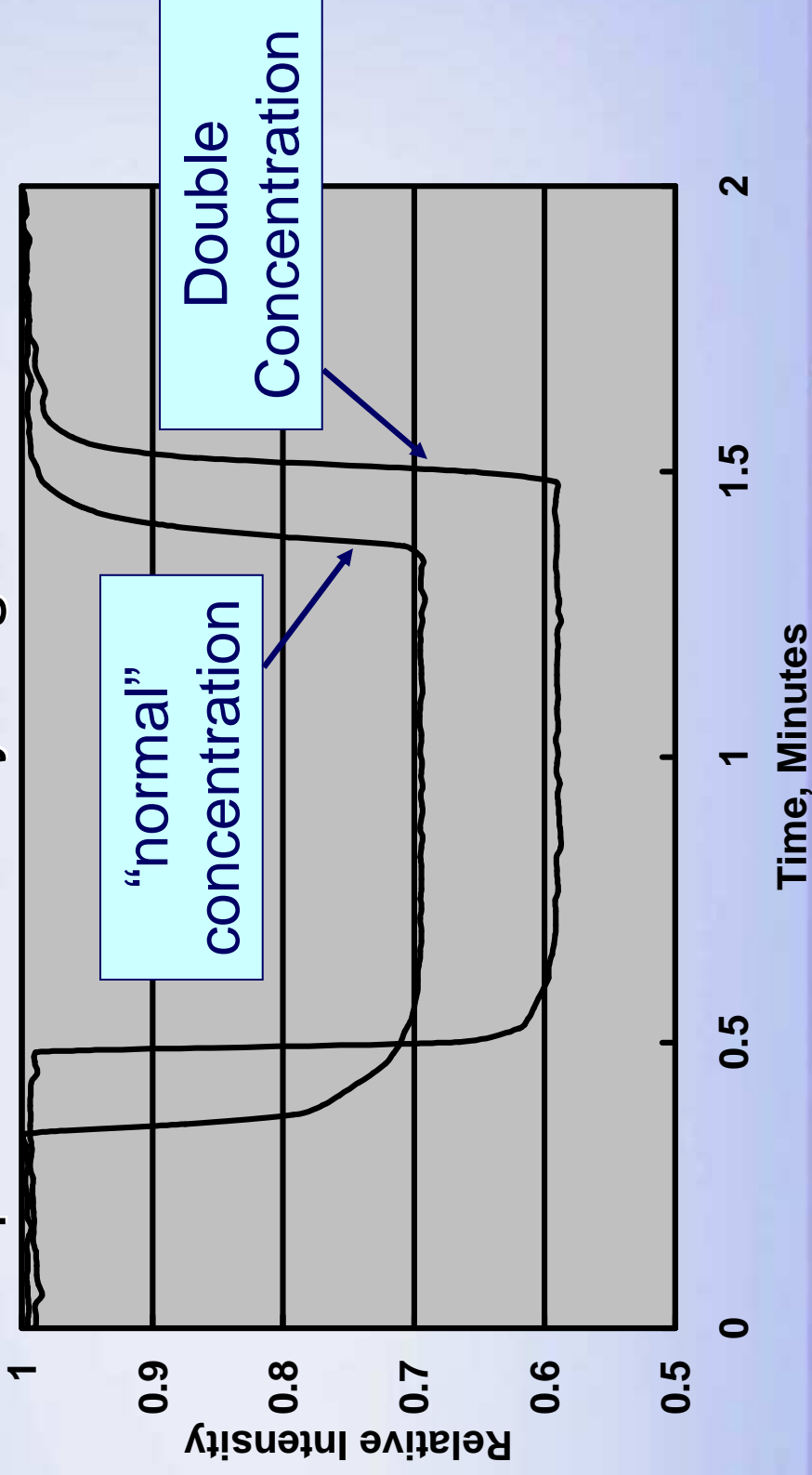
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# Process Control

## ■ Impact of indicator chemistry

### ■ Response to 5 % hydrogen

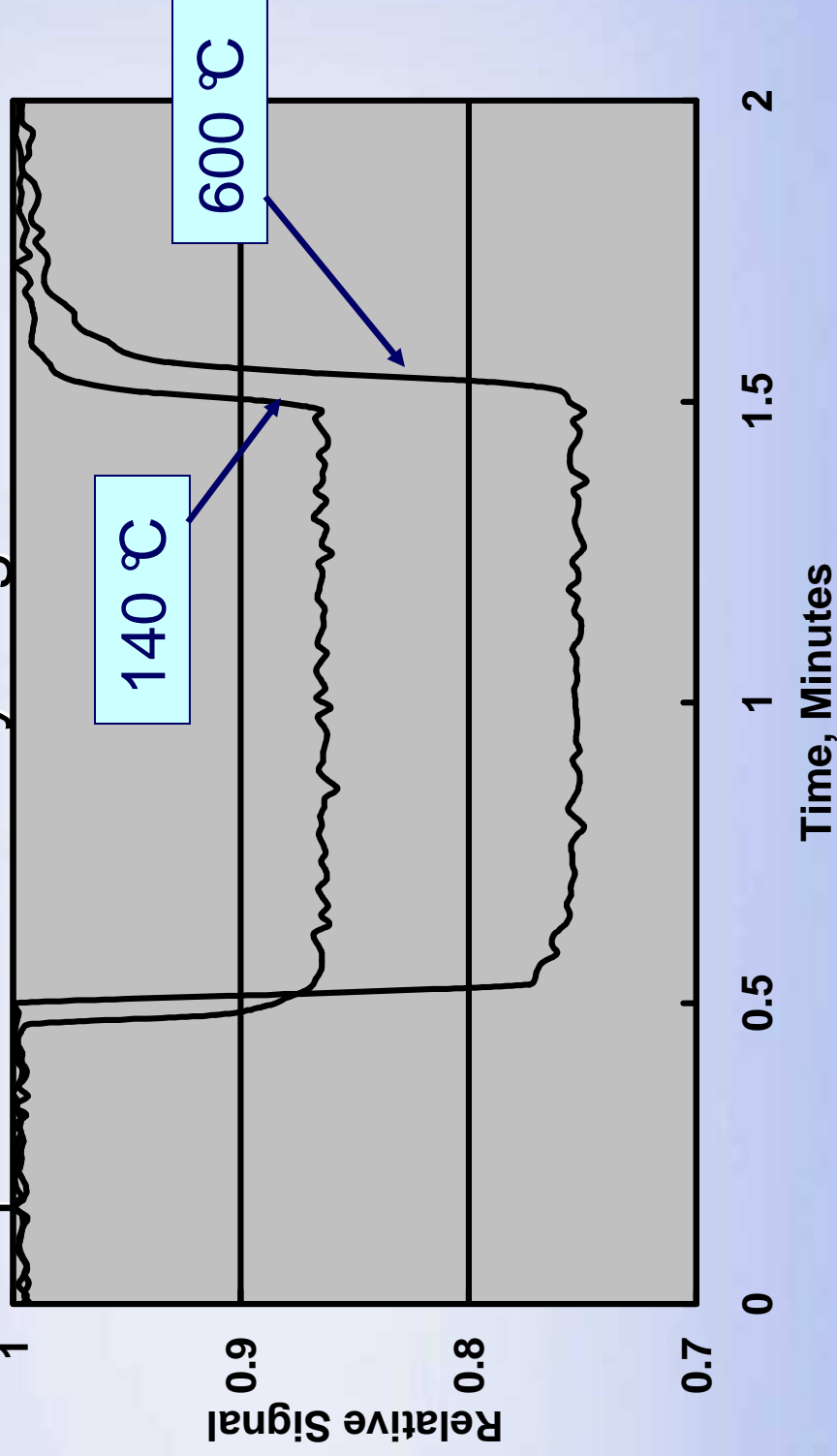


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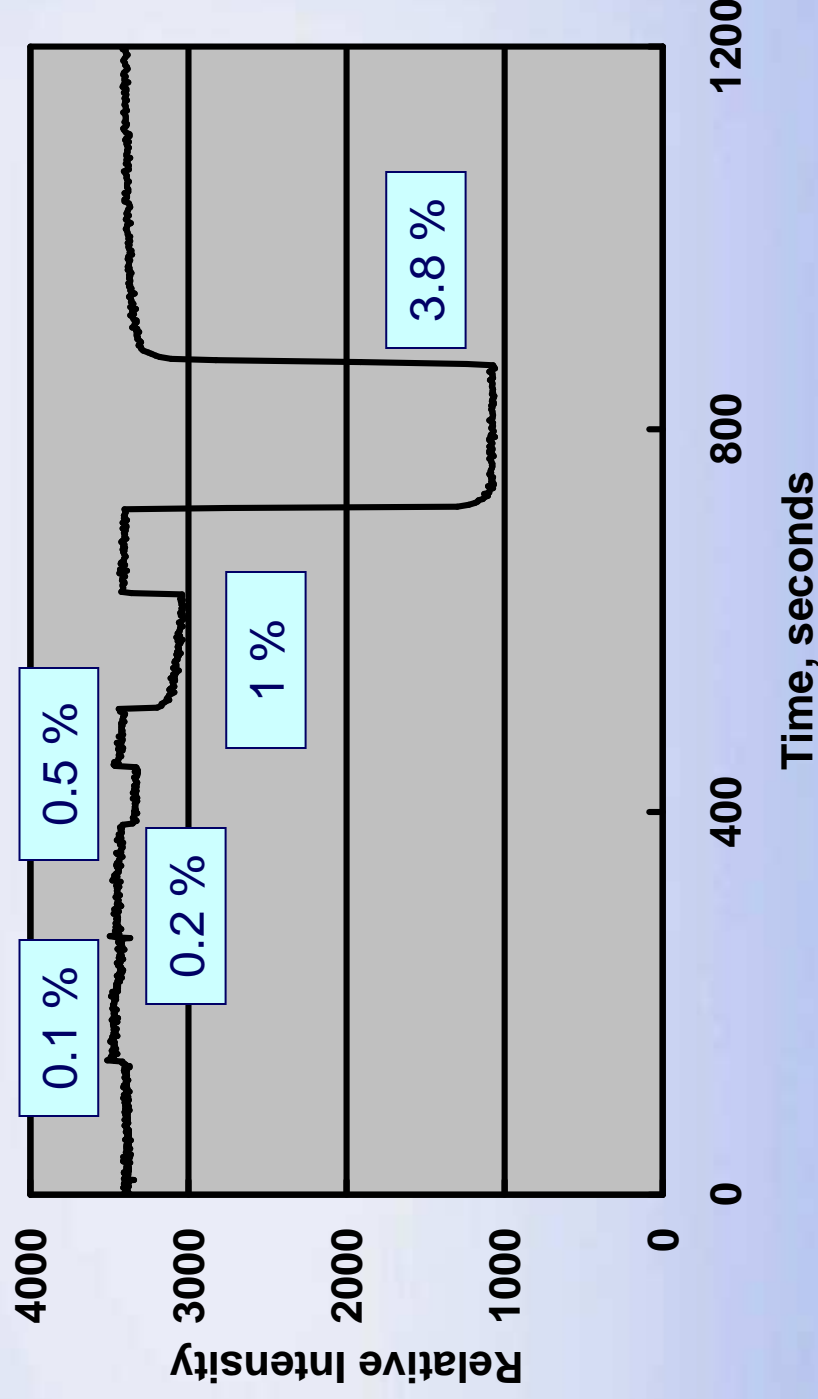
# Process Control

- Impact of cleaning temperature
- Response to 5 % hydrogen



# Oxygen Effect

- Reduced range in presence of air
- Response to different hydrogen concentrations

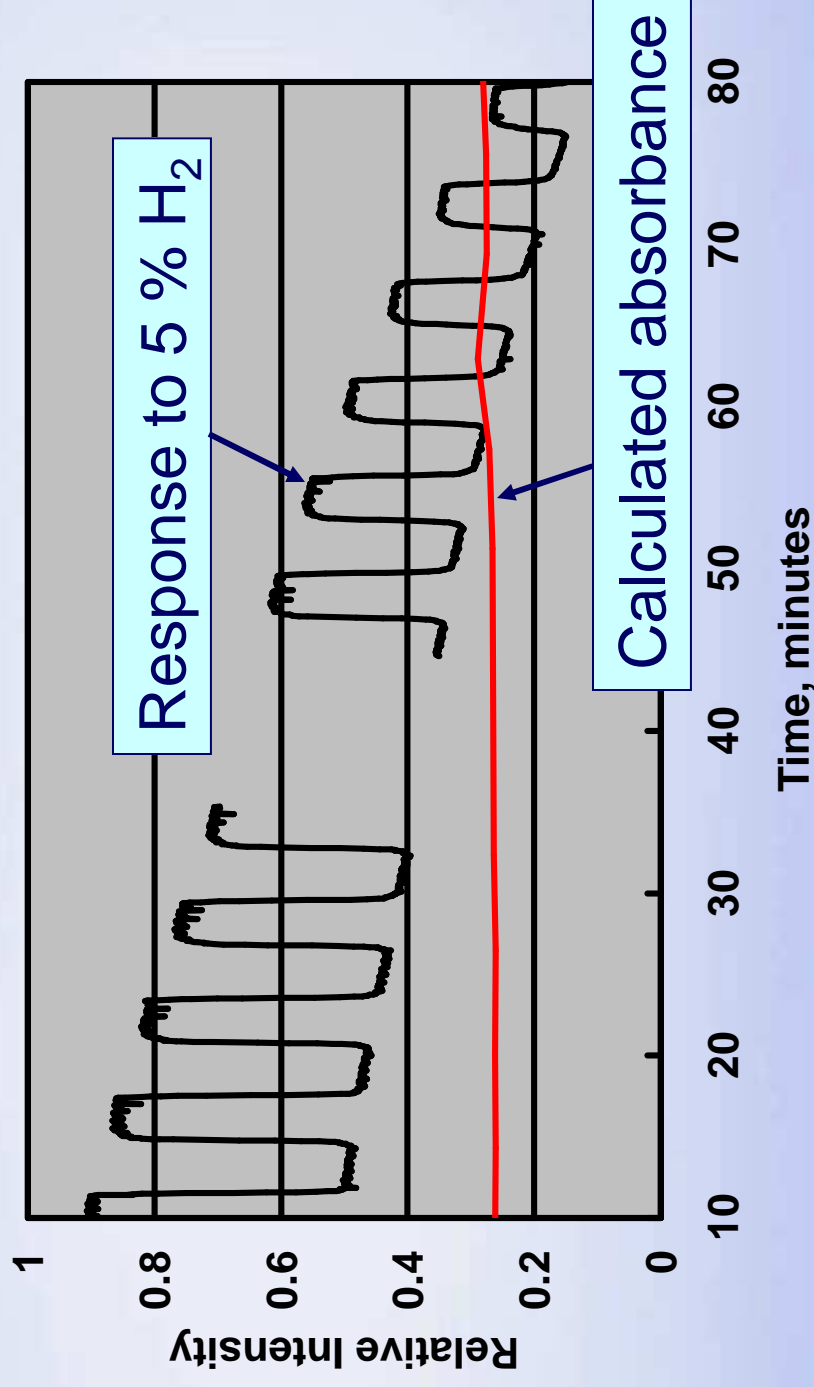


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# Humidity Effect

- Impact of exposure to 90 % r.h.

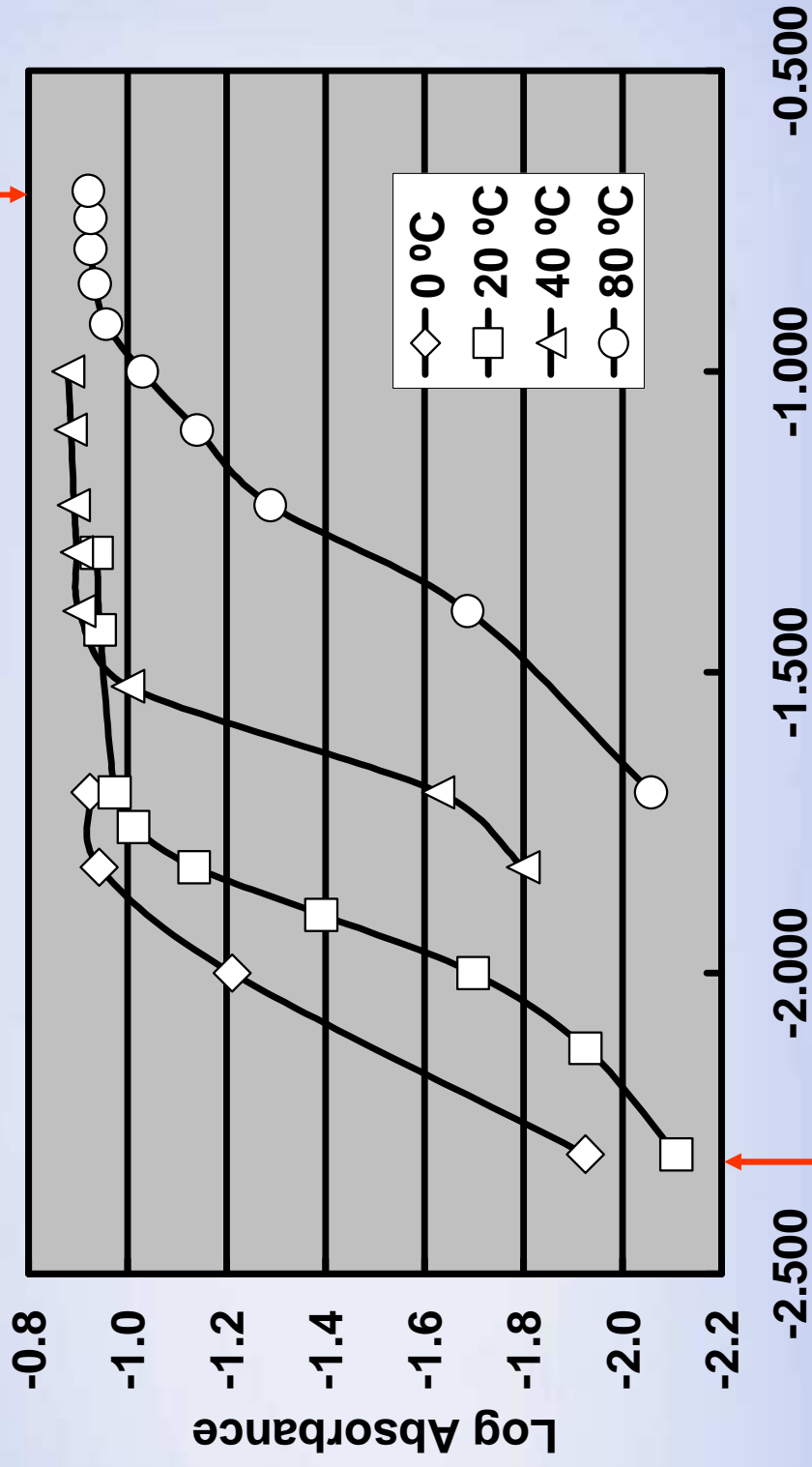


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# Temperature Effect

20 % H<sub>2</sub>



Log Hydrogen Mole Fraction

0.5 % H<sub>2</sub>

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# Summary

- Fast response time
- Wide dynamic range
  - ca. 1 ppm – 5 %
  - Limited in presence of O<sub>2</sub>
- Can be calibrated for temperature, humidity
- Opportunities for varied applications

