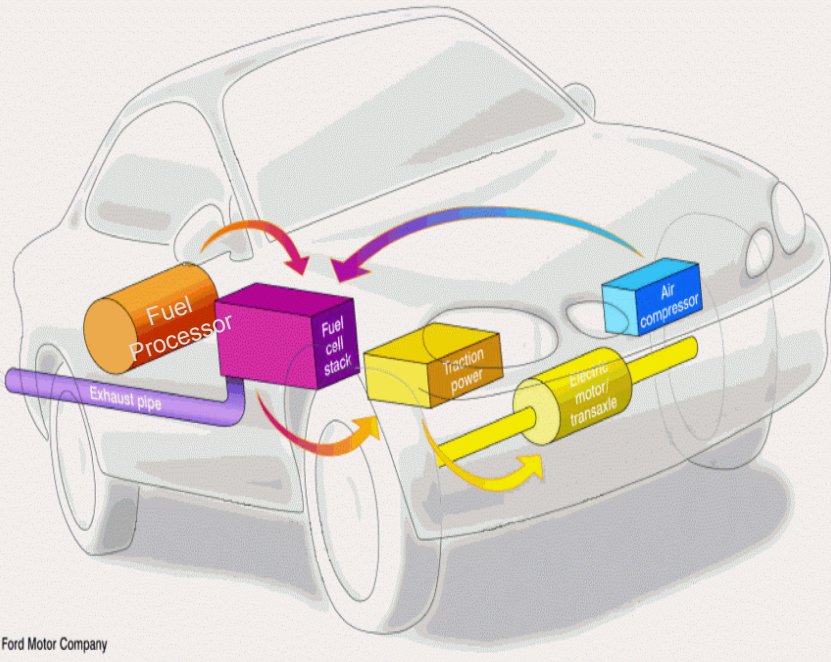




# *Sensors for Safety & Performance*

## Vehicles



Stationary Systems

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## Sensors for Automotive Fuel Cell Systems

Sensor	Op. Temp.	Response Time	Accuracy
CO:			
1-100 ppm reformat pre-stack sensor	<150 °C	0.1-1 sec	1-10% full scale (fs)
100-1000 ppm CO	250 °C	0.1-1 sec	1-10% fs
0.1-2% CO sensor	250-800 °C	0.1-1 sec	1-10% fs
H2 in fuel processor output	70-150 °C	0.1-1 sec for 90% response to step change	1-10% fs
H2 in ambient air	-30-80 °C	Under 1 sec	5%
Sulfur compounds	Up to 400 °C	<1 min @ 0.05 ppm	N/A



## Sensors for Hydrogen and Fuel Cell Systems

Sensor	Op. Temp.	Response Time	Accuracy
CO:			
1-100 ppm reformat	<150 °C	0.1-1 sec	1-10% full scale (fs)
100-1000 ppm CO	250 °C	0.1-2 sec	1-10% fs
0.1-2% CO sensor	250-800 °C	0.1-3 sec	1-10% fs
H2 in processor output	70-250 °C	0.1-3 sec for 95% response to step change	1-10% fs
H2 in ambient air	-30-80 °C	Under 1 sec	5%



# Sensor Types

- CO
- H<sub>2</sub> in Fuel Processor Output
- H<sub>2</sub> in Ambient Air
- Sulfur Compounds (H<sub>2</sub>S, SO<sub>2</sub>, organic sulfur)
- Flow Rate of Fuel Processor Output
- Ammonia
- Temperature
- Relative Humidity for Cathode and Anode Gas Streams
- O<sub>2</sub> in Fuel Processor and at Cathode Exit
- Differential Pressure in Fuel Cell Stack



- Must perform within required ambient and process conditions
- Fast response time
- Acceptable accuracy
- Must conform to size, weight, and cost constraints of automotive applications
- Acceptable lifetime (durability)
- Must measure properties within the required range



- Carbon Monoxide Sensors for Reformate-Powered Fuel Cells LANL
- Electrochemical Sensors for PEM Fuel Cell Vehicles LLNL
- Interfacial Stability of Thin Film H<sub>2</sub> Sensors NREL
- Sensors for Automotive Fuel Cell Systems UTC Fuel Cell
- Micro-Machined Thin Film H<sub>2</sub> Gas Sensors Advanced Technology Materials, Inc.
- Sensor Development for PEM Fuel Cell Systems Honeywell Sensing and Controls



- Gallium Nitride Integrated Gas/  
Temperature Sensors for Fuel  
Cell Systems Monitoring for  
Hydrogen & Carbon Monoxide  
Peterson Ridge LLC
- Robust Fiber-Optic Temperature  
Sensor for Fuel Cell Monitoring  
ORNL



## **Barriers**

- **Cost**
- **Application**
- **Lifetime**
- **Flexibility**
- **Public Perception**