Sensor Technology for Biomedical Applications

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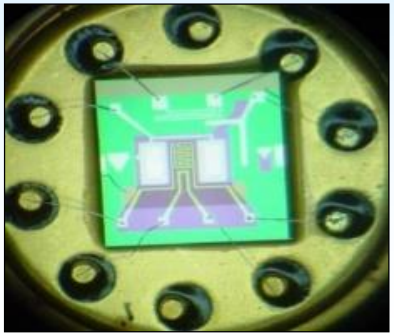
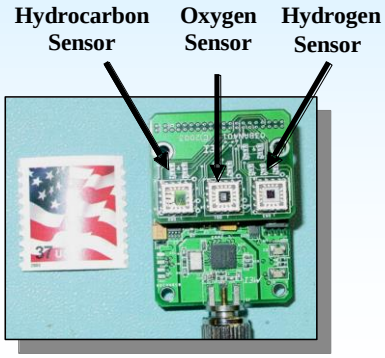
Chemical Gas Species Sensors
Smart, Small, Rugged, and Adaptable

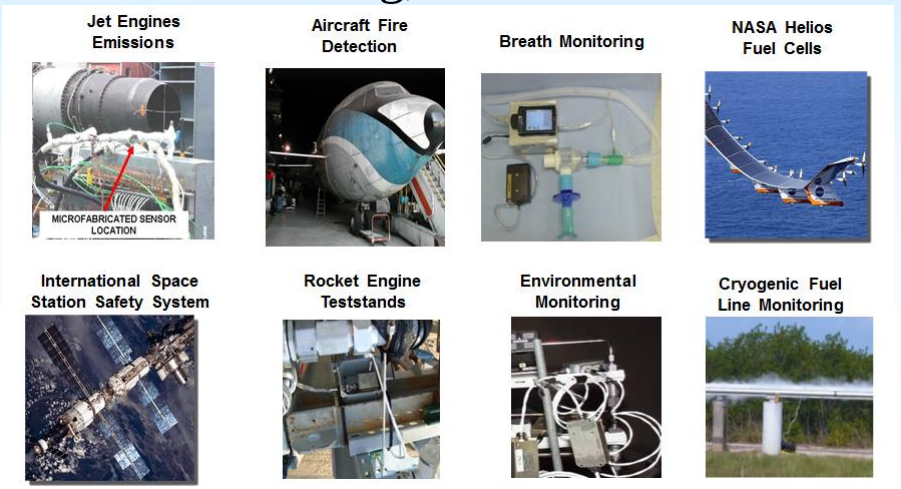
Emissions, fire and environmental, human health monitoring, and leak detection



Hydrogen Sensor



Wireless Smart Sensor System



Description of Technology

- Many aerospace sensors are simple single parameter measurement systems limiting adaptability/ data quality.
- This work provides adaptable Smart Sensor Systems (with microprocessor) and multiparameter detection, e.g., three sensors each providing unique data.
- Enables easy integration into different application environments without the need for mandatory changes in power and communication infrastructure.
- Multiple sensors available depending on application need: hydrogen, oxygen, hydrocarbons, nitrogen oxides, carbon dioxide, carbon monoxide, and others.

Applications

- Basic Approach: Building from a core set of smart microsensor technologies, sensor(s) and hardware configuration can be modified to meet the needs of specific applications.
- Health monitoring though selective detection of chemical species in the breath.
- Environmental and safety monitoring to detect levels of oxygen, carbon monoxide, and carbon dioxide.
- Leak detection measuring both and oxygen levels to determine hazardous conditions.
- Toxic gas or fuel monitoring.

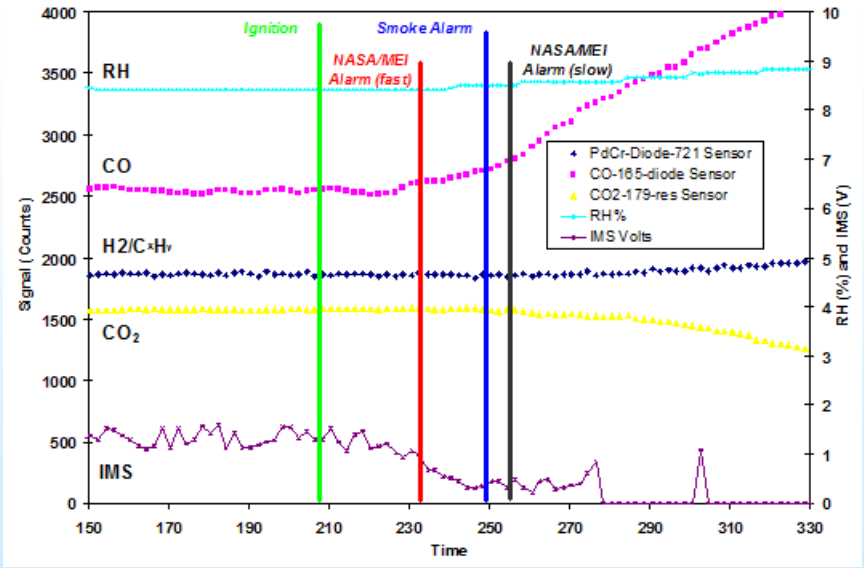
Micro-Fabricated Gas Sensors for Fire Detection and Environmental Monitoring

- Enhanced Environmental/Hazard Monitoring With Multiparameter Approach
- Demonstrated Reduction Of Fire False Alarms In Aircraft Cargo Bay With Improved Understanding Of The Environment
  - FAA Cargo Bay Simulation Testing: *No False Alarms/Consistent Detection Of Fires*
- Environmental Monitoring And Fire Detection; Dual Use System Targeting Key Species Of Interest To Human Health In Multiple Configurations
- First Responder Applications On-going: Portable Monitor For Exposure To Hazardous Species And Improved Situational Awareness

SMART SPACE FIRE DETECTION SYSTEM

HAND HELD UNIT

WIRELESS MODULE



AIRCRAFT CARGO BAY FIRE DETECTION

Smart Sensor Systems For Human Health Breath Monitoring Applications

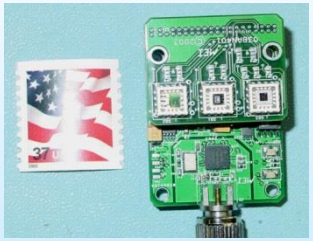
Approach: Use Array of Micro Sensors Combined with Smart Hardware to Monitor Breath For Exercise And Health

- Biomarkers For The Diagnosis Of Disease Are Present In The Breath
  - Correlation Between Chemical Species in Breath and Range of Health Conditions
- Example Project: State Of Ohio Third Frontier Program to Produce Breath Monitoring Technology For Asthma Detection

- NASA and Collaborators: World Leaders in Chemical Microsensor Technology
- Cleveland Clinic Foundation: World Leader In Exercise/Breath Monitoring Research
- Target Home Use as Well as Clinical Applications with a Hand-Held Unit
- NASA Role: Selective gas sensor miniaturization

Selected chemical species in human breath relevant to physiology/disease

Compound	Potential source	Implications for disease
Acetone	Acetyl-CoA metabolism	Diabetes mellitus
Acrylonitrile	Exogenous/tobacco smoke	Smoke exposure
Benzene	Exogenous/tobacco smoke/automobile exhaust	Lung and breast cancer/smoke exposure
Carbon Monoxide	Lung inflammation, hemolysis, smoke exposure	Asthma, hemolytic anemia, various exposures
Isoprene	Cholesterol synthesis	Cardiovascular disease
Methane	Bacterial metabolism	Carbohydrate malabsorption
Nitric oxide	Airway inflammation	Asthma/allergy/PH
pH	Gastric acid reflux	GERD/peptic ulcer disease



"Lick and Stick" Sensor System

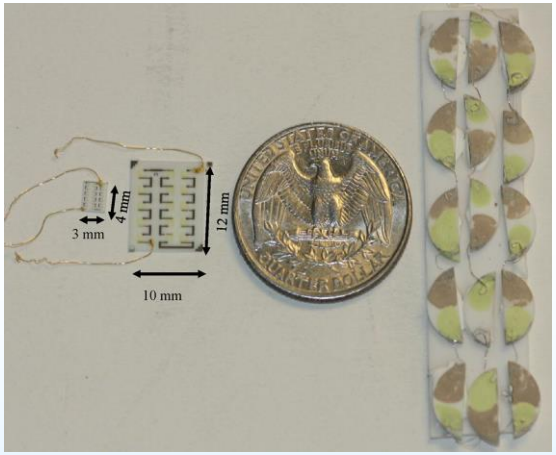
Example Breath Sensor System

International Breath Analysis Summit

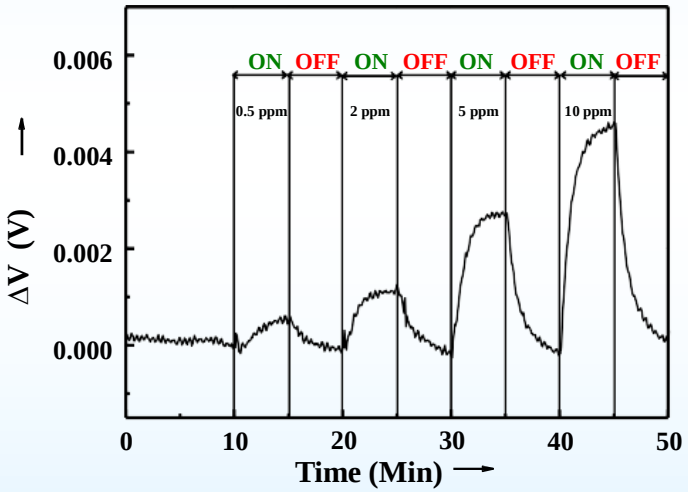
EXHALED NITRIC OXIDE DETECTION USING ELECTROCHEMICAL SENSOR: EXAMPLE OF ACTIVITIES

- Sensor Miniaturization Using Silicon Processing Techniques Based on Macro Sensor Approach
- Electrochemical Cells In Series To Reach High Levels Of Sensitivity (500 ppb) With More Than An Order Of Magnitude Size Reduction
- Fundamental Understanding Of Sensing Mechanism Needed In Order To Implement Miniaturization With High Sensitivity

Sensors and Actuators B 204 (2014) 183–189



Miniaturization Activity (right to left): Hand fabricated sensor (baseline), shadow mask sensor, and photoresist processed sensor



Sensor response of photoresist version sensor with 15 sensor arrays for 0.5–10 ppm nitric oxide in 20% O_2 with 200 cm^3/min total flow rate at 550°C.

Cleveland Clinic
MAKEL ENGINEERING
CWRU
THE OHIO STATE UNIVERSITY

- Core Smart Sensor System Technology and Miniaturization Approach Adaptable To A Range Of Applications
  - Correlation Between Chemical Species And Human Health/Environmental Factors

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