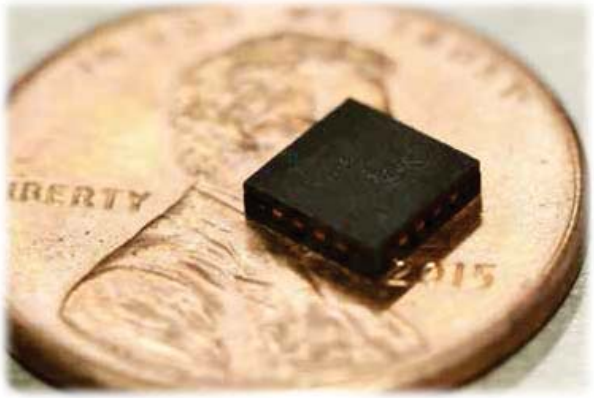
N5 Sensors, Inc.

smart sensors for a safer world

Developing Testing Program and Infrastructure for a Sensor Start-Up

Motayed, Founder, CEO



June 2017

IoT: A Sensor Heavy World

Sensors are enablers for host products and services

Monitoring Trends and Activities
Sleep, Athletic, Heart Rate, Energy Usage, Safety

Environmental sensors are in their infancy….
A billion dollar opportunity!

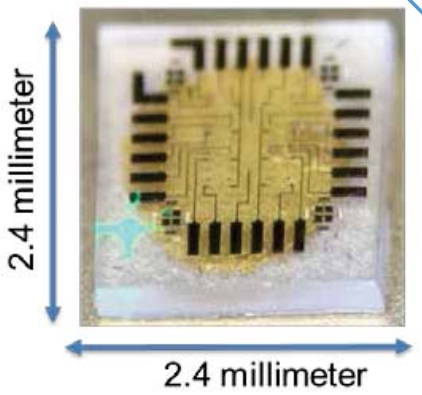
N5's Chip-Scale Gas/Chemical Sensor Technology

Chip-Scale Design (Ideal for Wearables and Compact Solutions)

Less than 10 milliwatts

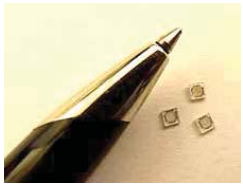
Manufactured using same methods as standard integrated circuits

Low-Power, Highly-Scalable, low-cost



A single chip contains multiple micro-sensors designed to detect different target gases

Patent-pending design allows for detection of variety of gases and chemicals – CO, CO_2, CH_4, H_2, NO_2, NH_3, H_2S, HCl, HCN, CL_2,VOCs (relevant to fire-gas and TIC/TIM)



Platform Technology

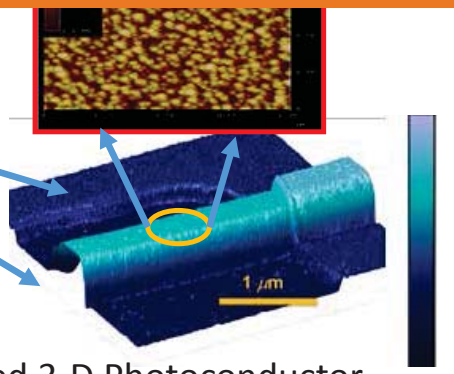
Robust and Reliable Sensors (Ideal for Industrial Applications)

Longer life-time and operation in wide temperature and humidity range

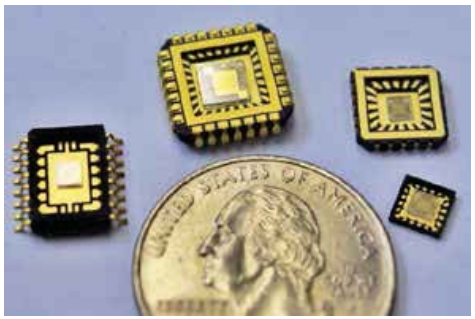
Technical – Sensor Design

Nanophotocatalytic Functionalization

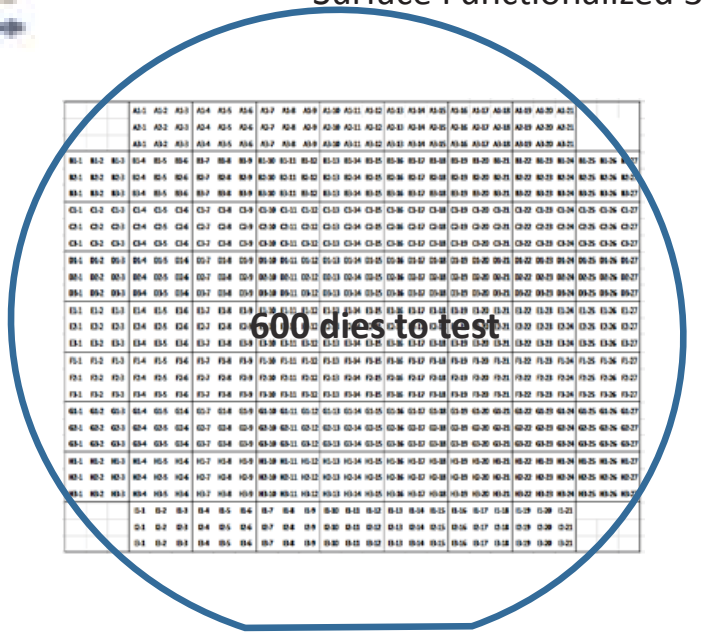
Individual Sensing Element



Surface Functionalized 3-D Photoconductor



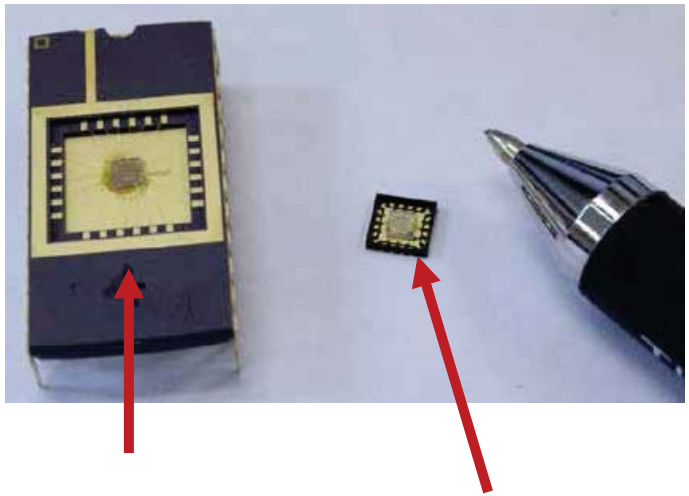
Packaging Can Make or Break the Product



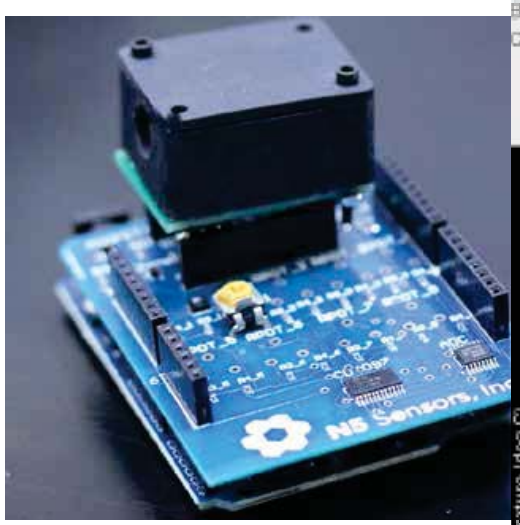
Challenges of Developing a Cost-Effective Testing Program

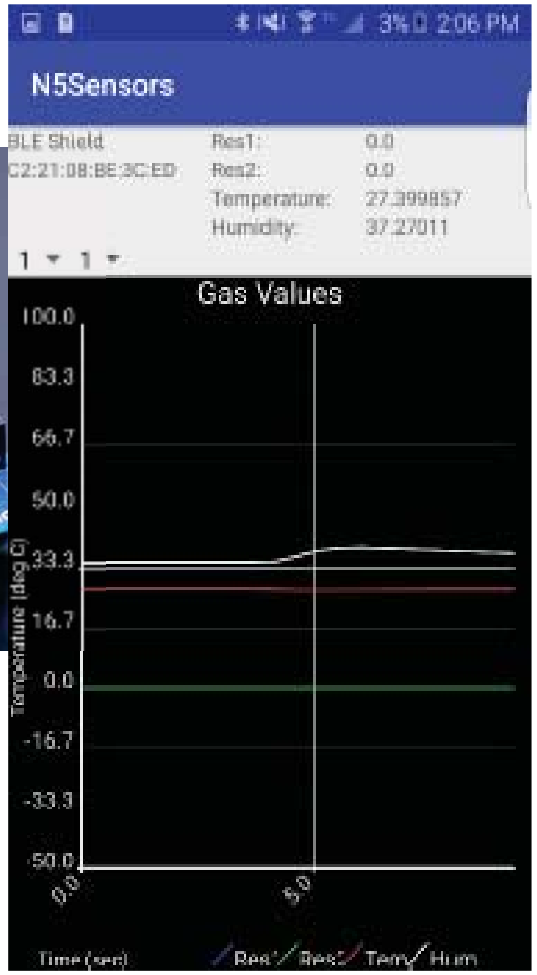
❑ Cost	**Turn Key or Custom Built**
❑ Accurate and Reliable	**Reproducible Vapor Stream and Concentration Set points and Profile**
❑ Effective	**Able to Produce Multitude of Testing Conditions**
❑ Versatile	**Able to Test Sensors, Packages, Modules, Systems**
❑ High-Throughput	**Rapid Testing and Fully-Automated**
❑ Upgradable	**Future Programs and Products**
❑ Maintenance and Repair	**Fast Turnaround, Redundancies**

Sensors Vs. Systems Testing

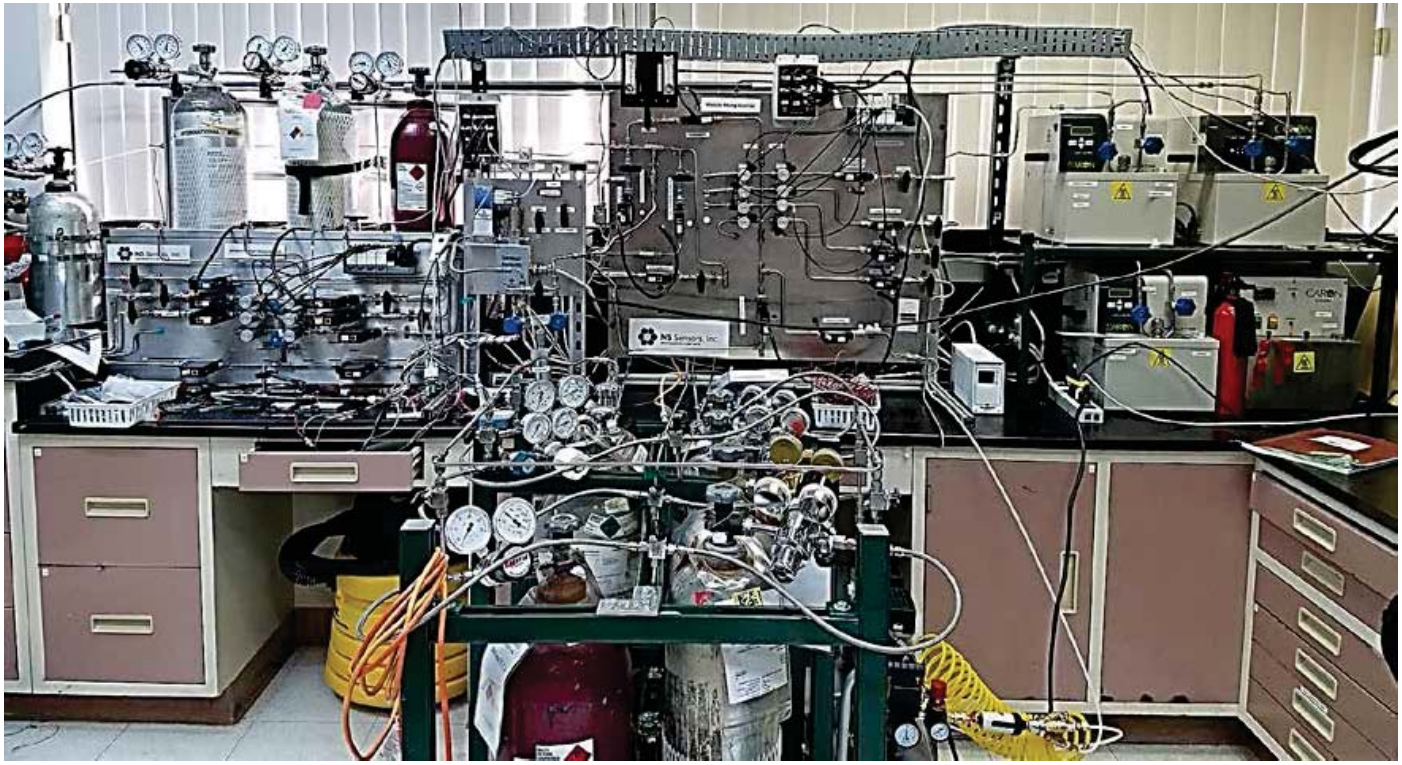


2015 2016



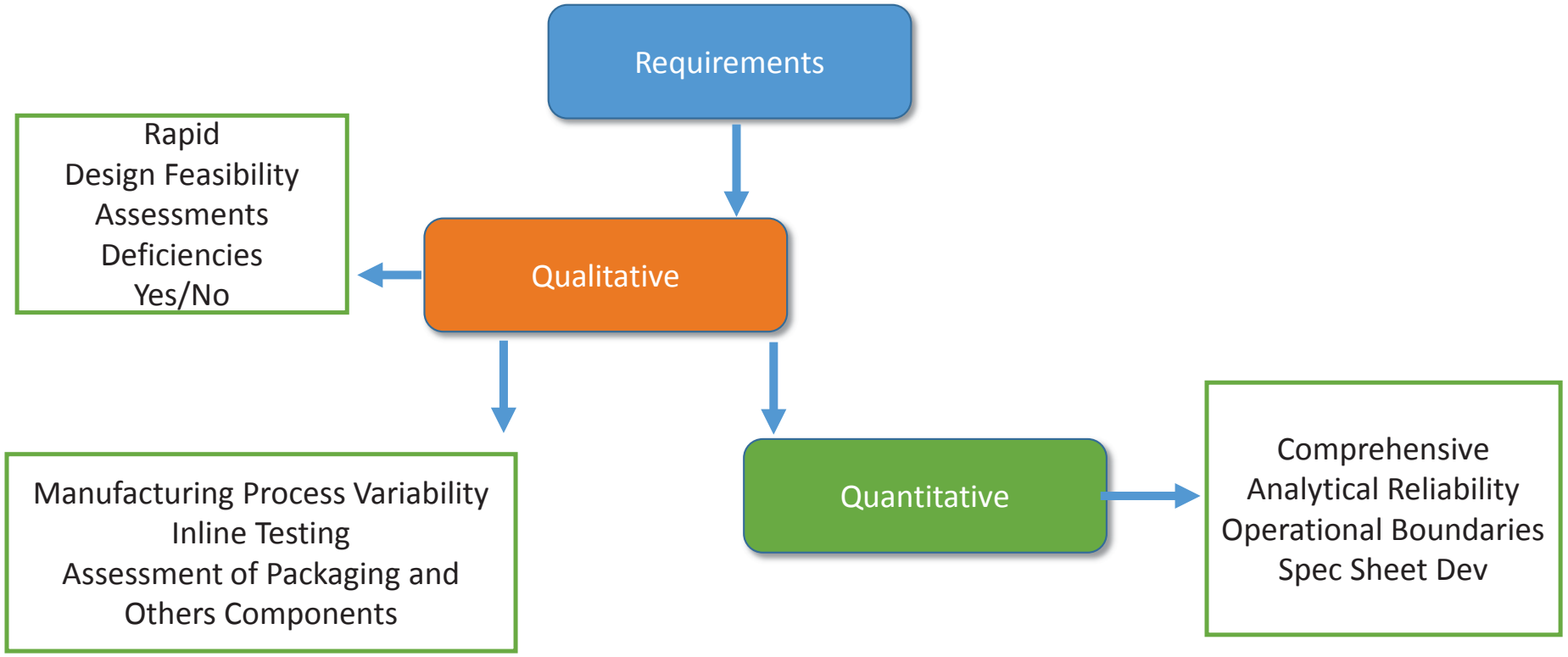


N5 Sensor Testing Lab

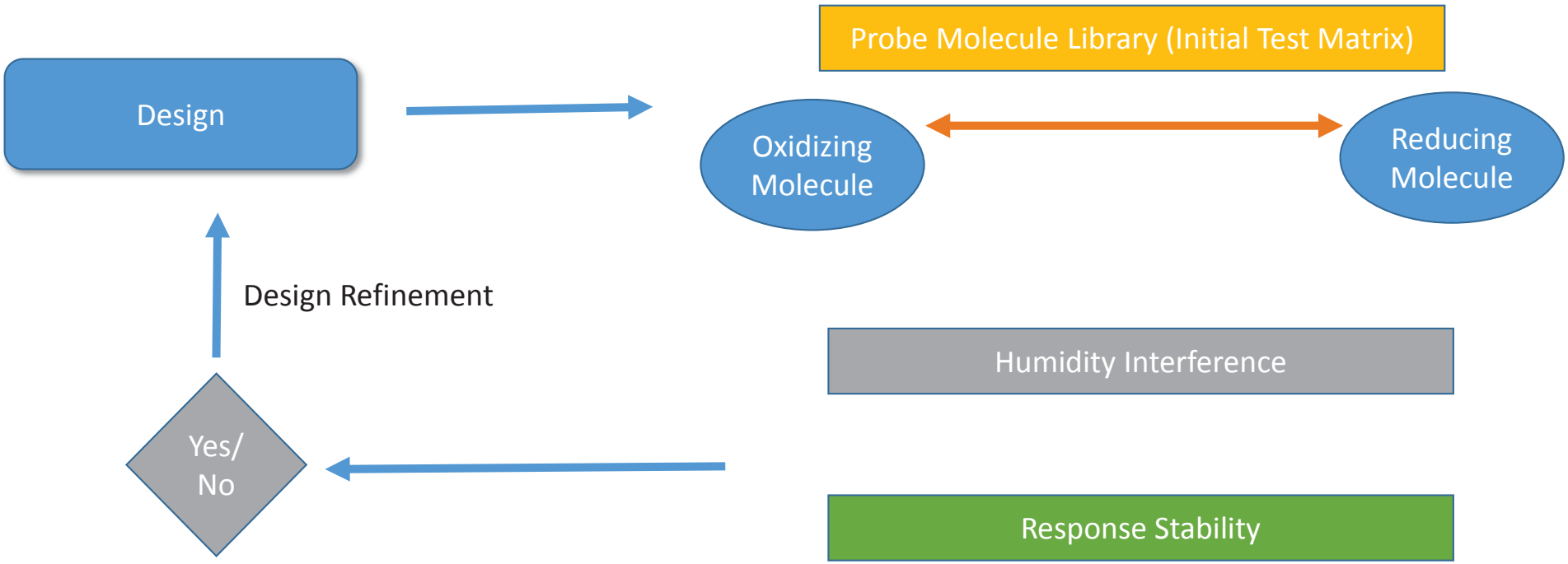


- 2 Independent Mixing Manifolds
  - Corrosive
  - Non-Corrosive Gases
- 8-Channel Manifolds
  - Independently controllable
- Carrier Gas – Air or Inert, O_2 Lean or Rich
- Ability to Derive Flow from Certified Gas Tanks and Bubbler
- Bronkhorst Accurate Humidity Controller 0 – 95% RH (1% RH Delta)
- Inline Humidity Monitoring
- Mode – Unattended, or Manual
- Able to Program Test Plans
  - Software Developed by N5

Developing a Testing Methodology



Qualitative Testing – Validation of Initial Sensor Design



Goal – Finalizing the Design with Least Amount of Time and Money

Quantitative Testing – Comprehensive Data Generation

Tier 1

Target Gas Concentration Span - Detection limit, range

Response and Recovery Times (T10 – T90)

Spot 1-2 Non-Target Gases

Response and Recovery Cycling

Humidity Points

Tier 2

Target Gas Concentration Span - Detection limit, range, resolution

4- 6 Non Target Gases

Different O2/N2 Ratio

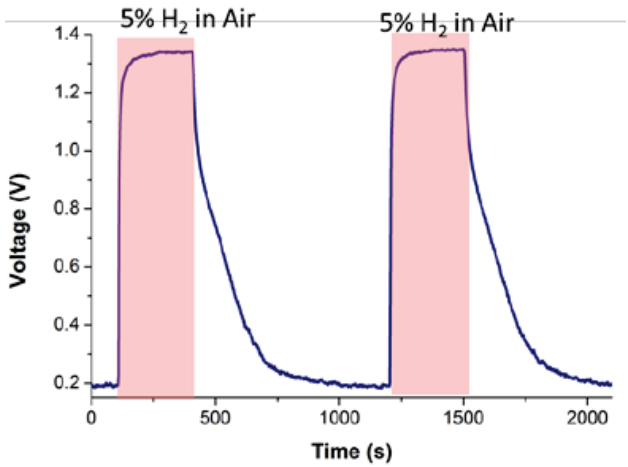
Temperature and Humidity Span

Complex Non-Target Matrix

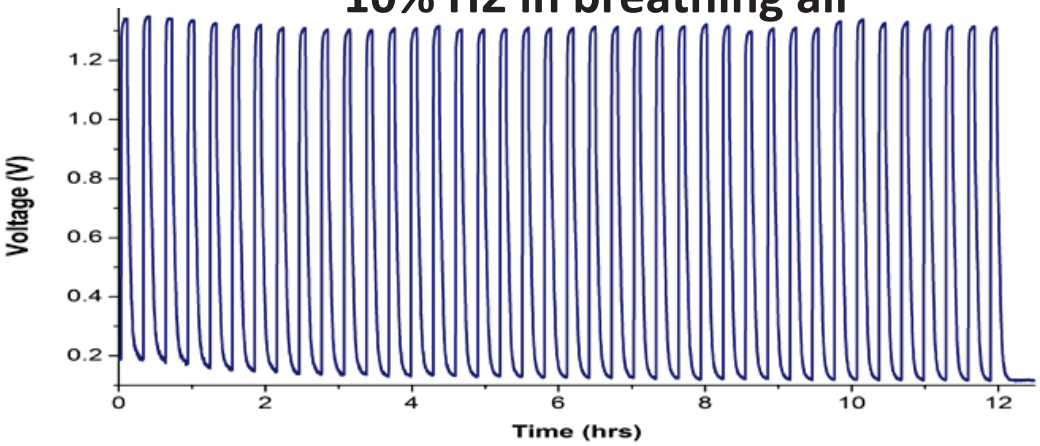
Short-term and Long-Term Drift

Life-Time Testing

Some Examples



10% H2 in breathing air



Analyte	Range of Detection	Response (%) = $(R_{gas} - R_{air})/R_{air}$
Ammonia	1 – 100 ppm	15
Chlorine	0.5 – 10 ppm	212
Hydrogen chloride	1 – 100 ppm	74
Hydrogen cyanide	1 – 100 ppm	10
Hydrogen sulphide	10 – 1000 ppm	20
Hydrogen	0.5 - 10%	500
Oxygen	10 - 30%	40
Carbon dioxide	0.1 - 1%	2
Carbon monoxide	10 – 300 ppm	15
Nitrogen dioxide	100 – 500 ppm	2
Nitric oxide	5 – 1000 ppm	2.6
Methane	50 – 5000 ppm	9

Acknowledgements

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