Honeywell

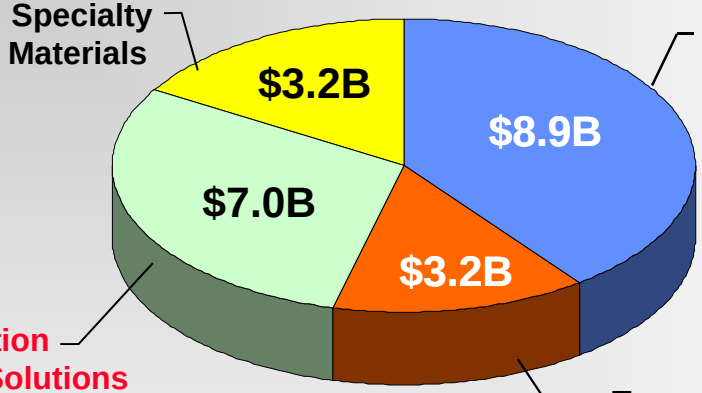
Gas Sensing: Products and Technology

EPA's Natural Gas STAR Program
October 27, 2003
Houston, TX

Klein Johnson
Honeywell ACS Sensor Labs

Honeywell Business Units

2002 Sales



Total = $22.3B

Broad and Diverse Businesses, Technologies and Products

Automation and Control Solutions

Products:

- HVAC controls
- Industrial process automation and control
- Video surveillance, people and asset tracking
- Security/fire alarm and industrial safety systems
- Home automation systems
- Sensors, switches, and control systems for measuring pressure, air flow, temperature, electrical current and more
- Drinking water solutions
- Combustion control solutions

Representative Customers:

- Alcoa, AstraZeneca, BASF, Boeing, Brinks, ChevronTexaco, DaimlerChrysler, DuPont, ExxonMobil, General Motors, PDVSA, ConocoPhillips, Procter & Gamble, Qatar General Petroleum, Sasol, Sinopec, Stora Enso, Sydney Airport, TotalFinaElf, Weyerhaeuser, and building and home owners, and others.

Products and services are used around the world in more than 100 million homes and buildings as well as in 24 of 25 top oil refineries.

ACS Products

Measure

- Fire/Smoke Sensors 
- Room Controls 
- Indoor Air Quality 
- Press/Temp Transmitters 
- Liquid & Gas Sensors & Analyzers 
- Press/Temp Safety Switches 

Record

- Paperless Recorders 
- Strip & Circular Chart Recorders 
- Data Loggers 

Control

- Building Automation Systems 
- Res/Comm Boilers 
- Loop & Logic Controllers 
- Actuators 

Supervise

- Fire System Panels 
- LAN/WAN Integration 
- PC Software 
- Wireless 
- Audio/ Visual 

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Gas Sensing Within Honeywell

Gasses and Applications

- CO — Safety and Fire Detection
- Humidity and CO2 — HVAC
- VOC's — IAQ and Cabin Air Monitors
- NOx — Diesel Engine Control
- CWA's — Homeland Security
- Combustibles — Portable Leak Detectors

COMMON TECHNOLOGIES FOR GAS DETECTION

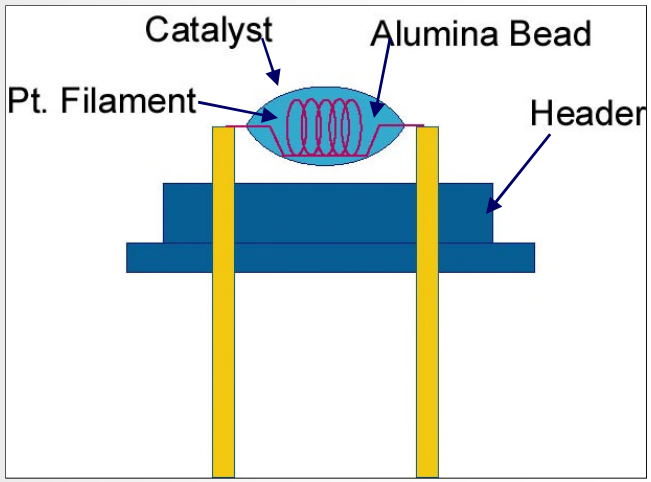
Gas Type	Gas Sensing Technology			
	NDIR	Catalytic	MOS	ElectroChemical
Toxic			X	X
Oxygen				X
Combustible	X	X	X	

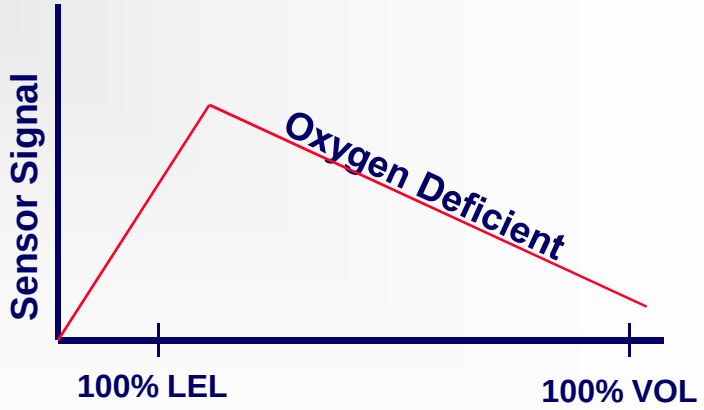
Catalytic Bead / Pellistor

Most Common Methane Detection Technology

- **Advantages**
  - Components Widely Available
  - Good Selectivity

- **Disadvantages**
  - High Power
  - Susceptible to “Poisoning”
  - High Transducer Cost
  - Oxygen Ambient Required
  - Not Failsafe
  - Frequent Calibration
  - 3-5 Year Sensor Lifetime

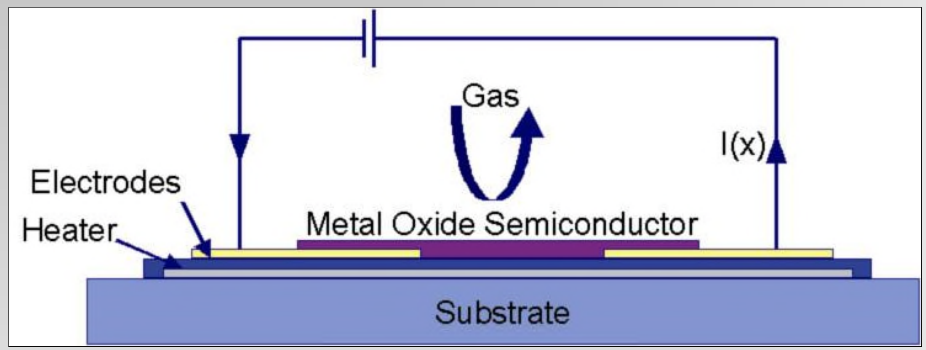




- **Adequate for Given Application?**

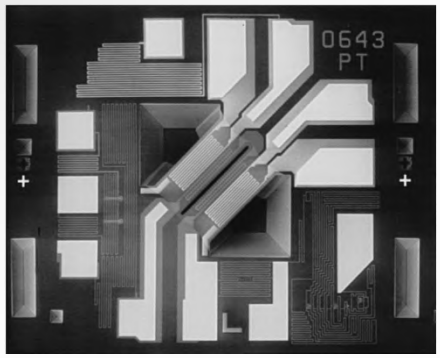
MOS Gas Sensors

- **Metal Oxide Semiconductor**
  - **Conductivity Modulation (SnO_2)**



Honeywell IAQ Sensor

  - **Transducers Widely Available (incl. CH4)**
  - **Low Cost**
  - **Poor Selectivity**
  - **High Power**
  - **Not Fail Safe**
- **New Low-Power MOS** →
  - **Microbridge Arrays**
  - **Improved Selectivity**
  - **Reduced Drift**



Micro-power MMOS

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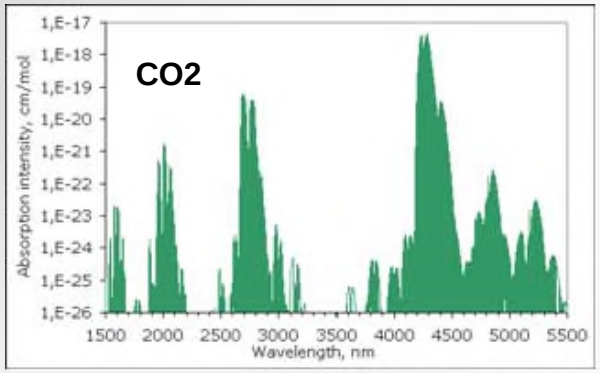
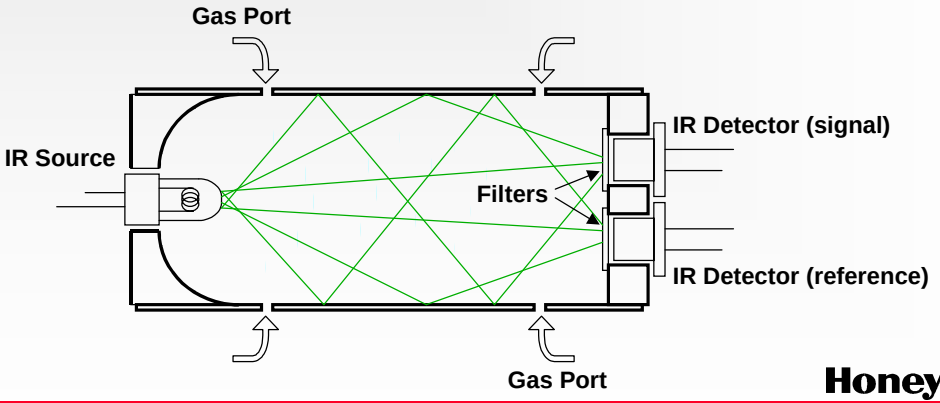
Non-Dispersive Infrared

NDIR

- **Optical Absorption Detection**
  - Non-Dispersive, i.e. No Grating, Prism, etc.
  - Detection via Mid-IR “Fingerprint”
  - Excellent Selectivity
  - Self Calibrating
  - Long Lifetime

- **Disadvantages**
  - High Power Requirement
  - Historically Expensive
  - IR Source Problematic



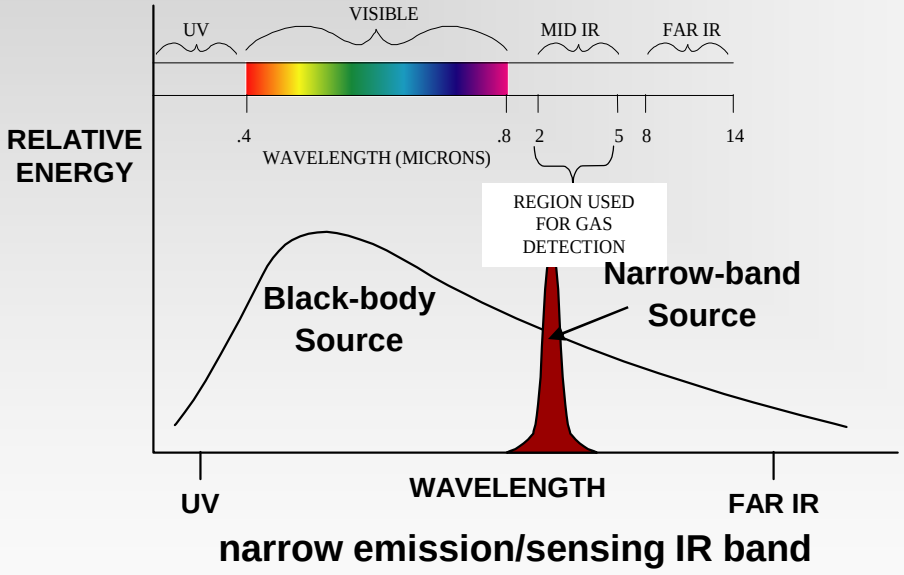


Honeywell CO2 Sensor

Non-Dispersive Infrared

High-Efficiency NDIR

- Matched Narrow-band Emitters and Detectors
- Reduced Cost
- Dramatically Reduced Power Requirements
- Higher S/N Ratio (Improved Sensitivity)



- Currently Targeted For Hand-held CH4 Leak Detectors

High-Efficiency NDIR

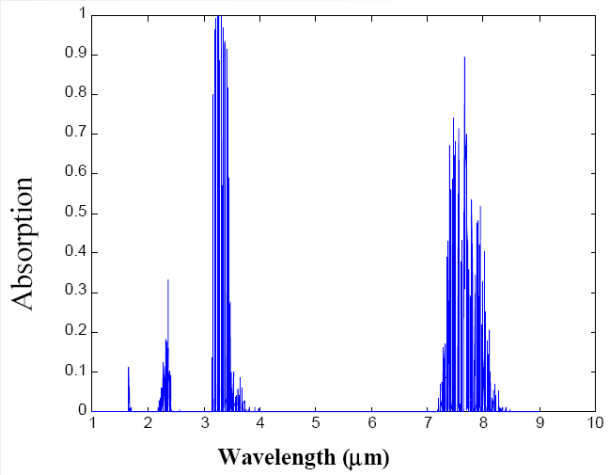
Representative Performance

•HYDROCARBONS (AS PROPANE)	0.001 - 1.000%
•METHANE	0.01% - 5.00% OR 0.1% - 100% OR PPM LEVELS
•CARBON DIOXIDE	0.004% - 1.00% OR 0.1% - 20%
•RELATIVE HUMIDITY	0.0% - 100%
•CARBON MONOXIDE	10 PPM - 20,000 PPM

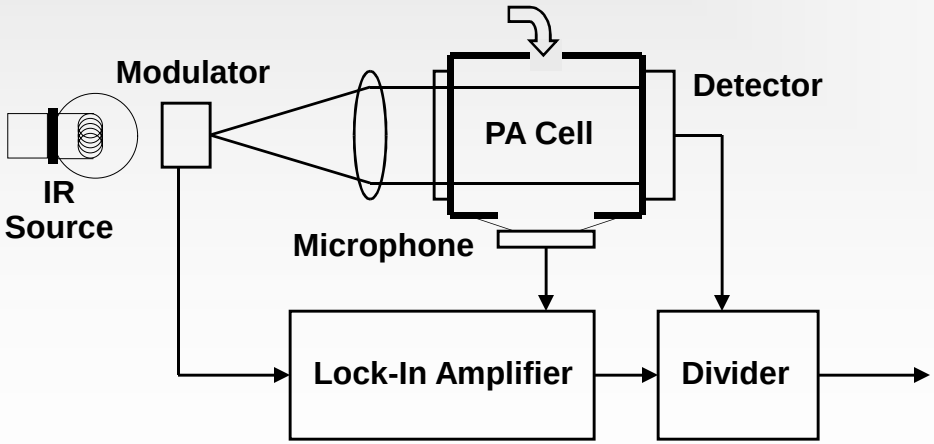
Photoacoustic Gas Sensor

MEMS Photoacoustic Cell

- Concept Phase
- Highly Integrated Si Platform
- Potential For:
  - Low Cost (Batch Manufacturing)
  - High Sensitivity / Selectivity
- Methane
  - 3.4 Microns: NDIR Source
  - 1.6 microns: (Telecom laser??)



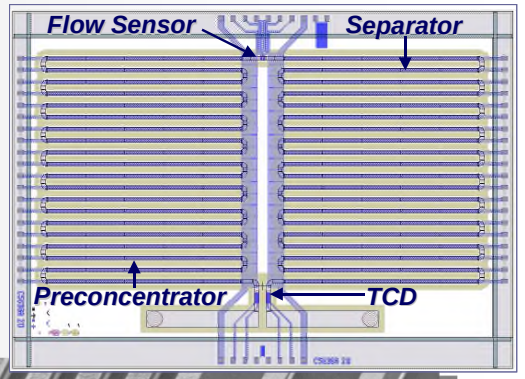
CH4 Absorption Spectra

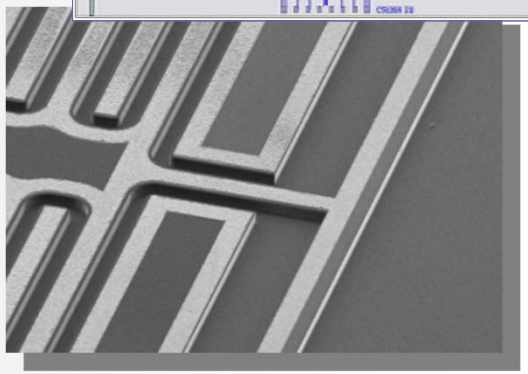


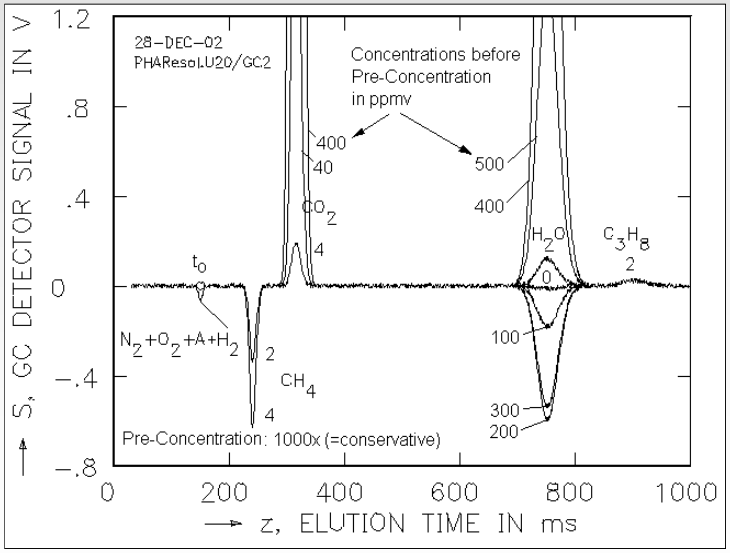
Micro Gas Chromatograph

"PHASED" Micro Gas Analyzer

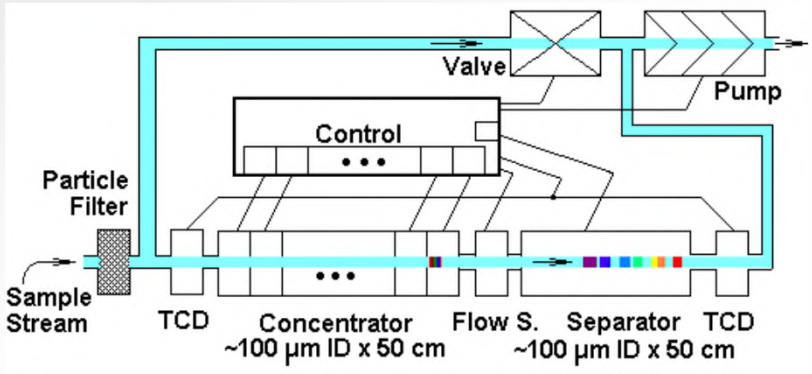
- **MEMS Chromatograph**
  - **CWA's, Fault Gasses**
  - **Integrated for High-speed, Compactness**
  - **"Low Cost"**
  - **High-Speed (<1ms thermal response)**
  - **Low-Energy Analysis for Extended Battery Life**
  - **Increased Selectivity**







Predicted Performance



Honeywell "PHASED" MGA Micro-System

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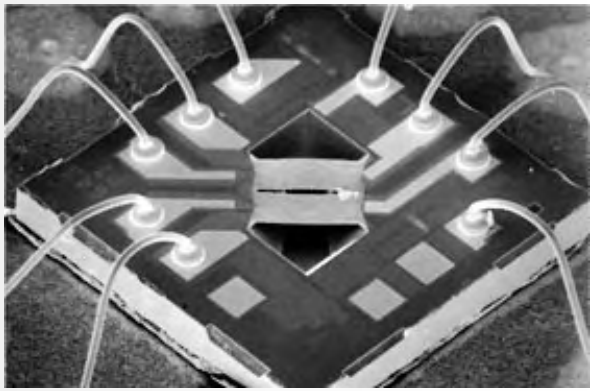
Mass Air Flow Sensors

MEMS-Based

- Microbridge Membrane Technology
- High/Low Flow Rate
- Multi-Gas
- Compact Design
- Low Power



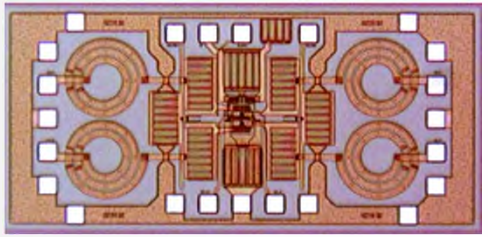
Honeywell Micro-Bridge Flow Sensor

Applications

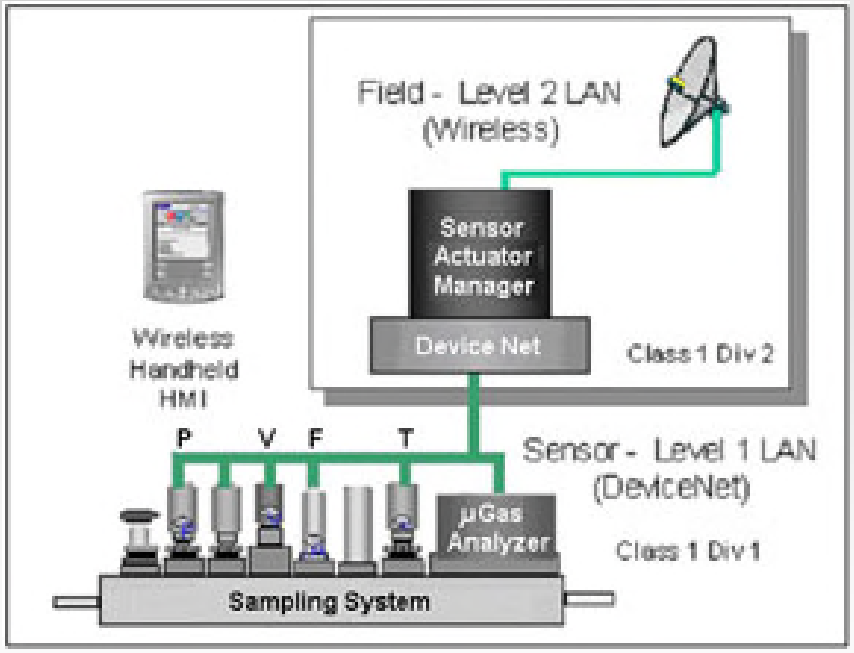
- Respirators/Ventilators
- Fuel Cell Controls
- Leak Detection
- Mass Flow Controllers
- Oxygen Generators

Wireless

- Significant In-House Technology
- Leverage Across Multiple Businesses
- Residential and Industrial Apps



5.6 GHz Transceiver ASIC



Wireless NESSI III Industrial Process Monitor Platform

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Conclusions

Honeywell Position

- Potentially Interested in Fixed CH4 Sensing Market
  - Not Currently in Combustibles / Methane
  - Consistent with Current Businesses
  - IM&C, Industry Solutions, Fire and Security
- Good Technology Overlap

Path Forward

- Collect Data
  - Functionality
  - Performance Metrics
  - Cost Expectations
  - Market Opportunity
- Open to Discussions