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

- $8.9B
- $7.0B
- $3.2B

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

<table>
<thead>
<tr>
<th>Measure</th>
<th>Record</th>
<th>Control</th>
<th>Supervise</th>
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</thead>
<tbody>
<tr>
<td>Fire/Smoke Sensors</td>
<td>Paperless Recorders</td>
<td>Building Automation Systems</td>
<td>Fire System Panels</td>
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<tr>
<td>Room Controls</td>
<td>Strip &amp; Circular Chart Recorders</td>
<td>Res/Comm Boilers</td>
<td>LAN/WAN Integration</td>
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<td>Indoor Air Quality</td>
<td>Data Loggers</td>
<td>Loop &amp; Logic Controllers</td>
<td>PC Software</td>
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<tr>
<td>Press/Temp Transmitters</td>
<td></td>
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<td>Wireless</td>
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<tr>
<td>Liquid &amp; Gas Sensors &amp; Analyzers</td>
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<td>Audio/Visual</td>
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<tr>
<td>Press/Temp Safety Switches</td>
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EPA Gas STAR Program
Technology Transfer Workshop

October 27, 2003
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

<table>
<thead>
<tr>
<th>Gas Type</th>
<th>Gas Sensing Technology</th>
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<tbody>
<tr>
<td></td>
<td>NDIR</td>
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<tr>
<td>Toxic</td>
<td>X</td>
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<tr>
<td>Oxygen</td>
<td>X</td>
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<tr>
<td>Combustible</td>
<td>X</td>
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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$_2$)

Transducers Widely Available (incl. CH4)
Low Cost
Poor Selectivity
High Power
Not Fail Safe

- New Low-Power MOS
  Microbridge Arrays
  Improved Selectivity
  Reduced Drift
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
Mass Air Flow Sensors

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

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

Honeywell Micro-Bridge Flow Sensor
Wireless

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

Wireless NESSI III Industrial Process Monitor Platform

5.6 GHz Transceiver ASIC

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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