Disruptive mobile-device based chemical sensor technology for industrial, environmental, and safety monitoring

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The Problems

Commercially-available handheld multigas detector

A Typical 4-Gas Handheld Detector Construction (RAE Systems)

- Bulky, power-hungry detectors (Inconvenient to carry)
- Sensors have drifts, cross-sensitivity to other gases, humidity (Difficult to interpret the measurement)
- Sensors need routine calibration, frequent maintenance, and replacement (Hard to maintain)
- Expensive (Acquisition and Maintenance)

North-American Revenue Distribution for Hand-held Gas Detectors
N5’s Single-Chip Sensor Solution

What our technology can offer

1 – Reduced Calibration, Maintenance, and Replacement Burden

2 – Ease of Use

3 – Additional Functionality

4 – Reduced Upfront Acquisition and Downstream Maintenance Cost

Toxic, Explosive, and Volatile Organic Compound Sensors – All in a chip!

Catalytic/Pellistor

Electrochemical

Photoionization

Replaces multiple power-hungry sensor technologies with arrays of microsensors on a single chip.
The Manufacturing Process

Fabrication of Sensor Devices and Packaging using Class 100 Manufacturing Facility

Sensor Testing and Reliability Assessment

Semiconductor GaN Epitaxial Wafers on Supplied by Commercial Vendor

Design Iteration
Background

Technology Overview - Uses patent-pending (US 13/861,962) hybrid nanocluster-semiconductor sensor Technology – results in microscale, low-power sensors on one single-chip for detection of different target gases in air

N5 Sensors, Inc. of Rockville, MD is a University of Maryland spin-off founded by Dr. Abhishek Motayed (lead inventor of the sensor technology) in 2012. N5 has obtained exclusive license to this patent-pending technology from University of Maryland.

N5 is currently funded at the level of $ 780,000/year with various SBIR and state projects. In 2014, N5 has won TEDCO Maryland Manufacturing Initiative award, EPA SBIR Phase I, NSF SBIR Phase I, DHS Phase I, ARMY STTR Phase I, and UMD MIPS awards.

N5 Sensors currently has 4 full-time engineers/scientists working on the R&D, with additional 2 supporting interns. Dr. Motayed is serving as the CTO. N5 is currently housed at 9610 Medical Center Drive, Suite 200 Rockville, MD 20850 - a 350 sq. ft. laboratory space, where the N5 operates a state-of-the-art chemical sensor testing facility.
N5’s Goals

Immediate Goal
Industrial Detection

Using N5’s Gas Detection Module Interfaced with Ruggedized, Intrinsically-Safe Mobile Devices Used in Various Industries

Target Customers – Oil and Gas, Mining, Construction, Water Treatment Hazmat/First Responders

Future Goal

Using N5’s Gas Detection Module Interfaced with Consumer Mobile Devices for Environmental Pollutant Exposure Measurements

Target Customers – People who want to track exposure to air toxics (people suffering from respiratory conditions)
Personal Breathalyzers
Home Monitoring
Immediate Market Opportunity

North American Portable Multiple Gas Detector Market (2015 – 2016) ~ $300 M (~ 300,000 units shipped, ~$ 1000/detectors with individual sensors cost ~ $ 150)
Worldwide ~ $2 billion (with NA and SE Asia being the largest consumer)

Our cost to make (4 –gas detector) ~ $ 300 (low-volume)

Major Players
Funding and Support

- TEDCO MII Phase III ($100,000) (Completed)
- US Environmental Protection Agency SBIR Phase I ($100,000) (Completed)
- National Science Foundation SBIR Phase I ($150,000)
- Department of Homeland Security SBIR Phase I ($100,000)
- ARMY STTR Phase I ($150,000)
- University of Maryland, 2-Year MIPS Award (~$180 K)
- National Institute of Standards and Technology Engineering Contract ($180 K)
- TEDCO JTTI Award ($75 K) awarded in 2015
- NSF Phase IB Awarded ($52K)
- Private Investment ($35K)
Team

Dr. Abhishek Motayed
Founder and President
10+ years semiconductor experience
amotayed@N5Sensors.com

Dr. Ratan Debnath
Director of Research

Dr. Baomei Wen
Senior Device Engineer

Ms. Nichole Sullivan
Research Engineer

Mr. Audie Castillo
Engineering Technician

Team with UMD students
Mr. Gavin Liu (MIPS)
Mr. Ting Xie (MIPS)

Business Team/Advisors

Ken Malone
Business Strategy Development Officer
Serial Entrepreneur
Early Charm Ventures

Steven Chen (Board of Advisor)
Serial Entrepreneur and Investors
Chair, IEEE Std for Wireless Sensor Networks
Member, Blu Venture Investors
Former CEO of an Intel Capital Portfolio company
## Comparison with existing sensor technologies for handheld detectors

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Photo Ionization Detector (PID)</th>
<th>Electrochemical Detectors</th>
<th>Metal-Oxide Sensors</th>
<th>N5’s Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Consumption</td>
<td>High</td>
<td>Low</td>
<td>10 – 100 mW</td>
<td>&lt; 0.5 mW</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Ppb – ppm</td>
<td>1 – 1000 ppm</td>
<td>100 ppm - %</td>
<td>Ppb - %</td>
</tr>
<tr>
<td>Selectivity</td>
<td>Non-selective</td>
<td>Partially Selective</td>
<td>Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Operating Temp.</td>
<td>-20°C to 70°C</td>
<td>Limited to Room Temperature</td>
<td>20°C to 70°C</td>
<td>10°C to 80°C</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Very High (% to ppb)</td>
</tr>
<tr>
<td>Start-up Time</td>
<td>&gt; 1 min</td>
<td>&gt; 1 min</td>
<td>&gt; 1 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>Operating Life</td>
<td>&lt; 1000 hrs</td>
<td>Very Limited</td>
<td>10,000 hrs</td>
<td>&gt; 2,000 hrs</td>
</tr>
</tbody>
</table>
What is Our Chip-Scale Sensor Technology?

Nanoscale photoconductors with reactive surfaces

Gases adsorb selectively at the surface of these particles and the “effect” is measured as a change in the photocurrent flowing through the resistor.