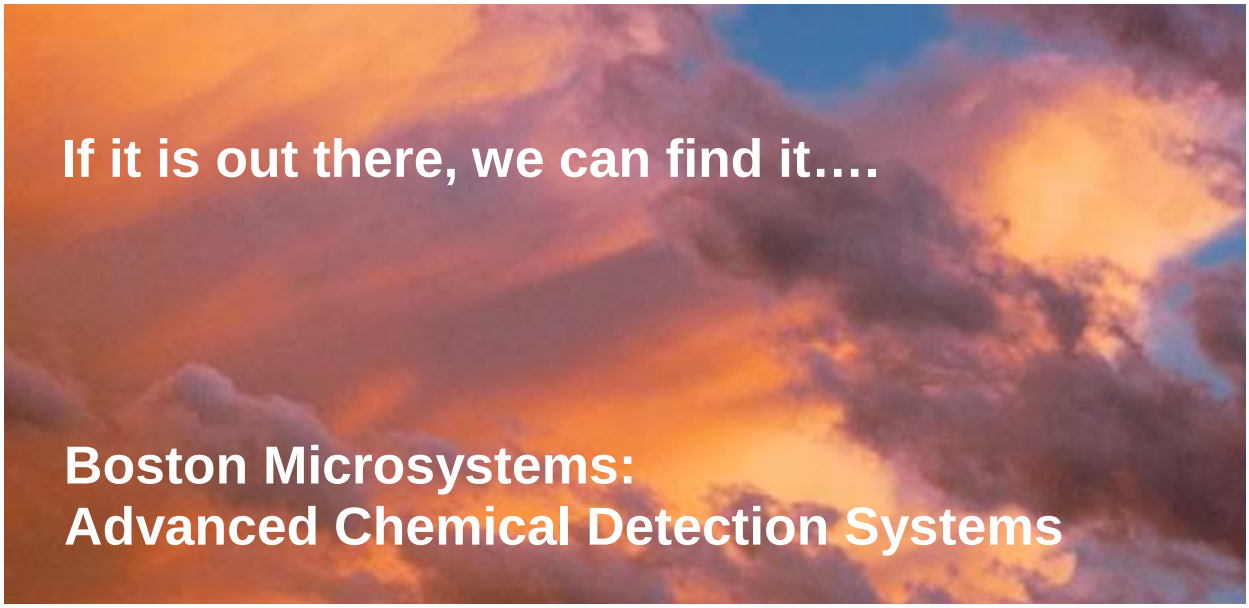


Boston MicroSystems, Inc.

The BMS PicoSensor: A Revolutionary Detection Technology

A technology white paper

The urgent need for detection technology

With recent increased threats of terrorism, the demand for detection technology has grown tremendously. Chemical detection devices, in particular, are expected to play a big role in security, from protecting soldiers from chemical weapons, alerting airport security to the presence of explosives, or signaling danger when lethal chemicals are present on a subway.

On May 8, 2005, The New York Times addressed this vital issue:

> *After spending more than $4.5 billion on screening devices to monitor the nation's ports, borders, airports, mail and air, the federal government is moving to replace or alter much of the antiterrorism equipment, concluding that it is ineffective, unreliable or too expensive to operate.*
>
> *“The federal government will likely need to spend as much as $7 billion more on screening equipment in coming years, according to government estimates. "One department charged with coordinating efforts and setting standards will result in far better and more efficient technologies to secure the homeland," said Mr. Roehrkasse, the Department of Homeland Security spokesman.*
>
> *Some experts believe that this high-priced push for improvements is necessary, saying the war against terrorism may require the same sort of spending on new weapons and defenses as the cold war did.*

"You are in a game where you are continually upgrading and you will be forever," said Thomas S. Hartwick, a physicist who evaluates aviation-screening equipment.

Both the U.S. Department of Homeland Security and Department of Defense have urgent needs for chemical detection equipment. Together they have issued Joint Service Operating Requirements (JSOR) setting out the standards that chemical detection devices must meet. Such devices must:

- Detect chemical warfare agents (CWAs) before they reach lethal levels
- Respond rapidly to threats, within 30 seconds
- Avoid false alarms (false positives)

Furthermore, it is highly desirable that such devices are also:

- Simple to use and portable
- Reliable outside of strictly controlled environments
- Affordable enough to deploy widely

While these requirements seem reasonable and quite logical, no company has yet produced a technology that satisfies all of these key requirements.

Limitations and fatal flaws of current technology

A number of companies have developed chemical detection technology to address security needs, but even the most promising have fallen short. Either their devices can't detect a threat before it is lethal, they produce too many false positives, or they are too big, too complex and/or too expensive to be practical.

Common solutions include ion mass spectroscopy (IMS) as developed by Smiths Detection, a MEMS-variation as developed by Sionex, and flame photometry as developed by Proengin. All of these approaches are susceptible to false positives and often require high operating voltages. They are also typically bulky and expensive – stationary units for explosives may cost $50,000 to $100,000 or more and require a full-time dedicated attendant. Many so-called "portable" devices are the size of a shoe box and cost $10,000 to $20,000 per unit – hardly the kind of technology that could be carried in the field by every soldier or front line emergency responder.

MicroSensors Inc. makes devices using surface acoustic wave (SAW) technology. These products are more affordable, with low end equipment selling for as little as $5,000 to $8,000. But they lack sensitivity: an unprotected person could die before the device could detect danger from nerve agents.

Cyrano Sciences, acquired by Smiths Detection in 2004, has produced a chemo-resistive solution that was recently hailed as breakthrough technology, promoting badge-sized sensors costing around $1,000. Industry sources report that the company struggled in 2005 to meet testing deadlines and has yet to pass the JSOR requirements in live agent testing.

SenseHolding is the second company to license Oak Ridge National Lab technology, a cantilever MEMS solution using a deflected laser beam. But the sensor readout technology is complex and unstable, and has proven unreliable and expensive; the first company to license it failed to commercialize it and had to give up the license.

Finally, dogs are considered a standard for explosive detection, and have decent sensitivity for some threats. But they can be used for only short periods of time, in quiet and controlled environments away from crowds, and cost roughly $100,000 per year with trainers and constant attendants.

Clearly a technology that can meet or exceed the JSOR and can be readily deployed will have tremendous potential for impact and growth, especially since sizable federal budgets, up to a reported $7 billion, [have been earmarked for this effort

The BMS PicoSensor: a true breakthrough solution

Boston MicroSystems (BMS) has patented the only solution poised to exceed JSOR standards and satisfy deployment needs on a large scale. The BMS PicoSensor clears the hurdles of sensitivity, selectivity, portability, reliability and cost by focusing on size.

The idea is simple: if you want to accurately measure something as small as a molecule of a chemical agent, you've got to use an appropriately small scale. The BMS PicoSensor uses a PicoScale – picture a microscopic diving board measuring two micrometers in thickness, about 100 micrometers on a side (the cross-section of a human hair), and weighing only a nanogram. Because it is micromachined from one of the hardest known substances in the world – silicon carbide – it can maintain its precision even at this incredibly small size and thinness.

The PicoScale is coated with a piezoelectric layer that causes it to resonate at a specific frequency, the way a diving board would flex with a child bouncing up and down on it. A special coating on the PicoScale attracts molecules of the target chemical. As molecules are absorbed into the coating, the frequency of the resonating PicoScale changes proportionately, just as a diving board would flex more deeply and more slowly if more weight was added to it. It's this simple principle that allows for extremely accurate measurement of the concentration of the target chemical present in the air. Because they are so small, multiple PicoScales can be placed on a single chip, allowing a single PicoSensor chip to detect of a wide range of different chemicals.

The PicoSensor chips are combined with a MicroConcentrator to increase sensitivity and supporting electronics to form a self-contained module that can be easily integrated into a variety of instruments. The entire PicoSensor module is about the size of a bar of soap.

The extraordinary design of the BMS PicoSensor gives it extraordinary competitive advantages:

Ultra-Sensitive : the BMS PicoSensor is extraordinarily sensitive and precise. It is expected to exceed the JSOR requirement by 10 times or more, detecting nerve agents at about 1 part per billion, while presenting minimal false positives.

Portable: a detection device incorporating a BMS PicoSensor may be the size of a walkie talkie and weigh about 1 pound, while most competing devices are the size of a shoe box, bread box, or larger, and weigh several pounds or more.

Reliable: because of the ruggedness of its materials, the BMS PicoSensor can withstand extreme temperature variations and can be taken anywhere. Other portable devices can take 30 minutes to adjust to cold surroundings.

Efficient: power consumption is ultra-low – a small fraction of that offered by other solutions – translating into lower costs and many more hours of operation before batteries must be recharged. Many competing products only work when plugged into 120V AC or special high voltage outlets.

Easy to use: products built with BMS PicoSensors are as easy to use as a smoke detector, and can be operated by virtually anyone or hardwired to work automatically. Many competing products require expensive trained operators, cartridge changes, or time-consuming calibrations.

Affordable: instruments using BMS PicoSensors can be produced for a fraction of the cost of competing 'ultra-sensitive' products. Simply put, on a per dollar basis, more devices can be sent out into the field where they will help save lives.

The future of BMS PicoSensors

The BMS PicoSensor technology changes everything. Instead of a few detection devices positioned at passenger security checkpoints, an airport can be blanketed with PicoSensors that can identify and track a suspect from the moment he enters the building. Cargo holds can be outfitted with detection equipment that works at high altitude. And because devices with BMS PicoSensors are rugged, ultra-portable and easy to use, every emergency responder and every soldier can carry or wear a chemical detector.

With nine patents on its ground-breaking technology, BMS has completed R&D and is working with a leading manufacturer of safety and security equipment for production and market introduction. There is great interest from the security marketplace, and BMS was recently awarded a significant contract from the Transportation Security Administration to develop next generation solutions for trace threat detection. And there are many additional markets where the BMS technology can have great impact, notably the medical and automotive fields. BMS has been contacted by leading automotive electronics companies. Work at MIT has demonstrated the viability of PicoSensor technology in helping to reduce harmful emissions.

For more information about the BMS PicoSensor, please visit www.bostonms.com.

Boston MicroSystems, Inc.
Design Specifics: Inside the BMS PicoSensor

The BMS PicoSensor is built to detect chemical molecules, which weigh on the order of picograms, or trillionths of a gram. The PicoSensor consists of three major elements:

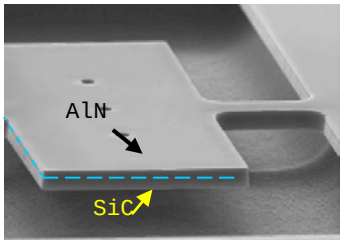
- A **PicoScale** micromachined from silicon carbide
- A **PicoSensor chip** containing multiple PicoScales, allowing for detection of multiple chemicals and virtually eliminating false positives
- A **MicroConcentrator** that increases PicoSensor sensitivity by up to 100 times

These components are co-packaged and combined with signal and temperature control electronics to form a chemical detection module about the size of a bar of soap. The module can be incorporated into any number of detection instruments for a variety of purposes.

The PicoScale: the heart of the PicoSensor

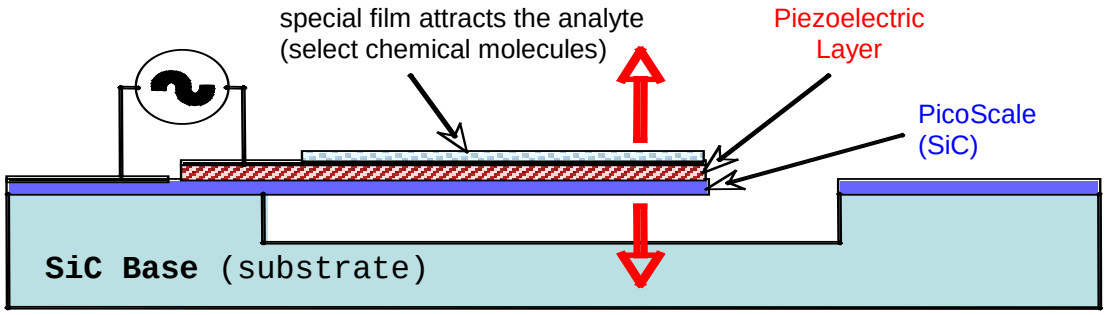
The PicoScale is a sliver of silicon carbide (SiC) micromachined to 2 to 5 micrometers in thickness and about 100 micrometers on each side – roughly the width of a human hair.

The PicoScale is coated with a piezoelectric layer of aluminum nitride (AlN) as well as an absorbent film designed specifically to attract molecules of a target chemical, or analyte. The film can be "tuned" to attract any one of a wide variety of chemicals.



PicoScale with ~100 micrometer footprint

A very low AC voltage applied to the piezoelectric layer causes the PicoScale to resonate, or vibrate, at a specific frequency. As the absorbent film attracts and absorbs molecules of the analyte, it increases the mass of the PicoScale, which itself weighs only a nanogram. This change in mass alters the frequency of the resonating PicoScale. By measuring that change in frequency – which is a relatively simple and cost-effective task – it's possible to determine with great specificity the amount of the analyte present in the surrounding air.



Cross-sectional diagram of a PicoScale

It's very much like a diving board. When a child bounces on the end of the board, it creates an up and down motion, or vibration, whose frequency can be precisely measured. If more children get on the board, the bouncing motion will be deeper and the frequency slower. Similarly, as

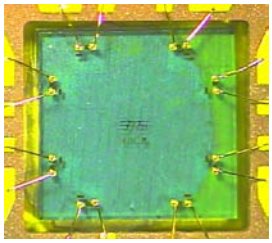
more molecules collect on the PicoScale, its frequency gets slower as well, and the change is easily measured.

The key to the success of the PicoSensor technology is size. After all, you couldn't effectively measure a slight change in molecules landing on something the size of a toothpick or a needle – it wouldn't be sensitive enough. BMS's breakthrough in this area is the result of a technique for creating an extraordinarily small scale that is both very precise and very durable.

The incredibly thin PicoScale is created from silicon carbide – one of the hardest substances known to man – through a powerful new proprietary process: photo-electrical-chemical (PEC) micromachining. The PEC process micromachines silicon carbide with exceptional precision and virtually no residual stress. BMS then applies the piezoelectric aluminum nitride via molecular beam epitaxy, a thin-film deposition technique that builds a thin layer of AlN, one layer of atoms at a time, without deforming the PicoScale. The PEC process allows BMS to create customized PicoSensors from materials that possess optimal electrical, acoustic, mechanical, thermal and chemical properties for the kind of work the PicoSensor must do.

The PicoSensor chip: testing for multiple chemicals

Multiple PicoScales can fit on a single PicoSensor chip. Because each PicoScale can be customized to detect a different chemical by changing the special film, a single PicoSensor chip can be configured to selectively detect a wide range of chemicals. A typical chip (a couple millimeters on a side) includes at least eight PicoScales. This is co-packaged with a MicroConcentrator and then complemented with signal and temperature control electronics to create a detection engine module. As PicoScales detect molecules of the analytes, electrical signals are generated by the PicoSensor module. This information is processed through software pattern recognition algorithms in the detection instrument made by BMS customers to determine which threats exist and to what degree.

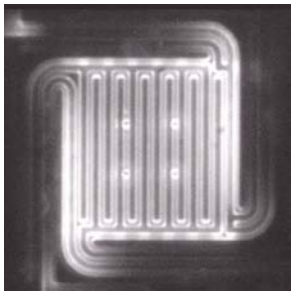


Chip with 8 PicoScales delivers versatility

The MicroConcentrator: improving sensitivity 100 times

While the size of the PicoScale allows for remarkable sensitivity, BMS has found a way to increase that sensitivity by as much as 100 times with a MicroConcentrator attached to the PicoScale.

The MicroConcentrator is a self-heated flow-through membrane coated with the same analyte-absorbent films that are applied to the PicoScale. The air being tested first passes through the MicroConcentrator which acts as a sponge for the analyte. The MicroConcentrator is heated to 100 to 200 degrees centigrade in just milliseconds, creating a high concentration burst of analyte which is then passed on to the PicoScale for measurement. This process amplifies the analyte by up to 100 times. It also filters out molecules that could interfere with the process of detecting the analyte.



MicroConcentrator ~ 100 X sensor amplification

The result is a much more sensitive reading. For example, without the MicroConcentrator, the PicoSensor might return a reading of 1 or 2 parts per billion (ppb). With the MicroConcentrator, the reading can be improved to read as low as $1/10^{th}$ to $1/100^{th}$ parts per billion, or 10 to 100 parts per trillion. This degree of sensitivity is just one quality that distinguishes the BMS PicoSensor from the competition.

The result: a superior chemical detection module

The PicoSensor's competitive advantages are the result of its size, structural design, simplicity and strength.

Size, of course, is the key to many advantages. The PicoSensor's small size allows it to be hundreds of times more sensitive and selective than competing sensors. The fact that an array of PicoScales can be incorporated into a single PicoSensor means that a detection device can test for a large number of chemicals without the need to power down, swap out cartridges, and power back up. It's small size allows it to be more portable and more versatile – PicoSensor modules can fit into existing detection equipment, whether portable, transportable or larger installed units. And since small things need less power, power consumption of the PicoSensor is a fraction of most competing products.

The structure of the PicoScale as a resonating sliver of silicon carbide is a key element of the PicoSensor's competitive advantage in sensitivity. Even the slightest frequency changes of the PicoSensor can be measured with precision using cost effective and compact electronics. This is not the case with other detection solutions, which require more power, are often bulkier and are more easily disturbed by handling or the slightest change in surrounding conditions.

The simplicity of design allows the PicoSensor to be less expensive to manufacture (with fewer rejects) and far more reliable in the field than most competitors' products.

And the strength of materials means the PicoSensor is extremely rugged and durable. It can be operated in extreme temperature conditions, while competing products often require room temperature conditions or up to 30 minutes to warm up and stabilize in cold air.

Boston MicroSystems, Inc.
The Road to Market
Turning exceptional technology into a new industry standard

It's one thing to see a need and invent a technology to fill it. It's quite another to have the experience, skill and business strategy to turn a prototype into a reliable supply of superior product and take that product to market.

BMS is perfectly poised to aggressively and successfully enter the marketplace. We have an extraordinary product with exceptional test results. We have a management team with proven ability to bring new technology to market. And we have a business strategy that will let us move quickly and aggressively to dominate this market.

An extraordinary product

When you're bringing a new technology to a demanding market, the product had better be remarkable. Ours is, and it's only getting better.

Early Test Results are Exceptional
We recently delivered prototypes of the PicoSensor to our lead customer, a leading supplier of safety and security equipment. They tested the product and here's what they found:

> The PicoSensor has a sensitivity of parts-per-billion in detecting simulated chemical warfare agents (CWA).

These results are astounding. BMS is on track to exceed the specifications set by both our lead customer and the U.S. Government's Joint Operating Service Requirements (JSOR) for chemical detection equipment. What's more, the PicoSensor presented *no false positives* in early tests of 7 out of the 10 interferents stipulated by the JSOR.

Engineering Refinements Will Improve Performance
While these early test results are quite promising, we're not yet satisfied. Though we're done inventing, we are in the process of applying some engineering refinements that will allow the PicoSensor to perform even better. These include:

> Low-noise electronics – our partner, Vectron International, has designed low-noise electronics for the PicoSensor. This improvement is expected to increase sensitivity by 17 to 50 times.
>
> Microconcentrator – this technology concentrates the target chemical before it reaches the PicoScale in order to provide a more accurate reading. The addition of the microconcentrator is expected to boost sensitivity by 10 to 100 times.
>
> Optimized polymer coatings – we're refining the analyte-absorbent film that coats both the PicoScale and the microconcentrator, based on trends we've observed in polymer thickness, polymer morphology and thermal characteristics. The resulting increase in sensitivity should be 2 to 20 fold.

Additional improvements – refinements to processes and fabrication adjustments will increase sensitivity by another 3 to 16 times.

Bottom line: While the PicoSensor already represents a remarkable leap in design and performance at the most fundamental level, the engineering improvements currently underway will increase the sensitivity of the PicoSensor by at least hundreds of times if not thousands. That means we can expect to exceed the JSOR specs by 10 to 100,000 times.

Nine Patents Provide Competitive Advantage
One important element in dominating a market is protecting your intellectual property, and BMS technology is well-protected in a number of ways. First, BMS holds exclusive licensing rights to the fundamental MIT photo-electro-chemical (PEC) micromachining patents. BMS has patented blocking extensions and refinements to the MIT patents, extending its patent protection by over ten years. BMS has also been awarded several key patents relating to numerous sensor and device applications, protecting processes, materials and device designs. In all, BMS holds seven patents relevant to three different sensor platforms including the PicoScale, a microhotplate based gas sensor, and a flexural plate sensor for fluids. In addition, BMS holds options to key MIT gas sensor patents, including several for diesel emissions control.

A proven team

It's no small feat to bring a new technology to market. The management team at BMS has the business savvy, technical horse-power and proven track record to successfully navigate this journey.

On the business end, **Dr. Dan Button**, President and CEO, has more than 20 years of experience launching and building technology-based businesses in global, high growth markets. He has repeatedly delivered products with industry-leading market share and margins. With a proven ability to spearhead partnerships across the value chain, Dr. Button's successes include developing electronic materials for microelectronics and packaging at DuPont; precision flat glass for LCDs at Corning; and electronic paper components for hand-held devices at E Ink, where he raised $40 million in equity and struck a major product deal with Sony.

The technical team is led by the co-founders of BMS and two of the world's brightest minds in sensor technology.

Professor Harry Tuller, Co-Founder and Chief Technical Advisor, is a worldwide authority on solid-state sensors, actuators and high-performance materials. He is the co-inventor of BMS' micromachining and sensor technologies. With more than 25 years of experience as a professor of Materials Science & Engineering at MIT, Professor Tuller has published over 250 articles, co-edited 11 books and been awarded 13 patents. He is the editor and founder of the Journal of Electroceramics.

Dr. Richard Mlcak, Co-Founder and Chief Technical Officer, has 13 years experience in microsystems processing, design, development and commercialization, and unrivaled experience with SiC micromachining. He is the co-inventor of BMS' novel micromachining and sensor technologies and leads development of sensor products and versatile R&D tools at BMS. Dr. Mlcak has been awarded 10 patents on microfabrication technologies, microsensor transduction mechanisms, high temperature compatible electronic materials and R&D instrumentation and methods for micromachined structures (MEMS).

An aggressive business strategy

Our business strategy is simple but sound. It's a strategy that will let us aggressively secure contracts and quickly ramp up to fulfill them.

Leverage government mandates
U.S. government mandates for better detection equipment provide significant opportunities for BMS.

These mandates have already enabled us to secure contracts with OEMs to design the PicoSensor module into equipment currently in development. In 2005, for example, BMS secured contracts worth over $1 million from the Transportation Security Administration (TSA) to develop a next generation explosive detection solution for air cargo security. (TSA has recently approved additional funding bringing this total to over $3 million, now awaiting authorization from the Department of Homeland Security.)

As a contractor to TSA, we are perfectly positioned to provide design-in solutions to TSA and other agencies that certify detection equipment. Currently, we expect to sub-contract with the leading suppliers of airport security systems, to develop new explosives detection solutions for portal and cargo applications.

Leverage best-in-class partnerships across the value chain
BMS has partnered with several well-established, competitive companies who provide leading market positions and channels, and a proven supply of product. These strategic partnerships cover the entire value chain and will let us reach market faster than competitors and deliver aggressive cost reductions.

> **Manufacturing** - we have partnered with Advanced MicroSensors, a leading manufacturer of micromachined structures (MEMS), to reliably produce superior components at high volume and low cost.
>
> **Packaging** - we've partnered with Vectron International, a world leader in manufacturing and design of high frequency electronics and robust packaging. Their expertise will let us cost-efficiently manufacture the supporting electronics and packaging used to assemble PicoSensor components into a stand-alone module.
>
> **OEM** – we've signed a partnership agreement with a global leader in the development, manufacture and supply of sophisticated safety products. With nearly $1 billion in sales and 2000 distributors in North America alone, this partner provides an ideal design-in opportunity and distribution channel.

By partnering and outsourcing with these best-in-class manufacturers, BMS can stay lean and mean, avoid delays, and focus our considerable expertise on engineering refinements and adaptation of the PicoSensor to the needs of specific customers and industries.

Appendix A: future opportunities

While the immediate demand for BMS technology is in homeland security, other industries are seeking simple, breakthrough solutions to fill major unmet needs.

Automotive
BMS has been approached by numerous automotive and electronics companies who must meet stringent government regulations for diesel emissions in 2010 in the US and Europe. By serving as a NOx emission sensor that controls a diesel "catalytic converter", BMS technology can accelerate the adoption of diesel fuel and fulfill the promise of a cleaner and more efficient energy source.

Medical
BMS technology can detect odors produced by the body's chemical reaction to infections and disease. As an "electronic nose", BMS PicoSensors could monitor or screen for infections like sinusitis and pneumonia and diseases like diabetes, kidney failure and lung cancer—often without the delays and expense associated with blood work or exploratory diagnostics. And because the PicoSensor is rugged and can be battery-powered, the power of instant diagnosis could reach every corner of the planet.

Food
Because odor from food is a strong indicator of edibility, BMS technology can be used to monitor food quality in processing, transit, restaurants and retail sales. This promotes safety and reduces unnecessary waste.

Other opportunities

The proprietary processes we've created have broad application beyond the PicoSensor.

Our patented PEC process, for instance, is able to micromachine virtually *any* semiconductor material in any crystallographic direction. Other existing techniques can only micromachine silicon as a semiconductor, and only in one crystallographic direction. This opens up whole new worlds of possibilities for semiconductors. With a wider palette of materials to choose from, fabricators will be able to select semiconductors with the ideal set of properties for each application.

BMS also has a microhotplate gas sensor that can measure permanent gases (NOx, CO, H2, and hydrocarbons, for example) while operating at extremely high temperatures and in chemically hostile environments.

And our fluid condition sensor has the potential to stimulate major efficiencies in the operation of refrigeration systems, engines and other heavy machinery.