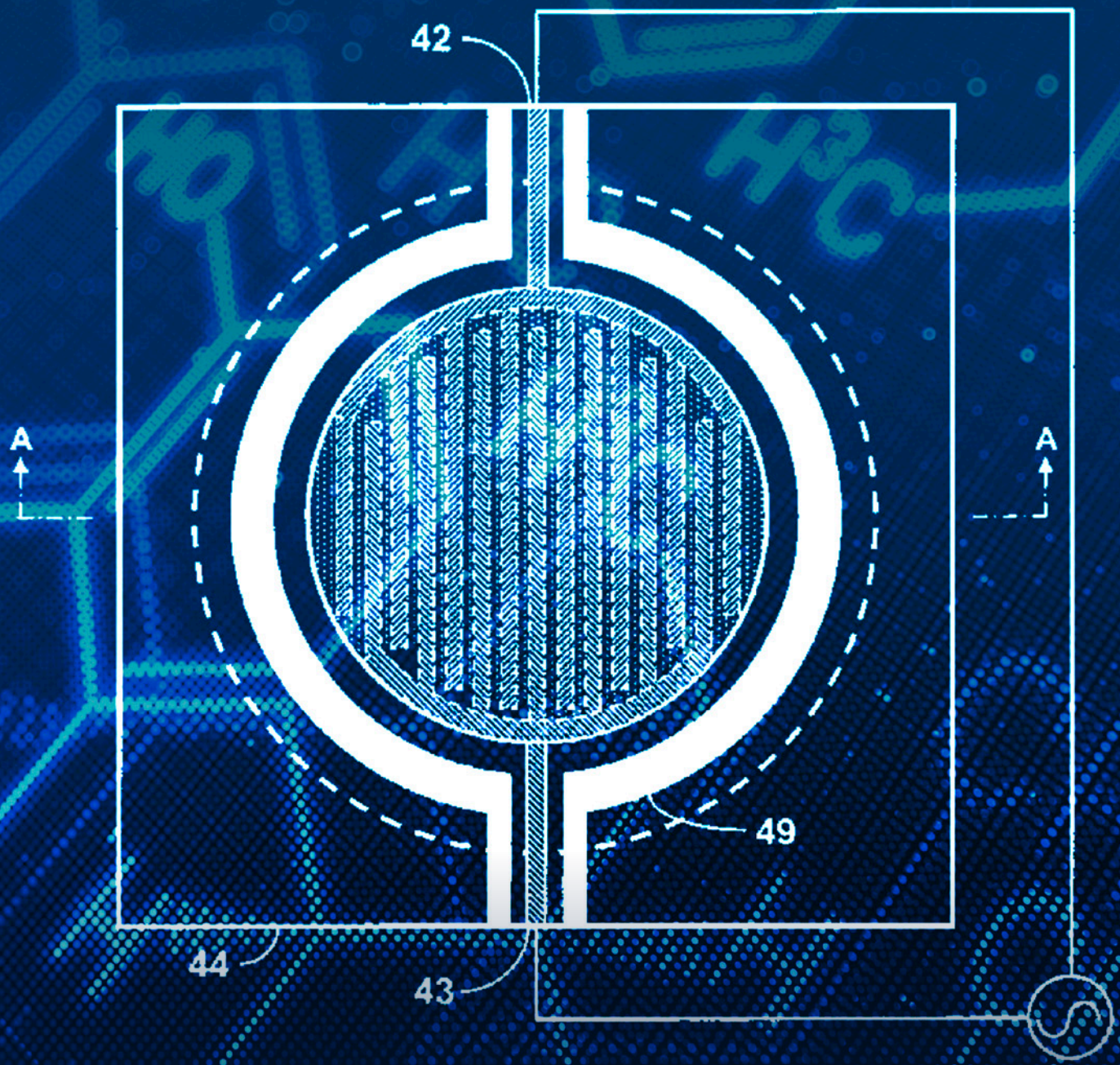
Sandia's INNOVATION MARKETPLACE

A QUARTERLY UPDATE OF AVAILABLE TECHNOLOGIES FOR INDUSTRY



September 2014 Vol 1, Issue 3

Sandia National Laboratories

Welcome to Sandia National Laboratories' Intellectual Property Showcase

Sandia's Innovation Marketplace is a quarterly e-magazine published by Sandia National Laboratories. This publication highlights exceptional opportunities for licensing Sandia's intellectual property, including patents, copyrights (generally software), trademarks, and mask works. Listings within should not be construed as an offer to license technology. All licenses are subject to negotiation and availability of the intellectual property for licensing. This publication is intended for indications of interest only.

Why Work with Sandia?

Leverage World-Class Technology and Research

For more than 60 years, Sandia has delivered essential science and technology to resolve the nation's most challenging security issues. A strong science, technology, and engineering foundation enables Sandia's mission through a capable research staff working at the forefront of innovation, collaborative research with universities and companies, and discretionary research projects with significant potential impact.

The Best and Brightest

In keeping with our vision to be the nation's premier science and engineering laboratory for national security and technology innovation, we recruit the best and the brightest, equip them with world-class research tools and facilities, and provide opportunities to collaborate with technical experts from many different scientific disciplines. The excitement and importance of our work, an exemplary work environment, partnerships with academia, industry, and government, and our record of historic contributions help us attract exceptional staff. Our employees are recognized by their professional peers for their outstanding contributions.

To discuss licensing opportunities, please send inquiries to: ip@sandia.gov
Or for more information, visit our website: https://ip.sandia.gov

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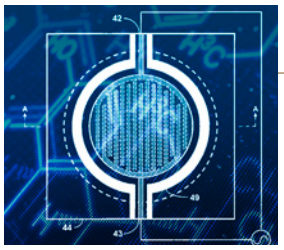
Exceptional service in the national interest

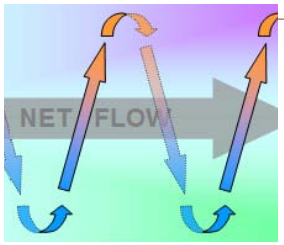
ON THE COVER

Sandia's millimeter-sized fringing-field capacitive sensor provides users with a low-power, self-heating chemical sensor suitable for remote and unattended sensing applications. Sandia's chemical sensor is able to optimize sample collection time enabling efficient, rapid, and accurate analysis of analytes.

Read more about Sandia's Capacitive Chemical Sensor on page 6.

Technology Categories





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Sandia Technology Showcase

Sandia National Laboratories strives to develop innovative and functional technologies that can be licensed to the general public. To further facilitate technology transfer, Sandia has launched the Sandia Technology Showcase - a series of events aimed at fostering partnership opportunities through the deployment of exceptional pieces of intellectual property. To learn more about the technologies selected for upcoming events, look for the Sandia Technology Showcase logo throughout the publication. For more information about Sandia's Technology Showcase, please contact Michelle Gonzalez at: mjgonz2@sandia.gov

Bacillus anthracis Detection Cartridge (BaD_x) makes anthrax detection safer, easier, faster, and cheaper

Bacillus anthracis, the bacterium that causes the disease anthrax, is commonly found in the soil of agricultural regions and can cause serious, if not fatal, illness in both human and animals. Sandia recently developed a portable device the size of a credit card that can detect the presence of B. anthracis spores and requires no battery or electricity to function. BaD_x is a unique and inexpensive alternative to current anthrax detection methods, with each cartridge costing around $5-$7.

Through the process of amplification, BaD_x can detect up to as little as 100 b. anthracis spores. A trained technician would place a sample swab into the amplification chamber containing a selective growth media. Through lateral flow assay, similar to a common pregnancy test, B. anthracis can be detected and a colored line will appear on the device several hours later if the test is positive for the bacterium.

Applications and Industries

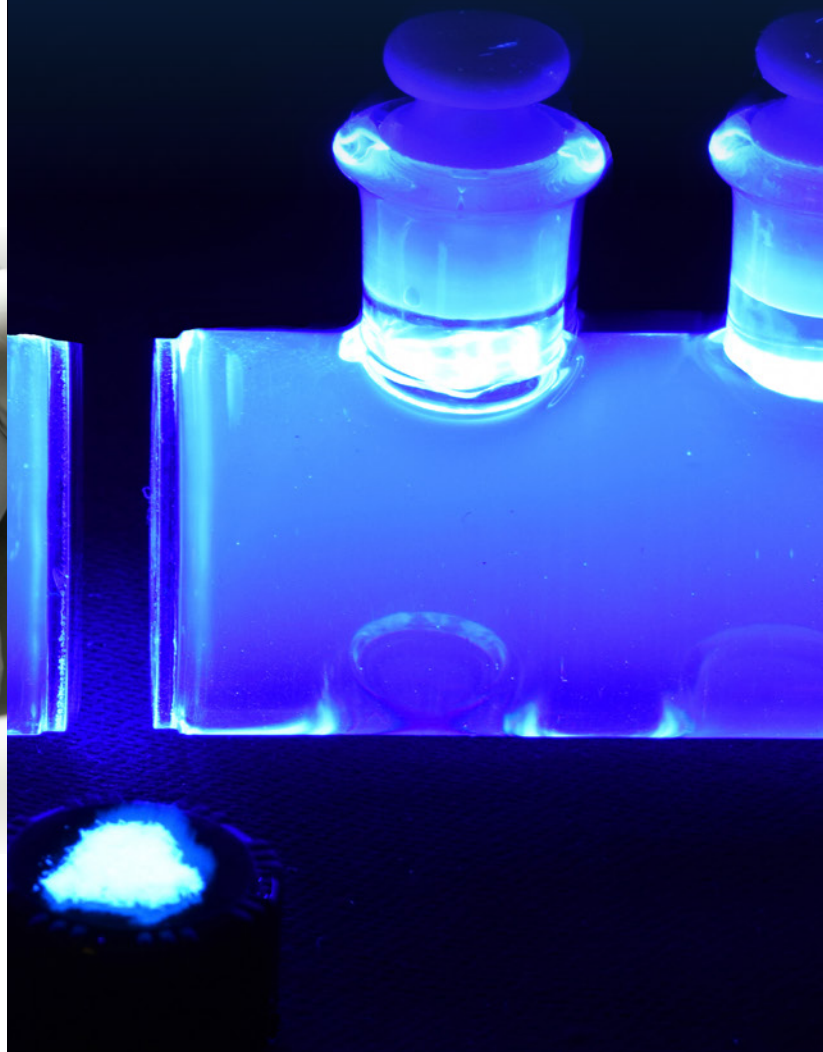
- Agriculture
- Health care
- Medical devices
- Pharmaceutical

Class of Hybrid Liquid Scintillators improves detection of nuclear materials while reducing costs and environmental hazards

Sandia has developed a class of hybrid liquid scintillators for the improved detection and discrimination of nuclear threat materials. The technology is composed of three key components: (i) at least one surfactant or emulsifier, (ii) a polar hydrogen-bonding solvent, and (iii) at least one luminophore. One embodiment of the invention comprises a water-based mixture that enables fast neutron/gamma-ray discrimination, as required for the identification of illicit Special Nuclear Materials (SNM). The application of water-based mixtures also enables large-scale deployment at lower cost and greatly reduced environmental hazards compared to traditional liquid scintillators.

Applications and Industries

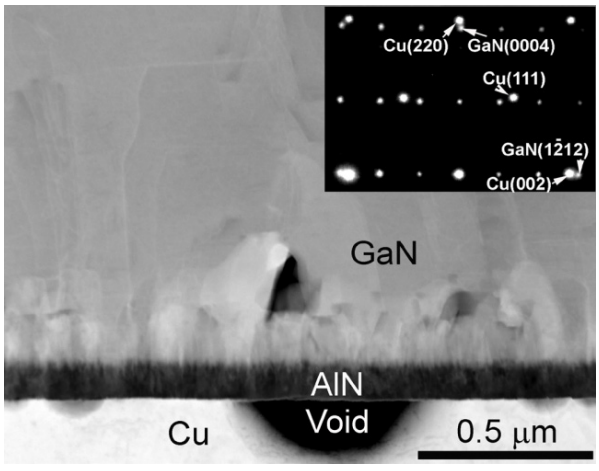
- Nuclear nonproliferation
- Radiation detection
- Homeland security
- High-energy physics



Sandia's Method to Grow Group III-Nitride Semiconductor Material uses copper substrates to increase device performance while reducing costs

Gallium nitride (GaN) is an important Group III nitride semiconductor material used in the areas of light-emitting, lasing, high-frequency, high mobility, and high-power devices. Due to the high cost and lack of availability of bulk GaN substrates, GaN is generally grown heteroepitaxially on foreign substrates such as sapphire, silicon carbide, or silicon. However, device performance is limited by the poor electrical and thermal conductivity of the substrates, decreasing efficiency and limiting device power.

Sandia has developed a method of growing GaN on copper substrates using the process of metal-organic chemical vapor deposition (MOCVD). Copper is the preferred metal of choice due to its superior thermal and electrical conductivity. A passivation layer is grown on the copper substrate, allowing a Group III-nitride epilayer to be grown on top. Benefits of this method include improved heat dissipation and current spreading ability, thus avoiding the need for the lift-off and bonding processes. By utilizing Sandia's method, the user can expect increased performance and reduced cost.



Cross-sectional scanning transmission electron microscope image of a single crystalline GaN film grown on copper using an aluminum nitride (AlN) passivation layer (Inset: electron diffraction pattern showing the epitaxial crystal relation of GaN and copper)

Applications and Industries
- Microelectronics
- Semiconductor manufacturing
- GaN-based LEDs, lasers, and high power electronics

Sandia Technology Showcase

Noninvasive Microneedle Arrays for Electrolyte Sensing enables users to monitor levels of various biofluids within the body

Sandia has developed a microneedle fluidic chip that can detect and measure the amount of electrolytes within the body. Electrolyte levels are essential in monitoring the health and strength of those who are subject to extreme conditions. The device features nine sampling needles, each around 800 millionths of a meter (microns) in height. The needles puncture the skin and sample the interstitial fluid (fluids that lie between skin cells) while funneling the fluid into a channel that spreads the fluid across electrode transducers. The electrodes can be selectively altered to measure a variety of different electrolytes and multiplexed to measure different electrolytes simultaneously, such as sodium or calcium, on the same device. The device is non-invasive and painless because it utilizes micro-needles that are so small they cannot traumatize nerves when pressed into skin.

Applications and Industries
- Health care
- Medical devices/sensors
- Microelectronics

Thermally Switchable Dielectric provides safety mechanism for capacitors prone to overheating

Sandia has developed a thermally switchable dielectric material that can be used in capacitors that fail when heated. The dielectric is comprised of a non-conjugated precursor polymer that contains a leaving group that eliminates overheating when it reaches a certain elevated temperature. The increase in temperature causes the polymer to convert from an insulator to an electrically conductive conjugated polymer. When a high temperature is reached, the elimination of a leaving group converts the precursor insulating polymer into a poly(pphenylene vinylene) (PPV). PPV is a conducting polymer and due to its stability and electrical and optical properties, has been a topic of research for its potential use in a variety of applications. Sandia's thermally switchable dielectric could be used as a built-in safety mechanism for capacitors that are prone to overheating, which may be useful in a variety of applications, such as hybrid and electric vehicles.

Applications and Industries
- Electric/Hybrid Vehicles
- Pulsed power
- Power conditioning

Sandia Technology Showcase

Capacitive Chemical Sensor provides autonomous, selective and sensitive chemical sensing with little to no maintenance

Utilizing parallel-plate technology, Sandia has developed a capacitive chemical sensor that can detect chemicals in a gas or liquid environment. The chemical sensors have the ability to provide autonomous, selective and sensitive chemical sensing with little to no maintenance. Switching the dielectric films of the sensor allows the user to tailor the sensor to chemically react with different target analytes, which can be observed through changes produced in the capacitance of the sensor.

Like the conventional chemical preconcentrator, the sensor adsorbs target analytes but has the added function of being able to determine the relative amount and type of the adsorbed species. The advantages of the Sandia's sensor include optimized or reduced analysis time of the total-system and assurance that analyte concentrations are within the systems detector's linear regime, all the while protecting the system from overloading.

Sandia Technology Showcase

Applications and Industries
- Industrial hazard detection
- Chemicals

Goma's ease of use makes it valuable for graduate research students learning the benefit of code development as well as high-end analysts in topical manufacturing and related industries

2014 R&D 100 Award Winner

Goma is an open-source, parallel, finite element software that excels in the analyses of multiphysics processes, particularly those involving the major branches of mechanics (i.e.fluid/solid mechanics, energy transport and chemical species transport). Sandia developed the software to appeal to those interested in simulating manufacturing processes, providing users with the ability and flexibility to mix and match physical-chemical interactions while developing physics models. Goma is based on a full-Newton coupled algorithm, allowing for simultaneous solution of the governing principles. The code is ideally suited for problems involving closely coupled bulk mechanics and interfacial phenomena. Example applications include, but are not limited to: coating and polymer processing flows, super-alloy processing, welding/soldering, electrochemical processes, and solid-network or solution film drying.

Applications and Industries

- Manufacturing processes
- Electrochemical phenomena
- Multiphase flow in porous media
- Rheological flow
- Thin-structure/region mechanics

Embedded Fiber Optic Sensors enable measurement of apparent velocity time histories in low to high shock regimes and for non-shocks

Current laser interferometry pressure pulse detection techniques use the shock induced change in index of refraction to track detonation and/or shock fronts in a single fiber optic by reflecting laser light off of the boundary created between the unshocked material and the shocked material. However, this technique cannot be used in regimes where there is not a strong enough shock front to reflect the laser light above the noise floor. Other embedded fiber techniques use a chirped fiber Bragg grating to track a shock position versus time by correlating a known spectrum of light to a calibrated position. The two systems described above use a single fiber and measure only time-of-arrival for a strong shock. Sandia has developed a novel Embedded Fiber Optic Sensor (EFOS) system able to measure apparent particle velocity time histories in low to high shock regimes and for nonshocks. The apparent particle velocity traces provide both time-of-arrival data and can be transformed into pressure time histories, a capability unique to the Sandia EFOS system.

Many explosives and/or combustion events have short run-up distances requiring sub-millimeter measuring techniques. Sandia's EFOS system utilizes Corning SMF-28 9/125-µm diameter fibers (but not limited to glass fibers) placed at known distances from a target surface and connected to infrared detectors coupled with Photonic Doppler Velocimetry (PDV). The PDV system uses the Doppler shifted beat frequency of reflected infrared laser light as compared to a reference leg of the laser source with a heterodyned signal. The probes detect apparent particle velocity traces similar to that seen in traditional laser interferometer particle velocity measurements that help interrogate the transient phenomena of explosives or shock waves, but at the microscale and potentially smaller.

Application and Industries:

- Aerospace – propulsion systems, "smart" materials
- Automotive – engine design and health monitoring
- Defense – design and/or evaluation of systems using energetic materials
- Medical – transducers for medical procedures involving pressure pulses
- Seismology, oil and gas

PDV coupled with the EFOS diagnostics could be used in both military and civilian weapons systems during the concept, design and fielding phases in measuring exerted chamber and barrel pressures (derived from particle velocities), timing etc.

Photograph of a Cessna propeller near the intake of the engine. The EFOS diagnostic could be embedded into the propellers to measure the apparent particle velocity induced by the propeller straining and bending during flight. This would serve as a health monitoring diagnostic and could give a history of what the propeller has seen in service.

Photograph of 4.6 Liter 4V Mustang Cobra engine. Monitoring of combustion events in engines are of significant importance because the data produced by EFOS embedded in the cylinder walls can tell the controlling computer the state of health of each cylinder

Microfabricated Thermionic Detector (TID) provides instantaneous analysis of pesticides, chemical warfare agents, explosives, pharmaceuticals, and more

Portable, handheld microanalytical systems, which have been termed "chemical laboratories on a chip," are being developed to enable the rapid and sensitive on-site detection of particular chemicals, such as pollutants, high explosives, and chemical warfare agents. These microanalytical systems provide a high chemical selectivity to discriminate against potential background interferents and the ability to perform the chemical analysis on a short time scale. In addition, low electrical power consumption and reagent usage is needed for prolonged field use. Conventional gas thermionic detectors (TID) provide precise and accurate results. However, the time between sample collection in the field and the availability of results from the laboratory can often be weeks.

Sandia has developed a microfabricated TID that can provide high sensitivity and selectivity to nitrogen- and phosphorous-containing compounds and other compounds containing electronegative function groups while minimizing the usage of reagents, including hydrogen. Furthermore, Sandia's microfabricated TID does not depend on the adsorption of vapor to produce a detector signal. Therefore, compared to polymer-coated microbalances that are commonly used in microanalytical systems, the response of the microfabricated TID is instantaneous. Due to its sensitivity and selectivity for nitrogen and phosphorus, the TID is especially useful for the analysis of pesticides, chemical warfare agents, explosives, pharmaceuticals, and other organic compounds that contain nitrogen or phosphorus.

Applications and Industries

- Gas chromatography

Sandia Technology Showcase

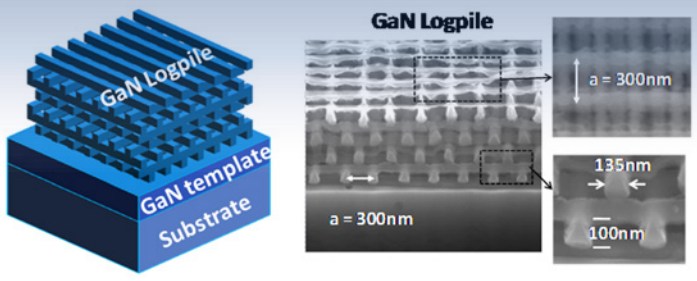
3-D Photonic Crystal Light Source enhances the performance of LEDs

Sandia has developed a light source comprised of a three-dimensional photonic crystal, which is an artificial structure that contains alternate regions of high and low refractive index materials. Within the three-dimensional photonic crystal is a semiconductor with a direct bandgap and wherein a p-n junction exists. As a result, electrical contacts create biasing of the p-n junction to produce light emission through the recombination of electrical carriers. 3-D photonic crystals possess the ability to modify the electromagnetic environment surrounding an emitter, allowing the user to control the amount of light being emitted. This is particularly useful in enhancing the performance of LEDs wherein wavelengths such as green, yellow and red provide particularly low efficiencies.

Current efforts that involve group III-nitrides as semiconductors utilize two-dimensional photonic crystals, improving light extraction efficiencies and achieving highly directional emission. However, two-dimensional photonic crystals are limited by their ability to operate on only one plane, and do not offer complete three-dimensional control.

Applications and Industries

- LEDs
- Lighting
- Medical devices



Gallium nitride epitaxial three dimensional photonic crystal

Security & Asset Management

Xyce™ analog circuit simulator allows users to solve large circuit problems designed for large-scale parallel computing platforms

The Xyce Parallel Electronic Simulator is a SPICE-compatible circuit simulator, developed internally at Sandia and funded by the National Nuclear Security Administration's Advanced Simulation and Computing (ASC) Campaign. In continuous development since 1999, Xyce is designed to run on large-scale parallel computing platforms, though it also executes efficiently on a variety of architectures, including single processor workstations. As a mature platform for large-scale parallel circuit simulation, Xyce supports standard capabilities available from commercial simulators.

As a SPICE-compatible tool, Xyce supports standard analysis methods, such as steady-state (DCOP), transient (TRAN) and small-signal frequency domain (AC). A number of more exotic analysis methods have also been implemented, including Harmonic Balance, Multi-Time PDE and model order reduction methods.

Xyce also supports a canonical set of compact models. These include most SPICE3f5 models, and industry standard models, such as: VBIC and FBH bipolar transistor models, various BSIM MOSFET models, the PSP MOSFET model and the VDMOS power MOSFET model. A number of nontraditional models are also implemented that support neuron simulation and reaction networks. In addition, Verilog-A models may be processed into Xyce-compatible C++ code using the ADMS model compiler with the Xyce/ADMS back-end. Finally, a powerful expression capability is included in Xyce, allowing for the parameterization of existing models, or the implementation of user-defined behavioral models directly in the input file. The expression capability includes user-defined functions, conditional expressions and time integration, among other features.

For more information, visit https://xyce.sandia.gov/

Sandia Cyber Omni Tracker (SCOT) incident response collaboration and knowledge capture tool focuses on flexibility and ease of use

Cyber Security Incident Response (IR) teams use a variety of systems to detect, collect and analyze cyber security data. Unfortunately, these systems often fail to work together to provide the analyst with the entire picture of what is occurring. To address these shortcomings, Sandia developed SCOT to coordinate incident response efforts, capture the team's knowledge, and to automate common incident response task.

Sandia's Cyber Omni Tracker (SCOT), a security incident response management system, aims to improve analyst effectiveness. A new approach to handling cyber security incident data, SCOT provides users with the ability to manage security alerts, coordinate team efforts, capture team knowledge, and analyze data for deeper patterns. SCOT also integrates with existing security applications, providing a consistent and easy-to-use interface that encourages greater sharing of cyber security analysis results. Designed to be scalable and easy to maintain and use, SCOT has processed over 1.6 million alerts since its deployment, while maintaining 99.9% availability on modest server hardware. The knowledge in SCOT has helped Sandia's incident response team train new members, detect subtle attacks by advanced adversaries, and manage the rising tide of cyber security events.

Why Use SCOT?

Developed by cyber security incident responders, for cyber security incident responders, SCOT provides many advantages to an IR team:

- Designed to be easy to use, learn, and maintain
- Instant updating keeps IR team in sync and their efforts coordinated
- Automated detection and correlation of common cyber security indicators such as IP addresses, domain names, file hashes, and e-mail addresses
- Alert collection and centralization from a wide range of security systems
- Extensible plugin infrastructure to allow additional automated processing
- Full Text searchable knowledge base that allows the entire IR team to easily learn from past cyber security events

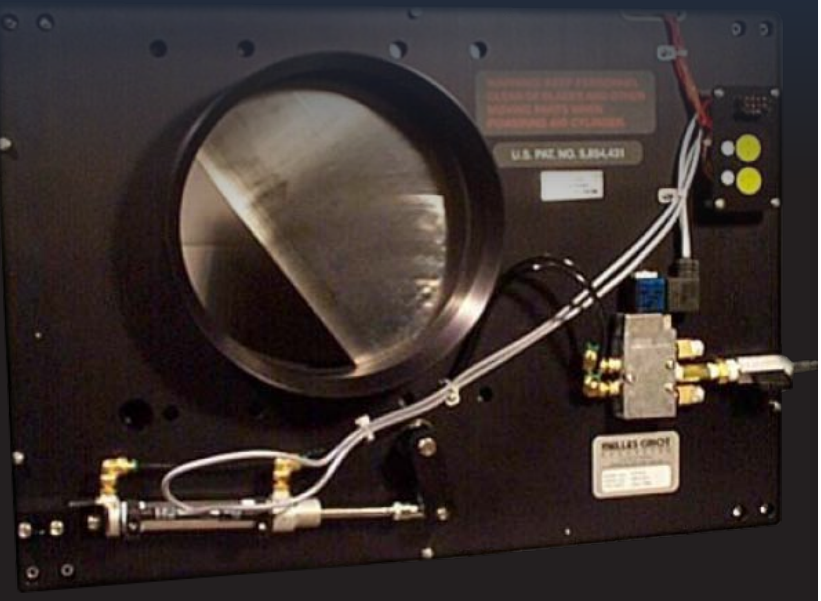
For more information, visit http://getscot.sandia.gov/

Preconcentrator uses a high volume chiller to detect explosive materials from minimal quantities of vapor

The ability to detect explosive materials from minimal quantities of vapor and/or microscopic particles is important to physical security and contraband detection systems. In applications where the general public is involved, such as airport screening, swipe collection of potential explosive particles through direct physical contact can be physically invasive and time consuming, so it is advantageous to base the collection process on air flows.

Sandia has developed a preconcentrator that detects high vapor pressure explosives. The device utilizes an apparatus that collects a large volume sample gas stream. Large volume active cooling creates a supply of cold air that is mixed into the sample gas stream, thereby reducing the vapor pressure of the particles. A chiller attached to the apparatus cools the air down to 0-15°C, while equalizing the volumetric flow rate of both the cold air supply and the sample gas stream. An adsorption media is heated in two stages, at a temperature where decomposition products of the high vapor pressure particle are generated.

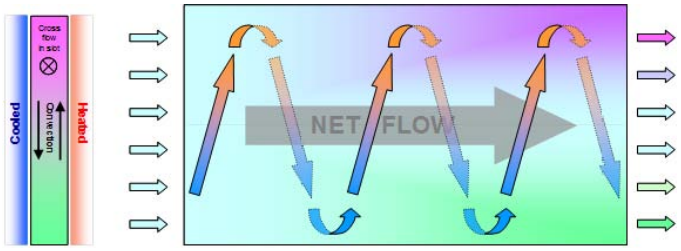
Applications and Industries
- Aircraft and aerospace
- Chemicals
- Public Safety
- Transportation and automotive



Sandia's Process and Apparatus for Separation of a Gas Stream improves detection limits for trace components in a gas stream or in the air

Flue gases exiting to the atmosphere may contain a high percentage of pollutants. Current mechanisms remove pollutants emitted from exhaust sources by separating and storing gas based on species weight. In many simple, static systems, the variation in the composition of the gas phase is minor. Sandia has developed a mechanism where larger degrees of separation is achieved by using an advecting-convecting cross-flow system.

Combining thermal-diffusive separation with convective flow can result in large degrees of separation. The best-known mechanism for illustrating this process is the Clusius-Dickel column— a gas-filled glass tube cooled on the outside with a water jacket and a heated wire in the center. Sandia has developed a modified design involving an air stream directed along the slot with heated and cooled sides. The convective flow forms a spiral while the rising and sinking air streams move across each other at an angle (cross-flow), instead of in opposite directions. The result is a compositional gradient that develops vertically in the slot in the direction of air. Rather than the development of a progressively larger gradient over time, as in a fixed column of gas, the gradient develops in the direction of flow down the slot. The advantage of this design is that a continuous air stream can be separated, rather than a fixed volume of gas in a closed column. The cross-flow slot is a new approach to gas separation, which may be useful in converting gas-phase thermal diffusion to a feasible industrial process.



Schematic of cross-flow slot for separation by thermal diffusion

Applications and Industries
- Oil and gas
- Analyzing trace components in gas/air streams
- CO_2 Separation and Sequestration

Heat Flux Sensors provide a more accurate and cost-effective way of tracking solar rays

Concentrating Solar Power (CSP) utilizes an array of mirrors that focus rays of sunlight onto a central receiver. The receiver contains a material that stores heat energy later used in a conventional power cycle to produce mechanical power, driving an electrical generator. To avoid losing reflected solar energy, it is essential that the solar collectors are aligned properly and centered on the receiver.

Sandia's heat flux sensor is comprised of two closely-coupled thermocouple junctions with opposing electrical polarities, separated by the thermal resistor. This arrangement creates an electrical signal that is proportional to heat flux intensity. When mounted on opposite sides of the focal point on a solar collector, changes in focal position triggers a change of flux intensity within the sensors. Flux intensity of one sensor increases while the other decreases— this difference of intensity is what is used to adjust the tracking of the solar collector. Sandia's innovative heat flux sensors provide a more accurate and less expensive way of tracking solar rays while minimizing the amount of reflected solar energy that is lost.

Applications and Industries:

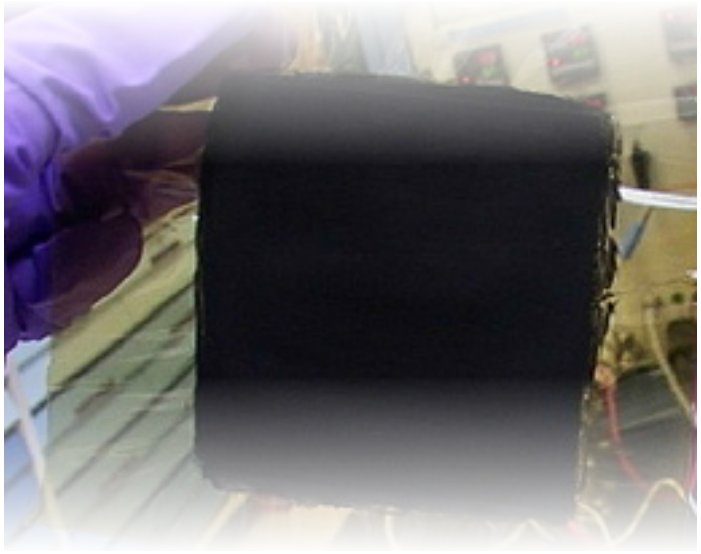
- Concentrating solar power
- Solar collectors
- Electric utility

Sandia Technology Showcase
Partnership Opportunities — Year-Round

Sandia Fuel Cells represent a revolutionary alternative to current methods of energy production, utilizing chemical reactions to enable clean and reliable power generation.

Polymer electrolyte fuel cells (PEFCs) represent a potentially viable alternative to current sources of power generation. Among the various types of fuel cells, PEFCs possess the advantage of having a high power density and a low weight to power ratio. The PEFC uses a polymer membrane as its electrolyte, yet current PEFCs suffer from interfacial resistance between the membrane and the electrode, resulting in decreased efficiency. Furthermore, there exists a need to create a fuel cell membrane that can withstand temperatures of up to 120°C and maintain dimensional stability when fully hydrated.

To combat these limitations, Sandia developed a fuel cell with an epoxy-crosslinked sulfonated poly(phenylene) copolymer as the proton exchange membrane. Crosslinking the polymers prevents the membrane from excessive swelling at higher temperatures, while also maintaining its high ionic conductivity. Sandia's membrane is tougher, can sustain a higher temperature range, and produces lower fuel crossover rates.



Similar to the Epoxy-Crosslinked Sulfonated Poly(phenylene) Copolymer Proton Exchange Membrane, Sandia has developed another variant of the proton exchange membrane (PEM). This version features a multi-block sulfonated poly(phenylene) copolymer composition that can be used in hydrogen fuel cells, direct methanol fuel cells, electrode casting solutions and electrodes. The composition features a multi-block architecture allowing for defined and controllable hydrophobic and hydrophilic segments. These membranes facilitate better ionic transport, leading to higher proton conductivity, while also limiting its ability to swell.

There is growing interest in utilizing anion exchange membranes (AEMs) in alkaline fuel cells and electrolysis. Hydrogen alkaline fuel cells that use a liquid electrolyte demonstrate the ability to generate higher power densities, however, liquid electrolytes are complex in both design and operations. Sandia has developed a membrane that is based on a poly(phenylene) backbone prepared by a Diels-Alder polymerization reaction. By combining the fully aromatic backbone with novel cationic head groups, the Sandia AEMs have a chemical stability that exceeds that of any AEMs reported while also maintaining state-of-the art conductivities.

Major problems associated with common methods of membrane-based separation processes such as reverse osmosis and ultra- or nano-filtration include fouling from organic and inorganic contaminants and high pressure loss. This results in a decreased efficiency of filtration, while increasing operation costs. Sandia's technology involves an array of airfoil-shaped micro-mixers that combats those problems by increasing local fluid mixing while minimizing pressure drops. The "airfoil" has a leading round edge, a tapered trailing edge, and an aspect ratio that is generally longer than its overall width. The airfoil shape is necessary in minimizing flow resistance in comparison to the standard cylindrical shape, while also possessing the capability to change the direction and magnitude of the fluid flow velocity vectors, increasing mixing while reducing the amount of fouling that occurs within the system.

Applications and Industries

- Transportation and automotive
- Hydrogen economy
- Energy fuel cells
- Chemicals
- Electronics
- Health care
- Public safety
- Semiconductor manufacturing
- Water supply and sewage treatment

Highlights From Past Issues

Compact, simple and inexpensive Neutristor may enable cancer patients to receive treatment at home

2012 R&D 100 Award Winner

Sandia has demonstrated the basic technology necessary for a tiny mass-produced neutron generator that can be adapted to medical and industrial applications.

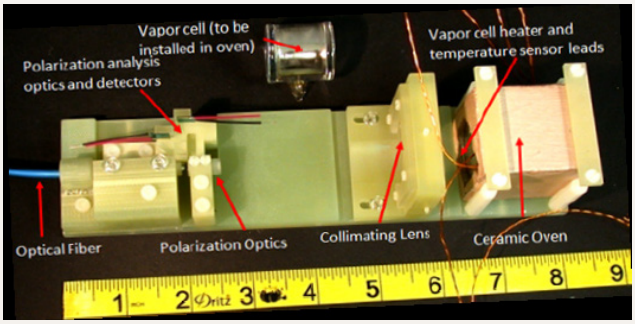
Traditional neutron generators operate on cylinders, which limit the size, beam current and neutron output. Rather than using these traditional cylindrical tubes found in most neutron generators today, the Neutristor technology is based on a computer chip-shaped neutron source. The chip configuration allows varying numbers of layers in a stack and can increase the number of neutrons by one or two orders of magnitude. This opens the door for a variety of applications, including cancer treatment. The tiny medical neutron source could be implanted near a tumor and provide a low neutron dose to cancer patients in the comfort of their own home instead of having to be treated in a hospital.

Applications and Industries
- Neutron generators
- Cancer treatment

Highly sensitive, cryogen-free Atomic Magnetometer magnetic field sensor substantially reduces cost of acquiring and operating magnetoencephalograhpy (MEG) systems

The Atomic Magnetometer MEG system uses a novel sensor design that allows it to be compact, highly sensitive, and versatile enough to be readily arrayed around the human skull. In the system, the pump and probe laser light are delivered via a single polarization-maintaining optical fiber, leaving the magnetometer with a single optical axis. The use of an optical fiber instead of beams propagating through free space allows the device to be oriented at any angle necessary for arraying the sensors properly around the head. The single optical axis allows the sensor to be long in one dimension but short in the other two dimensions so that the sensor has only a 4 cm by 4 cm footprint on the subject's head. The device has four spatially separated magnetometer channels to measure the magnetic field gradients.

The Atomic Magnetometer has the potential to substantially reduce the cost of MEG. With reduced cost, MEG would be available to a much broader user community. In addition, the technology could provide the essential sensor technology that would enable the combination of MEG and low-field MRI in the same device. The technology is also ideally suited for use in the detection of cancer cells by using functionalized magnetic nanoparticles. Such detection techniques could reduce the duration of cancer cells by using functionalized magnetic nanoparticles. Such detection techniques could reduce the duration of chemotherapy treatments and provide for earlier detection of cancer.



Channel sensor constructed of nonmagnetic materials with supporting structure made of G-10 fiberglass composite

Applications and Industries
- Magnetoencephalography (MEG) systems
- Cancer detection with magnetic nanoparticles
- Low-field MRI

Automated Molecular Biology Platform

enables the genomic sequencing revolution through automated sample preparation

2012 R&D 100 Award Winner

The advent of next generation DNA sequencing (NGS) technology represents a quantum leap in the field of genetic analysis: what once required a decade-long, multibillion dollar Human Genome Project can now be reproduced in 1-2 weeks time for less than $5,000. Despite advances in sequencing technology, upstream library (sample) preparation protocols, which require numerous sample processing steps and hours of hands-on laboratory time, have not benefitted from comparable increases in speed or efficiency. While automation of the library preparation process can help overcome this widely recognized bottleneck, current approaches rely on large and expensive pipetting robots designed for use in dedicated high-throughput sequencing facilities.

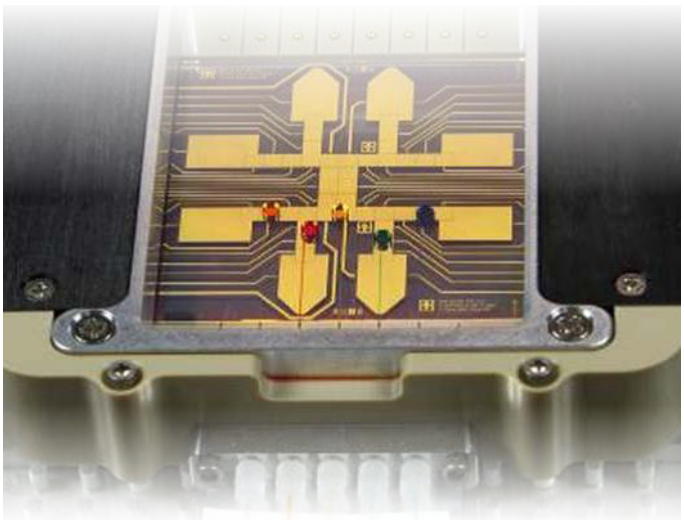
To fully realize the promise of next generation sequencing for more ubiquitous, individualized, decentralized applications such as personalized genomic medicine, point-of-care diagnostics, public health screening, and DNA forensics, technologies automating NGS sample preparation must also become more affordable and accessible. To address this need, our Sandia team has developed an Automated Molecular Biology (AMB) system enabling the cost-effective automation of complex protocols like NGS library preparation and other labor-intensive bioanalytical procedures and processes.

The heart of the AMB system is a unique droplet-based digital microfluidic (DMF) platform which functions as a central hub for the distribution and routing of samples and reagents. Digital microfluidic technology uses electrostatic and electrowetting forces to manipulate microliter-scale droplets sandwiched between closely spaced, hydrophobically coated substrates patterned with individually addressable electrodes. These devices enable discrete droplet movement and droplet operations such as merging, splitting, mixing, and aliquotting to be performed at scales much smaller than what can be conventionally achieved. Accordingly, our DMF platform functions instead as a sample distribution and reagent interface hub and fills a role equivalent to that of a pipetting robot in a high-throughput laboratory automation workflow, but at a fraction of the size, cost, and complexity.

The central innovation of our digital microfluidic platform was the development of a custom manifold frame providing self-aligning registration of top and bottom DMF substrates to achieve the precise tolerances required for reliable DMF operation. The open architecture of the frame enables access to the interior of the DMF device by in-plane transfer capillaries. This capillary interface allows liquid to be transferred to and from the DMF device with nanoliter precision using external syringe pumps, providing not only a method for coupling the DMF platform to external modules, but also the means to execute a variety of advanced on-platform operations including serial dilution, droplet subsampling, chaotic mixing, fraction collection and sorting, magnetic bead manipulations, and sample archiving. The AMB system is completed by integrating this adaptable digital microfluidic platform, its high-voltage control electronics, supporting syringe pumps, and functional submodules with a PC-based user interface enabling coordinated control and script-based automation of all sample preparation operations. We estimate that the full AMB platform including all supporting hardware and software will cost less than $3,000 per unit.

Applications and Industries

- Public health – rapid threat organism recognition system
- Forensics – automated DNA analysis and sampling system
- Biosurveillance – advanced diagnostic and sampling platform



Microsystems Enabled Photovoltaics (MEPV): Solar Glitter™ Photovoltaic Technology

revolutionizes solar energy collection

2012 R&D 100 Award Winner

These tiny glitter-sized photovoltaic (PV) cells could revolutionize solar energy collection. Made from robust semiconductor materials, miniaturized PV generate clean electricity that can work as safely, reliably, and durably as present day grid power, and can be cheaper than all other forms of energy.

Sandia's microsystems-enabled photovoltaics (MEPV) uses microdesign and microfabrication techniques to produce solar cells as small as 3-20 microns thick and 100-1000 microns wide. These PV cells are then placed or 'printed' onto a low-cost substrate with embedded contacts and microlenses for focusing sunlight onto the cells. Moving to micro-scale PV cell sizes results in distinct benefits at cell, module, and system levels, including reducing the amount of expensive semiconductors by 30 times while still achieving high efficiencies.

MEPV solar power systems can have impact in both mobile and stationary power applications. At the system level, the large number of individual micro-PV cells can be interconnected to tailor voltage and current output to meet system requirements. The flat panel profile with micro-optical focusing further simplifies sun tracking, reducing both the cost and complexity of the solar concentrating design.

MEPV units can be placed into flexible sheets that could wrap around unusual shapes for solar power integrated into buildings, tents, and maybe even clothing. Rooftop micro- PV modules could have intelligent controls, inverters, and even storage built into the chip— simplifying the grid-integration process.

Put together, glitter-sized photovoltaic cells become the building blocks for generating electricity in a new, efficient, versatile, and inexpensive way—the powering of anything could become as simple as exposing it to light.

Sandia Technology Showcase

RAZAR provides an instantaneous, push-button zoom that exceeds traditional (moving lens) zoom rifle scopes

2014 R&D 100 Entry

Traditional zoom imaging requires the mechanical movement of two or more optical elements along the optical axis, as is done in 35mm cameras or conventional, variable-power riflescopes. Adaptive zoom is a revolutionary method whereby true optical zoom is accomplished by cooperatively varying the focal lengths of multiple active optical elements in the system. Sandia has demonstrated and patented this using various optical elements, including liquid crystal (LC) spatial light modulators, adaptive lenses, and deformable mirrors. This technology is ideal for any imaging system that requires extremely fast, variable magnification but is limited by size, weight, and power (SWaP) constraints.

The U.S. Military requested a compact zoom riflescope, capable of rapidly toggling between magnification at the push of a button without changing the grip on the weapon or losing sight picture. The Rapid Adaptive Zoom for Assault Rifles (RAZAR) filled this request. RAZAR can zoom in milliseconds and perform 10,000 actuations on two AA batteries. The weight, power, and speed requirements for mechanical zoom make them prohibitive. RAZAR allows target engagement at diverse ranges and provides several distinct advantages including speed and high resolution at varying distances.

RAZAR, and its component lenses, are market leaders from a performance standpoint. The variable-focal length lenses we developed, and which are at the heart of the Adaptive Zoom concept, have the following distinguishing characteristics, relative to similar lenses:

- Mil-Spec Shock/Vibration/Temperature (per MIL-STD-810G)
- Largest Dynamic Range (Diopters/Focal Length)
- Largest Usable Clear Aperture (Actuated)
- Largest Clear Aperture/Outer Diameter Ratio
- Temperature Compensation (Focal Length vs. Radius of Curvature)
- Best Image Quality (Wavefront Error—WFE)

RAZAR provides instantaneous, push-button, zoom in a form factor that meets or exceeds traditional (moving lens) zoom rifle scopes.

Applications and Industries:

- Rifle scopes
- Spotting scopes
- Monoculars and binoculars

Small, robust Wireless Passive Radiation Sensor gives immediate real-time warning of radiation doses using a portable, inexpensive transceiver

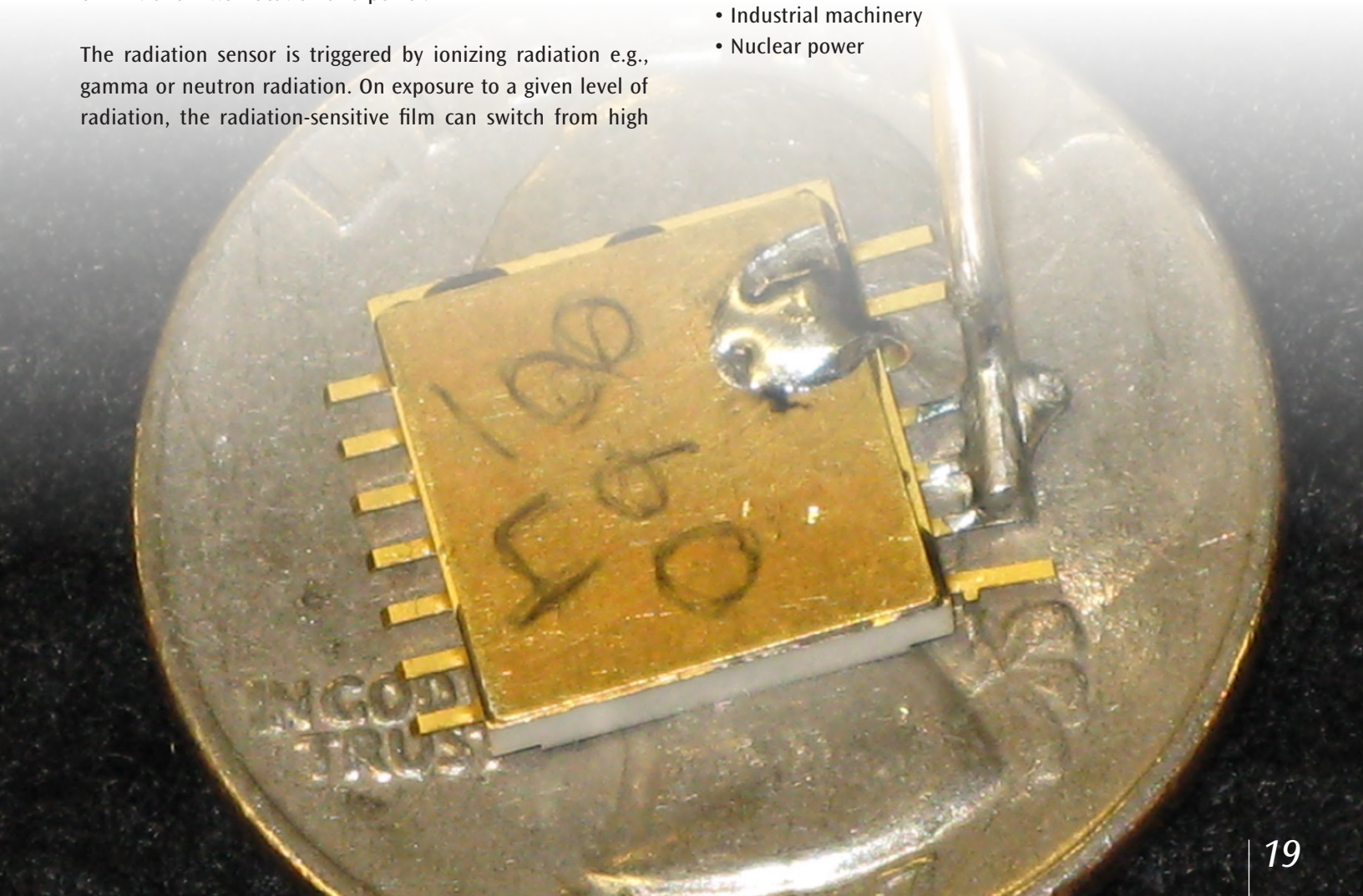
Existing small radiation detectors do not produce an immediate real-time warning of radiation doses because the detectors need to be sent to a lab for readout, which can require days or weeks to complete. Other detectors are fragile, need human interpretation of colors, cost hundreds of dollars each or are not easily mass produced. Therefore, a need remains for a wireless passive radiation sensor that can remotely detect radiation using a portable, inexpensive transceiver.

A novel measurement technique is employed using surface acoustic wave (SAW) devices, passive RF, and radiation-sensitive films to provide a wireless passive radiation sensor that requires no batteries, outside wiring, or regular maintenance. The sensor is small (<1 cm^2), physically robust, and will operate unattended for decades. In addition, the sensor can be insensitive to measurement position and read distance due to a novel self-referencing technique eliminating the need to measure absolute responses that are dependent on RF transmitter location and power.

The radiation sensor is triggered by ionizing radiation e.g., gamma or neutron radiation. On exposure to a given level of radiation, the radiation-sensitive film can switch from high resistance (e.g., $>10^5$ Ω) to low resistance (e.g., $<10^2$ Ω). The radiation-sensitive film forms catalytic sites when electrons are ionized from the molecules due to a radiation event and the resulting cascade reaction converts the initially dielectric film to a conductive metallic film. This response covers several orders-of-magnitude change in resistance after a minimum radiation threshold is reached. The sensor is analogous to a 'smoke detector' in that it detects either the presence or absence of radiation but also retains the exposure information after the radiation is gone like a radiation dosimeter. The sensor is comprised of non-moving parts, RF monitor, sensor film, and sensor chemistry, enclosed in a robust package. The advantage of this radiation sensor is its size, simplicity, and immediate response. The sensors do not require batteries that add unacceptable mass and maintenance to the structure or wires to retrieve the data, enabling remote sensing.

Applications and Industries

- Health care
- Medical Devices
- Agriculture
- Aircraft and aerospace
- Electric utility
- Industrial machinery
- Nuclear power



Intellectual Property Creation at Sandia

Sandia's intellectual property results primarily from R & D conducted for the government in the national security sector. We collaborate with industry, leveraging each other's strengths to develop innovative technology. We perform internal R & D directed at the most challenging issues in national security, for which breakthroughs would provide exceptional value to government and industry. All totaled, Sandia has more than 1200 patents and 500 commercial copyrights, the bulk of which are available for licensing.

Licensing Sandia's Intellectual Property

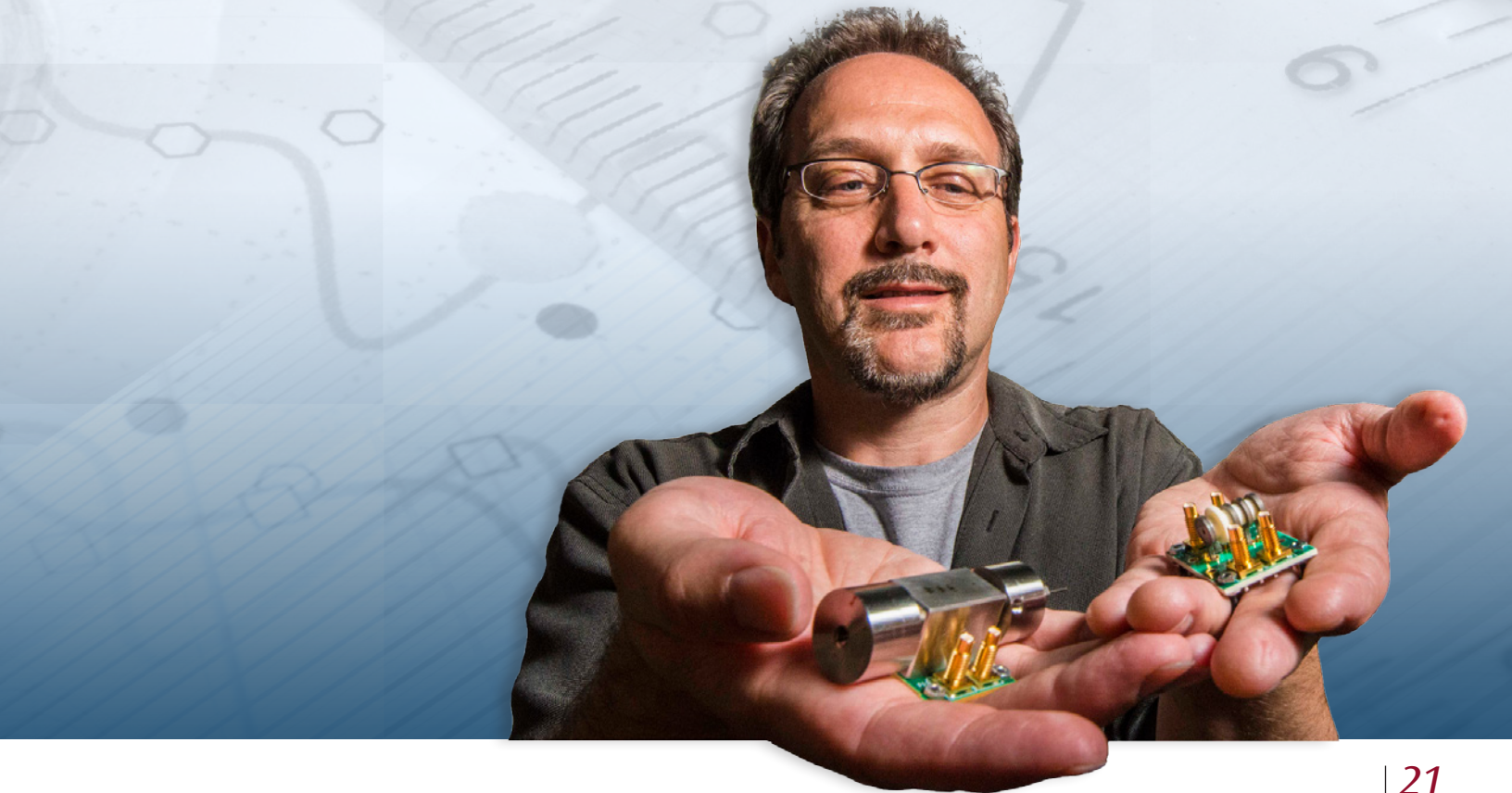
Sandia's intellectual property may be licensed for commercial use (internal or commercial sale), test and evaluation, or execution of a government contract. One may also secure an option on a future license. Example licenses include:

- Commercial Patent License
- Commercial Copyright License (software or design plans)
- Commercial Hybrid License (copyright and patent)
- Test and Evaluation License
- License Option
- Government Use Notice

Sandia is mandated by the Department of Energy to move its technology to the marketplace for the benefit of the U.S. economy. Given our national security focus, government is the primary customer for many Sandia licensees, but our technologies also find use in the industrial and consumer markets. Sandia issues licenses to companies ranging in size from start-ups to multinationals. Our qualification procedure considers a company's ability to bring a product to market as conveyed by their business plan, among other factors. The possibility to create a new company that can leverage our technology and achieve substantial growth is also important, given our interest in entrepreneurship.

Licensing Practices

- License term usually runs the length of the patent or copyright. Terms for Test and Evaluation licenses and License Options are limited in time.
- Financial consideration may include an upfront license fee, annual license fee, milestone fee, or running royalty, as appropriate. We seek an equitable return to the laboratory without impeding the licensee's ability to successfully commercialize the technology.
- Performance requirements may be established to insure the licensee is diligent in their commercialization plan.
- Licenses may be limited by field of use, region, or period of restraint. Non-exclusive licenses are preferred, but we consider exclusive licenses when the business case is justified. Exclusive licensing requires a competitive assessment of potential licensees to select the one having the highest probability of success. Performance requirements are also more stringent.
- Commercial licensees must substantially manufacture their product in the U.S., given the Department of Energy's intent to provide benefit to the U.S. economy.
- The U.S. government retains a right to use the technology for government purposes.



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Sandia National Laboratories

Business Development & Intellectual Property Management

For general information and comments, contact: ip@sandia.gov

See the back cover for details on Sandia's Ready-to-Sign express licensing program.

Sandia's

INNOVATION MARKETPLACE

A QUARTERLY UPDATE OF AVAILABLE TECHNOLOGIES FOR INDUSTRY

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