SANDIA'S

INNOVATION marketplace

A BIANNUAL UPDATE OF AVAILABLE TECHNOLOGIES FOR INDUSTRY

Sandia National Laboratories

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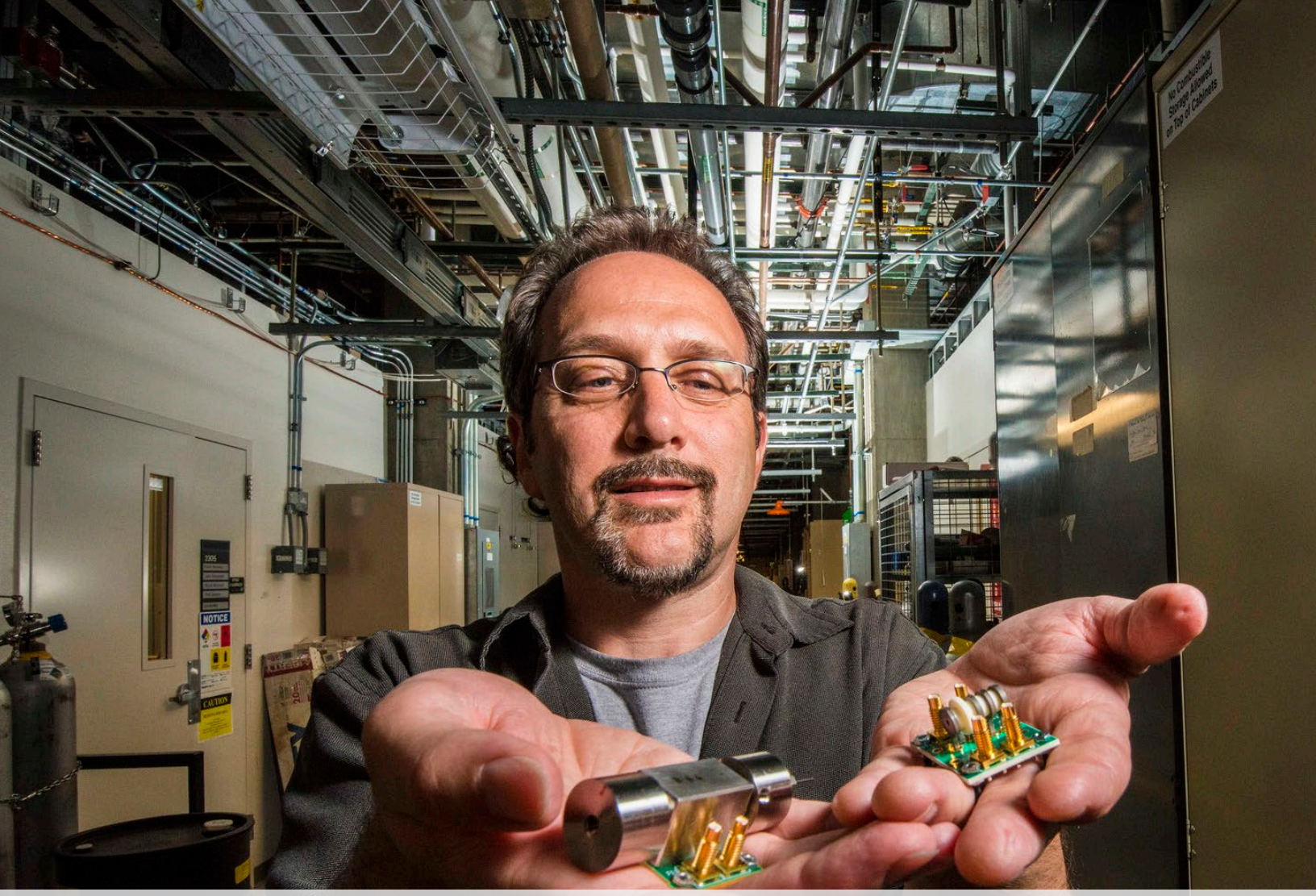


mini-PDID

A miniaturized pulse-discharged ionization detector

Building on decades of portable chemical analysis research, Sandia's latest chemical detector, based on our miniaturized pulse-discharged ionization detector (mini-PDID), makes it possible to diagnose illnesses by identifying volatile organic compounds (VOCs) associated with certain diseases and infections on a patient's breath or in the headspace of biological fluids. The Sandia system consists of a microfabricated sample preconcentrator, micro gas chromatography columns, and a miniaturized pulsed-discharge ionization detector. This system is sensitive enough to detect trace levels of analytes (parts per billion to parts per trillion range), making it possible to detect specific VOCs released by a pathogen, the patient, or both. This non-invasive diagnostic tool is inexpensive, portable, low-power, durable, and is designed for bed-side or field operation. It has the ability to produce rapid results, decreasing treatment costs and diagnosis cycle time.

The mini-PDID system has similar detection limits to gold standard mass spectrometers, but at a fraction of the size and cost. By creating a miniature version and improving its detection range, Sandia created a

powerful detector for a wide range of field applications. The central technology in the chemical detection portfolio, the mini-PDID, is approximately 40- to 80-fold smaller than traditional PDIDs and mass spectrometers. The mini-PDID is directly integrated with a circuit board, has a unique electrode design, and is approximately the size of a D cell battery (1″ x 1″ x 2). The device's detector core is self-aligned and compressed during assembly, eliminating the need for adhesives, which degrade detector performance. In addition to its small size, it has the ability to detect a wide range of chemical compounds. When paired with the microPC-microGC subsystem, it can identify both patterns of VOCs and specific volatiles with high sensitivity.

The microPC-microGCxGC subsystem provides sample collection of trace or transient analytes and robust separation which in turn reduces false alarms and ensures even complex chemical mixtures are separated. The novel flow-modulated subsystem utilizes gas pressure, which eliminates the need for cryogens required for thermal modulation. The GC columns are designed using thin membrane sealing structures that are only broken in a clean environment, ensuring the columns remain uncontaminated in their manufacturing process.

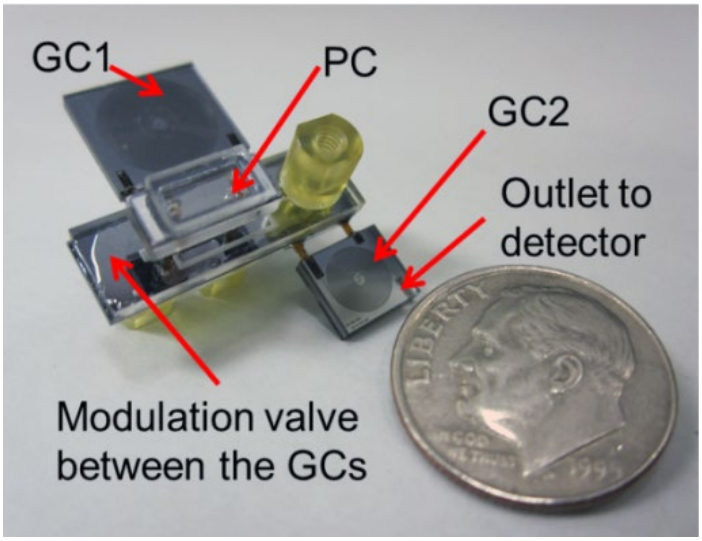
The Sandia mini-PDID system has proven applications in chemical, biological and explosives chemical detection and is currently being tested for veterinary disease diagnostic applications.

Technical Benefits

- Highly versatile, portable, low-power POC system
- Detection range on the same scale as MS systems
- Identifies both patterns of VOCs and specific volatiles
- Rapid results
- Offers universal or selective detection
- Does not require expensive radioactive ionization source
- Continuous operation for up to 9 hours on mini 1″ diameter by 5″ long He tank
- Does not require trained/expert personnel to operate

Industries & Applications

- Disease biomarkers and diagnostics
- Neonatal monitoring
- Population biomonitoring
- Epidemiology
- Pharmaceuticals
- Monitoring wound health for infections
- Bacteria, viruses, toxins exposure
- Veterinary



SmartLAMP

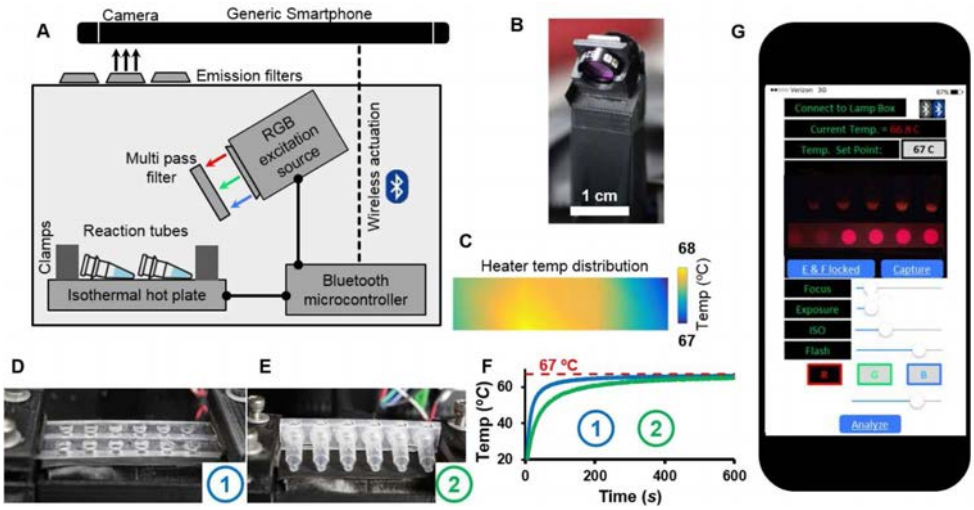
A portable point-of-care diagnostic device

Researchers at Sandia have developed a smartphone-controlled, battery-operated point-of-care diagnostic device that weighs under a pound, costs as little as $100 and can detect Zika and other vector-borne diseases rapidly and accurately. Current testing for mosquito-borne viruses requires a full laboratory that leaves patients waiting for days to get their results. The instruments used to perform these tests are roughly the size of a microwave and can cost up to $20,000. These expensive testing sites make rapid testing unrealistic for limited-resource clinics in developing countries where the viruses are most prevalent.

Sandia's SmartLAMP device is smaller than a shoebox and works by using a smartphone's camera as a fluorimeter via a Bluetooth connection. The device uses loop-mediated isothermal amplification (LAMP) diagnostic method that can work directly from human samples (blood, saliva or urine) without the need for complex sample prep. The user simply opens the app and places their smartphone on top of the SmartLAMP device and it will begin testing the human samples inside the device, giving the user accurate results in 30 minutes. The entire assembly requires little energy and can be powered by a 5 volt USB source such as a USB power bank or solar panel, meaning that it will be able to be used in the most remote areas where there is no stable power grid. The only equipment a user needs is SmartLAMP and a cellphone with an optical sensor. The smartphone used in Sandia's successful prototype testing cost a mere $20.

SmartLAMP is an affordable diagnostic device that offers ease of use and speed of diagnosis.

SmartLAMP can be used by almost anyone, anywhere—in hospitals, in the field, at airports, by first responders, military or minimally trained personnel—a doctor or medical professional is not required. This will allow small clinics to test patients and quickly get results, allowing them to make faster decisions about patient care and isolation, and rapidly alert public health authorities to help prevent the spread of the virus.



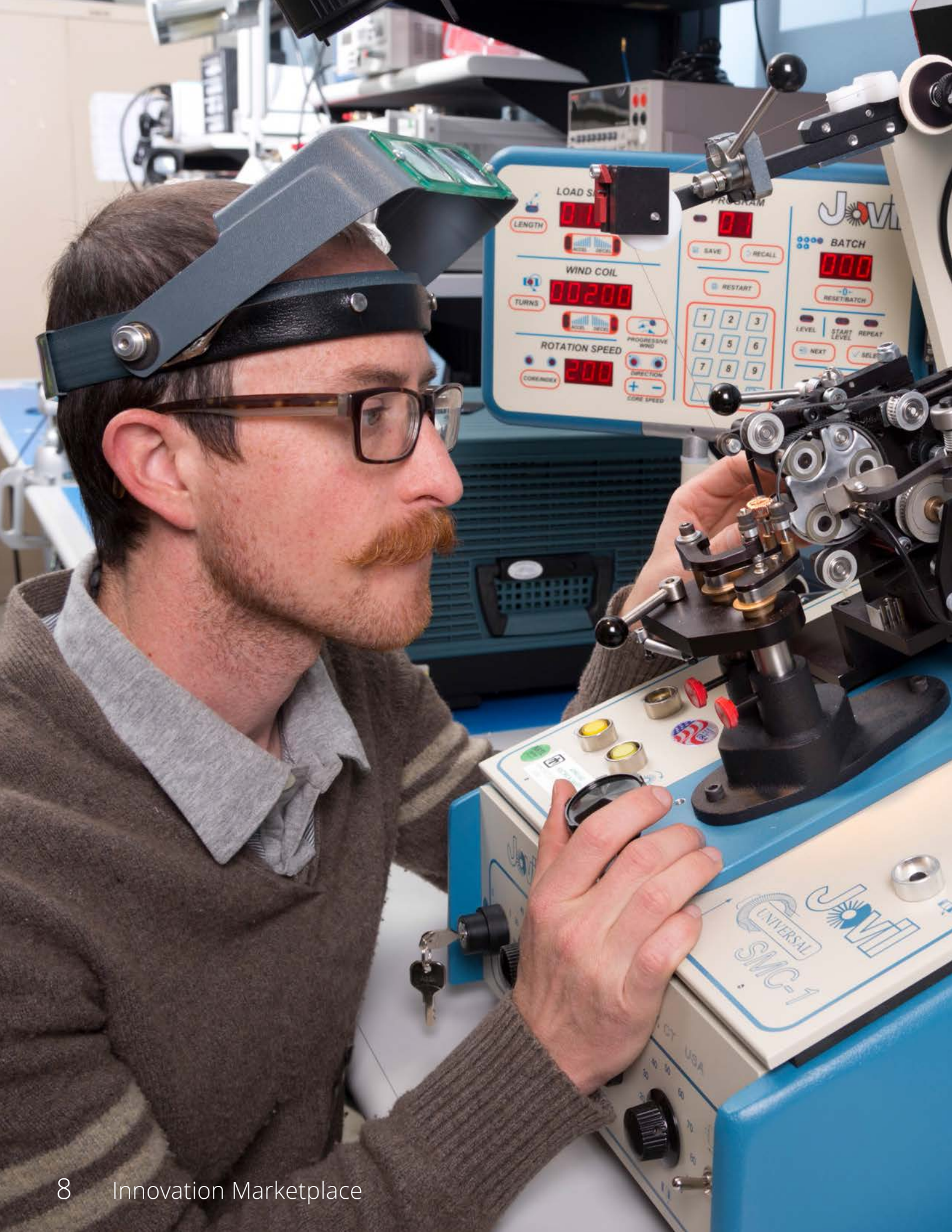
SmartLAMP: Smartphone enabled ZIKA detection: (A) Schematic of the RT-LAMP detection setup depicting the isothermal heater with reaction tubes, LED excitation source and Bluetooth microcontroller (Arduino Uno). (B) A 3 watt RGB LED coupled with an RGB multi band pass filter ensures a narrow excitation source for the assay reagents. (C) The isothermal heater provides a uniform surface temperature distribution within a 1° C variation. The heaters can be loaded with either (D) off the shelf PCR polypropylene tubes or (E) custom made laser-cut reaction wells. (F) Thermal management and heat ramp rates are greatly improved with custom laser-cut wells. (G) The smartphone app wirelessly actuates the isothermal heater and RGB LED excitation source to enable real time temperature monitoring, changing the heater set point and illuminating the samples with appropriate excitation light source. The illuminated reagents are captured by the smartphone camera equipped with an interchangeable emission filter and the images are analyzed subsequently.

Technical Benefits

- More accessible testing for mosquito-borne viruses
- Massively reduced cost compared to currently testing equipment
- Faster and more accurate testing of human samples—results within 30 minutes
- User-friendly—no need for expensive equipment and medical training
- Compact device that can work in areas with no stable electrical grid
- Eliminates need for lab preparation of biological samples and refrigeration
- Device can be adapted to detect other human or animal pathogens

Industries & Applications

- Any country affected by mosquito-borne viruses
- Limited-resource clinics
- Areas affected by mosquito-borne viruses that have unstable power grids
- Areas with minimally trained medical professional and limited medical facilities
- Any area that needs to detect human or animal pathogens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SMC-1

Hybrid Transformer

The benefits of two transformers in one design

Sandia developed a hybrid transformer which has the benefit of a full planar transformer design, but uses a wire-wound secondary winding to keep the parasitic winding capacitances lower. Alone, planar transformers have the advantage of a lower profile and better reproducibility, but wire-wound transformers allow for less parasitic capacitances. By combining elements from traditional wire-wound transformers and planar transformers, Sandia has improved overall performance and reliability.

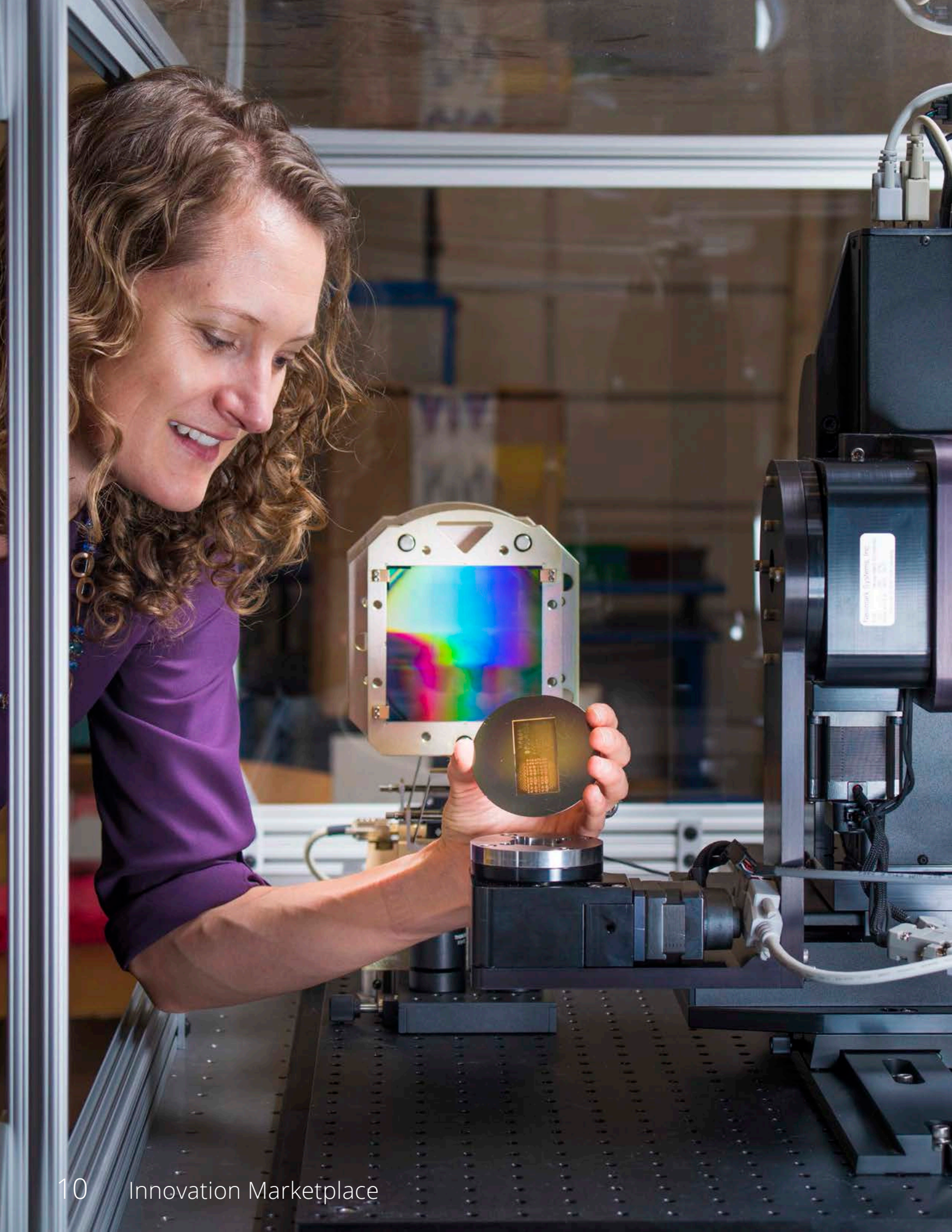
Sandia's hybrid transformer consists of a split planar primary winding. Between two primary planar printed circuit boards (PCBs), the secondary winding is wound using a traditional wire-wound transformer technique instead of conventionally stacking PCBs, which can lead to high parasitic winding capacitances. In addition, the use of the wire-wound technique reduces the profile height of the transformer, which would benefit many industries seeking to reduce volume of their assemblies. Separation between the primary and secondary wiring ensures the reliability of a high voltage transformer instead of relying on manual taping processes. The lowered parasitic capacitances can be beneficial for high voltage flyback transformers in which the parasitic secondary capacitance can significantly impact the output voltage performance.

Technical Benefits

- Lower profile height than conventional wirewound transformers
- Lower parasitic winding capacitances
- Higher voltage charges
- Increased performance and reliability
- Improved consistency of parts over conventional wirewound transformers
- Hybrid wire configuration can lead to a decrease in: shorts, instances of high voltage breakdown, and damage to equipment

Industries & Applications

- Companies offering high reliability high voltage transformers
- Suited for limited space applications – i.e. aerospace, personal power adapters, stacked circuit board, etc.



X-Ray Phase Contrast Imaging

A non-destructive system for evaluation and inspection

Sandia developed a high-sensitivity X-ray Phase Contrast Imaging (XPCI) system that provides a method for non-destructive 2D digital radiography and 3D tomography of low-density composite materials. Non-destructive evaluation and inspection is essential to establishing confidence in the functionality and security of a variety of components. Many of these parts contain low-density encapsulants to protect components from shock, thermal fluctuations, and high voltage breakdown. Sandia's XPCI system incorporates unparalleled grating technology, which enables identification of defects in low-density materials that are usually transparent or indistinct using traditional X-ray imaging.

Sandia utilizes an innovative semiconductor manufacturing process that combines Bosch deep reactive ion etching (DRIE), atomic layer deposition (ALD), and pulse gold electroplating to create higher aspect ratio gratings with better uniformity and larger surface area—increasing field of view and sensitivity over the current state-of-the-art. This novel grating technology enabled the creation of a compact, bench-scale XPCI device with the ability to detect cracks, voids, or delamination in low density materials. Sandia's XPCI system enables non-destructive inspection throughout the assembly process—improving overall confidence in part reliability. Sandia has also demonstrated advanced image processing techniques that enable extraction of features in low density materials in proximity to high density components such as foam microstructure in the presence of high-Z structures (e.g., wires).

This novel XPCI system will increase confidence in components used in high consequence national security systems and has potential impact on medical imaging, homeland security, building and material safety, transportation safety, and food safety inspections.

Technical Benefits

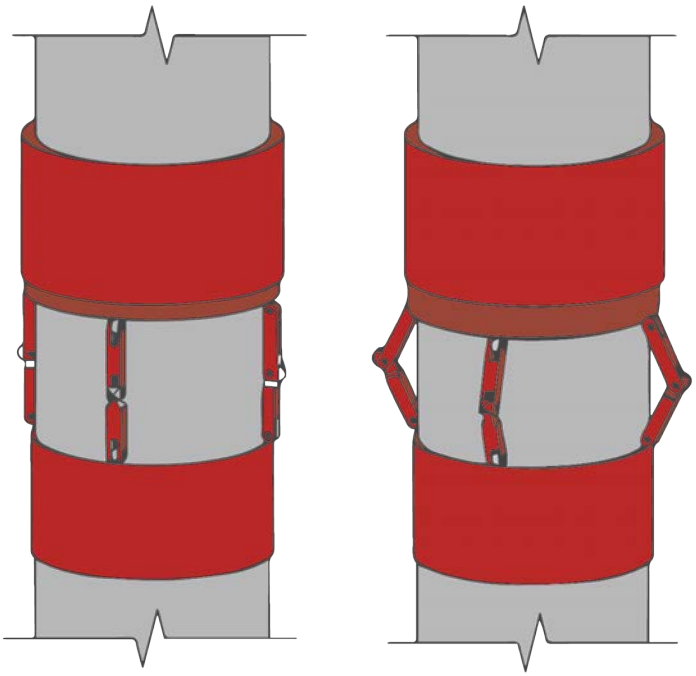
- Large field of view
- Capable of 2D digital radiography and 3D tomography
- Benchtop system
- Improved sensitivity and defect detection in low density materials
- Reduced costs by identifying defects early

Industries & Applications

- Non-destructive inspection
- Aging and state characterization
- Medical imaging
- Food safety inspections

DEPLOYABLE CENTRALIZER

Robust solution for directional or horizontal drilling



Sandia's robust centralizer actively centers casings in deviated, directional or horizontally drilled well bores. Traditional centralizers, most commonly based on a bow spring design, are economically optimized for use in vertically drilled wells, however, they can lack sufficient force to centralize casing in deviated or directional drilled wells. This may result in variations in cement jobs and an improper seal that is prone to failure.

Sandia's deployable centralizer comprises two collars that are joined together by articulated linkage. Once the casing is situated downhole, a power source integrated in the collars is activated, drawing the collars together while forcing the linkage outwards towards the borehole walls. The resulting deployed structure is similar in final shape to a bow spring centralizer, but it is powerful enough to properly support or displace the casing. Also, when deployed downhole in the retracted position, our centralizer alleviates drag and can transit through bends with less friction. Sandia's deployable centralizer is a robust solution for directional or horizontal drilling to ensure a uniform 360° annular space around the casing and ensure a competent cement seal to the borehole wall.

Technical Benefits

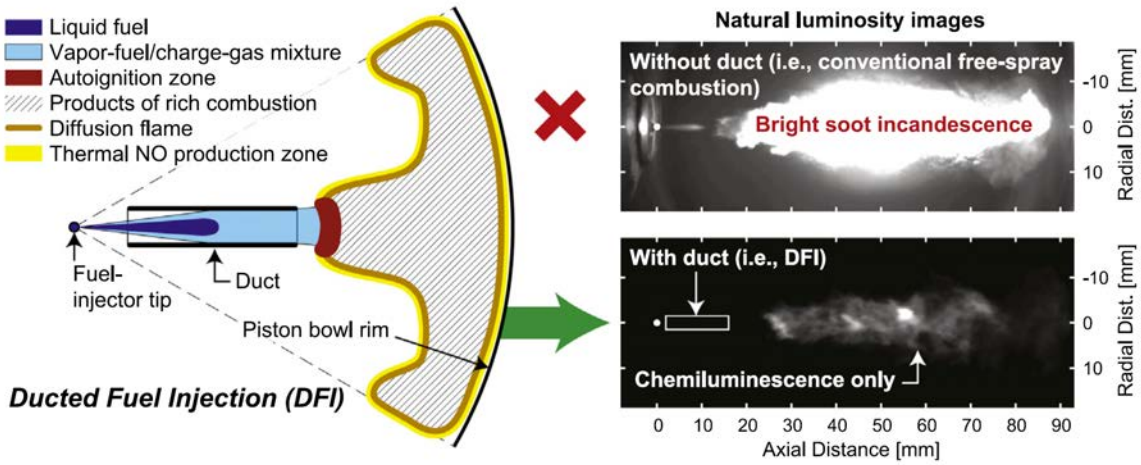
- Active centralizer system
- Large load carrying capability
- No installation drag
- Allows for complete concentric cement seal of casing to the borehole wall without variations in cement thickness

Industries & Applications

- Oil & Gas
- Geothermal

DUCTED FUEL INJECTION

Reduces soot and emissions at the point of combustion



Sandia's ducted fuel injection technology was developed for the reduction of soot and other EPA regulated emissions in direct-injection engines. Typical direct-injection engines, such as diesel engines, can produce soot due to fuel-rich combustion conditions. Filters and catalytic converters are currently used to reduce soot and harmful emissions, but these systems are expensive, large, complex, and they penalize engine efficiency. Sandia's ducted fuel injection technology reduces soot at the point of combustion, thereby reducing the need for these after-treatment devices and their associated costs.

Sandia's mechanical solution forces each fuel spray from the fuel injector through a small duct located within the combustion chamber. Oxygen is drawn into each duct due to the pressure field established during fuel injection, and the ensuing enhanced turbulent mixing creates an optimized mixture of fuel and oxygen. The more-homogeneous fuel mixture is then released from the duct into the combustion chamber where it ignites—eliminating soot that results from unevenly mixed, fuel-rich combustion.

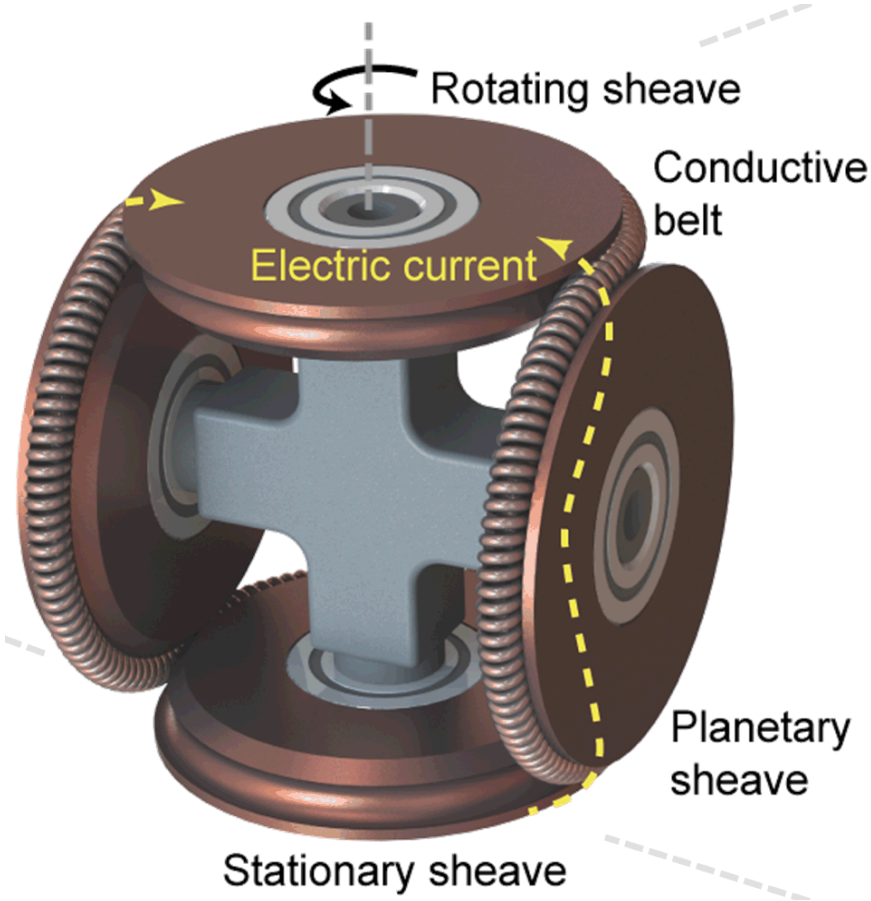
Sandia's ducted fuel injection technology could be a key technology for future engines because it is an effective, conceptually simple approach for lowering soot and other emissions, as well as potentially improving combustion efficiency. It also has potential applications in spark ignition engines, gas turbine engines, industrial boilers, and refinery flaring.

Technical Benefits

- Decreases emissions and potentially other harmful emissions
- Reduces engine system costs
- Increases engine efficiency
- Tolerant to a wide variety of fuels

Industries & Applications

- Diesel (compression ignition) engines
- Spark ignition engines
- Gas turbine engines
- Industrial burners/boilers
- Wellhead/refinery flaring



Twistact

A new type of rotary electrical contact technology

Researchers at Sandia developed a fundamentally new type of rotary electrical contact that addresses the two limitations of conventional brush/slip ring technology: (1) short operating lifetime due to sliding-contact wear, and (2) electrical arcing associated with contact bounce. Sandia's Twistact technology has a wide variety of potential applications, but was initially motivated by the need to eliminate rare earth magnets in utility-scale direct-drive wind turbines. As wind turbines are being scaled up in size to achieve better economies of scale, direct-drive wind turbine technology is being adopted by the wind industry to eliminate gearbox lifetime limitations. However, the rare-earth magnets used in these permanent-magnet rotor assemblies of direct-drive wind turbines present two challenges: high initial cost and the supply chain uncertainties of reliance on rare earth metals. Rare earth metals such as neodymium and dysprosium have always been in short supply, and competing applications like electric vehicles are increasing demand. The unpredictability of the future rare earth supply chain is a hindrance to large scale proliferation of wind power because it increases risk to investor return on investment. Moreover, the mining of rare earth metals is notorious for its adverse environmental impact.

Sandia's Twistact technology provides a solution both to high maintenance brush/

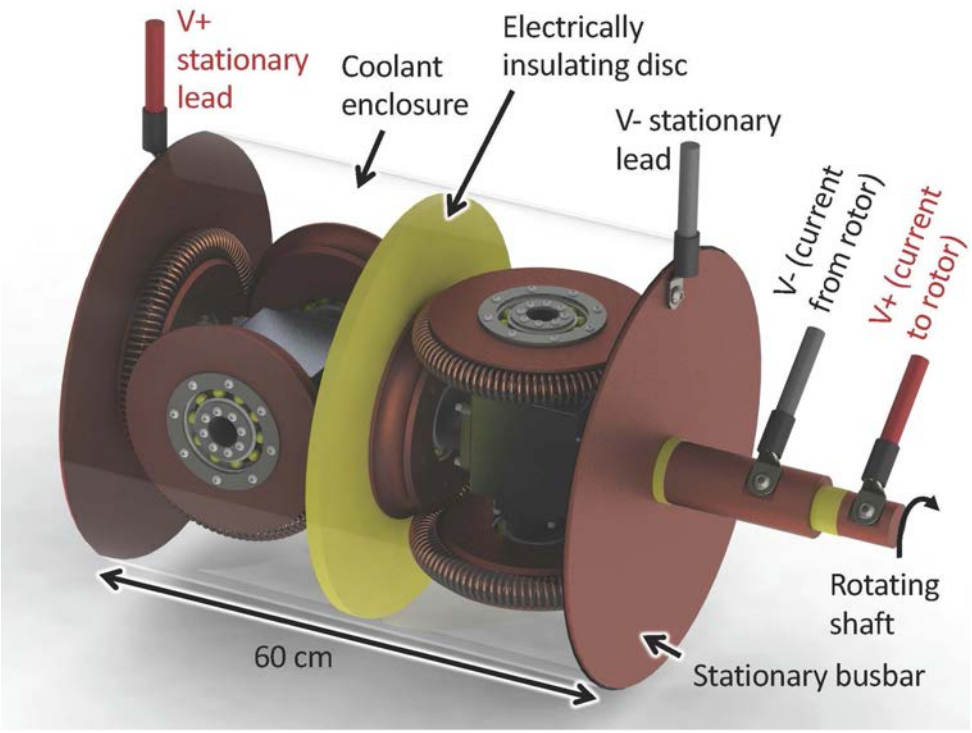
slip ring assemblies and rare earth metal dependent wind turbines. Twistact technology comprises a pure-rolling-contact device that transmits electrical current between a stationary and rotating frame (or two rotating assemblies having different speeds and/or direction of rotation) along an ultra-low resistance path (e.g. 1 milliohm). Twistact devices accomplish pure-rolling-contact galvanic connection using a flexible, electrically conductive belt and a matching set of epicyclic sheaves. Laboratory testing has proven that a single Twistact device will be capable of operating over the full 30-year service time of a multi-megawatt direct-drive wind turbine without maintenance or replacement. A technoeconomic analysis study undertaken by National Renewable Energy Laboratory on behalf of Department of Energy determined that the substitution of rare-earth magnets with a wire-wound rotor and Twistact module in a 10 MW direct-drive wind turbine eliminates the need for rare earth magnets without incurring any penalties in power generation efficiency or levelized cost of energy (LCOE). Having completed all of the milestones of its six-year R&D program on Twistact technology, Sandia is now ready to work with generator OEMs to assist with the transfer of Twistact technology into next generation direct-drive wind turbines. Sandia is also open to partnering on the development of high-rpm Twistact technology for applications such as electric vehicles or doubly-fed induction generators.

Technical Benefits

- Eliminates reliance on rare earth magnets
- No maintenance or replacement costs

Industries & Applications

- Wind turbines
- Synchronous motors and generators
- Doubly-fed induction generators
- Electrified railways
- Radar towers
- Grounding of rotating assemblies (e.g. lighting protection)
- Brush/slip ring replacement in existing applications



A 2-channel Twistact device for a multi-megawatt direct-drive wind turbine application

FLUORESCENT THALLIUM TRACERS

Easy to detect and durable tracers for underground fluid flows

The ability to track underground fluid flows in oil and geothermal wells is critical to allow operators to extract energy as efficiently as possible. This information will allow operators to focus on areas of known production rather than low or non-generating regions. There are many tracers that are currently used in combination with proppants, however they suffer from a variety of limitations— in particular the short lifespan limits the ability to monitor productivity past initial fluid flows. Sandia National Laboratories developed a tracer that is easily detectable and designed to withstand the harsh downhole environment that can be encapsulated in known coatings for time release to slowly liberate the tracer over an extended period of time.

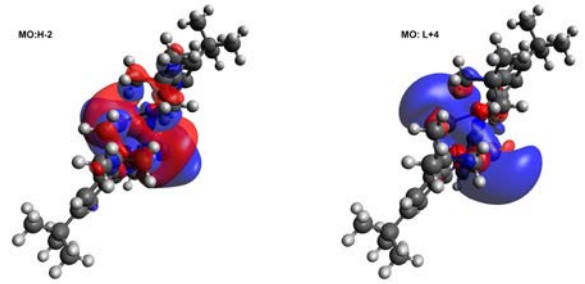
Sandia's tracer uses a thallium salen complex tag, which is then intercalated into a proppant. The Tl-salen tag is eventually released in to the bulk underground reservoir and up to the wellhead for routine sampling. These Tl compounds are easily detectable using simple hand-held laser excitation due to the tracer's intense luminosity, eliminating the need for specialized monitoring equipment. The Tl-salen tag can be used with other metal-salen tracers to target and monitor different areas of a well. Sandia's Tl-salen tag was designed for the harsh environments of deep underground wells and will remain stable at high temperature and pressures and has proven to be highly fluorescent at low concentrations. It also exhibits low adhesion or absorption to underground materials. The Tl-tag will enable more efficient and productive well creation by offering longer term monitoring capability of underground fluid flows.

Technical Benefits

- Stable at high temperatures and pressures
- High luminosity at low concentrations
- Low adhesion or absorption to underground materials
- Easily detectable with standard analytical tools
- Enables analysis to maximize energy production from wells

Industries & Applications

- Oil and gas production
- Geothermal energy production
- Fluid monitoring in industrial settings (power plants, chemical plants)



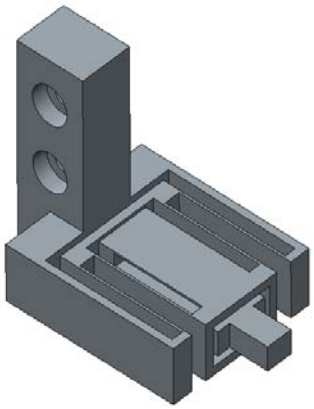
Molecular orbitals (MO) diagrams indicating Tl–Tl interactions for (a) H_2-salo-Bu^t (H−1 and L+2) and (b) H_2-saloPh-Bu^t (H−2 and L+4). Atom colors: Tl (brown), O (red), N (blue), C (gr ay), H (white).

NON-DESTRUCTIVE CHARACTERIZATION COUPON

A non-destructive testing for characterization of additive manufactured parts

Additive manufacturing (AM) material assurance has relied upon traditional test coupons and testing methods which work well for wrought materials, but fail to address the unique and not as well-known characteristics of AM parts. Sandia engineers have been working on a new standardized, integrated test coupon specifically designed for AM that allows for non-destructive testing of material properties, allowing for repeated testing through a series of environments in order to characterize part reliability.

This new multi-axis linear flexural cantilever test coupon is designed as one continuous part with no assembly required and can be printed using a variety of materials and AM methods. The linear flexure design enables simplified vibration (modal) analysis of structure-property information, and the multi-axis aspect of the design allows for determination of inhomogeneity in printed materials. Using various sensors, a non-destructive modal analysis measures time-dependent evolution of position following the convection of an impulse to the cantilever system, one axis at a time. Analysis of this data can be used to determine structural-property information, such as Young's modulus, damping coefficient, stiffness, shear modulus, and deviations from normal response pointing to microstructural defects. Due to the non-destructive nature of this testing, repeat studies of the same part can be carried out in varying conditions. This allows for an analysis of the impact on the structural-properties of the specimen before, during, and after exposure to varying environments. Non-destructive modal testing techniques also lead to more accurate data.



Sandia's AM test coupon offers testing of a number of different mechanical properties that can lead to a better understanding of the unique microstructures associated with additive manufactured parts.

Technical Benefits

- Test artifact can be printed using a variety of materials (metals, ceramics, plastics) and different AM methods
- Allows repeated testing of a material in various environments
- Offers testing of a large set of mechanical properties
- Modal testing technique results in extreme testing accuracy

Industries & Applications

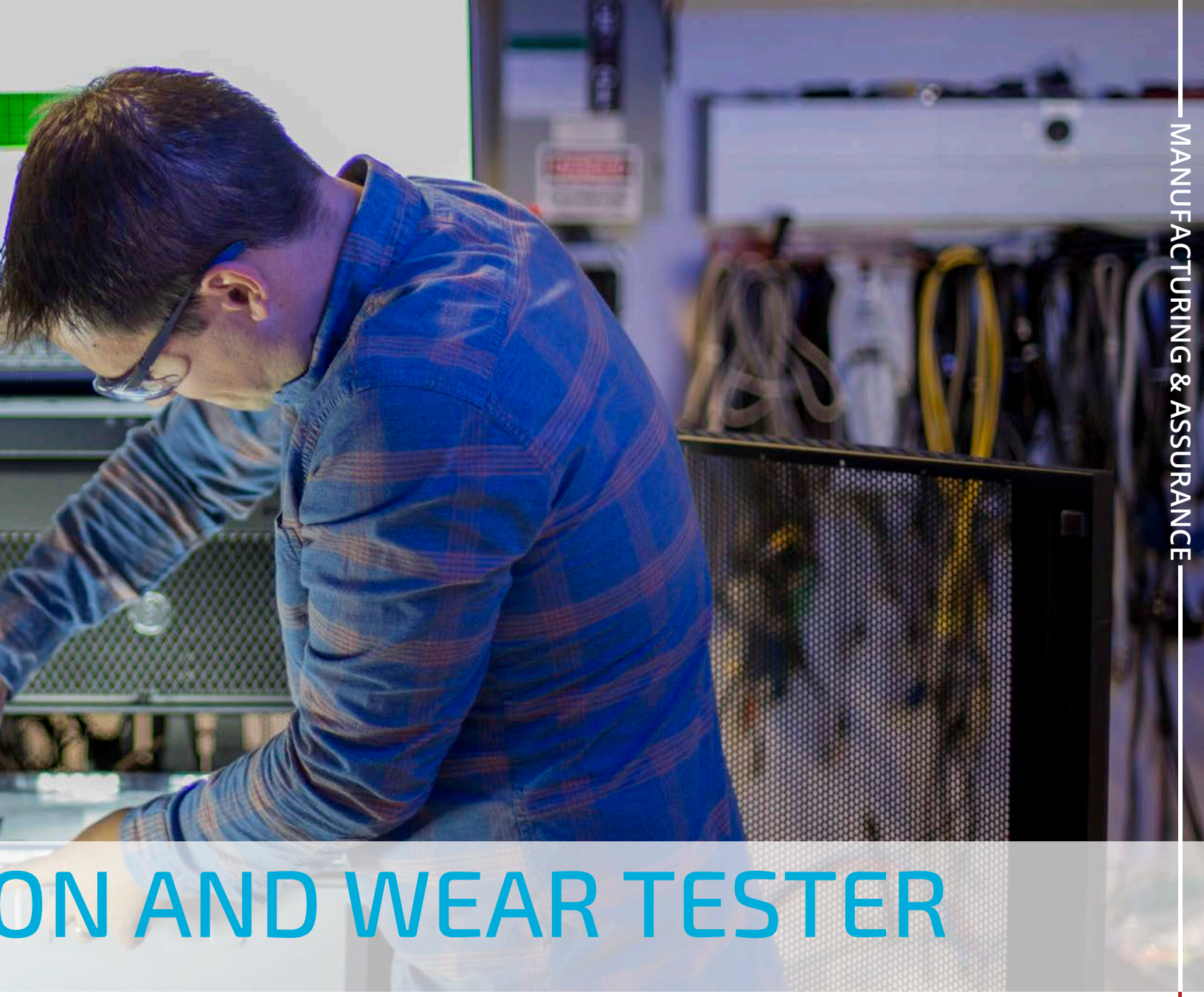
- Material assurance and qualification

HIGH THROUGHPUT FRICTI

Enables statistical studies of coatings and materials

There is a need for high volume material testing/qualification, but industry and researchers are currently limited by commercially available testing devices. Most wear testers can only handle one sample at a time and are often expensive. Sandia's High Throughput Friction and Wear Tester enables testing on up to 16 samples simultaneously. It can complete a statistical study of material coatings under a variety of environmental conditions in a few hours rather than months.

Sandia's High Throughput Tester can be used to investigate deposition and chemical optimization, speed dependence, reliability, uniformity of coating, and friction/wear behavior. The tester contains multiple environmentally isolated testing modules. Each module comprises four load cells, loading arms, deadweight loads and specially designed quick-change ball holders. Each module can have different environmental and loading conditions, allowing users to evaluate the same coating under different conditions. Alternatively, users can test different materials in similar environments to select the right coating for a particular application. Once the samples are in



ON AND WEAR TESTER

place, the system's specially designed software allows users to set test conditions (length, speed, cycle) in each module and automatically acquires, organizes, saves, and displays real-time testing data. In addition to real-time data, the software generates a comprehensive data analysis summary for quick and easy review. The entire system is less expensive and more user-friendly than current-state-of-the-art—enabling testing for material development, qualification, or quality control that would have been too cost prohibitive in the past.

Technical Benefits

- Low cost (approximately 5x-6x less expensive than conventional testing devices)
- Enables simultaneous testing using different environmental and loading conditions
- Automated system that requires minimal user interaction
- Corresponding software monitors results in real-time and reduces large amounts of data for quick review and analysis

Industries & Applications

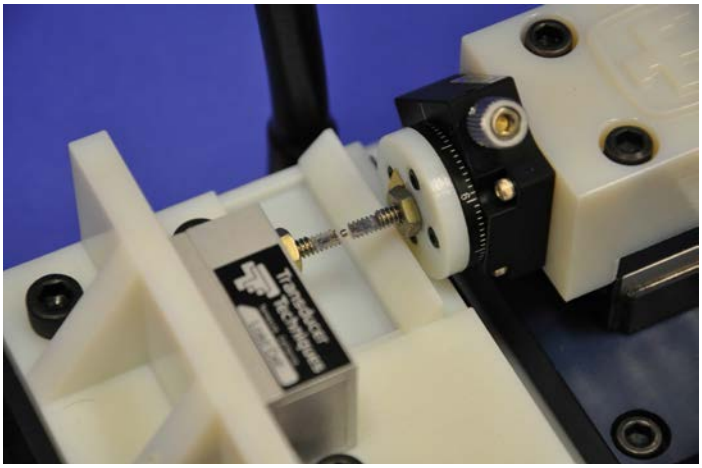
- Coating/material statistical studies, development, qualification, and quality control

MINIATURE SPRING TESTER

An improved testing platform for miniature springs

Many systems require miniature coil-wound springs, such as firing devices, medical, and precision instruments. In order to qualify miniature springs, manufacturers of these systems rely on commercially available testers that are designed for large-scale springs (>0.5 in. diameter). Current state-of-the-art devices lack sufficient force resolution or cyclic test capabilities for miniature springs. Sandia developed a testing platform specifically designed for miniature springs with improved accuracy and precision along with the ability to evaluate spring reliability over its lifetime.

Sandia's Miniature Spring Performance Tester consists of a testing device, control system, and operating system that automates spring testing, data collection and analysis. A voice coil actuator is used to cycle the test spring through extension or compression force. The system includes a linear encoder with a 1µm resolution to act as a feedback loop that enables the system to make automatic adjustments—reducing operator time. Sandia's tester allows interchangeable use of force cells ranging from 10g through 1kg. Data obtained during testing is recorded using a bus-powered data acquisition device capable of 16 bit resolution, 250,000 samples/second, and a ±10 voltage range. This data can be used to determine the cyclic degradation of the springs over a lifetime.



Closeup of testing stage and load cells

Sandia's device is the only testing platform that provides enough precision to accurately evaluate performance of miniature springs.

Technical Benefits

- Designed specifically for characterization of miniature springs
- Improved precision and accuracy
- Evaluates static or fatigue characteristics
- Evaluates degradation of a spring over a lifetime
- Automates testing process

Industries & Applications

- Manufacturers of any device that incorporates miniature springs
- Medical devices
- Firearms
- Aerospace components
- Compact electronic controls

MULTI-FUNCTIONAL NANOMATERIALS

An innovative crystallization method to produce nanomaterials

Due to current manufacturing methods, nanomaterials suffer from a lack of uniformity resulting in efficiency and reliability issues. Sandia National Laboratories developed an innovative crystallization method that produces well-defined multi-functional nanomaterials.

Sandia's nanomaterials are produced using a seeding and growing process within surfactant-confined nanostructures (micelles, emulsions, and mesophases). This process provides unique control over shape, size, composition, and reproducibility—currently unachievable with traditional manufacturing methods. This process also provides the ability to adjust chemical and physical nature of nanomaterials at different crystallization stages, enabling further tunability to achieve desirable functions and properties.

Sandia has used this method to successfully produced a wide variety of nanomaterials such as porphyrins, energetic materials, and nanoparticles. The functional materials produced through this process exhibit superior performance at a fraction of the cost in important applications including photo-degradation of organic pollutants, photocatalytic hydrogen production, synthesis of fuel cell catalysts, and phototherapy in comparison with existing catalysts.

Technical Benefits

- Cost effective manufacturing method
- Improved performance & reliability
- Scalable production
- Environmentally benign process
- Ability to create novel particle shapes
- Uniform shape, size, and composition

Industries & Applications

- Photo-degradation of organic pollutants
- Photocatalytic hydrogen production
- Synthesis of fuel cell catalysts
- Phototherapy

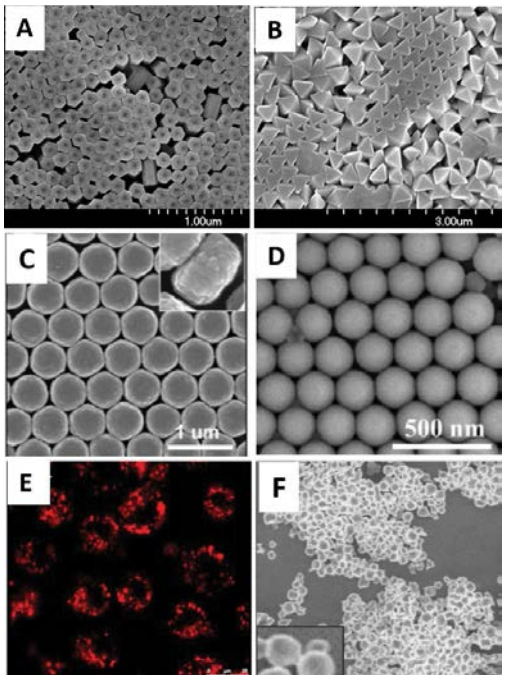
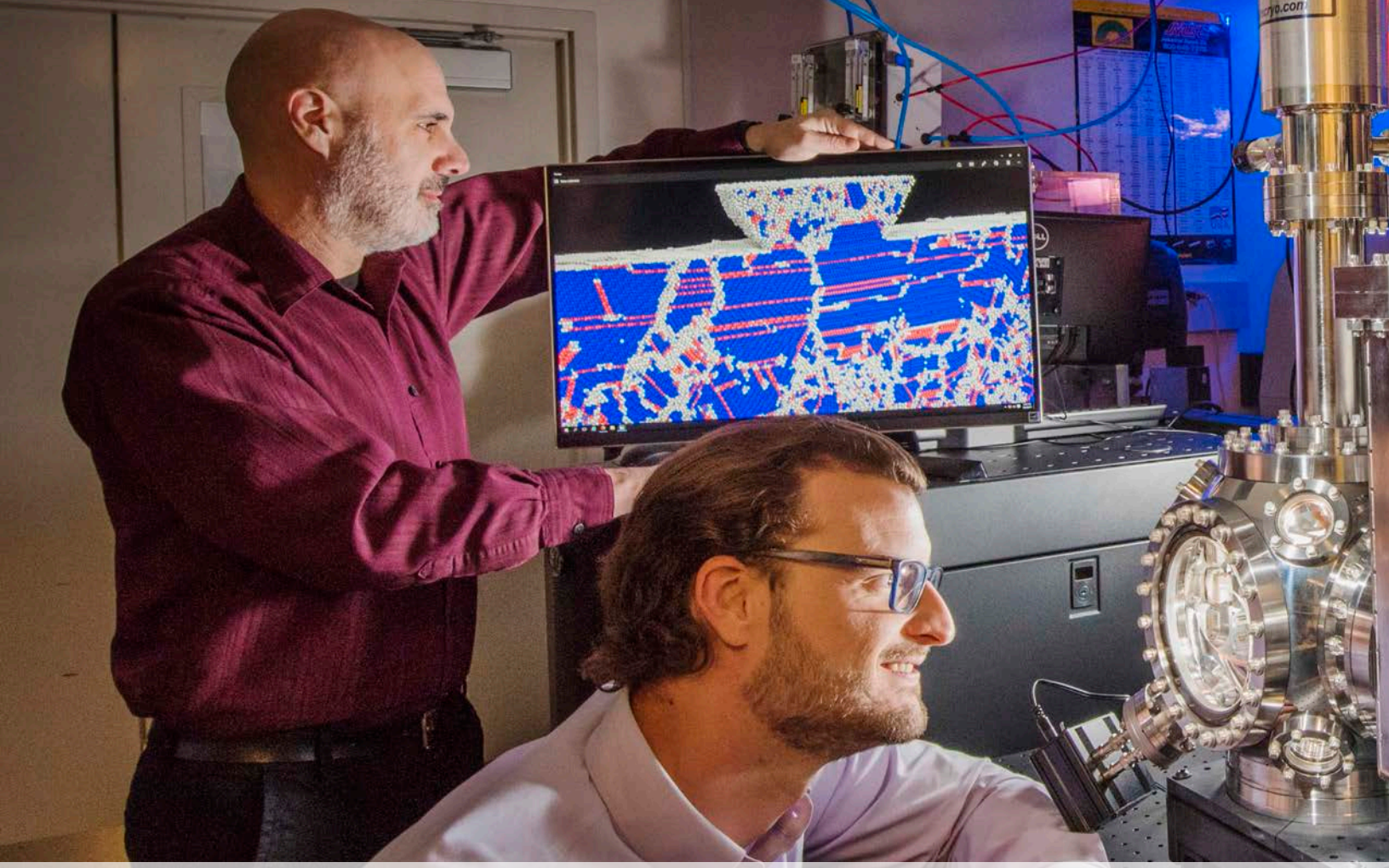


Image A & B: templated by surfactant micelles, Image C & D: nanospheres particles templated by micellar networks for phototherapy, and Image F: energetic materials (CL-20) confined by micelle/ emulsionstemplated by emulsion, Image E: particles templated by micellar networks for phototherapy, and Image F: energetic materials (CL-20) confined by micelle/ emulsions

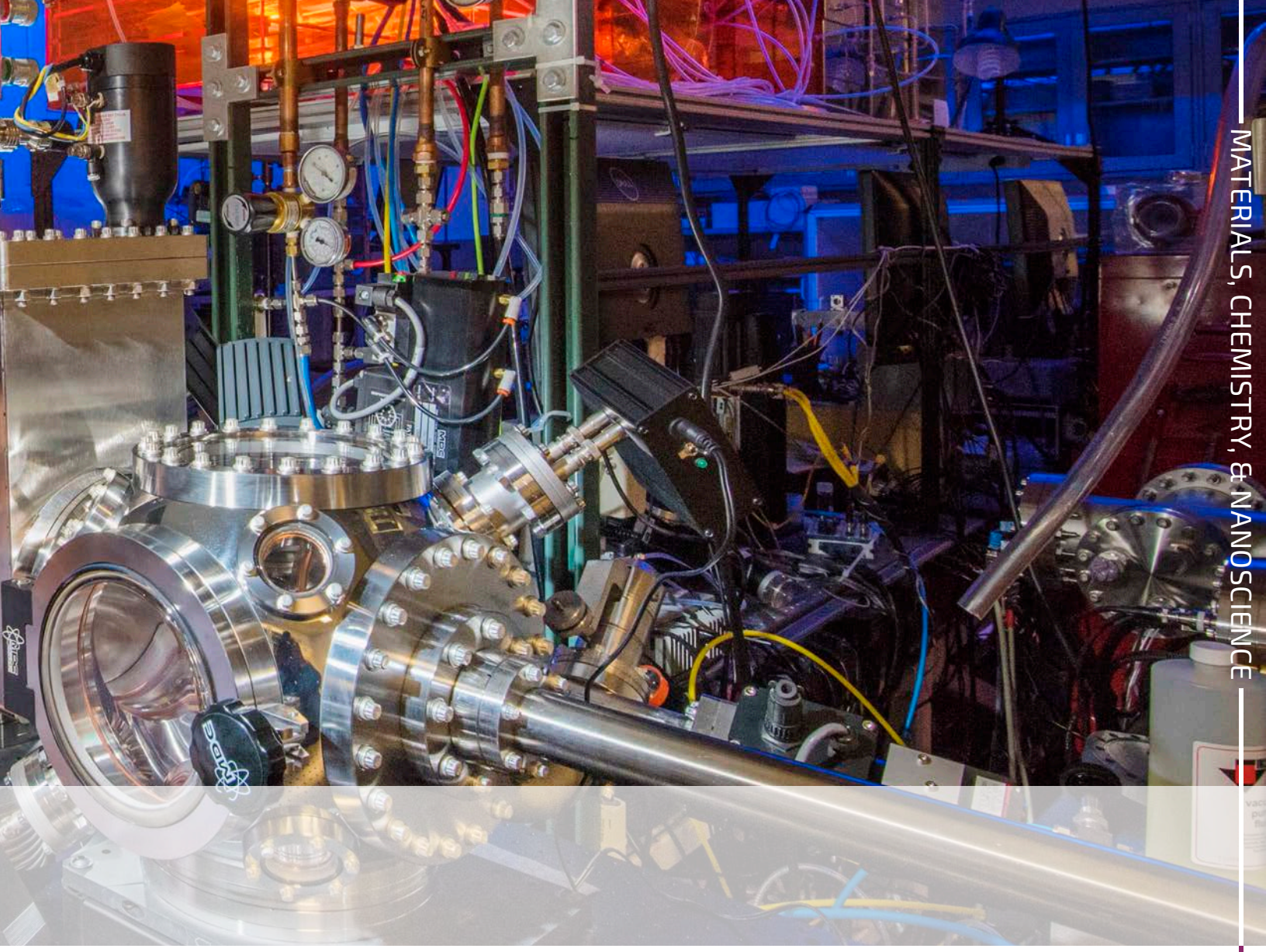


PLATINUM GOLD ALLOY

Ultra wear-resistant alloy to improve durability and longevity

From cell phones to satellites, industry spends millions on traditional gold alloy electrical contact coatings. While gold and other metal alloys have been an industry standard to protect metal components from wear due to metal on metal contact, they still experience deterioration over time. Using a novel synthesis approach, Sandia researchers developed an ultra wear-resistant platinum gold (Pt-Au) alloy that can replace gold alloys for improved durability, longevity, and reduced costs in electronic devices.

It has long been thought that metals with smaller grains are harder, and that harder metals wear more slowly. The present work challenges this conception, showing dramatic improvements in wear resistance by mitigating grain growth. Sandia has shown that Pt-Au, one example of a broad, new class of alloys, is able to resist changes in grain structure at remarkably high stresses and temperatures. Sandia's Pt-Au alloy has demonstrated 100x higher wear life than conventional coatings with superior electrical conductivity. With demonstrated stability at high temperatures (~500°C) and a remarkable resistance to fatigue damage, these alloys can reduce device manufacturing constraints, allowing for non-incremental improvements in the life of electrical contacts. These improvements allow for the reduction of coating thickness resulting from the unparalleled wear resistance, leading



to a reduction of material costs. This alloy can be applied using a number of conventional deposition methods, allowing for widespread application in the coatings industry.

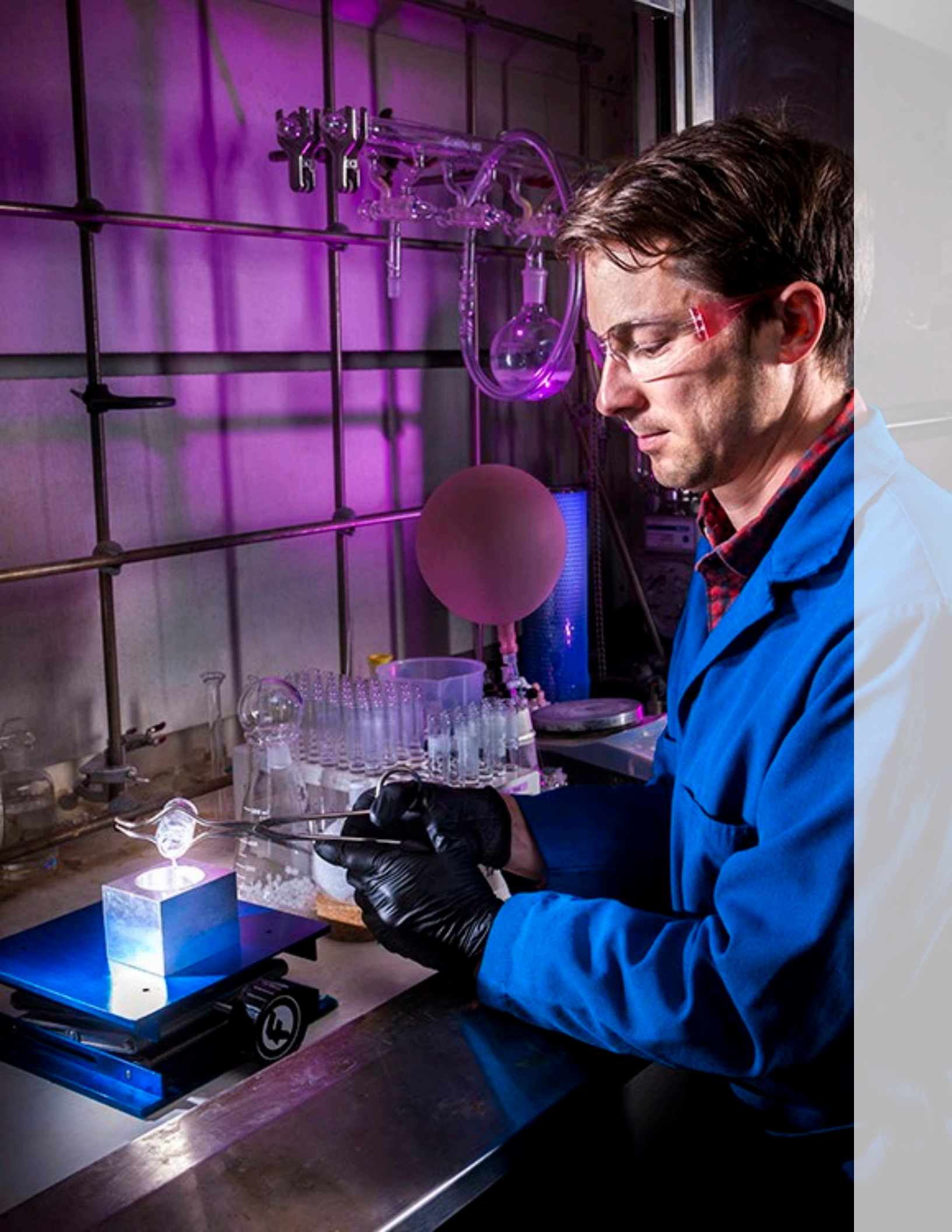
Sandia's wear-resistant Pt-Au alloy can be a cost-effective investment over time for industries seeking superior durability and protection against wear. While originally developed for electronic coatings, this alloy also has potential applications in tribological coatings due to its ability to produce a diamond-like carbon lubricant in service conditions.

Technical Benefits

- 100x more durable that traditional contact coatings
- Easy to apply using conventional deposition methods
- Stable at high temperatures (~500°C)
- Self-healing in anoxic environments enables formation of a diamond-like carbon lubricant

Industries & Applications

- Consumer electronics
- Electronics for harsh environments
- Tribological coatings



ORGANIC GLASS SCINTILLATORS FOR RADIATION DETECTION

Improved detection of potential nuclear threats

Sandia developed an organic glass scintillator that will improve safety and security at our nation's ports and borders. Current radiation monitors typically utilize plastic scintillators, which are unable to differentiate between special nuclear materials and normal or non-threatening sources of radiation without a separate helium tube. The type of helium used in these tubes is rare and non-renewable, adding cost and complexity to the system. Sandia's organic glass scintillator provides detection capabilities that were limited to expensive, fragile *trans*-stilbene in a cheaper and more portable form.

Manufactured via melt casting, Sandia's organic glass scintillators consist of a combination of two organic compounds that resist crystallization and can be formed into almost any shape, including thin fibers. The resulting scintillator demonstrates high scintillation yields and discrimination between gamma rays (environmental radiation) and controlled threat materials such as plutonium or uranium with high selectivity. This material is also suitable for other applications that require high luminosity, high electron/hole mobilities, and stable film-forming properties such as organic electronics.

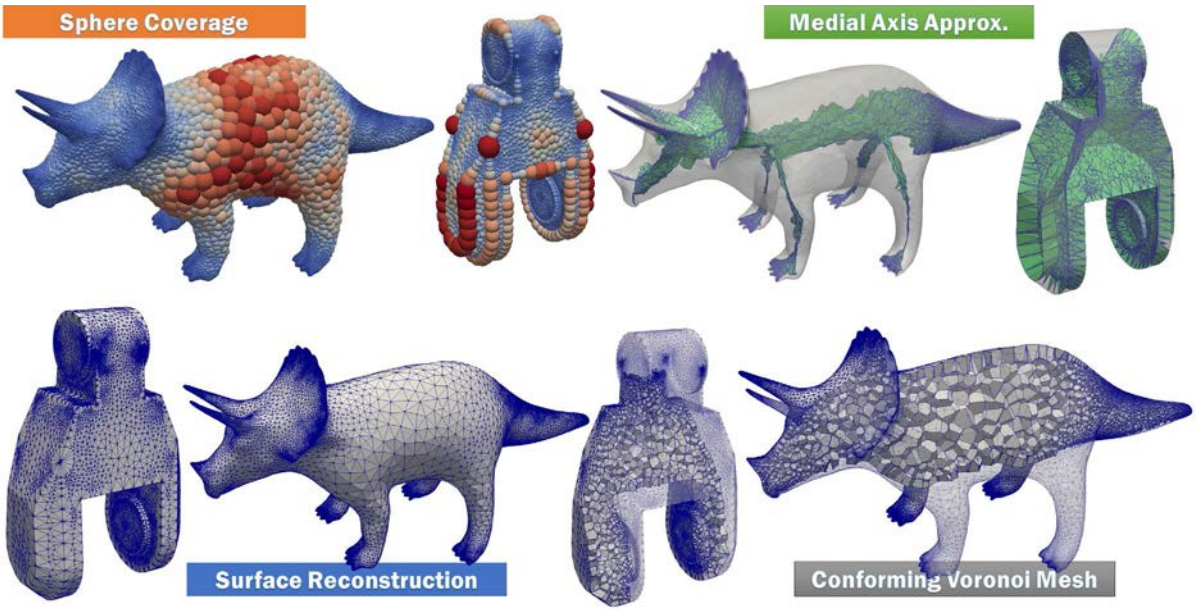
This new class of scintillation material outperforms *trans*-stilbene, the gold standard in radiation detection material, and is far quicker and easier to produce—making it a better option for incorporation in to detection devices used by our nation's security personnel and first responders.

Technical Benefits

- Light yields of up to 115% trans-stilbene crystals and better neutron/gamma pulse shape discrimination (PSD) performance
- Rapid, large-scale production
- Low cost
- Can be cast into nearly any shape
- Mechanically and physically stable from wells

Industries & Applications

- Nuclear non-proliferation
- Border security
- Radiation physics
- Organic electronics



VOROCRUST v. 1.0

An automated Voronoi meshing software for complex geometries

VoroCrust v. 1.0 is one of the first fully automated Voronoi meshing software programs reliable enough for anyone to generate a mesh that conforms to a complex model without clipping--regardless of experience. While there are other meshing software programs currently on the market, VoroCrust is the only one that utilizes unclipped Voronoi cells everywhere to produce provably correct polyhedral tessellations for domains with multiple regions which is not currently possible with traditional polyhedral or hexahedral meshing programs.

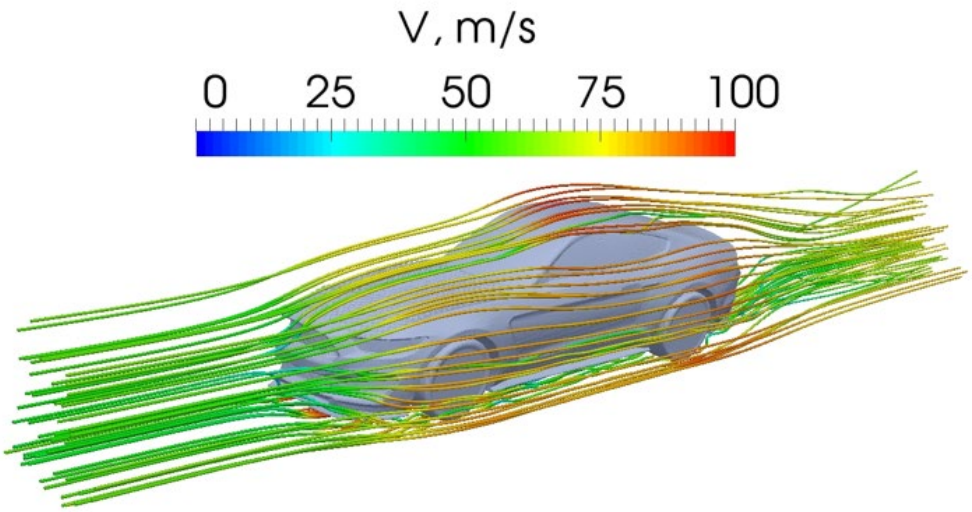
VoroCrust users input their CAD model and the program quickly and automatically produces well-spaced seed locations to generate a conforming mesh that simultaneously decomposes the enclosed volume and reconstructs the bounding surface. Each cell is an unclipped Voronoi cell which means it is a convex region bounded by planar facets that are convex as well--resulting in mesh that is more reliable than what is currently possible with other programs. Our Voronoi mesh is designed to handle complex models which may include sharp edges or curved surfaces. By generating a higher quality mesh that is truer to the original model, VoroCrust eliminates the need to clean-up or optimize models which results in time consuming user interaction, requires experience, and may sacrifice Voronoi properties. All meshes are stored as an implicit mesh that is based on seed locations which can quickly regenerate the underlying explicit mesh locally and on the fly, saving users valuable storage space.

Technical Benefits

- Programming Language: C++
- Operating System: Mac, Windows, Linux
- Hardware Requirements: PC
- Auxiliary Software: None

Industries & Applications

- Linear programming
- Surrogates modeling
- Automatic discontinuity detection
- Calibration
- Optimization
- Uncertainty quantification



RIGHT-SIZE DIMPLE EVALUATOR v. 2.0

Software to predict optimal dimpling for improved performance

There are many examples of surface modifications that reduce resistance to flow and improve performance. For instance, a dimpled golf ball can travel twice as far as a smooth ball when hit with the same force. Dimple modifications have had an impact on many application fields, most recently vehicles, aerospace, and energy systems. However, there is no methodology or tool to ensure optimal dimpling. Sandia Labs has developed a software that predicts optimal dimpling for any turbulent system for reduced flow drag.

Sandia's Right-Size Dimple Evaluator uses a unique set of independent turbulence equations, with input based on the system's specific characteristics. The software can also import fluid properties from the REFPROP NIST database.

The software uses the input to calculate an optimal dimpled pattern for the intended application—thereby eliminating guesswork or design by trial and error. The software ensures the dimple dimensions enable unimpeded flow through the dimple's concave cavity. This software will enable a wider range of applications to apply dimple modifications to enhance performance.

Technical Benefits

- Optimal dimple spacing and size for reduced resistance to flow
- Increased heat-transfer rate at surfaces for higher thermal efficiency
- Script runs on Matlab but can be easily programmed in C++ and FORTRAN
- Designed to run on a PC
- Can import fluid density and viscosity values from REFROP NIST

Industries & Applications

- Any system with turbulent flow
- Aerospace
- Vehicle design
- Microfluidics
- Solar, Wind, and Nuclear Energy
- Turbines

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