Welcome to Sandia National Laboratories’ Intellectual Property Magazine

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.

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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.

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**Synthesis of Nanocrystalline Iron Nitrides Using Two-Step Milling Process** is an efficient method for creating soft magnetic materials

**Patent Application # 62/105918**

Nanocrystalline iron nitride is an important soft magnetic material; however, conventional methods of production do not exist. Synthesis of dense nanocrystalline iron nitrides is not possible by simply annealing elemental iron in NH, at temperatures in excess of 600°C since Fe,N and other iron nitrides are unstable above 600°C and will decompose. Sandia researchers have discovered that by using a two-step reactive milling process and high pressure spark plasma sintering (SPS) they can quickly and efficiently fabricate bulk Fe,N parts.

The first step in this novel synthesis process takes pure Fe powder (such as commercial gas atomized iron powder) and cryomills it using liquid nitrogen, producing a finer grained material with a significant amount of vacancies, grain boundaries and dislocations, allowing for faster diffusion of nitrogen gas into the iron crystalline lattice. Unlike typical Fe powder, cryomilled powder allows nitriding during the second ball-milling step with NH₃ to occur at room temperature, eliminating the need for high temperatures. Finally, the raw iron nitride nanocrystalline powder is sintered to form dense iron nitrides (such as Fe,N) using SPS, which prevents significant grain growth and decomposition of iron nitride phases due to its low sintering temperature (< 600°C), fast heating rate, and brief consolidation cycle. The resulting product is produced in less time and with considerably less energy than other methods. Additionally, through the use of shaped dies, SPS can directly create parts using a process called net-shaping, which completely eliminates the need for follow-up machining. Parts, such as toroidal and E-core shaped transformer cores, can be fabricated directly from raw iron nitride powders.

**Applications and Industries**
- Medical imaging manufacturing
- Renewable energy
- Transportation
- Grid scale energy
- Distributed energy at the home & consumer level

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**Miniaturized Pulse Discharge Ionization Detector** is a smaller scale PDID that allows for increased field usage

**Patent Application # 62/195933**

This invention improves upon currently commercially available PDIDs by reducing size without compromising performance. PDIDs are becoming a laboratory standard for gas chromatographic measurement and miniaturizing it allows for increased field use. It also allows for integration with micro-GCs to provide additional sensitivity and the ability to detect more compounds.

Using circuit board integration and unique electrode design, Sandia researchers have been able to create a PDID that is approximately 1 inch by 1 inch by 2 inches, which is 40- and 80-fold smaller than commercially available PDIDs. 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 test for a wide array of volatile organic compounds. It is proven to detect explosives-related compounds, pesticides, toxic industrial compounds, greenhouse gases and more. The mini-PDID can stand up to high demand field usage as its detector core is self-aligned and compressed during assembly, eliminating the need for high temperatures. Finally, the raw iron nitride nanocrystalline powder is sintered to form dense iron nitrides (such as Fe,N) using SPS, which prevents significant grain growth and decomposition of iron nitride phases due to its low sintering temperature (< 600°C), fast heating rate, and brief consolidation cycle. The resulting product is produced in less time and with considerably less energy than other methods. Additionally, through the use of shaped dies, SPS can directly create parts using a process called net-shaping, which completely eliminates the need for follow-up machining. Parts, such as toroidal and E-core shaped transformer cores, can be fabricated directly from raw iron nitride powders.

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- Medical imaging manufacturing
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**Rapid Adaptive Zoom** is a fast, push-button, optical zoom that can replace digital zoom on cellular phone cameras or any imaging system requiring variable magnification

**US Patent # 6,977,777**

Cellular phone cameras and certain medical imaging devices are forced to rely on digital zoom, which does not increase resolution and may produce pixelated images, as traditional zoom lenses are too large, slow, and power-hungry to adapt. Sandian inventors have developed the Rapid Adaptive Zoom that produces true optical zoom in a compact, low-power system, making it more easily integrated into medical imaging devices, telescopes, drones and potentially cellular phones – any imaging system where size, weight, or power prohibit traditional zoom.

The Rapid Adaptive Zoom relies on variable focus mirrors or lenses. Rather than creating magnification by adjusting the position of two or more lenses, as is done in conventional zoom systems such as the optical zoom on a camera, Rapid Adaptive Zoom changes the focal length of two or more elements in the system in order to change magnification. In one implementation, a polymer lens core containing two flexible hermetically sealed membranes are paired with a piezoelectric actuator that electro-magnetically changes the flex of the lenses with a push of a button. The magnification happens within milliseconds and features a “zero-power hold”, reducing energy consumption. Originally designed for a push-button zoom riflescope for the U.S. military (https://youtu.be/4SuG93K7XU), Rapid Adaptive Zoom has gone through extensive imaging testing, in addition to shock, vibration, and temperature testing.

**Applications and Industries**
- Medical imaging
- Telescopes
- Cellular phones
- Digital cameras
- Surveillance systems
Monolithically Integrated Absolute Frequency Comb Laser System is a compact THz frequency comb used for precision timing
Patent Application # 14/859706

Laser combs are increasingly used to provide precision measurements. Typical frequency comb systems use non-linear elements, distinct from the laser gain media, to create a set of emission lines with equally spaced frequencies. Separate detectors and/or frequency mixing elements are needed to lock the comb and determine the absolute frequencies of the emission lines. As a result, these systems can be extremely large and expensive.

Sandia’s apparatus combines all the essential components for generating and locking a THz frequency comb: a multimoded laser, a non-linear mixer for generating mixed frequencies and a high frequency detector on a single mm size chip. With the decrease in size, the application potential increases. A simple quantum cascade laser emits many modes equally spaced. A diode is embedded in the laser, creating harmonics and the different frequencies can be used to lock the emission line frequencies while also serving as a possible detector if needed.

Applications and Industries
- Precision timing and clocking
- High-resolution broadband spectroscopy
- Remote sensing

Advanced Ultrasonic Device has an in-situ height adjustment for improved flaw detection
US Patent # 6,234,025 / 8,087,298 / 8,371,173 / 9,121,817

Ultrasonic testing is a nondestructive inspection (NDI) technique that utilizes ultra-high frequency sound to detect flaws within a part of interest. A fluid (e.g., water or gel) is used to achieve high coupling between the transducer and part under inspection. Typical probe holders (i.e., shoes) hold the ultrasonic probe at a fixed distance from the inspected part, which can lead to signals that are masked by harmonics and undesirable reflections in the part. Researchers at Sandia National Laboratories have developed an adjustable height ultrasonic testing device that overcomes the limitations of fixed-height probes and enables in-situ adjustment of coupling fluid height to eliminate the presence of confounding signals and produce improved flaw detection. The device is compatible with a focused ultrasonic transducer developed at Sandia or commercial off-the-shelf transducers.

Traditional probe shoes are open ended, leading to the spillage of large amounts of coupling fluid. The Sandia designed shoes minimize spillage and leakage through the use of a permeable membrane and sealing gasket as well as a vacuum system to remove excess coupling fluid.

Applications and Industries
- Aircraft
- Automotive
- Wind turbines
- Military
- Civil structures
- Oil and gas

Q-PUDID is a physically unclonable digital ID that will prevent mass data breaches
Patent Application # 62/175753

With the rise in e-commerce and payment platforms that work from smartphones, data security is becoming an increasingly important concern. Current methods of identity verification are based on static data that must be kept confidential like social security numbers, birth dates and credit card numbers. Hackers have access to millions of identities by hacking into one server. By creating a physically unclonable digital id, Sandian innovators have eliminated verification by static data offering a significant technical solution to rampant cybersecurity problems: digital identity theft.

The Q-PUDID process integrates a series of hashing algorithms with a physically unclonable digital key, i.e. Q-PUDID smartcard firmware, which acts as a physical watermarking device. The smartcard is tamper resistant and can be integrated in smartphones, laptops or credit cards among other digital devices. When the Q-PUDID smartcard is used for verification purposes, i.e. a sales transaction using a smart phone, the user would present their smartcard device and enter a pin or password which then creates a dynamic and unique digital signature that can only be producible by that specific Q-PUDID device. Forcing all digital transactions to be watermarked by a unique unclonable physical device ensures that potential identity thieves would need to have physical access to your Q-PUDID smartcard device and must somehow obtain your pin/password data. With Q-PUDID, static data such as social security numbers, can be released as public data since no transaction will occur without that data being digitally watermarked by an unclonable, physically unique Q-PUDID smartcard.

Applications and Industries
- E-commerce
- Smartphone
- Auto industry
- Home security
SecuritySeal measures variations of the surface and determines whether tampering has occurred

US Patent # 8,516,269

One critical area of security involves ensuring that a sealed container remains sealed. To address this concern, scientists at Sandia developed SecuritySeal, a small device that can be easily attached to a container or door and detects any evidence of tampering. The technology utilizes physical unclonable functions (PUFs), which are the small defects that are part of any manufacturing process. These variations during component manufacturing do not affect the functionality of the device, but ensure that each PUF is unique. As a result, the PUF creates a unique digital key that cannot be counterfeited.

SecuritySeal’s PUFs measure variations in an integrated circuit and in a film that is adhered to the container or door. Combining these measurements creates a unique signature that is analogous to a fingerprint. If an adversary tries to lift, slide or remove SecuritySeal from the surface to which it is adhered, the PUF response is altered, indicating that tampering has occurred. A digital reader can remotely check the device and deduce if there has been a change in signature if the tag-seal fails to properly respond. While the device and deduce if there has been a change in signature if the tag-seal fails to properly respond. While SecuritySeal is perfect for sealing nuclear materials, the device can be scaled to use for everyday items such as cargo containers, perfect for sealing nuclear devices. The technology utilizes physical unclonable functions (PUFs), which are the small defects that are part of any manufacturing process. These variations during component manufacturing do not affect the functionality of the device, but ensure that each PUF is unique. As a result, the PUF creates a unique digital key that cannot be counterfeited.

Applications and Industries
- Nuclear non-proliferation
- Treaty verification
- Industrial machinery
- Pharmaceutical
- Homeland security

Mild Method for the Surface Functionalization of Solid Polycarbonate is a simple and environmentally-friendly approach to introducing surface functionalization to polycarbonates

Patent Application # 14/817471

Surface functionalization is critical to the successful use of materials in a variety of applications from sizings agents on fibers for composites to antibiofouling coatings on medical devices. Polycarbonate is of particular value because of its wide applicability throughout a variety of industries and its overall stability. Its stability, however, makes it difficult for use in surface modification, often requiring harsh chemicals such as nitric and sulfuric acid to provide an aminated surface. These chemicals are expensive, harmful to the environment, and can cause morphological changes to the bulk properties of polycarbonate. Sandia has made substantial strides to alleviate this issue by using smaller amounts of chemicals to achieve a similar effect, reducing the overall cost and negative environmental impact.

Further, it has been demonstrated that this aminated polycarbonate surface can be prepared using a nonsolvent for polycarbonate, specifically water or ethanol. This has been demonstrated using highly sensitive surface characterization instrumentation such as XPS. While amine surface modification is one of the most valuable modifications for surfaces (due to the ease of covalent binding to amines), it has been demonstrated that these surfaces can also be converted to maleimides relying similarly on small quantities of reagents in nonsolvents. This modification enables the use of ubiquitous ‘click’ chemistries for further modification and flexibility.

Applications and Industries
- Biomedicine
- Wearable technology
- Diagnostics

Sandia Prosthesis is a dynamic prosthetic socket that provides comfort to amputees throughout the day

Patent Application # 13/829745, 14/047179

As an amputee walks in their prosthesis, the natural fluids in the leg shift and the muscles shrink causing a change in the shape of the leg which leads to rubbing and discomfort. With a rise in lower limb amputees, it is important to provide them with a prosthetic leg that they can wear for long periods of time without discomfort. Typical prosthesis are custom designed to fit the contours of the amputee’s limb, however, the hard plastic does not accommodate for any limb changes throughout the day. Specialized socks designed to deal with the shifting fluids in the limb provide some comfort, but they require the amputee to keep them on hand and to take off the prosthesis to change them.

Sandia researchers have developed a special sensor that is approximately the size of a quarter that can sense direct pressure and shear pressure in multiple directions. Using these special three-way pressure sensors, they have developed a lining that fits into a prosthetic leg socket and monitors the changing pressure on the limb. When the sensors detect a change in pressure, a liner with specialized bladders can fill with pressurized liquid to fill the space where you limb may have lost liquid during the day. The Sandia prosthesis adapts throughout the day ensuring the wearer has optimal comfort.

Applications and Industries
- Medical

JavaCleaner removes old and potentially vulnerable versions of JAVA

Sandia Copyright # 1655

When installing new versions of Java, preexisting versions remain on your system, presenting significant security risks. Currently available Java cleanup tools are web-based, ignore installations of the Java Development Kit (JDK), detect only those Java versions installed by the Java installer, and do not provide mechanisms to restore deleted Java versions. To address the problem, Sandia developed the SNL JavaCleaner, which removes old, and potentially vulnerable versions of the Oracle Java Runtime Environment (JRE) and the Java Development Kit (JDK) from a Microsoft Windows OS based PC.

The SNL JavaCleaner removes all previously installed versions of the Java JRE and JDK, and requires only minor updates to integrate new versions of Java as they are released by Oracle. The utility has been developed to minimize the chance for unintended file deletions, and has been successfully implemented to clean up old versions of Java on various Sandia network partitions.

Applications and Industries
- PC Security and cleanup
- Government entities
- Financial institutions
- Industry
Advanced Forms of Activated Carbon are capable of capturing and immobilizing radioactive materials
US Patent # 9,000,250

Nuclear power represents an infinite source of power generation but possesses multiple concerns—one of the most significant concerns is the safe disposal and isolation of nuclear waste. Trapping and immobilizing radionuclides, such as iodine and technetium, represents a great technical challenge due to their high mobilities. In addition, these radionuclides exhibit long half-lives that are highly soluble and poorly absorbed by natural materials.

To address this growing problem, scientists at Sandia have developed a method to capture and immobilize radioactive nuclei using metal fluorite-based inorganic materials. The process involves flowing a gas stream of radioactive species through an exhaust apparatus that contains the fluorite-based material. Fluorite-based materials perform better than current oxide-based materials, with their sorption affinity for gaseous iodine around two to three orders of magnitude stronger. Sandia’s material is highly effective, capable of trapping higher amounts of radioactive material than its conventional counterparts.

Applications and Industries
- Nuclear energy and security
- Medical devices
- Chemical separation
- Environmental cleanup

Membrane Projection Lithography is a novel technique that allows users to create multiple 3D structures at the micron level
US Patent # 8,981,337

Membrane projection lithography (MPL) is a novel microfabrication technique used to create three dimensional micron-scale integrated circuits. The process begins by forming a micro-cavity structure of matrix material that can take a curved, cylindrical, spherical, ellipsoidal, cubic, prismatic, or conic shape. The cavity is then filled with backfill material and a membrane is formed over the cavity. An opening is produced in the membrane which acts as a mask over the structure and controls the area of the cavity that is subject to the fabrication operation. Next, the backfill material is removed and structures are produced within the cavity by a deposition, implantation, or etching operation through the suspended, patterned membrane. By changing the direction of the operational beam in relation to the membrane opening, the various surfaces of the cavity can be utilized to form a plurality of structures. If additional structures are required, the original membrane can be removed, a new membrane formed, and further implantation, etching, or deposition operations can be executed.

Sandia’s MPL process can produce semiconductor components that do not run parallel to a wafer surface, allowing for a higher complexity of integrated circuits at the micro level. It is also capable of creating structured electromagnetic materials. While current sub-micron 3D fabrication techniques are complicated processes that require non-standard equipment and lack high-volume scalability, MPL is an efficient technique that can be performed in any standard semiconductor processing fabrication facility. MPL produces results that exhibit uniformity, repeatability, and high yield.

Applications and Industries
- Semiconductor manufacturing
- 3D integrated circuits
- Structured electromagnetic materials
- Thermal antennas

Packed Particle Bed Reactor creates hydrogen fuel using a thermochemical process powered by the sun
US Patent # 8,420,032

Sandia has developed a packed particle bed reactor for converting solar energy into a chemical fuel, such as hydrogen. Hydrogen fuel may be an environmentally-friendly alternative to gasoline, natural gas, and other carbon-based fossil fuels—especially if the hydrogen can be generated without using fossil fuels in the process. The reactor creates hydrogen fuel using a two-step thermochemical process powered by the sun.

In the Sandia reactor, minuscule metal-oxide particles (a few ten of microns in diameter) acting as the working “fluid” are transported between two isolated reaction zones: an upper chamber heated by concentrated solar energy and a lower chamber exposed to steam. Particles are lifted from the lower to the upper chamber using an elevator concept patented by the team. They are returned to the lower chamber by gravity. In the upper chamber, sunlight heats the particles to temperatures up to 1600 °C, providing sufficient energy to remove oxygen from the oxide particle. The oxygen is pumped away, and the oxygen-deficient particles flow to the lower chamber. Here, oxygen is the steam breaks away from the water molecule to deposit back into the reduced particle, creating hydrogen in the process. The re-oxidized particles are then elevated to the upper chamber to repeat the cycle up to thousands of times before particle replacement.

Applications and Industries
- Fuel cell technology
- Transportation
- Solar energy
Industry Impacts

Sandia partnership with Verrillon develops laboratory-based technology into valuable tool for US energy industry

Sandia’s intellectual property results primarily from R&D conducted for the government in the national security sector. Our laboratory collaborates with industry, leveraging different 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.

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