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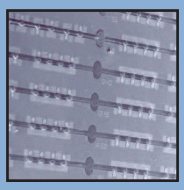
Missile Defense Agency

TechUpdate

A Quarterly Newsletter for MDA Technology Transfer

INSIDE



▲ ChemImage's technology combines digital imaging and Raman spectroscopy to provide fast, clear images that reveal material morphology, composition, structure, and concentration—allowing users to spot defects or anomalies in a material.

It's All in the Details

Integrated imaging system enhances detection capabilities.

by Joe Singleton/jsingleton@nttc.edu

Often the devil is in the details, especially when the details are microscopic. Now, an MDA-funded technology can help subdue that devil by picking out minute abnormalities in forged documents or suspicious biological spores.

The technology, developed by ChemImage Corporation (Pittsburgh, PA), integrates two specialized types of imaging—luminescence and Raman—into spectroscopes to provide high-throughput screening for defects or anomalies in microscopic semiconductor materials such as gallium nitride (GaN). Abnormalities in large, visible items such as paper documents also can be screened by these spectroscopes as part of forensic trace evidence testing. MDA predecessor BMDO originally funded the technology for GaN screening through an SBIR Phase I contract in 2000.

Scientists use luminescence imaging—or ultraviolet excitation—to find or target the anomaly or defect of a particular semiconductor or material. Raman imaging then provides specific identification of these undesirable occurrences. ChemImage has designed special software that integrates luminescence and Raman into a dynamic

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The Valley of Life

Though Tennessee Valley sees surge in MDA presence, agency program continues to help companies nationwide.

by L. Scott Tillett/stillett@nttc.edu

The Defense Department's Base Realignment and Closure (BRAC) activities mean that about 2,500 MDA workers will be moving to the Tennessee Valley—namely, to the Huntsville, AL, area. However, the headquarters function of MDA will remain in the Washington, DC, area. The Huntsville region already is home to the U.S. Army's Redstone Arsenal, serving for decades as the heart of the Army's rocket and missile programs. The area also is known for NASA's Marshall Space Flight Center, which develops transportation and propulsion systems for programs such as the Space Shuttle and the International Space Station.

The area is a hotbed of private-sector and university-led research, development, and innovation. And MDA has played a part in building that hotbed—even before BRAC activities got rolling. Specifically, over recent decades MDA and its predecessor agencies, through initiatives such as the SBIR and STTR programs have funded approximately 75 Huntsville-area enterprises to work on research projects that could lead to improved missile defense technologies. In fact, this issue of *MDA TechUpdate* features three of those enterprises: CFD Research Corporation, CG², Inc. (a Quantum 3D company), and the former Mevatec Corporation (now a unit of BAE Systems).

MDA-funded SBIR researchers often talk about the "Valley of Death"—the uncertain period between the end of their Phase II government funding and the beginning of solid commercial contracts. Having a presence in the Tennessee Valley—closer to a burgeoning MDA presence, closer to agency issues, and closer to major agency contractors—stands to offer an advantage to companies struggling through the Valley of Death.

But while Huntsville is definitely the missile defense industry sweet spot, it's not the only place where MDA-funded small businesses can seek a boost for their business. MDA, through its Technology Applications (TA) program, continues to offer survival help to companies far beyond Huntsville. We do that by offering free publicity for MDA-funded technologies—through the *MDA TechUpdate* newsletter and other publications, as well as the TA program Web site (www.mdatechnology.net). We also provide MDA-funded companies a boost by offering free Business Focus Workshops and Technology Applications Reviews, designed to help companies discover and explore their technology strengths and market opportunities.

Being in MDA's backyard is a wonderful thing. But it's not the only place where MDA-funded companies can find action. Agency-supported companies in Huntsville and elsewhere in the nation are wise to pursue commercial opportunities beyond MDA. And the TA program is there to help them do that—no matter where they are located. For information on TA program assistance, give us a call at (703) 518-8800, ext. 229, or send an e-mail to techapps@nttc.edu.

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CONTENTS

Powering Up

Innovative processes promise more reliable thermal batteries at a lower cost.

by Michele Rejonis/mrejonis@nttc.edu

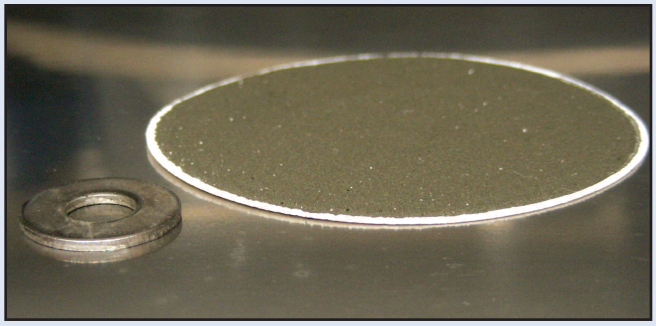
A thinner, more reliable thermal battery could save the military valuable time and money if it is faster and less expensive to produce than those made using conventional methods. One MDA-funded company, InvenTek Corporation (New Lenox, IL), has developed materials and a manufacturing process for a ceramic-fiber separator that may do just that. And, if successful, this combination can serve as a foundation for advanced thermal batteries, which can increase battery capacity and meet the high-power needs of various military systems.

The company's manufacturing process for the ceramic fiber separator (CFS) material, a thinner, lower-cost replacement for the current pressed magnesium-oxide (MgO) powder separator, can help create batteries that are more robust and require less production time. The company's approach does not require expensive equipment, and the strength of the CFS material allows it to be handled more easily than competing conventional products made with pressed powder such as MgO. Moreover, the separators result in thinner cells, allowing more electrolyte to be stored in the battery volume, which can lead to 30 percent more energy in the volume of thermal batteries.

Thermal-battery applications exist primarily in the military market, where the batteries can be stored for extended periods of time and then operate reliably, producing electricity from a chemical reaction almost instantaneously. Although such technology is primarily used for Department of Defense systems, InvenTek hopes to license its invention in anticipation of finding other applications for it. Additional avenues the company could pursue include small-scale thermal-battery manufacturing or supplying cell components to battery makers.

InvenTek's thermal-battery separators are made using a continuous tape-casting process, a well known and standardized method used as a manufacturing process for the production of thin sheets of ceramic materials that can include thin layers of ceramic-loaded polymers. The polymers can be used as single layers or can be stacked and laminated into multilayered structures. The processed CFS material can also serve as a carrier for new methods to "paint" thin electrodes directly onto the CFS separator material, becoming a basis for a new way of making the total battery.

In the first stages of development, InvenTek developed baseline processing for a 15-mil-thick tape-cast iron-disulfide (FeS_2; pyrite) electrode, which was laminated with the CFS. This new and very rapid method of thin-cell separator production reduces unit cost by 25 percent, with at least 25 percent reduced weight and a 20-fold increase in strength compared with current separator material, according to InvenTek. Also with this method, the CFS material can be produced in an efficient "tunnel-kiln" process that can produce the ceramic sheets to be processed into the separator 40 times faster than conventional separator build-up, and can free hydraulic presses used for conventional pressed powder separator material production for other component production.



▲ InvenTek's ceramic-fiber separator (white base of disk shown in image) is paired with an electrode (the dark layer) to produce thermal-battery components. The company manufactures components using a continuous tape-casting process.

This approach to thermal-battery production is exclusive to InvenTek, and the company has applied for a patent to protect its intellectual property. Competitors generally are working on technical approaches to making thin electrodes. However, InvenTek believes the separator is the key, and can include the electrodes as part of the separator.

InvenTek developed its processes with help from MDA, which awarded the company a 2003 Phase I SBIR contract, followed by a Phase II in 2005. The benefit to MDA would be improved national defense at a reduced cost, with greater reliability.

While the company believes its technology has been perfected, it is now working to complete product qualification and is hoping to move forward into a Phase III contract by the fall of 2007. InvenTek is collaborating with a thermal-battery manufacturer in preparation for such an award.

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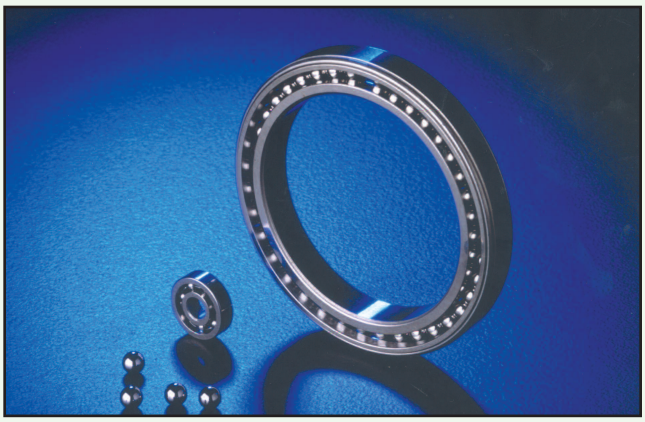
Titanium-carbide Process Crosses the Atlantic

MDA helps to requalify a defense-critical technology for U.S. shores.

by Joan Zimmermann/jzimmermann@nttc.edu

Leonardo DaVinci is credited with inventing them. During World War II, they were considered so critical to the machinery of war that the United States aggressively bombed the German factories that made them. What are they? They are ball bearings, created to reduce friction between moving parts of machinery, and an integral part of the industrial world. As technology has progressed, many different compounds have been used to coat bearings to improve their smoothness and lifetime. Titanium carbide (TiC) in particular lends hardness, long life, and better lubricant properties to bearings.

When a major Swiss supplier of TiC coating technology decided to eliminate the TiC portion of its business, the Department of Defense became concerned about preserving a reliable source of its novel chemical-vapor-deposition (CVD) process, which was vital to U.S. security interests. The Theater High Altitude Area Defense (THAAD) program had particular interest in the technology, as it has several important strategic and tactical missile defense systems supported by precision instrumentation. For this reason, among others, BryCoat, Inc. (Oldsmar, FL), became the top candidate to transition the Swiss process for deposition of TiC, with the aid of Phase I and Phase II MDA SBIRs. The SBIRs helped defray the costs of requalifying and validating the technology. According to Michael Smith, president of Brycoat, the company already had an extensive history of providing the defense community with "thin-film coating of super-hard materials, and was uniquely situated to take on the Swiss system." In fact, the company was independently identified by several defense contractors as the business of choice for this particular transition.



▲ BryCoat uses chemical vapor deposition to coat ball bearings with titanium carbide, ensuring smooth operation, long life, and reliable components.

CVD uses precursor gases that create a thin film upon reacting chemically with the surface of the substrate. Titanium-carbide-coated bearings ensure smooth operation, long life, and reliability wherever they are used, whether high in a geostationary orbit or on the ground. The CVD process used to deposit TiC ensures high uniformity of coating and "perfection" of spherical shape, an efficient yield, and very low coefficients of friction for a coating material (three times lower than steel). BryCoat has identified commercial markets for TiC-coated ball bearings in nonmilitary satellite gimbals and gyros, momentum wheels, mirror scanners, other high-value, low-noise/low-vibration applications, and positioning equipment for radiology devices (CAT, x-ray).

In addition to newly acquired CVD equipment and expertise, BryCoat continues its established leadership in high-performance thin-film hard coatings with other methods. BryCoat specializes in an environmentally friendly physical-vapor-deposition (PVD) process that has been touted by the Environmental Protection Agency as an alternative to electroplating. Used to impart exceptional adhesion, density, and hardness properties to materials, BryCoat's PVD process improves the surface properties of substrates and deposits compounds such as titanium nitride (TiN) and chromium nitride (CrN), which, like TiC, provide resistance to wear and impart nonstick properties to precision components. BryCoat's PVD process can also be used to deposit coatings of titanium carbonitride, titanium aluminum nitride, and zirconium nitride on a wide variety of components.

BryCoat continues to work on increasing the yield of the CVD process, with numbers rapidly approaching the optimal, and with the pursuit of commercial applications as the next step.

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Material Stops Cosmic Rays

Compound can reduce radiation-induced computer memory errors, parched skin.

by Joe Singleton/jsingleton@nttc.edu

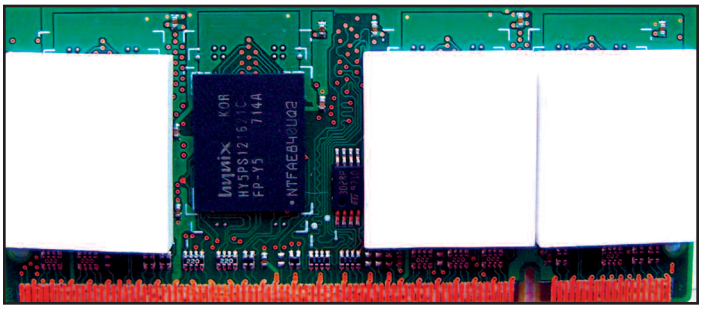
An MDA-funded company is marketing a material that can reduce computer memory errors, prevent cable and wire deterioration, and even minimize skin damage caused by cosmic radiation.

The material, developed by Hybrid Plastics, Inc. (Hattiesburg, MS), provides a lightweight, inexpensive, and highly deployable means to deter radiation.

Hybrid Plastics' patented NeuShield® technology is available in several forms to serve a user's needs: lightweight plastic caps, glue sticks, duct tape, and mascara.

MDA funded Hybrid Plastics' NeuShield technologies with SBIR contracts in 2004 and 2005 to develop a product that could shield computer memory chips from thermal neutron and x-ray damage.

When the first SBIR contract was awarded, Hybrid Plastics already had in-hand the core NeuShield technology, and the company was actively marketing it. The technology, in fact, had been successfully tested on Space Shuttle science missions. The SBIR contracts allowed the company to enhance its product to create additional variants of the material for new applications.



▲ Hybrid Plastics' rad-hard computer chip-caps (the white squares shown in this photograph) can reduce neutron-induced memory upsets for a fraction of the cost of off-the-shelf rad-hard chips.

Hybrid Plastics creates the NeuShield material by first inserting metallic atoms such as gadolinium into hollow, nanoscopic chemical "cages," made of a compound referred to as POSS, or polyhedral oligomeric silsesquioxanes. POSS reacts with the gadolinium and becomes a natural agent to attract and eliminate thermal neutrons and x-rays. The company then adds these gadolinium-filled POSS cages into conventional plastics, allowing several products to be manufactured for various applications.

Currently the company's most marketable product is a POSS-based plastic chip-cap that easily fits over a computer chip—whether in personal computers or other electronic devices—to reduce the effects of neutron-induced memory upsets. These chip-caps also can reduce the threat of such memory upsets in x-ray equipment used for treating tumors.

Given the nature of the POSS nanonchemical material, not all products formed from it have to be solid in nature like the chip-caps. For example, POSS-based materials can be manufactured in the form of a hot meltable glue stick that would allow for spot applications. The only problem with this form is that a particular application thickness cannot be guaranteed. But another adhesive variant—a radiation-hardened duct tape—offers an alternative for users who need a guaranteed thickness when wrapping wires and cables or interconnects. The radiation-hard duct tape will be most useful on military equipment and other space electronics housed in composite materials that provide little natural shielding.

Hybrid Plastics is also targeting the cosmetics market. Company scientists have been able to form the POSS nanochemical compound into a liquid that can be dissolved into existing cosmetics such as mascara and facial cream. The POSS mixture minimizes ultra-violet x-ray and cosmic radiation (thermal neutrons) with the same compound fomula used in the company's rad-hard computer chip-caps and duct tape. The POSS cosmetic product also would provide the user a cream that remains optically transparent. The transparent nature of the cream should offer users a more attractive alternative to the milky opaqueness commonly associated with zinc-oxide-based sunscreens.

Hybrid Plastics' NeuShield offers significant advantages over competing products. The product can be deployed virtually anywhere. No retrofitting or additional equipment is required when using NeuShield on any product. NeuShield's closest competitor provides only x-ray shielding, not both x-ray and thermal-neutron shielding, according to company President and CEO Joe Lichtenhan.

The product is also affordable. NeuShield caps—Hybrid Plastics' leading seller—cost $3 each for less than 30 caps, and as little as 88 cents each for bulk orders of more than 40,000. That price represents only a tiny fraction of the total cost for off-the-shelf rad-hard chips also used for mitigating radiation effects. Such chips can cost between $20,000 and $100,000.

Application performance, which Lichtenhan readily admits has been a challenge, is something that can only be

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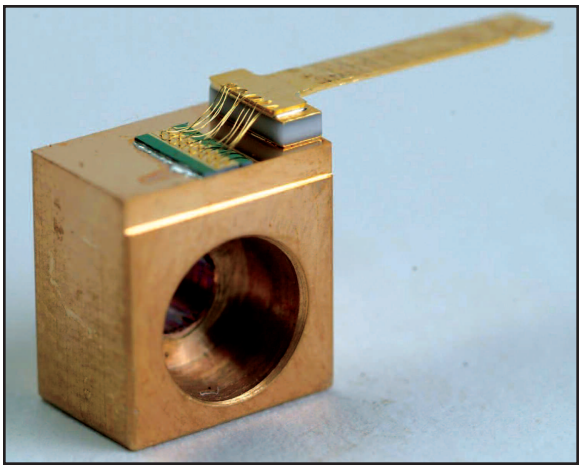
Lasers Alight on a Growing Market

Maxion's quantum cascade lasers enter the market for chemical sensing and noninvasive diagnostics.

by Joan Zimmermann/jzimmermann@nttc.edu

Thanks to strides made in semiconductor laser capabilities by Maxion Technologies, Inc. (College Park, MD), your local utility may soon cease to trouble you at home to search for gas leaks in your neighborhood; all it will take is a drive-through with a point-and-shoot device to let a beam of light do the job.

Maxion has had several MDA SBIRs for the development of quantum cascade (QC) and interband cascade (IC) lasers, in the quest for enhancing missile sensor technol-ogies in the infrared spectrum. After an intensive period of development, Maxion now offers room-temperature QC lasers that are efficient and cost-effective, expanding the capabilities of infrared-sensing devices for a variety of molecules with strong infrared absorption fingerprints. The interband cascade light-emitting devices are also superior to blackbody emitters. Compared to the silicon-carbide resistor arrays used in missile sensor training scenarios, which fail to simulate temperatures above 800ºK, these semiconductor LEDs can appear to be much hotter at 3,000ºK. Thus, in simulation schemes they provide a much higher dynamic range for infrared scene generation.



▲ Maxion's laser technology might one day be used in devices for optical glucose sensing, easing the testing burden on diabetes patients.

Maxion is actively pursuing the use of QC lasers in chemical sensing products, such as a sensor that can detect methane (natural gas) leaks in a "drive-by" scenario. Instead of walking pipelines and residential "T-lines" searching for dead vegetation, the company envisions a sensor that can alert an investigator to the presence of the gas in the parts-per-billion range. A similar device could be used for the industrial monitoring of benzene, a hazardous solvent.

The infrared spectrum also contains plenty of biomedical molecules of interest. Maxion is pursuing applications in health monitoring, such as optical glucose sensing to ease the invasive testing burden on diabetes patients. In an even more sophisticated future, however, the company foresees the day when an emergency-room physician may be able to place a portable sensor over an unconscious patient and immediately rule out a narcotics overdose. It turns out that there are five specific byproducts of narcosis that can be detected in the exhaled breath; an infrared sensor could eliminate the time lost in blood testing and speed up the differential diagnosis. In transplant patients, oxidative stress can cause minute amounts of ethane, a chemical cousin of good old alcohol, to appear in expired breath. This early warning sign can help alert doctors to impending organ failure caused by rejection, and provide a simple way to monitor such patients without repeated testing. Other airborne molecules detectable in the mid- to long-wave infrared include ammonia (from urea), useful for detecting ulcers. There is a current breath-testing method for this application, but it requires a time-consuming isotopic study that can involve the use of expensive and minimally radioactive materials.

The mid- to long-wave infrared is also superior for optical communications through high scatter and absorption atmospheres, or dust and fog. Maxion is pursuing this avenue with the U.S. Army for inherently secure optical communications in the field. At present, optical transmission through foggy conditions is being tested in the laboratory.

According to company researcher John Bradshaw, Maxion has largely retired the technical risk of QC lasers and their components. The company is now actively engaged in pursuing the chemical-sensing market and trading on its considerable history with leaders in laser technology, including Lucent Technologies. Maxion is also working with Princeton University's Mid-Infrared Technologies for Health in the Environment (MIRTHE), a sensor initiative led by Claire Gmachl, a MacArthur Foundation "genius grant" recipient and a pioneer in QC laser design.

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Revolutionizing Data Routing

New optical artchitecture transfers 1 terabit of information in a second.

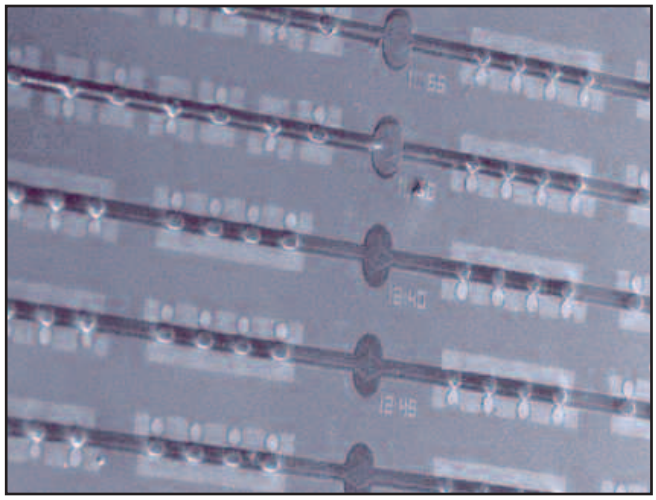
by Joe Singleton/jsingleton@nttc.edu

With a new MDA-funded laser-based technology for use with avionics, computers, fiber-optic communications, and satellites, 3.4 million frames of 0.25-megapixel image data—roughly the amount of data on 16 DVD movies—can be processed in about a second.

OptiComp Corporation (Zephyr Cove, NV) has developed a line of semiconductor optoelectronic components that support a crossbar data switching architecture for sensors, processors, and memory. The company's approach is geared toward applications requiring great bandwidth and fault tolerance, meaning that failure of part of a system would not bring down the entire system.

The technology should offer a solution to users of airborne surveillance imagery, who are continually seeking to process and route vast amounts of data in real time. And for civilian electronics users, the technology could help reduce the minutes-long process of downloading video to approximately one second.

Specifically, what OptiComp has developed is an optical platform onto which sensor and processor arrays can be built. Specially designed crossbar switches are installed to link the output from multiple sensor or processor arrays to other arrays. The approach generates real-time results while also offering size, weight, and power (SWaP) advantages. The end result for the military is "high-speed, signal-image data routing for target recognition, correlation, detection, and kill," said OptiComp President Peter Guilfoyle.



▲ This photo shows a microscopic image of OptiComp's optical data-routing architecture, which includes vertical surface-emitting lasers (VCSELs) and detectors. The devices shown in this image are roughly 250 microns apart from one another.

MDA originally funded OptiComp's optical data-processing technology through various SBIR Phase I and II contracts awarded over the past decade. These programs initially developed cost-effective, high-performance long-wavelength vertical surface-emitting lasers (VCSELs) for photonic switching. In 2007, MDA also awarded OptiComp a $3 million Phase III contract to continue developing its optical architecture.

Future commercial applications for the technology include areas where speed is key—such as avionics, electronics, and data communications. It will also apply to other industries wanting to interconnect and switch large amounts of data in short amounts of time.

The high-speed optoelectronic interconnects in OptiComp's architecture form a mesh that may provide a data transfer rate up to 10 gigabits per second (Gbps) per channel. The mesh could support up to 128 bidirectional channels. By using the patented optical connector (the crossbar switch), the company's technology, when fully configured, can transfer data from devices such as cameras or sensors to microprocessors at rates of 1 terabit per second, using parallel channels and multiple wavelengths per channel.

Such speed and fidelity could enhance data rates of sensors carried by unmanned aerial vehicles, for example. Data rates from a single 1,000-by-1,000-pixel gray-scale infrared camera—at 100 frames per second from a UAV—are close to 10 gigabits per second. So OptiComp's technology could handle up to 100 such sensors—moving data in real time between sensors and processors, between processors and processors, or between processors and displays.

In the short term, the company is focusing on military contracts, especially those that could lead to its product being integrated into satellite or data-communication systems.

OptiComp is looking for potential joint ventures and is exploring possibilities for getting its technology incorporated into a deployed military system. The company is now working with several aerospace prime contractors to realize different applications.

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Better Reality, Simulated

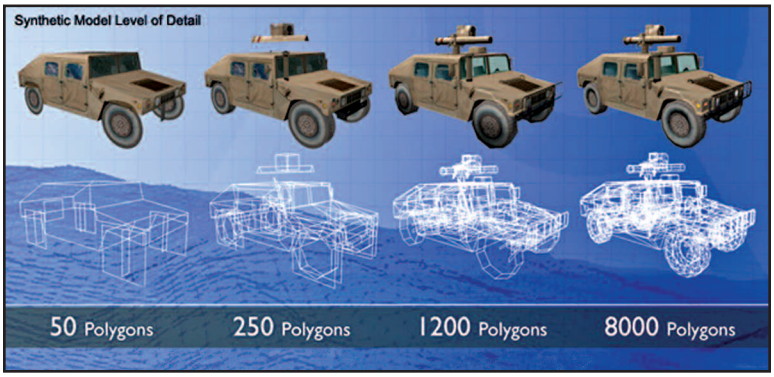
A PC-based system allows complex simulation on a practical scale.

by Joan Zimmermann/jzimmermann@nttc.edu

In video gaming systems, great pains are taken to simulate realistic appearance and movement, even if the game environment is entirely fantastic. Gamers crave the feeling of immersion in an alternate universe. Missile testing requires the same fidelity, but in dimensions that go far beyond the visual.

CG^2, Inc. (a Quantum3D company, Huntsville, AL), has devised a way to perform traditionally expensive missile simulation on an inexpensive PC-based system. Armed with a Phase II SBIR, CG^2 developed a hardware-in-the-loop (HWIL) system with the ability to "sync-up" visual and radiometric data, resulting in an off-the-shelf system that can train missiles to distinguish countermeasures in a multispectral environment.

Computer-based reality simulation engines are ordinarily quite expensive, owing to both equipment and the labor required to build the environment from the ground up, and they are usually limited to purely visual information. The CG^2 innovation simplifies the setup and reduces the cost of building a missile-seeker simulator, while also processing hyperspectral and motion-related (kinematic) data from a variety of sensors. The requirements for missile-seeker stimulation are rigorous and have strained the capabilities of previous PC-based platforms.



▲ CG^2's simulation tools can be used to create models for military systems, aviation applications, or other uses—such as developing simulators for training drivers of commercial vehicles.

CG^2's solution is composed of both software and hardware, and some of Quantum 3D's products, such as Independence® 2500, an off-the-shelf answer for image generation. The open architecture approach makes the system versatile and allows easy integration with other computing platforms. Combined with Radiance Technologies' optimized scene-generation codes, the enhanced PC-based system provides an infrared scene-generation system that employs multiple graphics-processing units that operate in parallel with Quantum 3D's patented pixel-level synchronization technology. In addition, the channel composition of the system acts as a means to deliver the high frame rate and extremely low-latency performance that are needed, with the high fidelity required by HWIL applications.

Imaging systems with high frame rate and high fidelity are essential for quickly recording data and providing useful interpretations. In one important example, affordable image-generation software can help to get more firefighters and police officers the realistic training they need in a safe, simulated environment.

The image-generation solutions offered by CG^2 can also be used for training commercial vehicle drivers (trucks, buses), in flight simulators for pilot training, for air-traffic-control simulation and training, on ship's bridge simulation and training, and in other areas where visual models are useful. Anticipated uses for integration of the infrared and multimodal sensor scheme for civilian applications include auto collision-avoidance systems, and intrusion-detection systems. Other applications include severe-weather warning systems (based on analysis of radar data), scene generation for motion pictures, police surveillance, and video gaming. The technology could also be applied to computed tomography for medical training, by constructing 3-D images of anatomy that could be rotated in free space and otherwise manipulated by students.

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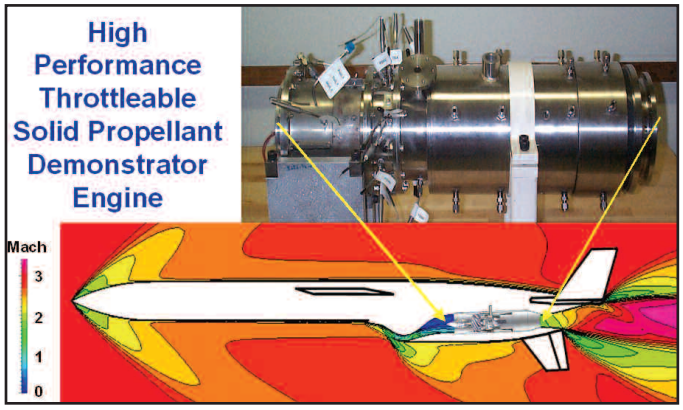
Modeling the Real World

Software tools bring advances in engineering and biotechnology.

by Joan Zimmermann/jzimmermann@nttc.edu

Engineering problems are a complex mixture of interacting variables: chemical reactions, physical forces, geometry, and time. Modeling these real-life conditions is like thinking through advance moves in a chess game, and every decision opens a new gateway to a new outcome. CFD Research Corporation (CFDRC: Huntsville, AL), has taken on this challenging task, modeling fluid, thermal, chemical, biological, electrical, and mechanical phenomena for engineering design and prototyping. CFDRC is now concentrating on three major areas: aerospace and defense, biomedical and life sciences, and nanotechnology.

CFDRC's software tools and prototyping efforts flow in part from modeling for insensitive munitions, a simulation that requires the coupling of detailed chemical kinetics and physical models. CFDRC has had eight MDA SBIRs for various modeling scenarios in missile defense and propellant characterization, which has translated into many real-world applications for biotechnology, nanotechnology, and the chemical manufacturing industry. A CFDRC software package called the CFD-ACE+ Multiphysics Solver has proven to be a workhorse for biotechnology and nanotechnology. The company has used this simulation tool to model systems for medical researchers and engineers, and has also created its own prototype devices, which have earned patents in some cases. Among its several accomplishments are a design for a disposable biochip for detecting oxygen and other biologically important chemicals, and the creation of a simulated microvascular network that can model cell-binding conditions in microfluidic and nanofluidic environments.



▲ CFDRC's software can be used for modeling missile systems or for other applications, such as developing biomedical devices.

The simulation technology has also served as a feeder stream into a number of products that are being developed or commercialized. One of these products is a device called a spacer, designed for a pediatric metered-dose inhaler. The spacer is a tube that facilitates the flow of medication from the inhaler to the patient. As youngsters have both a different physiological and physical make-up than adults, the spacer takes these variations into account to improve the delivery of asthma medication. CFDRC has also designed a hemodialysis catheter that allows higher flow rates without increasing the destruction of red blood cells, a condition that can be worsened by the turbulence that occurs in the blood vessels of kidney dialysis patients. Such patients are often anemic due to their essential treatment.

The CDF-ACE+ Multiphysics Solver has also led to other device designs, including a cell sorter that can detect specific bacteria, potentially useful in bioterrorism applications, and a biosensing chamber that binds antibody-producing B-cells at a 15-fold higher sensitivity than competing technology. CFDRC is also developing simulations for applications such as selective destruction of blood vessels to treat cancer, tumor-specific drug-delivery, wound-healing, and hemorrhage control. To better understand cardiovascular processes, the company is characterizing how blood flow affects the formation of cholesterol plaques, how aneurysms develop, and how blood-clotting factors convert from precursor molecules into their active form.

CFDRC is also working in the emerging field of nanotechnology and nanomaterials, where researchers come up against problems that are hard to predict without some advance modeling. The behavior of molecules at the submicron level is a new frontier, and while researchers pursue the nano-Grail for its special properties, those very properties can yield results that experimentalists would like to avoid. For example, in the effort to create quantum dots for imaging very small structures in cells, some nanoparticles, depending on their composition, tend to aggregate or clump together, often damaging or killing the cell under study.

Cancer researchers are also investigating nanoparticles for selective delivery of drugs, and must take care to determine whether the particles themselves can be toxic to the patient. CFDRC's software tools can simulate different force fields, reaction paths, and mechanisms for aerosol nucleation; homogeneous and heterogeneous nucleation of nanoparticles; growth of particles from condensation and coagulation; and the effects of flow and heat transfer in physical systems.

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On the Trail of a Bad Cloud

Software and sensor system could detect life-threatening chemical agents in the air.

by Joe Singleton/jsingleton@nttc.edu

A ground-based sensor system originally funded to detect airborne chemical threats also could enable homeland defense, environmental, and meteorological professionals to determine and track the composition of any cloud—natural or manmade—and use this information to save lives if there is an imminent threat.

The test system uses a specially designed software suite and ground-based sensors that work in sync to detect cloud composition and to project cloud motion. To test the effectiveness of the system in detecting life-threatening substances, MDA-funded Mevatec, Inc. (Huntsville, AL)—now a part of BAE Systems North America—to launch chemical-agent simulants into the air by cannon to create clouds. The ground-based sensors can track simulants in the clouds as far away as 60 miles.

Mevatec was awarded SBIR Phase I and II contracts in 2002 and 2003 to develop a directed-energy lethality and collateral-effects modeling program to estimate ground hazards after a missile carrying a chemical or biological payload is deployed or destroyed.

BAE Systems' Weapons Effects Group principal scientist Dr. Martin Richardson said that a commercial version of the system is possible, should there be significant interest in such a product. Manufacture of a commercial system would require designing nonclassified ground-effects modeling software that could interface with sensors to measure particulate composition of various clouds and to track where they are going. The system currently uses BAE Systems' proprietary data-fusion software in conjunction with MDA's Post-Engagement Ground Effects Model (PEGEM). The sensors used in the project can detect and define any types of particles in a given cloud to warn people on the ground if it poses a potential threat. The recoilless, vertical cannon used in the military-configuration tests would not be required for civilian demonstration or use, as the sensor system would measure actual cloud particulates and determine size distribution, not that of chemical simulants created by the cannon launch.

▲ Technology developed by BAE Systems uses components such as a profiling radar to analyze and track clouds.

The principle users of this type of system, if commercialized, would most likely be the Environmental Protection Agency, the National Oceanographic and Atmospheric Administration, and the National Weather Service. There also could be interest from various homeland security departments.

Richardson said the functionality of the software is the principle advantage of BAE Systems' collateral-effects modeling project over competing products currently marketed. Algorithms in the software configuration allow for multisensor data fusion, with coverage from the near-ultraviolet range to millimeter range. The data fusion, in turn, lets scientists easily describe the motions—previous, current, and projected—of a given cloud. Commercial radars and lidars exist for similar purposes but do not have as broad a multiwavelength capability, which enables detailed cloud characterization.

The collateral-effects modeling technology also has the advantage of characterizing the particle size of chemical components in a cloud, as well as tracking the cloud's coordinates based on wind-flow patterns. BAE Systems soon plans tests of the sensor system's ability to conduct windflow mapping around buildings as part of an urban warfare scenario.

While Richardson characterizes the system as still being in the "research phase," remaining technical issues are not anticipated to pose any significant problems. The easiest fix enhances software to improve the system's sensor data-fusion techniques.

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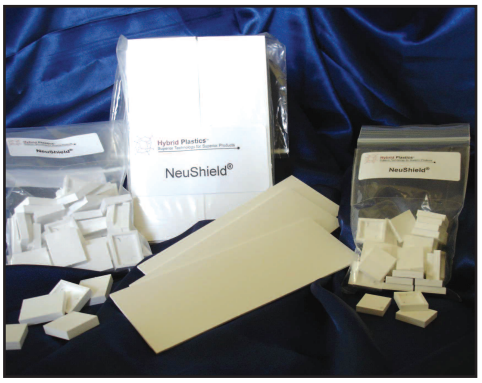
Material Stops Cosmic Rays from page 5

assessed knowing the type of chip and actual radiation environment in which the product is being tested. But in tests conducted by Hybrid Plastics, 1-millimeter-thick NeuShield caps have shown a 70 percent reduction in thermal neutrons, while the 2-millimeter variant allows a 90 percent reduction. In medical applications, the caps have reduced neutron-induced memory upsets from one every minute to about one every 10 minutes.

This summer, Hybrid Plastics opened a 14,000-square-foot addition to its Hattiesburg facility, allowing the company to produce 500,000 pounds of POSS in one year. By 2009, the company should be producing nearly 2 million pounds of POSS annually, according to Lichtenhan.

The company also plans to introduce in the near future a new POSS-related technology in the form of a rad-hard NeuShield paint. This development was spurred on by interest from the nuclear energy community in shielding the walls of power plants that contain certain electronic devices.

Despite Hybrid Plastics' numerous successes, the company still is hampered by customer resistance. Lichtenhan said most people still tend to first consider retrofitting and redesigning circuits and components, without realizing there is a simple, inexpensive solution available in the form of NeuShield.



▲ Hybrid Plastics' diverse rad-hard product line includes NeuShield chip-caps (shown here), duct tape, glue sticks, medical x-ray shielding, and even mascara.

Hybrid Plastics is now looking for additional strategic partners that will adopt the NeuShield technology and insert it into various platforms in the medical field. For electronics, the company is looking to develop an industry standard for radiation shielding and then pursue cross-licensing agreements. Company officials also are interested in pursuing cross-licensing agreements in the aerospace and cosmetics markets.

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Modeling the Real World from page 9

CFDRC has also developed specialized software for designing nanoelectronic devices such as submicron diodes, nano-MOSFET transistors, and quantum barrier devices.

From its inception in 1987, CFDRC has grown into a robust research and development firm that has licensed its principal workhorse software packages, CFD-ACE+ and CFD-FASTRAN, for widespread industrial use. In January 2004, CFDRC sold its commercial software products division to a software company (ESI Group), for further commercialization of CFD-ACE+ and CFD-FASTRAN through its global infrastructure for marketing, sales, and support. CFDRC retains a perpetual royalty-free license to use, modify, and customize the software for its R&D and service contracts.

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In addition, perfecting the vertical gun capability used in the collateral-effects modeling project is possible, should the military later show interest in that aspect.

Despite Mevatec being acquired in 2003 by aerospace and weapons systems giant BAE Systems for $82 million, the collateral-effects modeling project originally funded by MDA has not received support from any other sources, and lacks the funds necessary to conduct additional testing. While some research facilities have expressed interest in seeing the project continue—possibly moving toward commercialization or insertion into a military platform—BAE Systems' Weapons Effects Group is looking for collaborative partners or additional money to keep it going.

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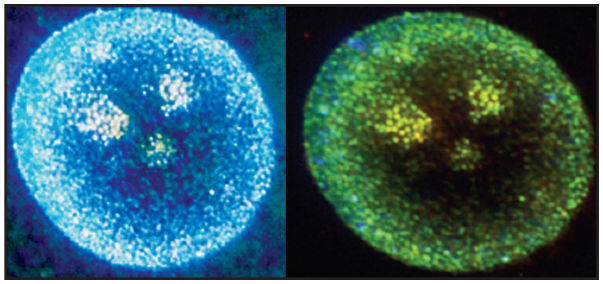
imaging system to find and identify an abnormality.

Detection of a defect or anomaly (such as dislocations, micropipes, and low-angle boundaries) in a GaN semiconductor or other object starts with a luminescence imaging device that floods UV light onto the material with wavelengths between 250 and 350 nanometers (nm). The UV illumination causes the device or object to glow, revealing any abnormalities. An imaging spectrometer then captures images of the material being examined, with images gathered at wavelengths of greater than 350 nm. After the images are taken, ChemImage applies a technique known as multivariate image analysis. This technique processes every pixel in each of the images independently. Each pixel has a luminescent spectrum associated with it. The imaging system generates a digital image showing all aspects of the object in question—including defect density—once the individual pixels are processed.



▲ ChemImage's technology supports photoluminescence chemical imaging of materials such as gallium nitride, which would allow users to screen semiconductor components for defects.

After the luminescence system completes its digital imaging of a particular semiconductor or other object, the data are transferred within the platform to the Raman device, which confirms defect types or other anomalies through what is known as hyperspectral imaging. Hyperspectral imaging provides quantitative analysis of the chemical makeup of an abnormality in a material. Though ChemImage received only Phase I funding from MDA, company scientists were determined to press on and develop a commercially available system. ChemImage soon integrated the fundamental concepts addressed in the Phase I contract into three systems that are now commercially available: the Falcon™, Condor™, and CI Vision™ multimodal hyperspectral imaging systems.

For the commercial customer, speed is a key factor in choosing ChemImage's products over competitors. The company's integrated luminescence-Raman process reduces hyperspectral image acquisition time from as long as a week to as short as a few minutes. Time reduction is primarily a result of not having to laboriously scan submicron areas of either a semiconductor component or other material, or use wide-field illumination with one spectroscopic device. ChemImage's spectroscopic devices also display three-dimensional images, rather than flat, two-dimensional images. These 3-D images allow for volumetric defect screening—a feature not commonly available in competing imaging systems.

ChemImage's systems also have broad applicability. The company's luminescence-Raman imaging technology has been successfully demonstrated and is being used in the fields of forensics, homeland security, law enforcement, medicine, and pharmaceuticals. After the 2001 anthrax scare, the Department of Defense used Raman and luminescence imaging systems to detect potentially harmful chemical and biological substances. The Secret Service also used ChemImage's technology for its forensic capabilities, particularly as an ink-analysis tool for evaluating counterfeit documents in several high-profile cases.

Medical and pharmaceutical industries can use ChemImage's technology in stents—small wires or tubes inserted into blood vessels or arteries to prevent or reduce localized flow restriction—as well as for screening inhalable drugs. Many stents have drugs implanted on their surface. ChemImage's system provides volumetric imaging of these drugs to ensure application of the correct dosage. For inhalable drugs, ChemImage, working with the Food and Drug Administration, has developed and is working to further validate imaging for ingredient-specific particle-sizing tools. The concept relies on the fact that a patient taking an inhalant inhales release agents and stabilizers, in addition to the actual drug. Imaging will help pharmaceutical companies and the FDA determine the dosage and particle-size distribution of the ingredients in the inhalers. The goal is to control the size of the active ingredient to get reliable performance and to ensure patient safety.

ChemImage has bold plans to have its imaging systems in all hospitals and doctors' offices. The imaging systems would act as a sensor technology to allow physicians to measure disease states quantitatively and to help align a particular therapy to one's body chemistry. The company is also looking to have its imagers become part of future portal screening systems at airports. ChemImage's systems would allow homeland security officials to discover all types of explosives, beyond what detection systems can currently screen.

ChemImage's greatest challenge is gaining market acceptance for its technologies. The company has only recently begun to explain in peer-review literature the workings of the technology and the performance characteristics of its various spectroscopes. It is now trying to break into the imaging market, primarily through direct sales in North America. Sales have recently been expanded to Europe and Australia, but the company has not tried to tap the potentially large markets of Asia in China, Japan, and South Korea.

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Too Much Internet Can Be a Bad Thing for Innovators

Using the Web wisely is key to finding opportunities and building a business.

by Thomas S. Hartwick/t.hartwick@earthlink.net

Many modern pundits would not hesitate to proclaim that the Internet enables collaboration, peer review, and open systems for achieving business success. These pundits claim that more traditional business practices inhibit R&D and the pace of new product development by being secretive, by possessing intellectual property (IP), by using stovepipe organization structures, and by stifling the innovative process.

SBIR firms that are trying to start a business are by their very nature competitive with others. Retention of intellectual property—and remember, IP is a lot more than just a patent portfolio—is essential for obtaining government funding and achieving a competitive edge. Moreover, most of these firms are founded by seasoned professionals in their particular fields. As seasoned professionals, they already have a global view of their specific technology and understand very well what the design issues are. Successful SBIR firms have "making money" as their motto, and professional business consultants quickly disabuse small firms of any pundit vision "to provide a product or service for mankind at large."

Most firms that fall into the technology transfer category are either start-ups or small firms with fewer than 100 people. Most are not well established in the marketplace, and they are still trying to find the best product space based on their proprietary technology.

To contradict pundit assertions, these SBIR firms do not need:

- Technical collaboration to establish a product technology.
- Widespread dissemination of their intellectual property.
- Or extensive use of Internet information to develop their technology.

But, based on my long history of dealing with SBIR firms, they do need:

- Exposure to markets beyond tradeshow booths.
- Easy avenues to explore partnerships and alliances.
- And an avenue for establishing product manufacturing without significant investment.

Most start-up SBIR firms believe they need an investor who will immediately see the advantages of their product technology and will leap into the enterprise with an investment without regard to the monetary return. (Sigh.) It doesn't work that way.

The key question to ask is: How can the Internet provide the assistance that SBIR firms do need to maximize their chances for success? In light of the needs and non-needs I've mentioned above, the following two areas of benefit emerge, offering SBIR companies special and potentially powerful ways to use the Internet:

- Engaging in product launch activities (such as advertising, customer contacts, customer feedback, and spec-sheet posting) to obtain the widest possible distribution for a brand-new company.
- And finding and establishing partners for assistance, alliances, and other business activities.

SBIR firms should not view the Internet as a panacea or a silver bullet.

To put the product-launch need in perspective, suppose an SBIR company develops a device with greater than $2 million in sales potential per year. The company is struggling to survive on a combination of angel and government contract funding, and it has little money to invest in extensive advertising and marketing activities. About the only recourse such a company has is to place the product on eBay.com or to build the customer base slowly through tradeshow attendance and personal contacts.

And while it might seem very useful to have a special interactive Web site called "OpticalProductIntroductions" (or "ElectronicDeviceProductIntroductions" or "NanoMaterialProductIntroductions"), such a Web approach would present its own set of challenges. For example, serious high-technology designers would not use information from such a Web site unless some assurance were given that the products and prototypes were the genuine results of

continued on page 16

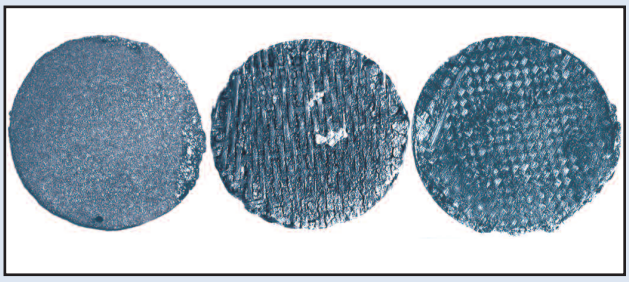
Online Archive Offers Up a Host of MDA Technology Profiles

The Technology Applications program creates detailed profiles of MDA-sponsored research with commercial applications. New profiles are added quarterly to our Web site, www.mdatechnology.net. Summaries of some recent additions can be found below.

For more information on a particular technology, visit www.mdatechnology.net. Enter the search code or a relevant term (e.g., #681, MEMS, Sophia Wireless) for the technology profile in the "Quick Search" box and then click the "Go" button. When using a search code, be sure to include the number sign.

You also can browse through our archive of technology profiles. On the far right side of the home page, you'll find the "Featured Technologies" link. Click the links there to browse all available technology profiles.

Processing of Carbon-carbon Composites Using a One-step Process



▲ Wright Materials' carbon-carbon composite.

Wright Materials Research Company (Beavercreek, OH) has developed a pressure-cooker-like approach to making carbon composites, which could bring strong and affordable materials to market for aircraft structure, automobile brakes, and a host of other applications. MDA predecessor BMDO funded the technology for its potential in creating low-cost, lightweight composites for space-based applications. The company is able to manufacture large blocks of the material and is exploring sales, marketing, and distribution channels.

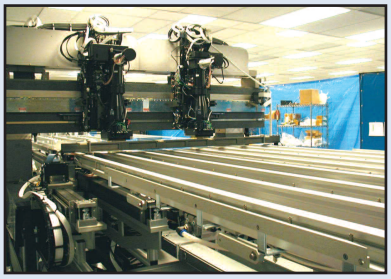
The company's technique heats a carbon mixture under high pressure in a one-step process to produce a lightweight composite foam. The resulting foam is called a carbon-carbon composite, since the company uses carbon fibers in a carbon matrix to create the foam. (Carbon-fiber precursors are used to create an open-celled microcellular/carbon graphitic network throughout the foam material.) The foam can be used as net-shaped preforms for reinforcement of structural composites, sandwich core, and components for high-temperature applications.

Wright Materials has a patent on its process and material. The company continues to look for ways to develop sales, marketing, and distribution channels, and it remains open to the idea of bringing on investors and undertaking new partnerships.

Search code for tech profile: #681

High-depth-of-field MEMS Inspection

Summit Imaging, Inc. (Colorado Springs, CO), received a Phase I SBIR to develop a MEMS inspection device based on a high-performance charge-coupled device (CCD) imaging system, which combined a high-frame-rate, low-noise camera with wavefront-coded optics to overcome the limitations of traditional inspection techniques (such as scanning electron microscopy) for MEMS systems. The CEO of Summit Imaging subsequently founded a company called Salvador Imaging to commercialize its advances in high-speed image processing, a scheme in which images are "pre-processed" as they come off a CCD, contributing to significant reduction of jitter, noise, and timing issues that can plague high-speed imaging systems.



▲ Inspection imaging tool.

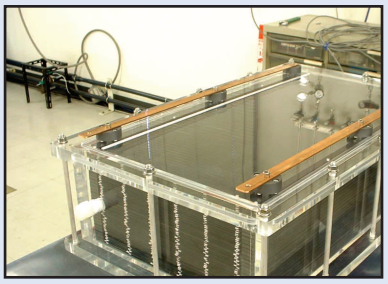
To quickly capture images, Salvador uses a CCD that can be divided into sections. These sections are matched up with field-programmable gate arrays that perform algorithmic and other functions to pre-process the images in real time. The company writes the code and designs the circuits that make this level of operation possible. As Salvador Imaging, the company has continued to refine and innovate its high-speed, thermally stable, CCD- and electron-multiplying CCD (EMCCD)-based cameras for many applications.

Applications for these high-speed imaging systems are semiconductor, printed circuit-board, and flat-panel inspection; medical imaging; laser-beam profiling; and ballistic imaging.

Search code for tech profile: #701

Purifying Water to Meet Emergency Needs

Turning dirty or brackish water into clean, potable water can become a simple process. Specially crafted brick-like AquaCells containing a carbon-aerogel material can absorb ions such as sodium and chloride, removing salt and impurities from water. The AquaCells, made by CDT Systems, Inc. (Dallas, TX), provide a simple way to treat impure water, using less energy and requiring less maintenance than conventional methods. In CDT Systems' process, water containing salts, heavy metals, or even radioactive isotopes passes over AquaCells made up of sheets of carbon-aerogel electrodes. An electric potential is then applied across the electrodes, attracting the negatively and positively charged ions to purify the water, with each pass over an AquaCell removing 1,000 parts per million of contaminant. One AquaCell (12"x 24"x30") can process up to 1,000 gallons of water per day. Each AquaCell should have a lifespan of approximately 10 years.



▲ CDT's AquaCell.

The CDT Systems technology has no moving parts and needs only 1.2 volts to operate. It uses simple electrostatic regeneration, compared with ion-exchange systems that require acids, bases, or salt solutions for regeneration. CDT Systems' product does not require the use of membranes or high-pressure pumps, which reduces maintenance requirements. When a CDT Systems AquaCell has become sufficiently loaded with removed contaminants, it is bypassed, and water is routed to other AquaCells with remaining capacity. The loaded AquaCell is then shorted out or reverse-polarized, expelling the contaminants into the waste stream for disposal or recycling.

More information can be found in the online special report *Emergency Response Tools.*

Innovative Operating Software: Autocoding Toolset

The Autocoding Toolset® from Management Communications and Control, Inc. (MCCI; Arlington, VA), automates the coding of programs for multiprocessor computers. A software designer creates a graphic representation of what mathematical operations need to occur and in what order. Autocoding Toolset can then code these operations and the data flow between them. Doing this automatically greatly reduces errors and development time. In addition, changes and subsequent versions can be accomplished in less time, with less frustration, and with fewer introduced errors. The autocoding idea has existed for some time, but the tools for troubleshooting and testing that MCCI has developed make this Autocoding Toolset unique. MCCI has worked with Lockheed Martin to evaluate its product. The Autocoding Toolset includes several tools that enable designers to get the most bang out of whatever architecture the program will run on.

▲ Tool reduces coding errors.

Search code for tech profile: #679

A Novel Interconnection and Assembly System for MMIC Circuits

Sophia Wireless, Inc. (Chantilly, VA), is using a micromachining approach to build integrated circuits, delivering a product that could offer size, weight, and cost benefits to the radar and aviation markets. BMDO, MDA's predecessor, originally funded the approach to improve interconnect performance in hardware such as microwave systems, wireless telecommunications, and radars. The company is actively commercializing its technology, specifically targeting markets that involve radars, sensors, and communications devices, and in which size and weight are critical issues. (Unmanned aerial vehicles are one such application.) Sophia Wireless has built filters at various frequencies and integrated transceivers for E-band point-to-point applications using some of these technologies. The company's approach focuses on monolithic microwave integrated circuits (MMICs; pronounced "mimic"), combining them with other active components such as diodes and transistors, as well as passive components such as resistors and capacitors, to create integrated solutions for millimeter-wave applications.

▲ Approach cuts assembly steps.

Search code for tech profile: #673

Too Much Internet Can Be a Bad Thing for Innovators from page 13

learned professional endeavor. Certain participation criteria, therefore, would be necessary for such a Web site.

SBIR companies planning to leverage the Internet should keep in mind that the Internet is not a panacea or a silver bullet. It does not serve as all things to all people wishing to build a successful company. Young companies seeking growth and success, therefore, should replace Internet pundit schemes and dreams with a hard-headed business analysis to make sure that real problems are solved.

Thomas S. Hartwick, Ph.D., is a technology and business consultant who frequently serves as a panelist for Business Focus Workshops and Technology Applications Reviews sponsored by the MDA Technology Applications program. With a specialty in electronics and optics, his background includes R&D and management work at Hughes Aircraft Company, the Aerospace Corporation, and TRW. He has served on numerous national advisory panels, including the Advisory Group on Electron Devices for DOD, various committees of the National Research Council, and the National Materials Advisory Board. Hartwick currently serves on four corporate boards and committees.

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