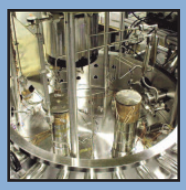
Summer 2007

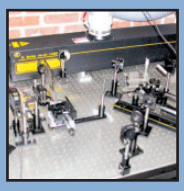
Missile Defense Agency

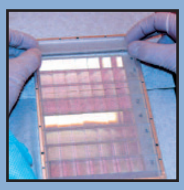
TechUpdate

A Quarterly Newsletter for MDA Technology Transfer

INSIDE







▲ An example of a pressure vessel that can be manufactured using 2Phase Technologies' reconfigurable tooling approach, which allows for quick molding and replication of parts.

Crafting with 'Quicksand'

Tooling system could provide fast, inexpensive way to fabricate large industrial components.

by Joe Singleton/jsingleton@nttc.edu

Imagine being able to mold and manufacture parts the size of a bedroom in two days' time. A new MDA-funded system for composite fabrication, based on a material that has been nicknamed "engineered quicksand," now can provide such fast and inexpensive tooling to both the aerospace and transportation industries.

2Phase Technologies, Inc. (Dayton, NV), has developed a reconfigurable tooling system (RTS™) that enables composite shops to quickly mold and replicate many tools and even parts on one platform at a fraction of the cost incurred when using conventional tooling approaches.

The company was awarded $820,000 in MDA funding through SBIR Phase I and II contracts between 2003 and 2006. The contracts focused on the manufacture, modification, and redesign of rocket motor casings using 2Phase's reconfigurable tooling approaches. The result was a tooling solution that allowed a motor case with precision-located features to be manufactured quickly and inexpensively over a lightweight mandrel that could be removed quickly and simply after the fabrication was complete.

2Phase's system has advantages in cost, speed, and scalability over competing

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Imagination Doesn't End at Invention

Report examines technologies trekking toward the future.

by L. Scott Tillett/stillett@nttc.edu

MDA-funded researchers are some of the most creative, driven, imaginative creatures on the face of the planet. And that's partly because they have to be. These are the people who are helping to solve the problem of hitting a missile with a missile—a challenge that has been described as hitting a bullet with a bullet. Creativity is paramount.

Along the way, their advanced and imaginative technologies—although originally intended for military use—have found other applications beyond missile defense. Key mainstream innovations have spun out of missile defense technology. Lasers for use in missile tracking have evolved for use in vision-correction surgery. Components for Patriot missiles have crossed into the commercial world to become key pieces of the mechanism for deploying airbags in automobiles. Semiconductor materials funded for missile defense have become the foundation for the next generation of lighting technologies. And the list goes on and on.

Commercial applications and commercial business are important because they can sustain and improve an emerging technology while it works its way into the Ballistic Missile Defense System. But for MDA-funded researchers, the challenge often lies in finding those applications beyond missile defense. With so much imagination devoted to solving technical problems—how to make a material lighter, how to produce a material at a lower cost, how to make a laser more efficient—it often takes a little extra effort to muster the imagination needed to find commercial applications for the technology. But the applications are out there—just waiting to be discovered. So blue-sky thinking should not end once the technical problems are solved.

Researchers and potential users of MDA-funded technology must continue to think beyond the here and now to find fresh applications for these innovations—because it's the efficient and progressive thing to do. If there's a technology in which the United States already has invested hundreds of thousands (perhaps millions) of dollars, limiting that innovation to a single user seems wasteful. And failing to seek a technology's full potential leads to a future that's not quite as fruitful as it could be.

At the MDA Technology Applications program, we constantly try to envision that fruitful future, and we've compiled a special report that highlights a wide array of promising MDA-funded technologies. The technologies featured in this publication straddle the line between today and tomorrow, and they represent commercially viable innovations that have arisen as the result of rich imaginations that have extended far beyond the inventing process.

You can view the special publication online by visiting our Web site (www.mdatechnology.net) and clicking on the *2007 Technology Applications Report—Technologies: Here Today, Here Tomorrow.*

Editor L. Scott Tillett
Production Manager Lisa Hylton
Contributing Writers Alan Sherwin, L. Scott Tillett, Joe Singleton, Joan Zimmermann
Advisors Paul Carroll, Jeff Reynolds, Alan Sherwin, Duane Zieg
Layout Lan Crickman

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Address inquiries and mailing list corrections to:
National Technology Transfer Center-Washington Operations
2121 Eisenhower Avenue, Suite 400
Alexandria, Virginia 22314
Attn: Editor, *MDA TechUpdate*
Tel: (703) 518-8800 x500, Fax: (703) 518-8986
E-mail: stillett@nttc.edu
Web sites: www.mdatechnology.net, www.mda.mil/mdalink/html/mdalink.html

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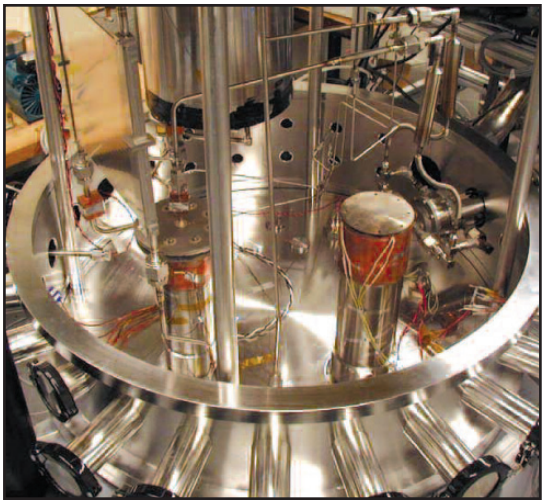
Cool Savings

Cryogenic expertise branches out into new frontiers of medicine.

by Joan Zimmermann/jzimmermann@nttc.edu

A cryogenic process for recycling precious noble gases can help make an enhanced magnetic resonance imaging (MRI) technique less costly, more portable, and more easily available to patients.

Creare, Inc. (Hanover, NH), has had numerous MDA SBIRs for the development of compressors, cryocoolers that can withstand high-radiation environments, and multistage coolers for spaceborne infrared (IR) imaging. As a result, the company developed a number of highly efficient, reliable, lightweight, vibration-free, adaptable cooling systems with many applications. One of its more famous accomplishments was providing a Brayton cryocooler for the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) camera on the Hubble Space Telescope. Back on Earth, Creare has devised an easier way to image the inner universe through a cryogenic technique for separating noble gas isotopes used in enhanced MRI techniques.



▲ Creare's technology can help reduce the overall cost of medical imaging by separating noble gas isotopes used in enhanced MRI techniques. The company's technique effectively recycles the rare and expensive gases.

Conventional MRI exploits the polarization state or "spin" of hydrogen atoms in water, of which humans are largely composed. To detect the spin, or really the signal that gets generated when the protons "relax" back into their nonmagnetized state, very powerful magnets are required. Other molecules can be used in MRI, however, and two in particular, ^{3}He and ^{129}Xe, can strengthen the signal up to 100,000 times. This augmented signal translates to much higher resolution and fine anatomical detail, and for other applications it can also translate to less powerful magnets and therefore more portable MRI.

Creare has devised a way to separate ^{3}He and ^{129}Xe isotopes from expired air for use in enhanced MRI images, which enable a sophisticated measurement of lung function. The gases provide a much stronger signal than naturally occurring protons (^{1}H), and allow highly detailed MRI imaging of the lung that could not otherwise be accomplished. Creare's method separates the exhaled isotopes used for the procedure and recycles the rare and expensive gases for reuse, reducing the overall cost of the MRI procedure and making it more widely available. Using a cryogenic method, Creare's technology captures nearly all the noble gas isotopes and leaves impurities in the waste stream, resulting in a recyclable supply of high-purity isotopes that can be used repeatedly. The enhanced MRI technique, under development since the late 1990s, can provide measurement of gas-tissue transport at the alveolar level in the lung (alveoli to red blood cell) and a detailed picture of lung anatomy. Hyperpolarized ^{129}Xe MRI also has the potential to image the vascular system, heart, and brain, as well as "void" spaces such as the nasal sinuses and colon.

The increased signal-to-noise ratio provided by hyperpolarized noble gases (HNGs) can also enable the use of a smaller magnet, which in turn allows use in an open access unit, in which patients can be imaged in an upright posture. An upright posture helps to avoid artifacts introduced by gravity. Lungs tend to get compressed when the subject lies prone in closed units, causing interference with blood flow and gas exchange.

Creare developed its noble gas recycling system in collaboration with a company whose imaging division was bought out by another company, which subsequently dropped any further technology development; Creare therefore is eager to find a home for this valuable technique. In the meantime, the company continues to develop its cooling expertise in other medical applications such as cryoprobes for freezing tumors.

On other cooling fronts honed by MDA SBIRs, and using a combination of cryogenic separation techniques, molecular sieves, and various membrane technologies, Creare is also developing onboard oxygen generating systems (OBOGS) and onboard inert gas (nitrogen) generating systems (OBIGGS) for military and commercial aircraft. An OBIGGS uses a semipermeable membrane to separate oxygen and nitrogen, which are in turn condensed with a cooling system based on novel turbomachinery and heat exchangers. An OBIGGS increases the safety of stored flammable liquids (gasoline, jet fuel) by displacing combustible oxygen with inert gases such as nitrogen.

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A Holographic Approach to Telecommunications

New process could lower cost, improve performance of semiconductor components.

by Joe Singleton/jsingleton@nttc.edu

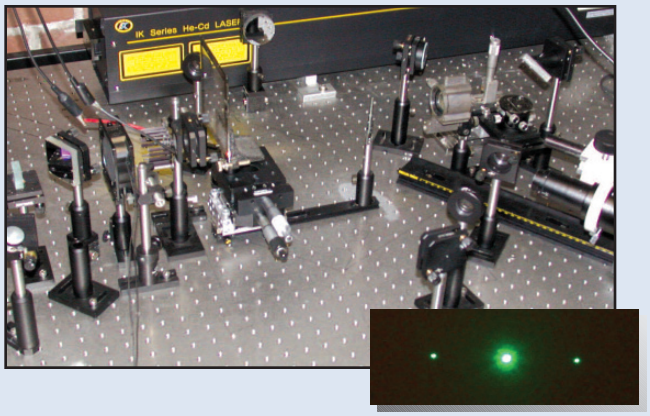
With MDA funding, researchers have developed a novel and cost-effective fabrication technique that improves performance of semiconductor optical components for the telecommunications industry.

The patented process, developed by Advanced Laser Technologies and Innovative Research Center, LLC (ALTAIR Center; Shrewsbury, MA), uses holography instead of etching to control the refractive index of semiconductor materials that enables light-signal processing. Refractive index is the property responsible for light focusing, waveguiding, and reflecting. The result is a process that allows for the manufacture of components with smooth, relief-free surfaces.

The advantage of relief-free surfaces becomes apparent when additional layers of crystal are grown or deposited onto the surface of semiconductor components. Crystalline growth is subject to stresses and flaws, and is more likely to yield perfect structures when starting from a smooth surface.

MDA predecessor BMDO originally funded ALTAIR Center's technological process through SBIR Phase I and II awards to develop and demonstrate an optics-based platform capable of handling 1.3-micron and 1.5-micron wavelengths for military communications systems.

Although ALTAIR Center has recently been focused on introducing its technology to military communications platforms, numerous applications exist in commercial niche markets. Broadly, ALTAIR Center's technology should prove beneficial in areas such as optical computing and communications, photonics, remote sensing and monitoring, and spatial light modulation. Specifically, the process could be used in manufacturing devices such as laser diodes, integrated optical waveguide structures, parallel optical interconnectors, beam splitters, infrared polarizers, retardation plates, and infrared diffraction gratings.



▲ ALTAIR Center's holographic fabrication technique for semiconductor optical components can be performed on a platform like the one show here to produce relief-free infrared diffraction gratings. (Inset shows diffraction of a laser beam on a grating.)

ALTAIR Center's process offers several advantages over traditional fabrication methods. The process is adaptable and can be applied to off-the-shelf components to improve their performance. Fabrication is also easy to manage and less expensive than traditional methods because it can be performed at room temperature, with minimal clean-room requirements, and operated by technicians with limited training. This process can be used as a step in an assembly line or it can be applied to existing devices to enhance their performance.

The company's unique process eliminates numerous steps involved in a common photolithography technique known as photomasking—the quarantining and local etching of a substrate that is not being chemically modified, along with the chemical modification of discrete areas on a substrate. This reduction in steps is possible because the semiconductor material's refractive index is changed only in areas exposed to laser beams and the beam exposure patterns can be controlled without the use of a photomask.

Specific steps eliminated by ALTAIR Center's process over traditional etching methods include cleaning the substrate; depositing a photoresist—a compound whose resistance decreases with increasing incident light intensity; exposing the photoresist with the light using a mask to illuminate the desired areas; developing the photoresist; and removing the photoresist once the etching is complete.

The company's manufacturing technique is not yet commercially available. ALTAIR Center is now looking for potential business partners or for opportunities to license its technology.

CONTACT INFO

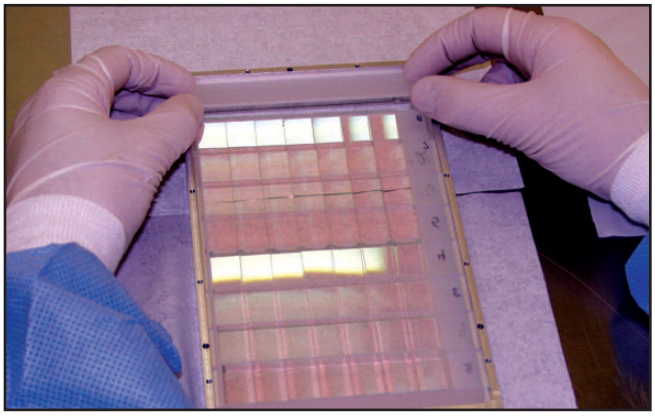
Dr. Sergei Krivoshlykov
ALTAIR Center, LLC
Tel: (508) 845-5349
E-mail: altairctr@aol.com
Web: www.altairctr.com

One Cool Laser

New device could zap missiles, mortar rounds, landmines, and more.

by L. Scott Tillett/stillett@nttc.edu

A high-power, solid-state laser system that could shoot mortar rounds out of the sky or neutralize landmines on the ground would need to be light and mobile, as well as durable and easy to service. But cooling solid-state laser components can require a heavy reservoir containing many gallons of liquid. And therein lies one of the key challenges.



▲ SIMMtec has employed special metallization and etching techniques to create solid-state laser diode pumps that operate coolly and efficiently.

MDA-funded company SIMMtec, Inc. (Allison Park, PA), however, has developed a laser-diode pump with minimal cooling requirements, meaning that more vehicles—and smaller vehicles—might be able to carry such a laser technology onto the battlefield. SIMMtec's laser-diode pump technology also could find use in fields such as medicine, telecommunications, and microchip manufacturing.

Solid-state lasers promise a safer, cleaner, and more efficient alternative to chemical lasers, and interest in solid-state solutions has grown as the technology has matured. But cooling them remains a challenge. And to a great extent, the power generated by a solid-state diode-pumped laser depends on how well it is cooled. Diodes that are well-cooled operate efficiently and deliver higher power, since they are less likely to burn out. Cooling a solid-state laser can involve such design features as heat-exchanger fins built into the device, but cooling also relies on liquid. And toting around a reservoir of liquid to cool a solid-state laser can be a heavy and cumbersome proposition.

SIMMtec has addressed the issue by employing special metallization processes and microchannel etching techniques to create its solid-state diode pumps. The end product is a 10-bar diode array that can be packaged with other 10-bar arrays to create powerful lasers capable of many kilowatts (kW). Each 10-bar array measures roughly 1/2" x 3/4" x 1/2" and can produce 2 kW peak power or 1 kW average power.

Fighting Heat

The foundation of SIMMtec's diode array is glass and silicon that is etched and then metallized with chrome, silver, nickel, gold, and indium to produce a part that can be soldered to diode bars—and through which current can pass to produce laser light. The very uniform metal thickness can pass 100 amps of current for lighting diode bars. But the metals, bonded with the etched silicon, also serve as an excellent cooling surface that takes away the heat produced by the diodes. For SIMMtec's technology, a 10-bar array can be cooled with only 5 gallons of liquid per hour, compared with an estimated 30 gallons per hour for competing solid-state laser technology based on copper microchannels.

"In terms of coolant, you could use significantly less because you don't need to carry as much—because the pumping loads are so much smaller," said Ron Wallace, president of SIMMtec. "If you are using 5 gallons an hour versus 30, you can carry a significantly smaller reservoir." A smaller reservoir means a lighter laser technology, which would be easier to install on smaller vehicles being sent into the battlefield.

MDA originally awarded SIMMtec a 2004 SBIR Phase II contract to develop improved high-power diode arrays for use in high-energy "heat-capacity" lasers, which could be used to defend against rockets, mortars, and other short-range artillery. And in 2006 the company received $2.3 million in congressional "plus-up" money for its MDA-sponsored project. The recent funding is tied to the U.S. Army Space and Missile Defense Command (SMDC).

Some of the MDA-related work has come under the guidance of SMDC. Additionally, the Office of Naval Research and the Electro Optics Center of Pennsylvania (a Navy Center of Excellence), and Lawrence Livermore National Laboratory (LLNL) have sponsored the SIMMtec technology. In fact, core technology for the MDA-funded project was licensed to SIMMtec by LLNL.

SIMMtec already has demonstrated an array plane consisting of 56 10-bar diode arrays, capable of 112 kW of peak power. Wallace said the company's next milestone will be to double that power by using super-high-efficiency diode

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Finding the Right Needle in the Right Haystack

Search engine tailors results to specific needs and profile of the user.

by L. Scott Tillett/stillett@nttc.edu

An MDA-funded company has developed a search engine that not only delivers fast and relevant results; it delivers results that are tailored to the needs, interests, and individual profile of the user.

The company, Knowledge Based Systems, Inc. (KBSI; College Station, TX), developed the search technology through an MDA-sponsored project for an "ontology-driven integration framework" (ODIF) that could be used for knowledge sharing and communication in large military enterprises or in multisystem computer application environments. In contrast to Web search engines, KBSI's product is geared for searches on closed networks—such as an organization's intranet or corporatewide computer system.

The technology developed by the company takes aim at a common problem associated with growing amounts of networked data and the rise of sophisticated search engines like Google, Yahoo!, and Windows Live Search: Such tools are excellent at finding all the "needles" in information "haystacks"—whether they're searching through databases and files on an organization's internal network or whether they're searching sites on the World Wide Web. But a user still has to cull through the search results to pick the "needle" or the piece of information that he or she is seeking.

For example, if you search for the word "launch" using the Google search engine, your top result will be a link to a Yahoo! Web site on music. But if you are a rocket scientist, you're more likely to be interested in space launches, not in a music Web site. And if you are a marketing person, you might be more interested in a product launch.

KBSI's ODIF technology, called AIOXFinder, addresses that problem by applying user profiles known as ontologies to its core search capabilities. Ontologies are software models or "representations of knowledge" allowing a software application to understand the semantics of—the meaning behind—a user's search query. An ontology, therefore, reflects a user's knowledge, interest, or expertise in a particular topic area. An ontology includes not only a vocabulary of terms of interest to a particular user, but it also includes a related framework of logic that shows the relationships and semantics—and thus meaning—among the terms.

Many ontologies exist for free in the public domain, and users can readily add them to KBSI's AIOXFinder. Users also can use tools to create their own ontologies, defining their specific areas and topics of interest.

▲ KBSI's search tool generates results based on the semantics or meaning behind a user's search query.

'Google on steroids'

AIOXFinder applies text-mining and natural-language analysis to a user's queries and ontology to produce specific, highly focused, highly relevant search results. Perakath Benjamin, senior research scientist at KBSI, refers to the capability, somewhat reluctantly, as "Google on steroids." That comparison is close—but not exact. AIOXFinder is not a bigger, bulked-up version of Google, per se. Rather, it is a finely tuned search application that delivers very precise user-specific results. Benjamin said competing products use vocabularies—a list of terms—rather than full-blown ontologies.

An organization could set up AIOXFinder capabilities in about a day, according to Benjamin. When the product is installed, it automatically indexes all documents on an organization's network so that AIOXFinder can direct users easily to the documents. KBSI used an open-source tool called Lucene as the foundation for AIOXFinder's indexing capabilities. In developing AIOXFinder, the company also used a free tool called WordNet, which organizes thousands of English words into sets of synonyms and definitions that are interlinked based on semantics and other word relationships.

From the desktop user's perspective, AIOXFinder has example-based search capabilities—another discriminator that sets

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it apart from competitors, according to Benjamin. The document-centric approach means that a user can feed into AIOXFinder an entire paragraph of text that could be used as search criteria. That paragraph would then be cross-referenced with the AIOXFinder-indexed files in the organization's network to generate a set of search results that are within the context of the particular paragraph.

AIOXFinder is a relatively light application. Users need only a standard PC with a Microsoft Windows operating system.

Searching for users

Byon Williams, KBSI director of sales and marketing, said AIOXFinder should prove useful in any organization that deals with vast amounts of text. Law firms and publishing companies are obvious potential users. And organizations that work with design documents, requirements-based documents, or source code should find AIOXFinder especially helpful. Moreover, engineering or construction firms could put the tool to use for tasks such as assembling proposals when bidding on government contracts.

Benjamin said AIOXFinder does not yet have the capability to learn—to analyze patterns in a user's search history and to adjust future results based on that history. However, the company plans to add a learning capability to AIOXFinder within the year.

MDA originally funded KBSI's ODIF work through Phase I and II SBIR contracts. For missile defense, the technology could prove useful in sorting through information used in the areas of command and control, battle management, and communications (C2BMC). ODIF technology from KBSI already has been installed at the MDA C2BMC Experimentation Lab, an environment where emerging technologies can be tried out and guided to the highest technology readiness level.

KBSI's ODIF work also has been funded in part by the Office of Naval Research, the Air Force Research Laboratory, and NASA. The first installation of the technology occurred in October 2006 at Cape Canaveral Air Station.

KBSI's search tool relies on software models known as ontologies.

KBSI continues to refine the ODIF-based AIOXFinder product to make it ready for broader government use and for widescale commercial release. The company has no patent on the technology, but KBSI officials are considering filing—with the possibility of eventually licensing or selling the technology outright to another software vendor. AIOXFinder now is available on a limited trial basis, according to Benjamin. The company continues to work on developing user guides and other documentation for the product, while also refining the user interface.

Additionally, KBSI is exploring ways to get AIOXFinder easily into the hands of new customers, especially Federal users. The company also is considering avenues that would bring in more development money for AIOXFinder.

CONTACT INFO
Dr. Perakath Benjamin
Knowledge Based Systems, Inc.
Tel: (979) 260-5274
E-mail: pbenjamin@kbsi.com
Web: www.kbsi.com

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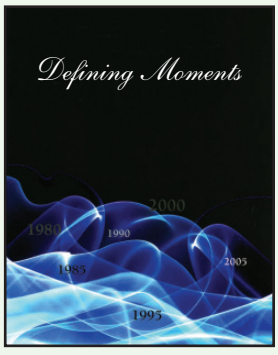
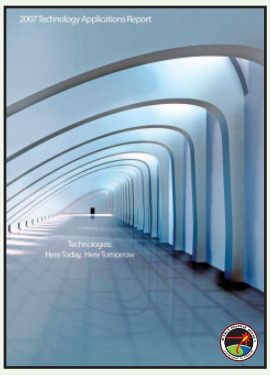
Visit www.mdatechnology.net to find two recent special reports on MDA technology transfer.

One report (*Defining Moments*) presents a historical perspective on U.S. missile defense and technology commercialization. The second report (*Here Today, Here Tomorrow*) offers a forward-looking perspective on MDA-funded technologies that can improve health care, home life, business, transportation, and security.





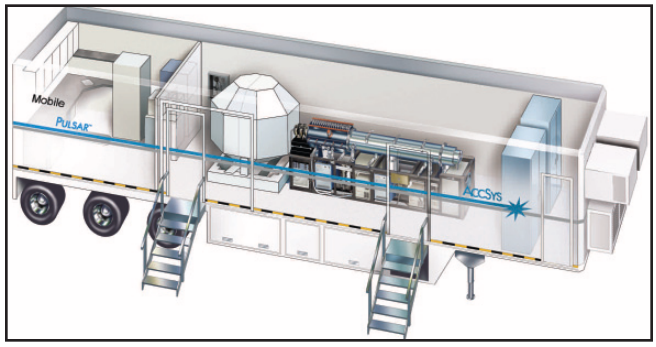
Tabletop Accelerators and Beyond

Robust, compact technology settles into the mainstream.

by Joan Zimmermann/jzimmermann@nttc.edu

A compact tabletop linear accelerator with some deep taproots in MDA funding has found a branch of service in numerous applications, such as neutron detection for hidden explosives, cancer treatment, isotope production for medical diagnosis, mineral and hazardous material analysis, and materials modification.

Based on a concept originally conceived in the Cold War-era Soviet Union, the radiofrequency quadrupole (RFQ) linear accelerator, or linac, was the stepchild of several collaborations, including Los Alamos National Laboratory (LANL), MDA (when it was SDIO), the Department of Defense, and the Defense Advanced Research Projects Agency (DARPA). A linear accelerator is a device that accelerates subatomic particles to very high velocities. Because of the RFQ linac's potential as a directed energy weapon, SDIO assumed partial support for LANL's work in 1984.



▲ This mobile medical unit for providing PET scans relies on Pulsar™ linear-accelerator technology from AccSys Technology, Inc.

An unusual duo of physicists, husband and wife Drs. Robert W. and Marianne E. Hamm, worked on this project and eventually left LANL with the technology in 1985, using it to found their start-up company, AccSys Technology, Inc. (Pleasanton, CA). The company underwent some classic Valley of Death travails as they struggled to establish their products, and now their company is the world's leading commercial supplier of RFQ linacs for medical, industrial, and research applications. AccSys provides three major product lines—Pulsar™, LANSAR®, and LiNSTAR™, as well as custom systems. All AccSys accelerators feature cost efficiencies, long life, and robustness, as well as footprints that are small enough to provide a portable device for the production of radioisotopes. The Pulsar fits this latter bill and can produce ^{11}C, ^{13}N, ^{15}O, and ^{18}F for diagnostic tests. In 1994, the Pulsar became available as a component of the first mobile-unit-based positron-emission tomography (PET) isotope production system; it is also available in more conventional hospital-based centers. The Pulsar's features make it superior to cyclotron-based systems due to low life-cycle cost, minimal space requirements, and simplicity and reliability of performance.

In 1989, the first LiNSTAR™ system was installed as part of the synchrotron injector system at the Loma Linda University Medical Center Proton Treatment Center. Since then, the device has helped to generate protons for the treatment of more than 10,000 cancer patients. The synchrotron system functions 24 hours a day, 6 days a week. While still costly compared to targeted x-ray-based therapies such as conformal radiation techniques, proton therapy is useful for deep tumors, those in delicate areas such as the brain and spinal cord, and in localized cancers. Unlike x-rays, which pass through the body and scatter damage both in the path leading to the tumor and the avenue outward, protons, which have a mass, actually stop at a certain depth and cause little damage until then. This property makes it possible for the therapist to plan treatment that leaves less collateral cell damage around the tumor site, and delivers more destructive energy to the tumor itself. The result is much less discomfort to the patient and little to no "radiation sickness." AccSys has also placed three LINSTAR™ systems in Japanese proton therapy centers and one at the MidWest Proton Radiotherapy Institute in Bloomington, IN.

Linear accelerators can also be used for low-energy, high-current applications such as bombarding lower-quality gemstones for the purpose of cosmetic enhancement. In addition to helping enhance gemstones, RFQ linacs can be used in neutron radiographic applications for detecting them. In neutron radiography, the radiation transmitted through an object is detected, giving a picture much like a classic x-ray. DeBeers, a well-known diamond company that pioneered the use of radiation systems for detecting diamonds in kimberlite, a kind of "diamond ore," made a significant discovery using an AccSys LANSAR® system developed for this application.

AccSys accelerators are compact enough to be placed in trucks at security checkpoints to detect such hazards as conventional explosives or even highly enriched uranium, which some fear could be smuggled in shipping containers at busy port facilities. Much attention has been trained on these containers, millions of which circulate the globe on ships, aircraft, rail cars, and trucks. Individual inspection of these containers at large ports and cargo transfer sites is physically and economically infeasible, thus inspectors rely increasingly on nondestructive evaluation of their contents. In neutron inspections,

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a substance is bombarded with neutrons, after which the bombarded material emits a pattern of gamma (or other) radiation by which it can be identified. Other applications of note include ion implantation, a method used to dope semiconductors, harden steel, and engineer surfaces to improve their resistance to corrosion and wear.

AccSys is a private company and an affiliate of Hitachi, Ltd. The company continues to design and manufacture high-quality, commercial systems and is actively engaged with research laboratories to improve the state of the art. AccSys has designed, built, and delivered 35 linacs worldwide since demonstrating its first prototype in 1987.

CONTACT INFO

Gerard C. Goldner
AccSys Technology, Inc.
Tel: (925) 462-6949, ext. 103
E-mail: ggoldner@accsys.com
Web: www.accsys.com

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The oxygen generated by an OBOGS can be used for emergency oxygen supplies, oxygen-breathing engines, and special operations missions requiring oxygen pre-breathing. The generation of oxygen and nitrogen from ambient air eliminates the logistical burden associated with ground resupply of these gases as liquids or under high pressure, saving weight onboard, and increasing mobility, safety, and aircraft operability. Other applications of portable and lightweight oxygen- and nitrogen-generating systems may be found in military field hospitals, mobile civilian hospitals, home oxygen therapy units, and remote servicing equipment.

CONTACT INFO

Dr. Michael Izenson
Creare, Inc.
Tel: (603) 643-3800
E-mail: mgi@creare.com
Web: www.creare.com

One Cool Laser from page 5

(SHED) bars and new nanofluid cooling technology. SIMMtec currently cools the diodes with a solution consisting of water and alcohol.

Easy and Efficient

Once in the field, SIMMtec's product should be durable and easy to service. Each 10-bar package is sealed with only two O-rings, compared with 20 O-rings for a comparable package based on copper. Fewer O-rings means fewer opportunities for coolant leakage, according to Wallace. Also, copper cooling microchannels have a propensity to erode over time, resulting in lost efficiency, hot spots, and burnt-out components. But the inert nature of SIMMtec's glass/silicon material should make it longer-lasting, according to Wallace.

As for modularity, because the technology consists of individual 10-bar units that can be joined together to create a compound array, an entire array does not have to be returned to SIMMtec for repair or replacement. Instead, users in the field should be able to replace by themselves any malfunctioning 10-bar unit with ease, Wallace said. Meanwhile, if a diode bar were to burn out in a competing system that has microchannel copper cooling, a user would face the challenge of having to slide out the tiny burnt-out diode bar, replace it, and resolder the contacts.

Compared with some tactical chemical lasers, SIMMtec's diode-based technology has the advantage of easy on-off operations. Wallace said that using a powerful chemical laser can be sort of like shooting a machine gun. "The first two rounds do the kill, but the gun keeps firing. The beauty of solid-state lasers is that you can turn them on and off at will, and they're available at full power almost instantaneously, within milliseconds," he said.

In addition to defending against ballistic missiles, diode-pumped lasers could destroy other incoming ordnance, such as a mortar or a rocket. The lasers also could damage control surfaces or blind sensors on a cruise missile. And when pointed toward the ground—whether from an aircraft or the top of a field vehicle—such lasers could destroy landmines or roadside bombs.

Beyond defense, SIMMtec's diode technology is appropriate for illuminating all sorts of crystals, as well as disk lasers and slab lasers—or for illuminating or pumping fiber lasers. SIMMtec's technology could be applied to medical lasers used for tattoo removal, for example. Wallace said it's possible the technology could show promise for applications involving long-haul telecommunications, as well as for various manufacturing processes in the semiconductor industry.

In the short term, the company is focused on various military applications and expects that delivery of just one laser weapon capable of putting out more than 100 kilowatts would mean about $12 million in sales for SIMMtec. Wallace said the company continues to investigate the use of robotics to set and die-bond the components in the array faster and more efficiently. SIMMtec also continues to look for new funding and sponsors for the technology.

CONTACT INFO

Ronald Wallace
SIMMtec, Inc.
Tel: (724) 444-8800
E-mail: rwwallace@simm-tec.com
Web: www.simm-tec.com

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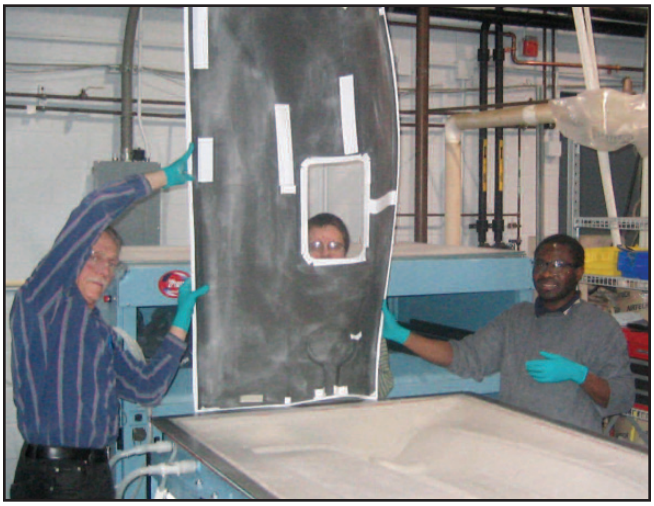
rapid-tooling approaches. The company expects the overall manufacturing cost of a generic 4' x 4' rapid tool to decrease 10-fold from $5,000 to $500 while providing improved tool performance. Using a unique replication process to create tools from a master model or original part is the key to the cost savings.

Speed is also a factor, with the total turnaround time from master to mold to finished product being one to two days, as compared with the several weeks to months required to fabricate tooling for composites using conventional methods.

Scalability is also key, as the RTS can make use of large tool beds—which can vary in size depending on the customer needs—currently ranging from roughly 2' x 3' to 6' x 9'. The company already has built concept tool beds that can handle the fabrication or replication of parts more than 65 feet long. For the U.S. Army, it also has designed tool beds that have successfully replicated the hood of an M35 truck and the cargo-bay door of a Black Hawk helicopter.



▲ Using a water-soluble, ceramic-based slurry, 2Phase Technologies can form composite industrial parts—currently as large as 6'x 9'—in a tool bed like the one shown here. The company's patented system is capable of forming parts in as little as 15 minutes.

2Phase's system is commercially available in its fourth iteration, the RTS 4000. The customer base for the equipment is expected to be aerospace and transportation manufacturers who need rapid, low-cost, and very large original or replacement parts.

The RTS machine design in no way resembles a conventional tooling system. Its tool bed is a large, deep, flexible tray filled with a slurry of 2Phase's unique "engineered quicksand"—a "state-change material" composed of a ceramic powder mixed with a water-soluble inorganic binder solution—and covered by a thin, flexible silicone membrane. To replicate a part, the master is placed on the membrane and covered by a vacuum cap. The air around the master is evacuated and the master sinks into the slurry mix, which exactly conforms to the part's shape. Using the controls and pumps of the system base station, the machine then withdraws the liquid from the "quicksand" and rapidly hardens it to a firm, chalk-like consistency. The entire process takes just 15 to 30 minutes, and in many cases the solidified mix can then be used as a tool for low-temperature composite molding. If a harder, more durable tool is required, the mold is then heated up to temperatures as high as 400ºF to remove the last of the liquid and harden the mix to a ceramic-like state. The process of fully hardening the tool takes between six and eight hours.

In this form the tool can be removed from the tool bed and used to mold composites by processes such as autoclave curing or vacuum thermoforming.

When the fabrication of the composite part is complete, the tool can be used again or, even if fully hardened, can be reconfigured to make another type of part. To reconfigure the tooling material, the water-based binder mixture is reintroduced, dissolving the inorganic binder, and the solidified state-change material is reliquified. The tool bed is thus returned to its original slurry state, allowing the shop to begin work on another tooling project.

The RTS 4000 comes with a hefty price tag of about $250,000 per machine. While 2Phase President John Crowley admits the cost may be prohibitive for some smaller composite shops, large composites users like the aerospace industry should find the price reasonable. The innate value of a machine is that a single system can quickly allow production or replication of many different composite pieces and thus replace numerous tools that can cost up to $100,000 each.

With continued development, 2Phase anticipates that the technology will provide aerospace and transportation manufacturers a means of creating faster, less-expensive products or repairs with conventional or high-temperature composites. In some or many applications, 2Phase officials believe their technology may replace altogether tooling materials and approaches currently used.

2Phase now is looking for customers as well as joint-development partners willing to invest some nonrecurring engineering money to embed the RTS technology into their applications. Crowley says the incentive of such investments would provide companies a unique capability to gain a competitive advantage.

CONTACT INFO

John Crowley or Linda Clements
2Phase Technologies, Inc.
Tel: (775) 246-8324
E-mail: jcrowley@2phasetech.com
lclements@2phasetech.com
Web: www.2phasetech.com

Taking Care of Trade Secrets

Protecting sensitive information requires a plan.

by Henry E. Fradkin/henry.fradkin@comcast.net

When MDA-funded companies show up for one of the special Technology Applications Reviews (TARs) held by the MDA TA program, they often end up hearing me dispense advice on whether they should protect an invention with a trade secret or a patent, how to go about protecting a trade secret, and then what can be done to leverage the value of a trade secret.

But before that advice can be taken to heart, a company must understand fully what constitutes a trade secret, and company leaders need to ask themselves a few questions about their invention process.

Knowing What You Have

A trade secret can be any information that derives independent economic value from not being generally known or readily obtainable. Trade secrets are very different from patents, trademarks, and copyrights. An entity cannot maintain both a patent and a trade secret on the same invention. They are mutually exclusive. Once a patent is published, all knowledge becomes public domain and thus no longer is "secret."

Trade secrets include formulas, patterns, compilations, programs, devices, methods, techniques, or processes. All of those factors often are considered "proprietary technology and/or information." For example, courts consider items such as the following to be trade secrets: machining processes, blueprints, stock-picking formulae, customer lists, pricing information, and nonpublic financial data.

When a company ponders whether to treat an invention as a trade secret or as an innovation to be patented, company leaders must consider the following tenets:

- Demonstrating that everything possible is being done to prevent public disclosure; e.g., locking up all key documents, not allowing general access to a manufacturing machine or process, etc.
- Making sure that such secrets are disclosed only to outside companies after appropriate written secrecy documents have been executed.

Key points to address include:

- The extent to which the information is known outside the business.
- The extent to which it is known to those inside the business—i.e., by the employees.
- The precautions taken by the holder of the trade secret to guard the secrecy of the information.
- The savings generated and the value to the holder in having the information that the competition lacks.
- The amount of effort or money expended in obtaining and developing the information.
- The amount of time and expense it would take for others to acquire and duplicate the information.

Nondisclosure agreements are key to maintaining secrecy of confidential information.

Keeping a Secret

So what should a company do to protect its trade secrets? Keep them secret! There are no forms to fill out or applications to register; no government approval or registration is required. If the possessor of the secret exercises reasonable means to keep the information a trade secret, then as long as the information stays secret and has economic value, trade secret protection remains available.

Therefore, a company should take reasonable precautions to protect any information regarded as a trade secret. This includes marking documents containing trade secrets as confidential or proprietary, locking trade-secret materials away after business hours, maintaining computer security, and limiting access to people with a reasonable need to know. In particular, a company should:

- Restrict access to the trade secret by preventing unauthorized entry into the facility where the trade secret is kept.
- Obtain nondisclosure agreements (e.g., part of an employment contract) from key employees who came into contact with the trade secret, and conduct exit interviews to remind departing employees of their secrecy obligations.
- Obtain nondisclosure agreements for the trade secret from suppliers and manufacturers, including those who are subcontractors, suppliers of raw materials, and component manufacturers.

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- Make pertinent documents available to suppliers only for the sole purpose of bidding on or manufacturing.
- Mark all materials and drawings related to the trade secret with a proprietary legend, as noted above, restricting their use and disclosure.
- Follow up any oral disclosure with a letter citing the confidentiality of the material discussed and the resulting obligation by the company or people to maintain the material as a trade secret. The obligation still holds with an oral disclosure but certainly is made stronger with a written account after the fact.

Courts have repeatedly indicated that the use of nondisclosure agreements is the most important way to maintain the secrecy of confidential information.

Money talks

Because a technology or invention—including product, process, and software—is a trade secret, that doesn't mean that it cannot be used to generate new revenues or profits through commercialization on the outside.

Based on my experience and that of others, trade secrets in the form of technical or business know-how have formed the basis of many licensing deals. Regarding the question of how to ensure no loss of secrecy, there is no silver bullet. But one important action is to try to lock the licensee in to the protection scheme. The best way is money—by having the licensee either make an upfront payment or at least commit to make payments over time. In essence, if the licensee has to pay for use of the know-how, it is unlikely to release this knowledge into the public domain for free.

Fradkin frequently serves as a reviewer on panels for the MDA Technology Applications program. He is the founder and principal of Value Extraction, LLC (Dearborn, MI), a consulting company offering services related to commercializing IP and technology. A 30-year veteran of Ford Motor Company, he founded the corporation's first dedicated business office for extracting value out of technology and business intellectual assets. He can be reached at (313) 278-1549.

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