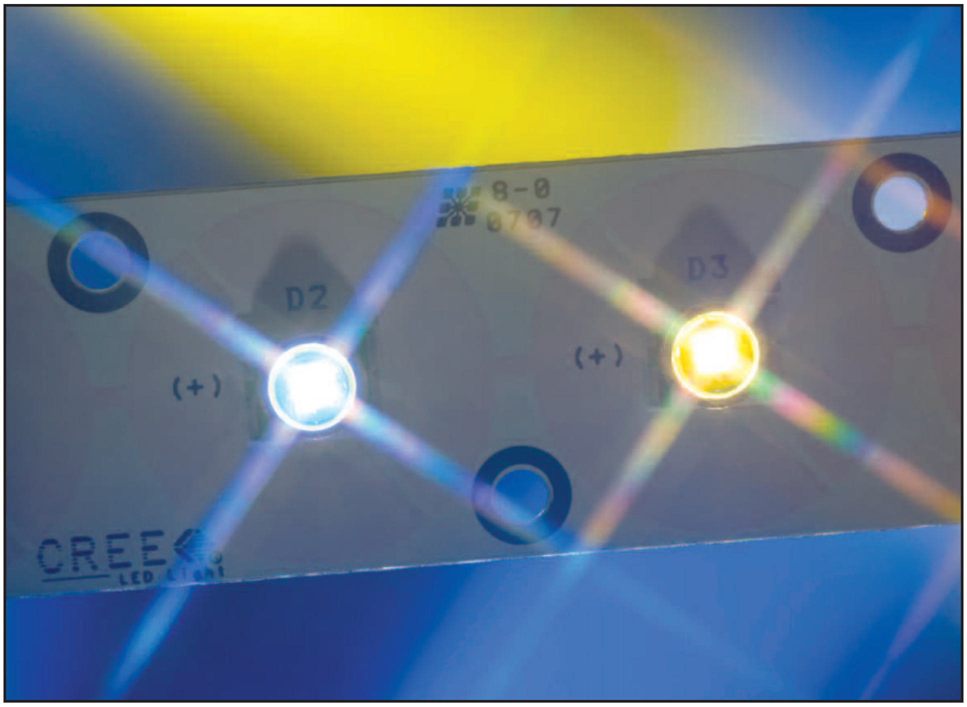
Winter 2007-2008

Missile Defense Agency

TechUpdate

A Quarterly Newsletter for MDA Technology Transfer

INSIDE



▲ This image shows Cree's XLamp light-emitting diodes (LEDs) producing cool-white and warm-white light. Missile defense R&D programs originally helped Cree develop LED technology.

A Revolution of Light

Breakthroughs in white LEDs pave the way for big changes in the illumination industry.

by Keith Costa/kcosta@nttc.edu

In 2007, Cree, Inc. (Durham, NC), announced a series of breakthroughs in its ongoing research of white light-emitting diode (LED) technology, including the demonstration of a device that can produce as much light as a standard lightbulb or fluorescent tube.

Cree's latest milestone, announced in September 2007, is the 1,000-lumen mark. (A lumen is a measure of brightness as perceived by the human eye.) And the company, a recognized leader in white LED development, believes reaching this milestone shows that the technology is well on its way to making ordinary incandescent lightbulbs obsolete.

Cree, which has a legacy of funding from MDA predecessor BMDO, also announced in September 2007 that it had improved the efficiency of high-power white LEDs. Specifically, it made a "cool-white" LED that achieved 129 lumens per watt (LPW)—the best results to date for this kind of device—and a "warm-white" version that achieved 99 LPW. Warm-white LEDs produce an effect similar to the light that comes from incandescent bulbs. White

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Missing the Point

An overdone presentation shackles your message and isolates your audience.

by L. Scott Tillett/stillett@nttc.edu

Here at *MDA TechUpdate*, our specialty is explaining complicated technologies and their potential in a crisp and concise manner. Our objective is to introduce a wide audience to emerging MDA-funded technologies and to stimulate interest in those technologies—interest that, we hope, will lead to commercial opportunities for the organizations developing the technologies.

The idea is that commercialization of MDA-funded innovations helps create mature and cost-effective products that can then transition back into real MDA systems. In other words, MDA cannot by itself fund the entire life cycle of every promising technology. To reach the point of viability, most of the innovations will need nongovernmental investment and commercial support, too.

We help those MDA-funded companies as best we can. We make a pitch for them here in *MDA TechUpdate*. But ultimately, the MDA-funded companies will have to use their own words to seal the deal—to convince investors, to make sales, to woo partners. And a lot of those companies will resort to a PowerPoint presentation to do that. And in so doing, many of them will fail to communicate effectively—despite their best efforts to cram the presentation chockfull of useful and pertinent information. The reason? They have assumed too much of PowerPoint, and they have forgotten to put themselves in the shoes of their audience.

I am an expert at PowerPoint presentations. I have been on the receiving end of thousands of PowerPoint slides, and here are the challenges that I, as an audience member, have faced repeatedly.

- **Dealing with word overload.** It's difficult to read huge blocks of text on a slide while also listening to what the speaker is saying. The result: The audience has to tune out the speaker or tune out the text on the screen. When an audience member tries to absorb both a wordy slide and the speaker's voice at the same time, the two modes of communication often can cancel each other out.

- **Dealing with slide overload.** A slide presentation does not require every iota of information you can muster. You are trying to get through to your audience with a core message tailored specifically for them. You can save the nittier, grittier details for a handout or for an unabridged PowerPoint file that you distribute to your audience—while your stand-up presentation remains abridged, focused, tight, and powerful. Cut through the clutter for them. Don't stun them with more slides than they need.

- **Listening to a presenter explaining a slide rather than explaining a topic or an issue, or stating simple facts.** A slide should speak for itself. If, as a presenter, you find yourself

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CONTENTS

A High-Performance Optical Challenger

Rad-hard silicon-carbide mirrors offer alternative to toxic beryllium.

by Joe Singleton/jsingleton@nttc.edu

A small Hawaii-based company wants to give the beryllium optics market a run for its money with innovative, high-performance silicon-carbide mirrors originally designed for MDA.

Trex Advanced Materials (Lihue, HI), a division of Trex Enterprises Corporation, manufactures silicon-carbide mirrors using chemically grown materials that have higher optical performance and thermal stability than beryllium. These silicon-carbide mirrors, in contrast to beryllium, meet the military's radiation-hardened requirements for space-based surveillance optics, and they are manufactured in a nontoxic environment. Beyond missile defense, Trex's mirrors could find a home in products used in chemical-corrosive environments, cryo-applications, and the high-energy laser market.

MDA funded Trex through three SBIR Phase II contracts to design lightweight, thermally stable, rad-hard mirrors that could be used as seeker optics on space-based, missile-interceptor weaponry. After successfully completing the contracts, MDA further awarded Trex an IDIQ (indefinite delivery/indefinite quantity) contract for silicon-carbide mirrors. Most recently, the agency awarded Trex a new SBIR Phase I contract to focus its silicon-carbide material on divert and attitude control system components, given the material's demonstrated performance in high-temperature environments.

Trex manufactures the mirrors using a patented material known as CVC SiC™, or Chemical Vapor Composite Silicon Carbide. To make CVC SiC, Trex engineers insert silicon-carbide seed particles into a gas stream as the optical material is chemically grown. The seeds act as stress relievers for the highly pure silicon-carbide optical material. Without the silicon-carbide stress relief, an excessively stressed columnar grain structure would form during chemical growth, making the material difficult to handle, manufacture, and polish. The silicon-carbide seeds enable the formation of an equiaxial grain structure in which the optical material can be grown five times faster than without the additive.

The chemically grown structure of the material also provides strength benefits, with silicon carbide providing a specific stiffness—defined as material strength per unit of weight—that rivals beryllium. Due to the inherent strength of the product, CVC SiC mirrors are lightweight, requiring only one-sixth the amount of material that would be needed when using competing glass optical materials.

▲ Workers display a silicon-carbide "face sheet" used in the production of large, industrial mirrors made by Trex Advanced Materials.

The material can be grown into complex geometries, at thicknesses from 0.02 inches to 2 inches. And the size of the mirrors can be scaled to demand, from 0.5 inches to 50 inches in diameter.

Another advantage silicon-carbide mirrors provide is radiation hardness. Successfully tested to be radiation-resistant, the optics meet the rad-hard requirements for space-based military equipment such as kill vehicles, something beryllium cannot do.

Silicon carbide also has a high thermal tolerance that makes these optical materials useful in the commercial high-energy laser market. Beyond these markets, Trex plans to look at the possibility of selling its mirrors to manufacturers that need such optics for cryo-applications and for products used in chemical-corrosive environments.

Manufacturing silicon-carbide mirrors also has an environmental and health advantage over the beryllium competition: The product is not toxic. Beryllium particles are a known inhalation hazard, and rigid environmental controls must be put in place for the safety of employees working around the material. "With silicon carbide, you don't have that issue at

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A New Vision for Robotics

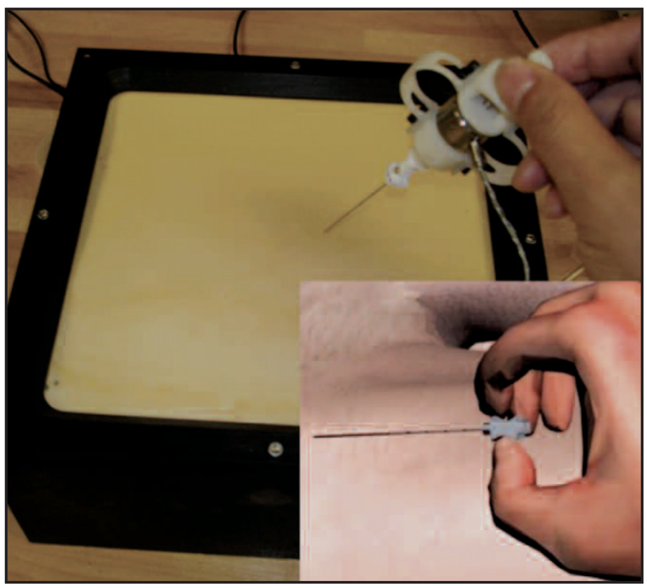
Software enables tools for surgical simulation and satellite repositioning.

by Joe Singleton/jsingleton@nttc.edu

Using algorithms formulated for MDA, a Massachusetts-based company is developing a cost-saving, highly configurable software backbone for robotic aircraft passenger gateways, robotic repositioning systems, and surgical training simulators.

This software backbone, created by Energid Technologies Corp. (Cambridge, MA), identifies and tracks the position and orientation of any 3-D object. The system requires nothing more than computer-aided design (CAD) data to identify and track a new object, be it a tool, robot, vehicle, or satellite. During live tracking, the system produces synthetic 3-D views and, using fast calculation in PC graphics cards, maps observations of the real object to the synthetic views.

MDA funded Energid's software development through an SBIR Phase II award to track and model missile body and plume trajectories. These algorithms developed for the original MDA project are now being leveraged through the reusable software backbone into a large and growing number of applications. The software can track virtually any object type given its CAD data. It also can track any number of objects simultaneously, and it can use almost any sensor type—such as black-and-white cameras, color cameras, ladar, and hyperspectral imagers.



▲ Energid's surgical simulator enables surgeons in training to learn new procedures and operate on 3-D computer-synthesized models.

Energid's strength is the ability to identify, in a fraction of a second, the position and orientation of an object in three dimensions, even with only a single camera. The software separates the referenced object digitally from its natural environment. It then provides multiple possibilities for the object's type and orientation—defining what it is and which way it is facing. Possible object types and orientations are refined using a graphics processing unit (GPU) on a PC graphics card to make a photorealistic rendering of the object. After the computer-generated model of the object is complete, a sequence of images—similar to a video—is created by the GPU to correlate the accuracy of the model on a frame-by-frame basis. With video input, this process tracks the movements and the geometric changes of objects over time in any environment.

Surgical simulation

A new application that arose during Energid's MDA project was surgical simulation. During a simulation, Energid's technology guides a surgeon through an operation and tracks the path of the surgical instruments as they are used to operate on a computer-synthesized body. With this technology, surgeons in training use real instruments, connected to a simulator, and they operate on patients "in the air," like using a video game controller. The surgical motions performed are relayed back to the simulator's digital processor to show the activity in real-time video. Surgical residents learn new procedures using anatomically correct virtual-reality models—cutting open air instead of flesh, and errors are made on the virtual patient instead of on a real human. Surgeons who train in a high-fidelity virtual environment subsequently perform operations far more safely on real patients, said David Askey, Energid's director of business development.

In another new application, the company is developing a robotic high-intensity focused ultrasound (HIFU) system. This system will bring the concept of minimally invasive surgery to a new level, as surgery using robotic HIFU will not require even a single incision, but instead will manipulate tissue within the body by focusing ultrasound. The focused beam heats small spots of tissue to stop internal bleeding or remove cancer tumors. It does not harm tissue located away from the target treatment site. The ultrasound system will use the same vision algorithms used to track missile plumes for MDA.

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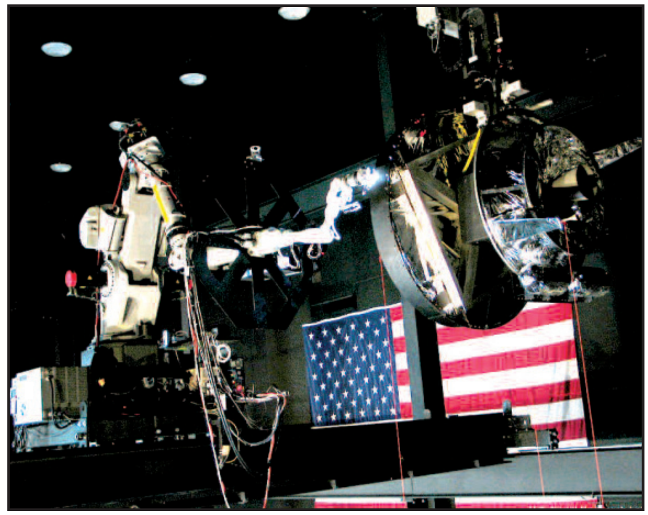
Airports and satellites

Beyond the human body, a terrestrial application for Energid's technology has been fielded at a major U.S. airport. The company has developed vision software that guides fully robotic aircraft bridges at the airport. The aircraft bridges use sensors and machine vision to perfectly align passenger gateways between the aircraft and airport terminal. The bridges allow passengers to enter and exit at both the front and back of the aircraft. This approach significantly reduces the amount of time needed to load and unload aircraft cabins—possibly by 10 minutes or more—thereby increasing airline efficiency, especially in the area of on-time departures.

But space is Energid's final frontier. Using its proprietary methods, the company is working on the Navy's Spacecraft for the Universal Modification of Orbits (SUMO) program. Some multimillion-dollar satellites simply run out of fuel and drift out of their designated orbits. SUMO will give these failed satellites new life. The SUMO system, for which Energid is designing machine-vision control software, will have three kinematically redundant arms that can capture a troubled satellite and move it into a better orbit by docking with it and powering it with its own thrusters. This project is expected to save the government and commercial companies millions, perhaps billions, of dollars in lost satellite time.

> **Energid's technology is being used to guide aircraft bridges at a major U.S. airport.**

Besides aircraft bridges, medical simulators, and satellite repositioning technologies, Energid continues to find new applications for its machine-vision product. The company has created an improved interface for ground robot control for the Navy, and it is developing a helicopter identification and tracking system to support safe landing. Energid plans to expand its commercial product line in 2008, with new offerings tailored to industrial inspection, home-health monitoring, and citrus harvesting. The company is now looking for limited outside investment on certain programs, especially robotic HIFU.



▲ Energid is participating in the Navy's Spacecraft for the Universal Modification of Orbits (SUMO) program. This photo shows grapple testing of a SUMO arm.

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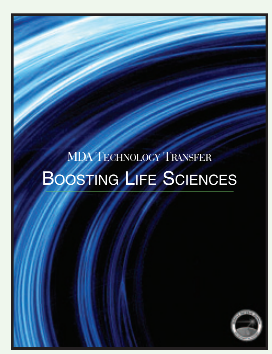
Visit www.mdatechnology.net to find past issues of the *MDA TechUpdate* newsletter. The online archive extends back to 1994.

The Web site also features nearly 20 special reports on missile defense technology applications. The reports cover topics ranging from life sciences to emergency response to wide-bandgap materials.



LED Milestone

Electric vehicles, TVs, and sensors also could benefit from breakthrough in lighting material.

by Joan Zimmermann/jzimmermann@nttc.edu

There's good news coming for blue and white light-emitting diodes (LEDs), as well as their technological cousins, laser diodes, and the semiconductor industry.

Kyma Technologies, Inc. (Raleigh, NC), has reached a milestone in its long-term effort to grow native, defect-free gallium-nitride (GaN) boules, expecting to produce four-inch-diameter wafers by the end of this decade. This diameter is particularly important for microelectronic applications such as X-band radar. Kyma President Keith Evans credits a series of MDA SBIRs, with strong support from the Air Force, Army, and Navy, with improving its GaN-substrate production technology to the point where it has clear potential to become a viable replacement for silicon-carbide (SiC) and sapphire substrates for several applications. GaN withstands higher temperatures than SiC and sapphire and, as has already been proven for laser diodes, enables greater performance and reliability. Additionally, there are important heat-handling implications, since Kyma's native GaN has a much higher thermal conductivity than GaN grown on sapphire or SiC.

▲ When it comes to handling heat, these gallium-nitride wafers from Kyma offer advantages over competing materials.

The commercial potential for GaN devices is great, and a strong market in lighting already exists. Notably, leading developers of LEDs are looking to GaN for next-generation high-performance applications in backlighting, projection displays, and ultimately for general lighting. And as the world pays more attention to energy issues, lighting in particular can benefit from long-lasting white LEDs. Incandescent bulbs are fragile and inefficient, accounting for up to 20 percent of a home's energy bill, and fluorescent bulbs contain toxic metals, such as mercury, that end up permeating landfills and waterways. In addition, LEDs have extraordinarily long lifetimes, from 100,000 to 1 million hours, according to one estimate by LED manufacturer Philips Lumileds. Fluorescent bulbs last roughly 30,000 hours, and incandescent bulbs last from 1,000 to 2,000 hours. White LEDs also offer the possibility of exploiting their broadband capabilities. Ten years from now, you may be getting your Internet signal through your room lighting, even when it appears dark, by using transmission wavelengths "left over" in the spectrum.

Kyma's GaN manufacturing technology is based on the well-known hydride vapor-phase epitaxy (HVPE) crystal growth process and benefits from technology exclusively licensed from North Carolina State University. Kyma is currently delivering substrates to leading GaN device manufacturers as well as research and development laboratories worldwide.

Kyma has learned a lot about "managing" the strain that arises during GaN crystal growth due to lattice and thermal mismatch—strain that can lead to defects in the crystal and to subpar device performance. These same issues also can lead to formation of cracks in otherwise high-quality boules. A major issue was the ability to grow high-quality crystals with a seed crystal. In the case of Kyma, the company had to develop its own GaN seed. According to Evans, once the seed manufacturing process gets good enough, it will be a simple matter to regenerate better and better seeds and head toward full manufacturing capability. Kyma is well along this road and expects to be past the seed maturation hurdle in 2008, thereafter concentrating on improving the engineering process, driving down cost and increasing efficiency.

There are many other applications for this versatile material, such as in electric drives for military and commercial hybrid electric vehicles, distribution transformers in the power grid, high-power radio-frequency jamming devices, terahertz devices for luggage screening, high-definition television, and ultraviolet LEDs for water purification and chemical/biological sensing. In addition to native GaN, Kyma also offers polycrystalline GaN, GaN templates, aluminum-nitride (AlN) templates, and related products and services for high-performance nitride-semiconductor applications. According to the company, the combined nitride-semiconductor market is expected to top $9 billion in 2010, with the GaN and AlN substrates making up $500 million by that year.

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Diamond is GaN's Best Friend

New material can address heat and power issue for electronics.

by L. Scott Tillett/stillett@nttc.edu

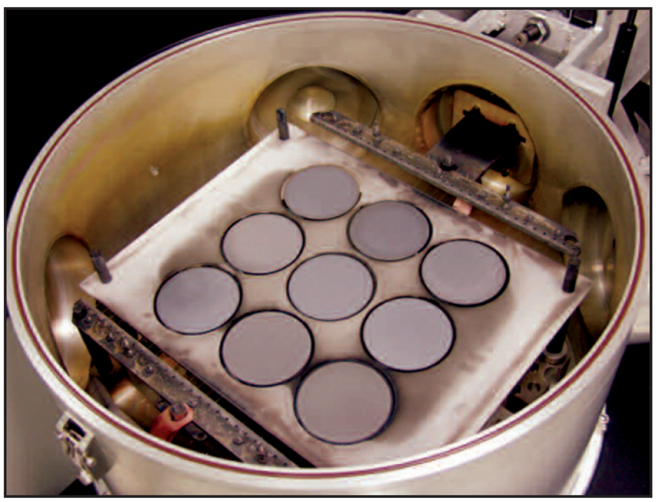
A new diamond-based material developed by an MDA-funded company should help solve power and heat problems for next-generation electronic devices, leading to smaller, higher-performance products.

Technologies such as lasers, high-bright light-emitting diodes (LEDs), and radio-frequency (RF) devices are all pushing the envelope in terms of power density. Designers of such products would like to make them more powerful and functional by packing them with more microchips, which would require more power. But putting more power into chips generates a lot of heat, and the secret to dissipating that heat is the material at the base of those chips.

Semiconductor materials such as silicon, silicon carbide (SiC), and gallium nitride (GaN) have proven to be choice platforms on which to build devices such as integrated circuits. But device designers continue to crave methods that will improve the thermal capabilities of such materials.

MDA-funded sp3 Corporation (Santa Clara, CA) is adding polycrystalline diamond to the mix in an effort to address concerns about heat. Diamond is an excellent thermal conductor. So adding a layer of diamond close enough to a device that is built on a thin layer of GaN can allow designers to put more power into the device, according to Dwain Aidala, president of sp3. MDA funded the company through a 2006 Phase II SBIR contract to develop manufacturing process improvements by putting GaN on a silicon-on-diamond (SOD) material. MDA's interest in the technology has come as electronic systems across a wide array of defense applications are being designed to accommodate higher-power transmitters that generate larger thermal loads.

Managing heat while putting more power through a device can mean that the end product—be it a communications system, a computer, or a laser—can be made smaller, since chips might be packed more closely together. Also, a single, more powerful final product incorporating the new chips might do work that was previously accomplished by multiple units.



▲ This photo shows multiple 100-millimeter wafers coming out of sp3's Model 650 Hot Filament CVD Diamond Deposition Reactor. This process is the initial stage for making silicon-on-diamond wafers.

sp3 uses chemical-vapor deposition (CVD) to create a silicon-diamond-silicon "sandwich" onto which GaN can be deposited. The SOD sandwich substrate, since its surface is silicon, provides a known base onto which GaN can be deposited.

At least two major commercial suppliers already grow GaN on silicon substrates, according to Jerry Zimmer, chief technology officer at sp3.

"Doing GaN on a silicon-based wafer has the opportunity for scalability, which therefore drives cost and production-volume capability very strongly," said Aidala, who explained that silicon-based substrates, including sp3's SOD material, could be produced easily as 12-inch-diameter wafers. By comparison, competing material SiC typically can be grown only up to 4 inches in diameter.

sp3 expects that an SOD wafer will cost about 25 percent of what it would cost to produce an equivalent-size SiC wafer. And from a thermal-conductivity standpoint, SOD is nearly 2.5 times as good as SiC, according to Zimmer.

The material the company is creating is very pure. "One of our advantages is we know a lot about growing diamond under very repeatable deposition conditions, which allows us to do it, No. 1, the same way every day, day in day out, and No. 2, to do it over large enough areas with sufficiently uniform conditions that we can actually use the product that comes out to produce these SOD structures," Aidala said.

sp3 officials said that the biggest challenge they face is fine-tuning their ability to produce diamond in specific thickness ranges and with the necessary degree of flatness that manufacturers will need for producing semiconductor devices. As it continues to work on its MDA Phase II SBIR, the company is producing structures and analyzing them in an effort to improve performance.

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Tough Ceramics Tackle Extreme Stress

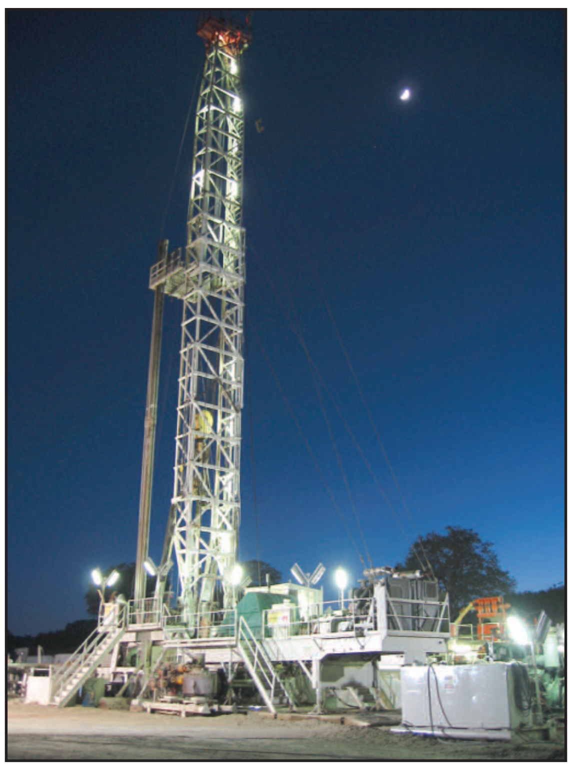
From oil exploration to biomedicine, unique manufacturing method opens new markets.

by Keith Costa/kcosta@nttc.edu

An Arizona company funded by MDA has developed a way of making ceramic composite materials for longer-lasting industrial cutting tools, as well as drill bits that can dig deep into the ground to search for oil, and it also is applying this know-how to produce artificial bone.

Traditionally, ceramics have been thought of as hard and brittle, yet able to tolerate high temperatures. Now, with offerings from companies such as Advanced Ceramics Research, Inc. (ACR; Tucson, AZ), a new generation of ceramics offers strength and toughness, proving useful in a variety of applications.

Seeking high-performance alternative materials for parts such as rocket nozzles, MDA predecessor BMDO funded ACR through a Phase II SBIR contract. Additional MDA support for ACR ceramics projects has come through various SBIR and STTR awards over recent years. Much of MDA's interest has been in finding new materials for thrusters and rocket motor throats for the Theater High Altitude Air Defense system. Beyond missile defense, makers of aerospace components and industrial machinery could find ACR's technology useful.



▲ ACR has developed fibrous-monolithic composites for roller-cone drill bits that could be used in oil exploration or other projects, such as this scientific drilling operation along the San Andreas Fault.

A recipe for toughness

In developing new materials, the company has focused on fibrous-monolithic (FM) ceramics, which have a cellular, or "fiber-like," structure that stops cracks or imperfections from propagating to the point at which the material shatters, according to Matt Pobloske, ACR's vice president for business development.

The BMDO project explored using FM technology with composites such as zirconium carbide, hafnium carbide, and tantalum carbide. By itself, each carbide is very brittle. But when two of them are combined, the result is a material that can be twice as tough as each carbide alone, according to Ranji Vaidyanathan, an ACR consultant.

Manufacturing FM ceramics involves encasing strands of a hard material, which are relatively easy to fracture, in a softer, more ductile material and then bundling these into cells. ACR takes ceramics or metal powders and mixes them with a thermoplastic polymer binder. The resulting fiber can be easily manipulated and extruded into a variety of shapes, such as a strong honeycomb configuration. Components made with the process are sintered, or "hot pressed," at temperatures greater than 2,000ºC.

ACR's process offers a cheaper and faster way of making ceramic composites than more standard methods such as chemical-vapor infiltration, according to Pobloske and Vaidyanathan. Historically, higher costs—compared with industrial metals and other advanced materials—has limited market acceptance of ceramic-based products, Vaidyanathan said.

Company officials hope that results from ongoing development work will make FM technology an easier sell, especially to aerospace companies. These days, aerospace companies prefer using rhenium, coated with exotic materials to resist oxidation, for those parts that come into contact with aluminized propellants. But rhenium is a rare metal, and fashioning it into parts can be difficult and lengthy work. Because ACR's unique manufacturing process promises lower costs and easier manufacturing, possibly cutting production time down from months to weeks, company leaders believe FM materials are a good choice for replacing rhenium in nozzles and other rocket parts—because they can withstand very high

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temperatures and offer protection to sensitive components in extreme environments. Compared with rhenium, FM composites are also lighter and exhibit smaller dimensional changes at high temperature.

From bits to bones

ACR already has licensed its FM technology to Smith Tool, a subsidiary of Houston-based Smith International, Inc., one of the world's largest suppliers of products and services to the oil industry. The two companies had initially worked with each other under a Department of Energy research project for developing roller-cone bits. Smith Tool's FM ceramic drill bits last longer than conventional metal ones, which saves users money.

ACR also has licensed its FM technology to Japan's Kyocera, a global leader in ceramics manufacturing. Kyocera has exclusive rights to use FM technology for metal cutting tools. And ACR is open to negotiating FM licensing arrangements with other companies for different fields of use. Possible future products could include FM blades for graders used to make dirt and gravel roads, and FM bed liners for trucks, according to ACR.

Beyond aerospace and industrial parts, ACR has been applying its know-how for making FM ceramic parts to the biomedical field. The company can use the same extrusion process to produce artificial bone from high-strength plastic. ACR calls this experimental product "Plasti-Bone." The biomedical industry craves new kinds of implants because today's metal bone replacements, screws, and pins are so hard that over time (5 to 15 years) they can damage adjacent healthy bone through constant friction. But with Plasti-Bone, there are no such worries about destroying healthy bone through wear and tear, according to ACR.

▲ ACR's material could be used in treating broken bones, serving as an alternative to metal bone replacements, screws, and pins.

▲ This image shows a cross-section of a product incorporating ACR's FM ceramic material.

While strong enough to carry bodyweight, Plasti-Bone is osteoconductive, which means bone cells can grow right on top of it. And it is porous enough so that it will disappear, absorbed into the body, when its job is done. Right now, Plasti-Bone takes nearly 18 months to dissolve, but ACR is working to develop a "polymer blend" material that would be absorbed in just six months to a year, Vaidyanathan said. Plasti-Bone has not yet been tested in humans, but it has been successfully tested in rats and dogs. Rabbit tests are next, Vaidyanathan said.

ACR likely will partner with one or more companies to bring Plasti-Bone to market, because it will need help developing the product and carrying it through an arduous Food and Drug Administration regulatory process, according to Pobloske. ACR also wants to talk to companies with experience distributing medical products, he said.

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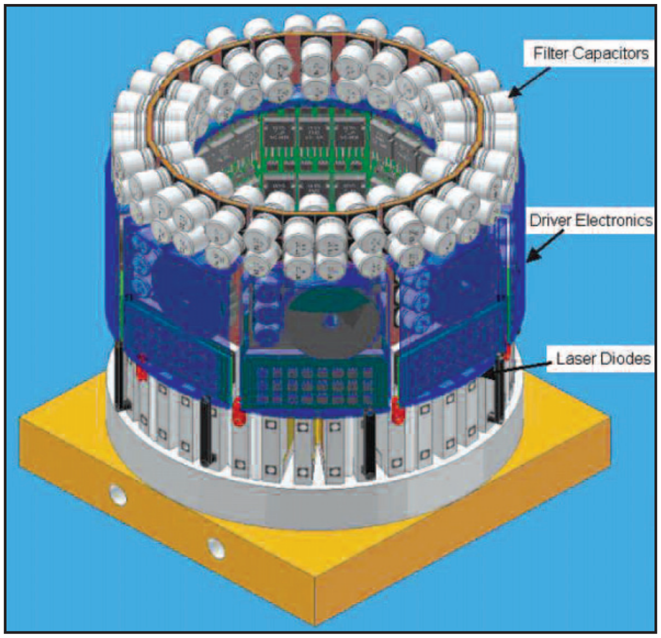
Giving New Life to Laser Diodes

Driver technology decreases cost, increases performance.

by Joe Singleton/jsingleton@nttc.edu

A new MDA-funded technology designed to increase the performance and reliability of laser diodes soon could reduce costs for the industrial welding and biomedical markets.

Science Research Laboratory, Inc. (SRL; Somerville, MA), an innovator of power supplies, is extending the life of laser diodes with an innovative solid-state controlling mechanism, commonly referred to as an intelligent driver. This driver can interrupt and reset a diode's power supply by monitoring and responding to dynamic current and voltage signatures that indicate the device is close to failure. The technology provides laser operators a tenfold cost savings over operating systems not using an SRL driver by enabling the diodes to operate at high power 10 times longer.



▲ This diagram shows the layout for SRL's driver mechanism. The design seeks to boost the longevity of laser diodes operating at high power.

SRL's ultra-compact solid-state drivers are now being incorporated into a high-energy defense-related laser system. SRL's subcontract on this project had its origins in SBIR Phase I and Phase II contracts from MDA, which directed the company to design and test a driver technology that would improve the performance and lifecycle of laser diodes. The Phase II contract was extended in summer 2007 by one year, until June 2008, so the company could "take on manpower and work on the [high-energy laser] project," said company president Jonah Jacob.

Based upon what they had heard from MDA officials regarding the SBIR Phase II contract's success, planners of the high-energy laser project asked Jacob to contact a prime systems integrator, which needed a method to improve the lifecycle of laser diodes. SRL was awarded a subcontract to incorporate its solid-state driver technology into the system.

The defense industry is banking on SRL to deliver a driver that can increase the lifecycle of laser diodes and reduce the high associated costs. Jacob said that a 2.5-kilowatt laser-diode array costs between $25,000 and $30,000 for a stack of 600 diodes. A laser module typically uses about 80 stacks, which would put the total cost between $2 million and $2.4 million. A diode operated at high power lasts about 100 hours, or just over four days. But with SRL's driver technology, the same diodes could last for 1,000 hours.

SRL is considering expanding beyond the defense realm, into commercial markets that involve such applications as biomedicine, laser cutting, and laser welding. The biggest challenges facing the company in the commercialization phase will be gaining market acceptance and licensing the technology. Despite the plans, Jacob said tapping these markets may still be long into the future, as SRL is currently focused on the defense laser market.

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Molding Cost Savings

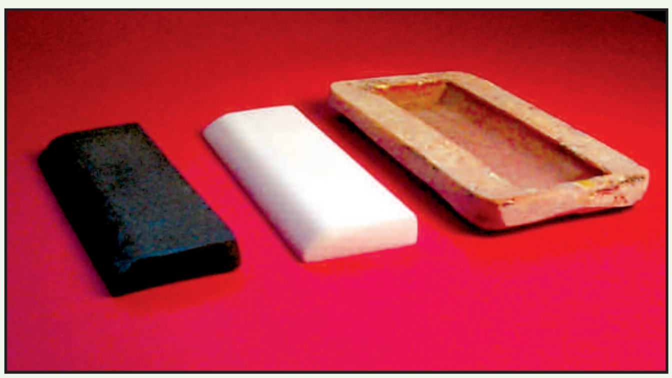
Tooling method could economize manufacture of auto parts.

by Joe Singleton/jsingleton@nttc.edu

Using a new MDA-funded tooling system, designers of prototypes and manufacturers of auto parts could reduce their costs and production times from a few weeks to a few hours.

A tooling system developed by Cape Cod Research, Inc. (East Falmouth, MA), uses a patented ultraviolet polymerization technique known as photomolding to create hard, ceramic-like copies of auto parts and prototypes of small tools. MDA funded Cape Cod Research with an SBIR Phase II contract to develop a system capable of composite prototyping, injection-mold fabrication, carbon-carbon composite tooling, and on-aircraft repair.

The manufacturing process is relatively simple. An original part is sprayed twice, first with a commercially available boron-nitride mold-release agent, followed by a thin layer of nanostructured ceramic material. After being sprayed, the part is subjected to UV light and polymerized. To make a mold, the part is placed in a tool bed filled with ceramic material, and the ceramic material is thermally cured. This entire process can be performed in about 15 minutes. Once cooled, the part is removed, with the resulting piece representing the female side of the mold. This process must be repeated to create the male side of the mold. A finished product can be delivered in hours, compared with the days required by conventional tooling houses.



▲ Cape Cod Research's composite tooling system uses a patented polymerization technique known as photomolding to fabricate small parts and prototypes such as the pieces shown in this photo.

Ceramic molds provide an advantage over steel molds in that the ceramic's coefficient of thermal expansion matches that of the composite part. With steel molds, the coefficients of expansion do not match, requiring the mold design to be a different size and shape than the composite part desired. With Cape Cod Research's tooling system, "the ceramic material on the surface is such that the polymers that you inject into this to make the part don't stick to it," said Myles Walsh, the company's president. "We still use a mold-release agent, but they basically don't stick to it. So you can use this mold over and over."

Even though the company's design resembles an all-purpose ceramic tooling system, Walsh said an individual tool bed will not be reused. "Once we make the tool, the tool is basically photocured, and it is rigid and is in the shape of just one part," he said. "You couldn't reuse the material." So the best-case scenario for Cape Cod Research's system is one that produces prototypes and small runs of replacement parts for automobiles—items that do not require mass production.

Cost savings are expected to be considerable over what machine shops generally charge. The average cost of having a simple mold created in a machine shop can run between $10,000 and $20,000. Walsh said his tooling system could reduce the cost to between $100 and $200, a hundredfold savings for the making of one part.

Though Cape Cod Research can build a tooling system that can cut cost and time, the company is still looking to find larger market acceptance. Walsh said it is difficult trying to build inroads and compete against the well-established plastics manufacturers in northern Massachusetts and the steel manufacturers in Pennsylvania.

While Cape Cod Research continues to build market inroads, it is also looking to restructure its mission, and pursue opportunities outside of the defense industry. The company transferred intellectual property for its composite tooling system to its sister company, ePaint, in early 2007, and ePaint now is taking the lead on commercial development and marketing of the product.

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A Revolution of Light from page 1

▲ An artist's rendering depicts the National Aquatics Center for the 2008 Summer Olympics in Beijing. Cree is providing the artistic LED lighting for the building.

LEDs that operate at lower levels of current can reach even higher efficiency levels.

None of these devices tested last year was made for commercial use. However, Cree will apply what it has learned from the experiments to improve its XLamp® line of LED products. For nearly a decade, Cree has been refining white LED technology in order to offer more efficient, longer-lasting, and cost-effective alternatives to traditional lighting sources.

Already, LED lighting products, including devices that emit colors such as red, green and blue, last longer than incandescent lightbulbs—burning for 10,000 to 50,000 hours, depending on their use. And not only do white LEDs function nearly 10 times as efficiently as ordinary lightbulbs, they also outperform halogen bulbs by at least four times, and they outperform some fluorescent bulbs by a factor of 1.5, according to Bernd Keller, general manager of Cree's Santa Barbara Technology Center in California.

Cree sees the efficiency and long life of LED technology, as well as accompanying energy savings, as top selling points. A wide array of customers have turned to LED systems for applications that range from automobile taillights to traffic signals to architectural lighting.

Still, the company is focused on producing less-expensive white LEDs that can send the incandescent lightbulb to the dustbin of history, and in the process capture a significant share of the general illumination market. The total addressable market for LED lighting systems is estimated to be about $18 billion, according to Keller.

The company is not alone in this pursuit. Several heavy hitters in the lighting industry—General Electric, OSRAM, and Philips—also are developing products to position themselves as dominant forces in the white LED business.

Converting blue into white

Cree's corporate roots lie in research conducted in the 1980s at North Carolina State University. Some of the early research included BMDO-funded programs for semiconductors based on silicon carbide and gallium nitride. Students involved in the research eventually formed Cree, and BMDO became one of the company's biggest supporters, awarding Cree three SBIR research contracts and one Innovative Science & Technology contract.

In 1993, the company went public and continued to grow, inventing and acquiring new technology as it expanded—including know-how that BMDO had funded elsewhere. In 2000, Cree acquired a company called Nitres, which one year earlier had received funding from BMDO to develop an indium-gallium-nitride-based white LED lamp that would operate more efficiently and last longer than state-of-the-art incandescent flashlight bulbs. The underlying technology did not pan out as originally hoped, but Cree treated the research as a learning experience, making it an "incremental step" in eventually producing white LED systems that are comparable in quality to established light sources, according to Keller, who worked on the project.

LEDs, solid-state semiconductors that convert electrical energy into light, have come a long way since they were first used for indicator lamps for consumer electronics and for illuminating small displays on mobile phones and other portable devices. The first LEDs on the market were red, followed by green and yellow. These colors can be created by a variety of semiconductor materials. (The materials regulate the wavelength and, therefore, the color of light emitted.) The key to producing white light, though, depended on the development and efficient exploitation of blue LEDs.

White light could be generated by combining emissions from red, green, and blue LEDs, although this approach is not favored by those making LED systems for the commercial market today, because of the difficulty in maintaining the consistency of three light sources. Rather, most white LED devices are made by covering blue LEDs with a yellow phosphor, which to the human eye gives the appearance of white light.

Some companies explored the use of sapphire as a substrate for the blue LEDs, while Cree, for its part, focused on silicon-carbide (SiC) semiconductor materials because they are elec-

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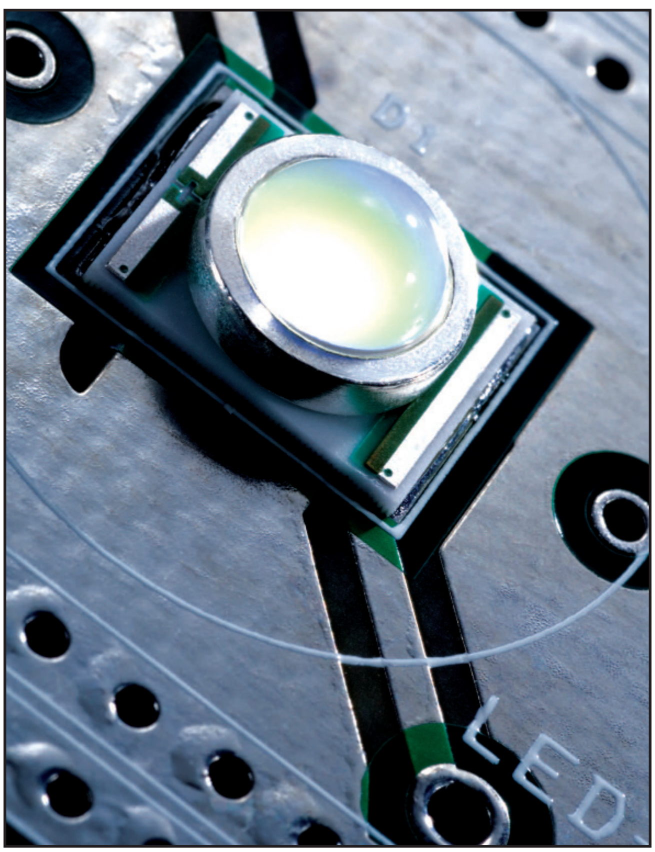
trically conductive and because they are better heat conductors. Cree uses SiC as a growth substrate, with gallium nitride (GaN) as the active blue-emitting lighting element on top. Much of the success to date in developing white LEDs can be attributed to advances in the performance of blue-light emitters.

From Durham to Beijing

In the LED business, Cree for most of its history was known mainly as a supplier of LED chips. Others packaged its chips into LED lamps, primarily low-power lamps used for applications such as backlighting mobile-phone displays. Three years ago, however, Cree decided it also would become a player in the business of producing high-power LED lamps for a variety of customers. The company developed its XLamp LED product line, including cool-white and warm-white LED components, as well as a range of colors. As for applications, these solid-state components can be used for personal and portable lighting, industrial lighting, emergency lighting on police cars and fire trucks, and the illumination of streets and parking areas.

Municipalities are particularly interested in white LEDs for street and parking illumination because they save money by employing longer-lasting and more energy-efficient lights. Cree's XLamp LED product line also is used in color-changing systems for mood and architectural accent lighting. In fact, Cree announced in October 2007 that XLamp LEDs would provide the artistic lighting for the National Aquatics Center at the 2008 Summer Olympics in Beijing. The building, known as the "Water Cube," will employ 444,000 color-changing XLamp LEDs to illuminate the bubble shapes that appear all along its translucent exterior.

Cree is also turning its own Durham headquarters and plant into a showcase for XLamp LEDs. In early November, the company announced plans to convert all the lights there to LEDs. White LEDs are now being used in Cree parking lots, entranceways, lobbies and conference rooms, and the company claims it has realized significant energy savings from the move.



▲ This photo shows a product from Cree's XLamp line of LEDs. General illumination applications for XLamps include portable and personal lighting, outdoor lighting, indoor directional lighting, and commercial lighting.

Shine it all around

Manufacturers such as Cree are trying to foment a revolution of sorts that one day will dethrone the incandescent lightbulb as the consumer's choice for home lighting needs.

Households and businesses alike are poised to reap the benefits of white LED technology. Not only can these devices save energy; they also are more environmentally friendly than some light sources because they do not contain lead or mercury.

But before the general public starts rushing to the local store to replace their old lightbulbs, manufacturers need to find ways of reducing the upfront costs of LEDs. Right now, it costs about $60 for a white LED lamp that produces similar light output to an inexpensive incandescent bulb, according to Keller. Cree's goal is to get that price point down and assist the lighting industry to reach a lamp price in the range of $10. Such a price shift should help make the case for switching to a better-performing product, said Keller, who added that a resulting ripple effect would open up new applications to the technology.

The majority of the cost for white LEDs is associated with the semiconductor itself, according to Keller. More experience working with the materials—and improving efficiency in the manufacturing process for LEDs—should in time lower costs. "With the incandescent lightbulb, you're looking at a system that has matured over 150 years or so," he said. "Here, you're looking at the learning cycle for white LEDs in the range of less than 10 years. It's really as simple as that."

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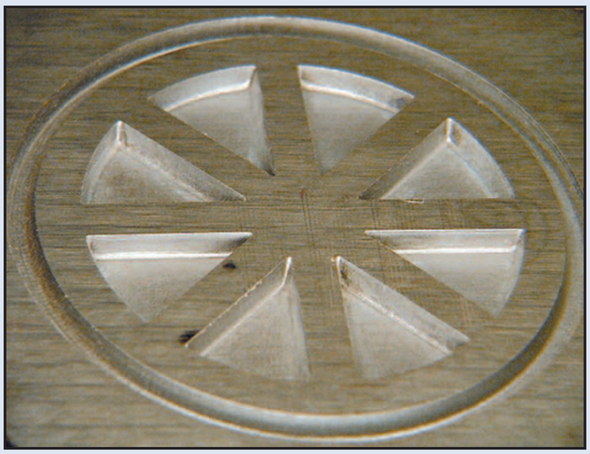

▲ Laser-machined silicon carbide.

Laser Micromachining for Mirror Fabrication

Laser micromachining offers the ability to machine products with significant automation while also requiring less post processing and enabling machining that is impossible with conventional equipment.

Mound Laser & Photonics Center (MLPC) is developing new techniques to use laser micromachining to produce objects such as mirrors and parts for medical devices. The company is unique in its approach to commercialization, as it aims to make 50 percent of its revenue through commercial services.

MLPC uses an 8-watt laser system that emits laser pulses only 10 picoseconds in duration. The time between pulses is adjustable down to 20 nanoseconds of separation. This laser system can machine features on the order of a few microns over a 12-by-12-inch area.

Diamond is GaN's Best Friend from page 7

As for a business model for the GaN-on-SOD technology, Aidala said the company likely would produce SOD substrates and sell them to manufacturers producing GaN devices.

Beyond the MDA project, the company has an existing line of diamond-based films and other products. Aidala said that the company's hot-filament CVD reactor, which sp3 sells as a commercial product, has been instrumental in developing materials for the MDA-related work. "There is very definitely a path for scalability, of even licensing both the IP and the know-how, and the equipment, if that appears to make sense for the company as a business path," Aidala said.

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A High-Performance Optical Challenger from page 3

all," said Dave Kane, Trex Advanced Materials vice president. "You can just walk though a silicon-carbide machine shop or polishing house and not even put a mask over your nose. It's an inert material."

Despite Trex's successful development of lightweight, silicon-carbide mirrors, the company still faces a few challenges, namely supply-chain management and cost increases due to a highly energy-consumptive process. The company is now in the process of transforming itself from what was an R&D company to a full-fledged production company.

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Capture is King

To win Federal business, do the heavy lifting well before the RFP.

by Doug Allen/dallen@schaferdayton.com

When pursuing Federal business, it's not enough to choose your opportunities wisely. You also must target opportunities well before the procurement process gets officially under way.

This concept of focusing early on potential business reflects an approach known as "capture management"—which must begin many months before writing the proposal for a Federal business opportunity. Capture management—essentially planning and managing the pursuit of a government project throughout its entire lifecycle, from pre-solicitation needs assessment to contract award—requires a focus on action, as opposed to a focus on a message (which is the approach to take when the capture process gives rise to actual proposal development).

An action-oriented strategy involves developing an understanding of the customer and its needs, developing an approach to fulfill those needs, ensuring that your approach is better than the competition, and communicating that to the customer—all before the customer publishes its procurement. (By comparison, the message-oriented focus of the actual proposal work involves showing compliance and responsiveness to stated requirements; describing offerings and showing benefits; substantiating claims; and defining how risks will be mitigated and how past performance issues will be resolved.)

Getting wise

The key to taking action in this capture-management approach is to understand the buyers and what they value. Know who will be involved in the procurement and proposal evaluations. Know their "hot buttons"—what is really important to them. Know what they want to achieve and why they want to achieve it. Also know their personal backgrounds and their knowledge base.

But go beyond understanding the frontline buyer. Understand who the key decision makers are. These people are the source-selection leads, the influencers, the champions—i.e., your customer's leaders. Also build a strong sense of the users (the service commands, the Federal agencies—your customer's customers). Define their needs and wants. Find out what capabilities they desire. But keep in mind that the level of their desire does not always match up with budget levels.

Wise company leaders invest resources early and use decision milestones to funnel opportunities. According to some studies, successful bidders regularly will spend more than half of their capture/proposal budget before the final RFP is released. Prior to starting the proposal, capture resources should be used to (A) understand potential customer's needs, (B) understand who your competition is and why they're your competition, (C) modify and/or augment your technology to meet customer needs and beat the competition, and (D) get the customer comfortable with your company and your solution. It is important to use decision gates along the way. If you determine that competitors' solutions are better or if the customer just likes another company better, focus your resources on different opportunities—the ones you expect to win.

Learning from mistakes

Even with extensive pre-planning, proposals can and do fail. The reasons are numerous. In many cases, the failed bidder did not understand its own weaknesses, or simply did not submit a proposal that was fully compliant. Many failed proposals result from not understanding the customer well enough. Examples include picking the wrong partners (who may have a poor history with the customer), proposing a higher-risk solution than the customer is comfortable with, pricing the effort too high, and selecting a program manager who doesn't meet customer expectations.

The lessons to be learned from the loss of such a campaign should be fairly obvious. In the pre-proposal realm, companies especially need to develop excellent customer relations early (at all levels) and improve competitive analysis. Other takeaways include ensuring that proposals are well written or, in many cases, realizing early on in the process that "no bid" is the right choice.

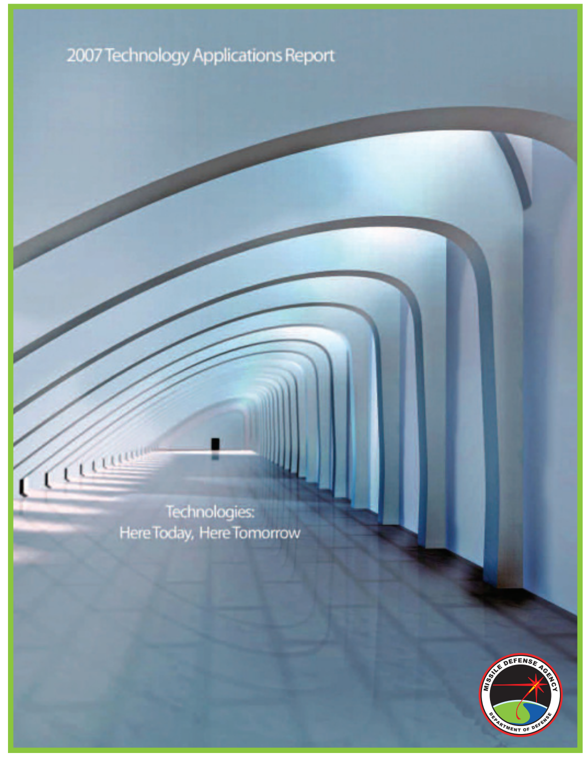
Legendary football coach Vince Lombardi said, "Winning is not a sometime thing; it's an all-the-time thing. You don't win once in a while; you don't do the right things once in a while; you do them right all the time. Winning is a habit. Unfortunately, so is losing." The same approach applies to capture management: Do the right things all the time. Don't wait for the RFP to come out before you start doing things right.

Doug Allen leads business development activities for Schafer Corporation and he frequently serves as a panelist for Technology Applications Reviews sponsored by the MDA TA program. He manages $200 million in contracts with the Air Force Research Laboratory and the National Air and Space Intelligence Center. He also has served as program manager for the Innovative Science and Technology program, providing systems engineering support to MDA predecessor BMDO.

Missing the Point from page 2

often pointing to a slide and saying something along the lines of, "This figure shows our X, and these lines show the Y, and this diagram represents Z," your slide has done a lousy job of speaking for itself. (Busy, intricate "eye chart" slides, with details the audience can barely see, almost always fail to convey meaningful information.) The slideshow is there to support you. You are not there to decipher the slideshow for your audience. Also, consider rehearsing the presentation beforehand and making an audio recording. Listen to the recording. If it makes sense without the visuals, consider yourself a good explainer. If not, you might want to rework your presentation.

Being a good explainer, whether in the pages of a newsletter or on a projector screen, is the key to stimulating interest in a new technology—interest that can lead to commercial activity. Good explainers move good technology forward. Bad explainers often move good technology nowhere. Making clear, clutter-free presentations filled with information that is relevant to the audience should be the goal of anyone who aspires to be a good explainer.



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