FALL 2003
ISSUE #47

# MDA Update

Linking American Businesses to Missile Defense Technology
www.mdatechnology.net

INSIDE



## Light Years Ahead —*by Tabatha Spitzer*

*MDA-funded companies endeavor to reduce the cost, size, and weight of space propulsion systems.*

Since the inception of the space program, sending payloads into space—whether for exploration, communication, or military use—has brought with it an expensive price tag.

From 1993 to 1997 the U.S. spent roughly $11 billion, more than $2 billion per year, on unmanned space launches.[1] Launching astronauts raises the price even more. Sending the space shuttle into space costs $470 million each time, according to Space.com.

Efforts are underway to develop new technology that reduces the cost of space propulsion systems. MDA-funded companies, Sierra Lobo, Inc. (SLI; Milan, OH), and Materials and Electrochemical Research Corporation (MER; Tucson, AZ), are involved in these efforts. SLI is developing a densified cryogen system that can safely store propellants as cryogenic liquids, thus reducing the size and weight of the storage system needed to hold them. MER is developing lower cost materials with high thermal conductivity for propulsion systems.

### Compressing propellants

Space technology has come a long way since the days of the Gemini and Apollo missions. New technology led to the inception of the space shuttle program in 1981 and the International Space Station in 1998, ensuring that human travel in space will continue. But achievements in space exploration often come with sacrifice.

The space shuttle program in particular has taught NASA and the Nation some of their hardest lessons. The explosions of the Space Shuttle Challenger shortly after launch on the morning of Jan. 28, 1986, and of the Space Shuttle Columbia while reentering the atmosphere on the morning of Feb. 1, 2003, reminded everyone that there is still a long road to travel.

NASA's Orbital Space Plane (OSP) initiative is an effort to replace the space shuttle with a new, safer space transportation system. SLI is working with NASA's Johnson Space Center in Houston to develop a densified cryogen system to fit the requirements of the OSP.

"The OSP embodies NASA's priority to transport Space Station crews safely, reliably, and affordably, while it empowers the Nation's greater strategies for scientific exploration and space leadership," according to NASA's Space Launch Initiative Web site.

Continued on page 15

Courtesy of Orbital Sciences

***Taking off.*** *With MDA and NASA funding, Sierra Lobo developed a densified cryogen system to store propellant. The technology is now being modified for use on NASA's Orbital Space Plane, a new, safer transportation system to replace the space shuttle.*

[1]Domenici, Pete. (June 25, 1998). Amendment No. 3028 to the National Defense Authorization Act for Fiscal Year 1999. http://www.fas.org/spp/military/congress/1998/s980625-dod-scorpius.htm.

MDA Update

**Editor**
Patrick Hartary

**Production Manager**
Lisa Hylton

**Graphics**
Lan Crickman

**Contributing Writers**
Adam Gruen, Patrick Hartary, Tabatha Spitzer, Scott Tillett

**Advisors**
Jamil Albertelli, Joel Price, Jeff Reynolds, Duane Zieg

The MDA Technology Applications program sponsors publication of the *MDA Update* to encourage the transfer of missile defense technology to American businesses and other government agencies.

Readers are encouraged to copy or reprint articles in the *MDA Update,* under the following conditions: Context is preserved and MDA is credited for providing the information. Our staff also requests that you send us a copy of any publication using information from the *MDA Update*, whether it does so in whole or in part.

Please address inquiries and mailing list corrections to:
**National Technology Transfer Center-Washington Operations**
2121 Eisenhower Avenue, Suite 400
Alexandria, Virginia 22314
Attn: Editor, *MDA Update*
Tel: (703) 518-8800 x500
Fax: (703) 518-8986
E-mail: pat@nttc.edu
Web sites:

- www.acq.osd.mil/bmdo/bmdolink/html/transfer.html
- www.mdatechnology.net

The *MDA Update* is written and produced for MDA by the National Technology Transfer Center-Washington Operations.

This project is sponsored by MDA. The content of the information does not necessarily reflect the position or policy of the Government; no official endorsement should be inferred.

FROM THE EDITOR

## IS THIS SPACE TAKEN?

Heads up NASA. MDA is headed into space, again.

Actually, I'm exaggerating quite a bit. Back in the 1980s, the Strategic Defense Initiative Organization (SDIO) was very interested in fielding space-based weapon platforms. And SDIO, perhaps better known then as the "Star Wars" program, pursued that goal by funding many advanced space technology concepts.

The mission changed when SDIO became the Ballistic Missile Defense Organization (BMDO). Space-based defenses were out. Terrestrial-based defenses were in. Missile interceptions were targeted for the upper atmosphere, just below outer space.

Today, BMDO's successor, MDA, still pursues some technology development for use in space surveillance and sensing platforms to detect and track enemy missile launches. For example, the Space Tracking and Surveillance System, now being developed, could benefit immensely from lighter, stronger composite materials. The MDA High-Altitude Airship, still on the drawing board, also could use technology originally designed for space, even though this unmanned lighter-than-air vehicle will operate in the upper atmosphere.

But until MDA rolls out its orbiting surveillance and sensing platforms, this technology won't sit on the shelf, inactive and gathering dust. Rather, NASA and a whole universe of companies with business and research interests that involve space could use it. Some already are.

The cover story of this issue highlights two MDA-funded companies—Sierra Lobo and Materials and Electrochemical Research—that are working on innovations in propulsion. One came up with a safer system to store larger amounts of cryogenic propellants. The other developed low-cost composite materials to make thick-section propulsion components that maintain thermal protection throughout.

On pages 4 and 5, we feature a two-page story on Touchstone Research Laboratory and its CFOAM® carbon foam, a new class of material like plastics. Among its many commercial applications, this coal-based material can be combined with another composite to provide lightweight spacecraft structural thermal insulation. Because CFOAM has a very low coefficient of thermal expansion, it also could provide a less expensive material for composite tooling in the aerospace industry.

On page 13, we detail a tube-joining technique, recently developed by The Technology Partnership, that holds better than traditional methods of bolting or gluing. Industries handling liquid oxygen and hydrogen could realize significant benefits with prestressed cryogenic piping and connectors.

Space may be the final frontier, but MDA's interest in this vast realm hasn't come to an end yet. In the meantime, with many of these space innovations on the launch pad, we're bound to see some good potential spinoffs blasting off soon.

Patrick Hartary
pat@nttc.edu

UP FRONT

## TA PROGRAM LAUNCHES NEW LOGO

Moving to boost public awareness of MDA technology transfer, the MDA Technology Applications (TA) program recently launched a bold new logo at the Space and Missile Defense Conference and Exhibition in Huntsville, Alabama.

The logo was approved by Paul Koskey, director of the TA program. This approval follows development, review, and editing by the National Technology Transfer Center-Washington Operations (NTTC-WO), which supports the TA program through a cooperative agreement with MDA.

The new logo will soon appear on all TA program literature, including this newsletter, the yearly *Technology Applications Report*, special applications reports, and other outreach publications. It will also be integrated with the TA program's conference booth and Web site (www.mdatechnology.net), which is currently being redesigned.

Key design elements include an overall contemporary look and the use of blue and green colors that are similar in hue to those featured in MDA's logo. The letters "T" and "A" are featured as word art, putting emphasis on the acronym, TA. The swish crosses both letters and ends with a burst, replicating the plume and successful hit of a missile interceptor and reinforcing the TA program's connection to MDA. The burst also symbolizes the essence of innovation, with the culmination of this process leading to a great idea.

The swish also depicts a "bridge" or "link" between the two letters. This aspect is further strengthened by the tagline located underneath the word "program." The tagline, "Linking Technology to Application," sums up what the TA program is all about. The TA program exists to help MDA *technology* developers find commercial and other government *applications.* It accomplishes this goal by creating links between those who develop the technology and those who are interested in using the technology.

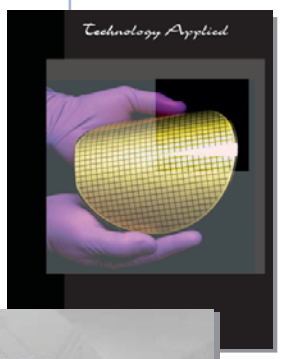
*"A recognizable identifier will help us focus our branding efforts," said Lisa Hylton, NTTC-WO outreach manager. "Our ultimate goal is to increase the overall awareness of the TA program within our target audience—users of MDA technology. We also want to create a memorable impression among other important groups, such as the media, the general public, and the technology transfer community as a whole."*

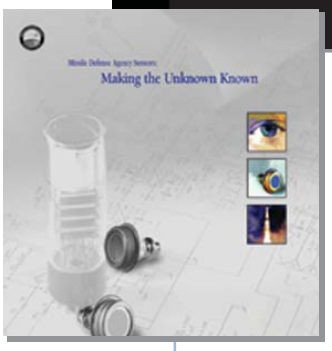
## FREE REPORTS HIGHLIGHT COMMERCIAL APPLICATIONS

The MDA TA program has developed three free reports that highlight many commercial applications of MDA-funded technologies.

- The *2003 Technology Applications Report* features 24 technology companies that have successfully commercialized their MDA-funded research in areas such as materials, computing, electronics, electronics processing, imaging, optics and photonics. (Code: TAR)
- Designed for first responders, such as fire, rescue, and law enforcement personnel, *Tools for Responding to Emergencies* contains information on 12 innovative MDA-funded technologies with emergency response applications. Technologies have been categorized into the following topic areas: detection and monitoring, information access, human protection, and support equipment. (Code: RESCUE)
- *Sensors: Making the Unknown Known* highlights 12 sensor technologies with a wide variety of both military and commercial uses. Some of these technologies include laser radar systems, focal plane arrays, accelerometers, and capacitance sensors. (Code: SENSOR)

To receive a free copy of any report, call (703) 518-8800, ext.239, or send an e-mail to pgroves@nttc.edu. Please provide your name, company name, mail and e-mail addresses, telephone number, and the code(s) of the publication(s) you want to receive.



ADVANCED MATERIALS

## CFOAM® HITS THE BEACH

*MDA funds studies for applications of a new coal-based carbon foam material.*

***Resistant to fire.*** *Pictured above are three different CFOAM-based composite panel structures that provide alternatives for fire-resistant walls or barriers. CFOAM appears as the blackened strip in the panels.*

Burn coal? You might as well throw money into the fire. In the future, the black stuff will have more value as building block than fuel. Converted into carbon foam, it can make just about anything from walls and bulkheads to space platforms, and can be used in a variety of advanced industrial applications from fuel cells to composite tooling.

Carbon foam is a new class of material like plastics. As with some carbon nanofibers and carbon nanotubes, the underlying source material for carbon foam—coal—is plentiful, inexpensive, and easily available. But up until now, carbon foam has been manufactured in a time-consuming, expensive, multi-step process. The breakthrough? An MDA-funded company, Touchstone Research Laboratory, Ltd. (Triadelphia, WV), has invented a proprietary process for making CFOAM® carbon foam cheaply and quickly. According to Touchstone president Brian Joseph, "We believe that our process is the least expensive way to make carbon foam material."

MDA is always interested in new, lightweight materials that can offer advantages in areas such as thermal protection or structural integrity. CFOAM, because of both its plethora of uses as well as lower cost, has the potential to improve dozens of industries simultaneously.

### What it is and how it works

Foam is all about internal microstructure: ligaments surrounding empty space. A beehive's honeycomb and a termite mound are good natural examples of foam-like structures. The properties of carbon foam depend upon three things: the length and width of the ligaments (which in turn determine the size of the cells); the chemical composition of the ligaments (how much carbon and additional trace elements); and how these cells are arranged (open or closed).

CFOAM carbon foam is a cellular foam. Its microstructure looks like sponge with stiff walls. This makes the material itself extremely strong. The Touchstone carbon foam-making process can vary the cell size, wall thickness, and the degree of openness of the cell structure. Similarly, the carbon foam is tailorable: it can be produced in a range of densities between 0.08 and 0.80 g/cm$^3$.

Touchstone can tailor CFOAM carbon foam properties with heat treatment. Under normal heat treatment, the foam becomes an electrical conductor, thermal insulator, fire resistant, and very strong. At higher temperatures the foam can be made to be more thermally and electrically conductive. Its ability to conduct heat can be increased through almost three orders of magnitude, and its electrical conductivity can be varied through more than nine orders of magnitude.

CFOAM carbon foam has desirable mechanical properties. It has high compressive strength and good shear and tensile properties. When it buckles, it does so predictably. Touchstone estimates that at higher densities its compressive strength can exceed 6,000 psi.

Yet another CFOAM advantage is that it can be machined, shaped, and finished fairly easily using conventional machine or wood-working tools. This is an important consideration for many engineers who may have very precise requirements for fitting parts to each other or for making molds.

Not all coals are alike. Coal has dozens of properties and each has some effect on the manufacturing process. Since 1998 Touchstone has studied and catalogued the effects that different kinds of coal can have on the final CFOAM carbon foam product.

### A thousand and one uses

Because CFOAM® carbon foam can be tailored with so many different properties, MDA's interest in the material is very broad-ranging. The agency awarded four SBIR Phase I contracts and one STTR Phase I contract to Touchstone in 2002 for three different application studies. "Think of CFOAM not as a product but rather as a technology base," said Joseph. "MDA's interest is to see how well CFOAM-based products can solve certain classes of problems."

One such problem is thermal protection for space applications. In combination with

Continued on page 5

ADVANCED MATERIALS

CFOAM® Hits . . . from page 4

Clemson University, Touchstone is working on an STTR contract to see how well CFOAM can work in tandem with other materials including MetPreg™, a fiber-reinforced aluminum also developed by Touchstone. This work examines how well the materials can provide lightweight structural thermal insulation for spacecraft. Another area of MDA interest is the ability of CFOAM to provide a large, relatively inexpensive space-based structure for optical components. The radar-absorbing qualities of a modified CFOAM are also intriguing, as is its potential use as structural material in aircraft.

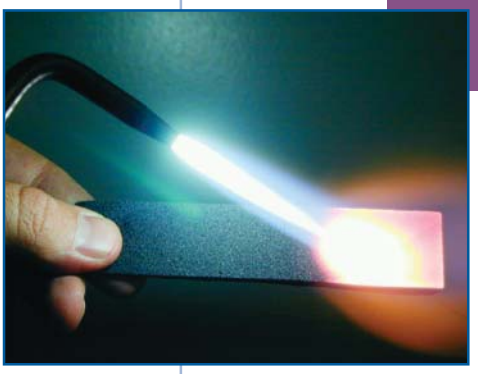
CFOAM carbon foam has a very low coefficient of thermal expansion. One of its most marketable applications is to provide a less expensive method for composite tooling in the aerospace industry. Making composite polymer matrix parts requires the use of a mold on which a part is shaped. If the mold changes in shape during the temperatures reached during a curing process, the part will be manufactured incorrectly. To prevent this, manufacturers traditionally have used a superalloy that is expensive and almost impossible to modify once the tool or mold is manufactured. CFOAM would be an inexpensive, easy-to-use, and effective substitute in composite tooling because it is easily shaped and matches the thermal expansion of carbon fiber pre-pegs.

As the scale of CFOAM production increases, its price would drop to a point rivaling or besting the price of other construction materials. Its impact on residential and commercial architecture is currently under study in cooperation with the U.S. Department of Housing and Urban Development (HUD). Strength, fire resistance and blast resistance offer unique properties for construction. If architects want to safeguard an office building from heat and blast, CFOAM might be a lightweight and reasonably affordable material means towards fulfilling that end.

This point was not lost on the U.S. Navy, which sponsored early research on CFOAM. Bulkheads, blast doors, and other ship components might all benefit from the unique properties of carbon foam. Still another application for CFOAM would be armor. And because CFOAM can be made electrically conductive, it can be useful in electrodes and fuel cell production.

It's no surprise that Touchstone has strong support from the state of West Virginia, whose economic development offices have an enormous interest in promoting the use of coal as an advanced technology material and fostering a new market for coal producers. Touchstone is expanding its pilot plant facility. The expanded facility will be capable of producing 170 tons of CFOAM per year by the end of 2003. Additionally, plans are in place for creation of a major plant that will produce 2.5 million pounds of CFOAM per year by the end of 2004.

—A. Gruen



***Torch this.*** *CFOAM, exposed to a 3,000°F acetylene flame, does not burn and provides excellent insulating properties.*

### Contact Information:

Gerrill Griffith
Touchstone Research Laboratory, Ltd.
The Millennium Centre
Triadelphia, WV 26059-9707
Tel: (304) 547-5800
Fax: (304) 547-5764
E-mail: cfoaminfo@trl.com
Web Site: www.cfoam.com

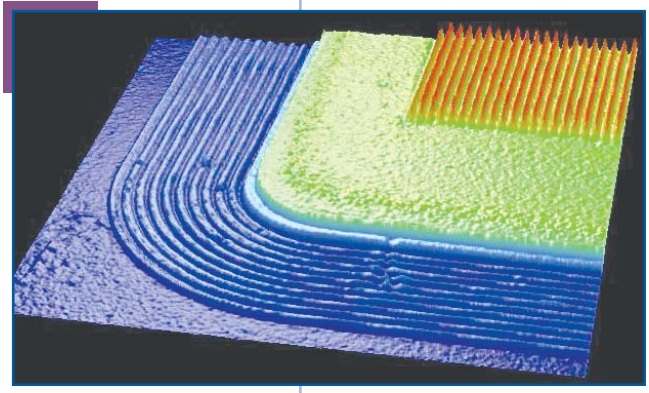
### MDA TECHNOLOGY NEWS ONLINE

Is this information below news to you?

- Pacific Advanced Technologies' gas-leak detector is featured in *Sensors* magazine.
- Boston Applied Technologies introduces the Eclipse Micro Variable Optical Attenuator.
- Picolight and IBM achieve unprecedented bandwidth density for optical data transmission.
- CoreTek members form new company, Ahura Corporation.

If so, be sure to visit our Web site at www.mdatechnology.net. Under the Corporate Tech News section, you'll find hyperlinks to more press releases from MDA-funded companies.

## SiC TO CUT TRANSISTOR BULK, COST



***Easier to make.*** *White-light interferometry is used to create an image of SemiSouth's SiC transistor, which is being developed with MDA SBIR funding. SemiSouth can make electronic SiC products in fewer steps than competing techniques, reducing production cost and time.*

Transistors for radar, high-power electronics, air-traffic control, and communications systems could be made more cheaply and could operate more efficiently with new technology being developed by SemiSouth Laboratories, Inc. (Starkville, MS)

SemiSouth, with funding from the Missile Defense Agency, is developing silicon carbide (SiC) transistors that could replace traditional silicon transistors in existing applications—cutting in half the size, weight, and costs of components. By helping to make such systems more affordable and more portable, the technology should deliver key benefits to users of equipment such as military radar systems, which have to be transported and assembled all over the world.

A transistor based on SiC can produce 10 to 100 times the power of a silicon-based transistor, according to SemiSouth. And SiC products also are considered further along in development than similar products based on gallium nitride (GaN), another high-performance wide bandgap semiconductor technology. SiC products transmit at up to 3 GHz, with some developers considering the technology useful up to 10 GHz. "Somewhere in that range is where it kind of runs out of steam, and then GaN takes over and goes to higher frequencies," said Dr. Jeff Casady, SemiSouth's president.

Meanwhile, Cree, Inc., another MDA-funded company, has released a metal-semiconductor field-effect transistor (MESFET) based on SiC geared toward radio-frequency (RF) devices. With RF technology, the role of transistors focuses on power amplification, and, like Cree's technology, the SemiSouth SiC transistor also will focus on power amplification. SemiSouth officials said, however, that their focus is on developing a product with higher power density.

SemiSouth's technology also will differ from other offerings in that SemiSouth is attempting to create a "vertical" technology—a single product with uses beyond RF. So SemiSouth's SiC transistor also should address power-switching needs in electronic circuits such as motor controls.

SemiSouth's processes—covered by patents and trade secrets—also boast time savings over competing SiC production methods. Casady said his company could produce SiC products in only six steps, compared with 13 steps in competing techniques—resulting in a time savings of about 50 percent. Fewer steps also mean lower costs, since SemiSouth has eliminated some of the more expensive steps from the process. Casady estimated cost savings at 60 percent of competing SiC production techniques. SemiSouth's transistor also should boast performance and efficiency of 25 to 30 percent over competing SiC techniques, when measured in terms of factors such as voltage gain, power gain, and power loss in switching.

SemiSouth also claims its processes can produce a higher yield—double the yield of current SiC process technology. Yield refers to the number of working parts on a wafer. Better yield should bring cost savings, according to the company.

The company continues development work on its transistor technology, with a focus on integrating the SiC epitaxy process into its fabrication process. SemiSouth is looking for strategic partners with abilities in marketing and product packaging. The company this fall will move into a new $4 million multitenant building, giving the company control of a 5,000-square-foot cleanroom where it can perform prototyping and manufacturing of transistors.

—S. Tillett

### CONTACT INFORMATION:

Dr. Jeff Casady
SemiSouth Laboratories, Inc.
One Research Boulevard, Suite 201B
Starkville, MS 39759
Tel: (662) 324-7607
Fax: (662) 324-7997
E-mail: jeff.casady@semisouth.com
Web: www.semisouth.com

ADVANCED MATERIALS

## UNEXPECTED DISCOVERY COULD YIELD COUNTERFEITING DETERRENT

They set out to develop tiny optoelectronic devices for faster, denser computing (see page 8). But researchers at Optodot Corporation (Allston, MA) came up with something far different: a new type of security marking that is virtually impossible to counterfeit.

This serendipitous discovery could significantly reduce product fraud, a prevalent and growing problem that results in worldwide losses of $1 trillion annually, according to Optodot. For example, a simple hand-held scanner could be used to examine suspect products. If the unique security mark is detected, the products are authentic. If not, they are potentially counterfeit.

The key to Optodot's security marking technology is a photochromic ink that is extremely sensitive to ultraviolet (UV) light. The ink is a multicomponent formulation that contains organic semiconductor material. While conducting MDA-funded research on optoelectronic devices, Optodot researchers unexpectedly discovered that electro-oxidation of this material causes it to change color and infrared transparency. This switching rapidly reverses in the dark. By adding certain polymers and additives, the same reversible color change was made to occur in response to UV light.

More specifically, when exposed to UV light, the organic semiconductor changes its color from a light tan to a bright blue and allows more infrared light to pass through it. When the light is removed, the material returns to its original color and infrared transparency.

"The photochromic ink shows excellent durability over time upon storage and repeated photochromic color changes," said Dr. Steve Carlson, Optodot's president. "It also is visually transparent, which makes it very attractive for use in overprinting of printed information."

For example, the photochromic ink, combined with an infrared reflective ink containing organic semiconductor material, can be applied by common ink jet or thermal transfer printing methods directly over bar codes and official documents, such as visas, passports, and driver licenses. The ink could also be used to create an invisible bar code on branded goods, currency, and financial documents to prevent counterfeiting. A simple scanning device would quickly detect this unseen security mark, providing clear evidence of authenticity.

The photochromic ink also could be adapted to measure incident doses of UV light. This capability would be useful in semiconductor lithography processes, which rely heavily on UV light for electronic chip making.

Optodot is showing its security marking prototypes to companies involved in anti-counterfeiting, such as those that handle identification cards, currency, bank documents, credit cards, and branded goods. It also spun off a new company, Edison Security Marking, to handle all commercial aspects of this technology. Optodot seeks inquiries from those interested in partnering to explore security and other applications of its photochromic ink.

—P. Hartary


***Blue to the rescue.*** *Counterfeiters will have a tough time duplicating Optodot's new security marking technology on personal identification cards. The security mark can be made invisible to the eye but visible as a blue rectangle under ultraviolet light, as shown above in the upper left corner of the driver license.*

### CONTACT INFORMATION:

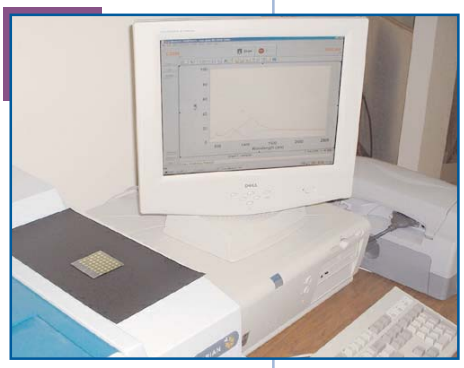
Dr. Steve Carlson
Optodot Corporation
214 Lincoln Street, Suite 305
Allston, MA 02134
Tel: (617) 562-0800
Fax: (617) 562-0811
E-mail: scarlson@optodot.com
Web: www.optodot.com

***"A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty."***

**—Sir Winston Churchill**

OPTOELECTRONICS

## OPTODOT SEEKS ORGANIC FUTURE FOR OPTOELECTRONICS



***On the bench.*** *Researchers at Optodot are developing organic semiconductor materials that could lead to organic optoelectronic circuitry. Tests of the materials show that active semiconductor regions can be reduced to about 1 micron.*

Optodot Corporation (Allston, MA) has demonstrated the performance and miniaturization of organic semiconductor thin films necessary for future optoelectronic devices. The breakthrough materials technology ultimately could lead to organic optoelectronic circuitry—an essential building block for super-high-speed optical computers and networks.

In 2002, MDA awarded Optodot an SBIR Phase I contract to show that its proprietary organic semiconductor material could be used to build optoelectronic devices, including modulators.

Thin-film layers of anode and cathode materials on a substrate were created. Sandwiched between these layers was an active organic semiconductor region on the order of 1 micron. This area is roughly 700-times smaller than that found in indium phosphide modulators and 25,000-times smaller than that found in polymer-based and lithium niobate-based modulators. Tests of the material showed very high speeds, low energy photo-optic switching, low electro-optic switching voltages, low insertion loss, and excellent stability.

During this early research, Optodot made an unexpected discovery. Electro-oxidation of the organic semiconductor material causes it to change color and infrared transparency. This switching rapidly reverses in the dark. The same reversible color change was made to occur in response to ultraviolet light. This serendipitous effect has been exploited in the form of an organic semiconductor-based photochromic ink that could be used to tag products and documents with security marks that are virtually impossible to counterfeit (see page 7).

In 2003, under an MDA FasTrack SBIR Phase II contract, Optodot began work on developing prototype organic modulators and photo detectors. MDA funded this SBIR research because it may lead to smaller, faster, and cheaper computer chips in the future.

"We believe that organic semiconductors could provide the breakthrough materials technology for optoelectronic devices," said Dr. Steve Carlson, Optodot's president. "We envision a wide variety of military and commercial applications."

For example, organic modulator and photodetector devices would enable board-level optical interconnects that could alleviate the ever-tightening electrical interconnection bottleneck and could provide greater computational power for military and commercial uses. Integrated into a transceiver module, they could be used for free space and waveguide interconnections and for on-chip, inter-chip, inter-board, and inter-box connections.

These smaller, high performing organic modulator and photodetector devices also could be used in nonintegrated optical transceivers and optical interconnects for low-cost optical communications, particularly for metro/regional and local optical networks. Currently, over 90 percent of the modulators used in communication networks today are lithium niobate interferometric modulators, and they are much too large and expensive to meet the requirements and industry specifications for 10-GHz communications in metro and local applications.

Optodot is working with a large U.S.-based optoelectronics manufacturer to build organic modulator and photodetector prototypes. Together, the two companies plan to commercialize this technology. Inquiries from potential customers are sought.

Optodot has significant financial backing to support its technology development efforts. Seed Capital Partners of Buffalo, NY, an early-stage investor affiliated with Japanese Internet investor Softbank, has invested over $1 million. CRE Investments also has made a sizable financial investment.

—P. Hartary

### Contact Information:

Dr. Steve Carlson
Optodot Corporation
214 Lincoln Street, Suite 305
Allston, MA 02134
Tel: (617) 562-0800
Fax: (617) 562-0811
E-mail: scarlson@optodot.com
Web: www.optodot.com

OPTOELECTRONICS

## POLARIZATION TECHNOLOGY READY TO SHINE

Light has three characteristics, but many people can only name two of them: intensity (brightness) and frequency (color). The telecommunications industry has known about the use of the third—polarization—for some time. Now, the imaging industry is about to take notice.

With funding from BMDO (now MDA) and the U.S. Air Force, Optellios Inc. (Ewing, NJ) has developed a single-pixel device that can not only integrate information about the polarization, brightness, and color of incoming light, but also rapidly adjust a filter to admit different frequencies. In the past, similar devices created by Optellios and others have only been able to look at one light frequency. If the company can overcome non-uniformity problems caused by scaling the technique to a large surface area of coated glass, it will have developed the world's first commercial rapidly tunable polarization camera.

In research sponsored by the USAF, Optellios had already proved a method whereby a single pixel could measure both polarization and wavelength simultaneously, but only in the infrared frequency range. Desiring more flexibility to examine the rest of the spectrum, BMDO awarded Optellios a 2001 Phase I SBIR contract to demonstrate the feasibility of creating a tunable or wavelength-agile polarimeter at a single-pixel level. In 2002, MDA awarded it a Phase II follow-on contract to develop and test a complete wavelength-agile polarization imaging system with an aperture of 0.5 to 1.0 inches in diameter.

The Optellios wavelength-agile single-pixel polarimeter works on the principle of a tunable Fabry-Perot wavelength filter. Instead of moving two parallel dielectric-coated glass plates closer together or wider apart (to change the wavelength that can pass through both), the plates are a fixed distance apart, and the gap between them is filled with a liquid crystal that changes its index of refraction when voltage is applied. By varying the voltage, engineers can tune the wavelength filter at high speeds to allow different frequencies to pass through.

Optical components in single-pixel polarimeters are small. Scaling the technique larger could be a problem. Even the tiniest of wrinkles in an otherwise smooth surface can create non-uniformity distortions. The new challenge, still under investigation, is to create a multi-pixel polarimeter effect over a large aperture area.

The potential for spectral-polarization imaging is huge, because polarization is a characteristic of light that, up until now, has been almost completely ignored for imaging purposes. Polarization cannot be seen by the human eye, but it is there and it reveals information about its reflected light source. Any industry that uses cameras could find some potential benefit in imaging systems that can reliably and efficiently incorporate polarization information as well. For example, transportation departments worldwide could benefit from ice detection on roads in thick fog conditions. Other industrial sectors that could benefit would include microscopy, security, gas detection, geologic survey, precision agriculture, tool machining, and medical scanning equipment.


***Shine on.*** *Optellios' polarization imaging system is based on an off-the-shelf infrared camera.*

There is also a military application for spectral-polarization imaging related to target acquisition and identification. Decoy methods that might work against cameras and sensors equipped for measuring light intensity and frequency would fail against imaging systems also measuring different kinds of polarization effects. Optellios seeks a commercial partner, perhaps a company currently working in defense or homeland security-related areas, to help further explore and investigate the possibilities inherent in leveraging what was formerly a telecommunications technology into the area of imaging.

—A. Gruen

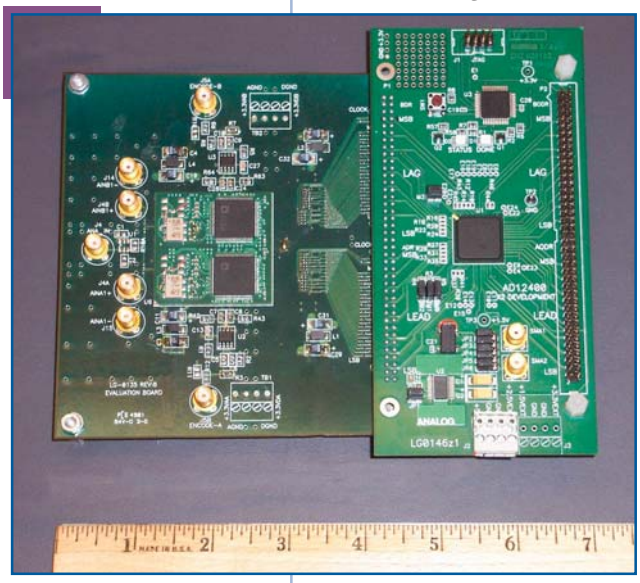
### CONTACT INFORMATION:

Dr. Jay S. Patel
Optellios Inc.
250 Philips Blvd. Suite 255
Ewing, NJ 08618
Tel: (609) 671-9800
Fax: (609) 671-9801
E-mail: jpatel@optellios.com
Web: www.optellios.com

SIGNAL PROCESSING

## MORE HORSEPOWER FOR YOUR DIGITAL DATA CONVERSION

Analog data processing is painstakingly cumbersome. The job is much easier if the data is converted to digital form, processed, and, in some cases, converted back to analog. That's the idea behind analog-to-digital data conversion, which has brought tremendous speed and accuracy gains to radar and wireless communication systems.



***Need speed?*** *V Corp's signal processing technology could provide an 8-fold increase in the speed of analog-to-digital conversion. Pictured above is the company's prototype hardware developed with MDA SBIR funding.*

V Corp Technologies, Inc. (Carlsbad, CA), is developing a variation of this technology that could provide up to an 8-fold increase in the speed of analog-to-digital conversion while maintaining high-resolution, wide dynamic range performance. V Corp already has proven the feasibility of its analog-to-digital converter (ADC) by demonstrating a working prototype with a 340-MHz sample rate, 12-bit resolution, and direct intermediate-frequency sampling. A compact prototype module with a 400-MHz sample rate and 12-bit resolution is expected to be available within the next year. Current ADCs typically offer 200-MHz sample rates, 12-bit resolution, and baseband sampling only.

V Corp's ADC incorporates two proprietary digital signal processing algorithms. The Advanced Filter Bank (AFB™) algorithm uses time-division multiplexing to split the input to each ADC in the array. It also uses multirate digital filters to reconstruct the digitized signal. This multirate digital filtering in the AFB significantly improves the speed and resolution of the conversion by attenuating the effects of analog mismatches, such as gain mismatch, phase distortion, and other variations.

The Linearity Error Compensator (LinComp™) algorithm is used to predict nonlinear distortion (e.g., harmonic and intermodulation) and to subtract out the linearity errors. LinComp can improve dynamic range by up to 24 dB, enabling very accurate conversion and synthesis of data at high intermediate frequencies with very high sample rates.

The ADC itself consists of a parallel array of individual ADC chips, a field programmable gate array (FPGA), and various support electronics. The algorithms are designed to allow existing ADC components to be replaced with higher performance versions as they become available, further increasing speed and resolution. "This allows our technology always to be two steps ahead of the competition," said Dr. Scott Velazquez, V Corp's president.

Through SBIR contracts, MDA is funding V Corp to develop the ADC technology for battlefield communication applications. In Phase I, V Corp successfully integrated its AFB technology into a Harris Corporation advanced all-digital multiple beamforming array receiver for theater ballistic missile defense. In Phase II, V Corp is working with the U.S. Navy at China Lake to test the new system in an operationally relevant environment. MDA is particularly interested in increasing the speed and resolution of this beamforming array receiver.

V Corp is collaborating with Analog Devices, a semiconductor manufacturer, to build and demonstrate the ADC. Analog Devices is contributing funding and technical expertise for the MDA SBIR Phase II effort. Eventually, V Corp hopes to license the technology to Analog Devices for use in multiple product lines.

The company also is looking for customers who can license the ADC technology. High-speed, high-resolution analog-to-digital conversion is needed in a wide variety of military and commercial applications, including radar, wireless communications, test equipment, Global Positioning System receivers, wide-bandwidth modems, and software radios.

—P. Hartary

### CONTACT INFORMATION:

Dr. Scott Velazquez
V Corp Technologies, Inc.
P.O. Box 130582
Carlsbad, CA 92013
Tel: (760) 931-1011
Fax: (760) 454-4692
E-mail: info@v-corp.com
Web Site: www.v-corp.com

SIGNAL PROCESSING

## OPTICAL MEMORY MATERIALS TO ALLOW HIGHER-BANDWIDTH RADAR AND DATA APPLICATIONS

New optical memory technology under development at Scientific Materials Corporation (Bozeman, MT) could allow radar systems to process higher-bandwidth data, yielding more information about targets. The technology involves specialized materials and a technique known as spectral holeburning, and company researchers say their current undertaking marks the first time such materials will be incorporated in a commercial-grade project.

Scientific Materials' technology centers on materials that it developed with funds from an MDA SBIR Phase II award. Company researchers, in collaboration with scientists at Montana State University, will incorporate the materials into a prototype information processor for radar systems. Officials say the project is significant because it represents the first application of high-quality, commercial-grade spectral holeburning materials in a real-world information-processing scenario.

For radar, faster processing is important because systems increasingly must handle many stages and sources of information—initial encoded radar pulses, analog information returned from the pulse, correlation of the transmit and return signals, conversion of that information to digital form, and, finally, analysis of that digital information. The tasks are difficult to do at high bandwidth, thus many signal processors working in radar systems today operate only in the range of hundreds of megahertz. The Scientific Materials-Montana State University team has demonstrated 3 GHz signal processing in the laboratory, promising higher-resolution radar systems that can provide users with information and radar analysis in real time. "You are able to process information at a higher bandwidth, which means higher time resolution," said Randy Equall, research director for Scientific Materials.

Equall added that the company's innovation lies in its ability to produce ultra-high-quality materials and engineer their properties to meet the specific device requirements. For example, to meet bandwidth requirements in signal processors, the company can tailor or "broaden" materials suited for 1 GHz processing into materials that can be used for processing at 3 GHz.

The optical memory materials created by the company are based on rare-earth doped crystals that provide high-bandwidth storage and processing capabilities through a technique called spectral holeburning. If the material is exposed to laser light at a certain frequency, a spectral hole is burned—that is, the absorption at only that frequency is reduced.

The change in the ions can be short-term or long-term, depending on the materials used, and is chosen to match the signal-processing requirements of a given application. The approach allows the spectrum of each radar pulse to be processed and stored optically in the material with high resolution. Thousands of such spectra, each containing more than 100,000 spectral channels, are summed in the material at each laser spot. Researchers expect their new optical materials will lead to processors for data bandwidths up to hundreds of gigahertz.

MDA funded the technology for target identification, and the technology should prove useful in military and commercial radar systems. The company's high-bandwidth materials also could bode well for users who must store and process massive amounts of information—detailed records of consumer financial transactions or medical records, for example. Officials at Scientific Materials expect such data-storage applications will be limited to high-end uses.

Scientific Materials holds its research as a trade secret. Meanwhile, Montana State University holds some patents related to the collaborative project involving the company and the university. Scientific Materials continues to search for pilot users or development partners who are users of radar technology.

—S. Tillett

***Rare finds.*** *Scientific Materials produces a variety of rare-earth doped oxide crystals, with the most promising ones for signal processing being yttrium aluminum garnet and yttrium orthosilicate doped with thulium and erbium.*

### CONTACT INFORMATION:

Randy Equall
Scientific Materials Corporation
310 Icepond Road
Bozeman, MT 59715
Tel: (406) 585-3772
Fax: (406) 585-8606
E-mail: rwesm@montana.com
Web: www.scientificmaterials.com

STRUCTURAL CONCEPTS

## ENCAPSULATED POWDERS REPLACE BERYLLIUM IN DEFENSE PARTS

***Killer replacement.*** *Powdermet has developed technology to create magnesium graphite-based encapsulated powers to replace highly toxic beryllium in parts for defense systems. Pictured above is a small magnesium graphite disk made with the powders.*

A decades-long need for a material with the same valuable traits as beryllium (Be)—without the deadly toxicity—is now being answered in highly uniform encapsulated, or coated, powders.

MDA funded Powdermet, Inc. (Euclid, OH), to develop new materials that can replace Be used in defense parts. The National Science Foundation and the University of California-Davis provided additional funding. Powdermet is currently manufacturing magnesium graphite encapsulated powders to replace Be mirror backings and electronic enclosures in MDA's exoatmospheric kill vehicle (EKV). Raytheon will be testing the parts to ensure they fit the EKV requirements.

Powdermet's encapsulated materials offer the same attributes as Be—light weight, high stiffness, and good thermal conductivity. In the MDA project, Powdermet is fabricating magnesium graphite (50 percent magnesium and 50 percent graphite) to replace Be. When the magnesium graphite powders are consolidated, the end product is a part having 1.8-g/cm$^3$ density with 35,000-psi tensile strength and more than 120 Watts per meter-Kelvin (W/mK) of thermal conductivity, fitting the requirements for EKV electronic enclosures. MDA's goal is to replace all Be parts in the EKV with a safer and substitute material with comparable characteristics.

Powdermet's process replaces current powder mixing and blending operations with their fluidized bed chemical vapor deposition process. This process blends materials at the atomic, rather than the particle level, improving uniformity and performance at approximately the same cost as alternate blending techniques. Powdermet's encapsulated powders combine lightweight metal behavior with ceramic stiffness. Components made from these powders have a high modulus of up to 35 Msi combined with metal-like ductility exceeding 4 percent. To accomplish this, Powdermet controls the phase distribution, composition, and chemical interactions of the material during processing; this atomic level of control enables optimized microstructures to be produced resulting in a 30 to 50 percent increase in material properties.

Currently, Powdermet's primary commercial sales are for coated carbide particles, which are formed into parts by outside vendors. For instance, one customer is utilizing a boron carbide thermal spray powder developed by Powdermet to increase the wear life of its paper rollers by 400 to 700 percent. In a related joint effort with Caterpillar Inc, Powdermet developed a composite coating that wears five times slower than the current chrome based coating, while simultaneously providing a lower coefficient of friction.

Additionally, a strategic investment by Kennametal Inc., a Pennsylvania-based advanced materials supplier, has enabled the company to expand into a 54,000ft$^2$ production facility in Euclid, Ohio and install a fully automated powder production line. This new equipment and added space will increase Powdermet's capacity from hundreds to thousands of pounds per day, while reducing product variability. In return, Kennametal has received the right to exclusively develop and distribute Powdermet technology in specific market sectors.

An advanced materials company, Powdermet focuses on the research, development, sales, and services of coated powders and technologies. The company seeks partners to explore new applications of its encapsulated powder technology.

—T. Spitzer

### CONTACT INFORMATION:

Andrew Sherman
Powdermet, Inc.
24112 Rockwell Road
Euclid, OH 44117
Tel: (216) 404-0053, ext. 103
Fax: (216) 404-0054
E-mail: powdermet@earthlink.net
Web: www.powdermetinc.com

***"Every day I get up and look through the Forbes list of the richest people in America. If I'm not there, I go to work."***

**—Robert Orben**

STRUCTURAL CONCEPTS

## PRESTRESSED CONFORMAL CONNECTOR MAKES A TIGHT SEAL

The weak link between two pieces of pipe, as any plumber knows, is often the joint or fitting that holds them together. This is especially true for composite polymer matrix pieces, where traditional methods of bolting or gluing don't work very well. A recently developed technique solves that problem, however, and gives engineers a quick, lightweight, and efficient way to use composite polymer piping to handle liquids at cryogenic temperatures.

With funding from BMDO (now MDA) and the U.S. Air Force, The Technology Partnership (Grosse Ile, MI) has invented and patented a technique of prestressing cured polymer matrix pipe to prevent embrittlement, shrinking, or cracking at cryogenic temperatures. This invention opens up the possibility of significant weight savings in aerospace applications including rocket engine ducts and lines, and conventional piping carrying fuel or corrosive chemicals.

In 2000, MDA awarded The Technology Partnership an SBIR Phase I contract to model, fabricate, and evaluate fixed and expansion dynamic polymer composite (DPC) cryogenic connectors against equivalent flanged and bellow members. The company did so and in 2001 was awarded a Phase II follow-on contract to use space-qualified materials to develop and test a series of connectors designed and scaled for actual rocket engine components. Subsequently, in 2002 MDA also awarded the company a new Phase I SBIR to study the effectiveness of prestressing actual lines and ducts.

Prestressing cured composite polymer pipe is achieved by filament-winding a high-modulus fiber at high tension around a length of pipe. The added fibers are prestressed to approximately 50 to 80 percent of their maximum strength. The University of Dayton Research Institute retrofitted a single-fiber winding machine with a high-strength tensioner arm to make prototypes for testing.

Cutting off a short (12- to 16-inch) length of that cured polymer pipe can also produce what is called a conformal connector. The connector slides over two pieces of pipe (which can be metal, metal alloy, or any other material) and then is heated. This is a design configuration innovation that is independent of materials. Since the connector is already in prestressed tension, when its polymer matrix is heated, filament tension forces it inwards. The polymer matrix, acting like putty, fills every available pore and microcrack, and when the connector cools, it seals the two pipes perfectly with no gaps.

During research originally performed in 1994 for the U.S. Air Force relevant to the all-composite airframe, company engineers discovered that prestressing a composite polymer matrix counteracts polymer embrittlement which occurs at low temperatures in the -183 to -253ºC range. Subsequent MDA-funded research proved that prestressed polymer composite connectors can be used as fixed or expansion joints up to 4,500 psi at cryogenic temperatures. DPC connectors can be used as lightweight replacements for metal alloy bellows. Using the same basic technique of prestressing pipe, the company also demonstrated that DPC pipe could replace metal pipe in cases where no fittings are needed.

***Secure fit.*** *Prestressed conformal connectors developed by The Technology Partnership seal two pipes perfectly.*

Industries handling liquid oxygen and hydrogen would benefit from prestressed cryogenic piping and connectors. Such industries include aerospace and missile launch platforms and facilities, as well as airbases and airports desiring to store fuel at cryogenic temperatures. There is also a potential application for the Airborne Laser program, which might benefit from reducing the weight of its high pressure coolant lines.

To produce literally miles of cryogenic piping and connectors, The Technology Partnership, or one of its commercial partners or customers, must build a high-strength tension arm for a single-fiber winding machine that can withstand the rigors of mass production. The company invites interested parties to inquire about the unique capabilities of this technology.

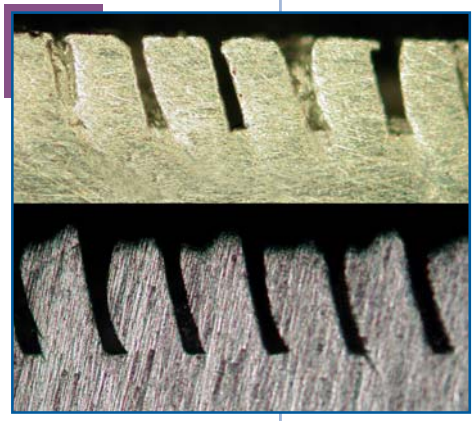
—A. Gruen

### CONTACT INFORMATION:

Mr. David Bettinger
The Technology Partnership
8030 Coventry
Grosse Ile, MI 48138-1119
Tel: (734) 675-8295
Fax: (734) 675-8296
E-mail: techpart@comcast.net

THERMAL MANAGEMENT

## PRECISION COOLING USING CRYOGENIC VARIABLE CONDUCTANCE HEAT PIPES



***Getting the groove back.*** *Clogged grooves (top) degrade heat pipe performance. Engineers at ETA discovered how to mill them more precisely (bottom).*

There are some machines, such as antenna arrays or sensor systems, that need to operate within a very narrow range of temperatures and can't afford to get too hot or too cold. What a designer of those same machines sometimes really wants is a feedback mechanism that can remove heat from a source at a variable, not fixed, rate without vibration and noise. In short, something like a variable conductance heat pipe (VCHP).

With BMDO (now MDA) funding, ETA, LLC (ETA; Hauppauge, NY), designed, built, and successfully demonstrated that a monogroove heat pipe could be used effectively as a variable conductance device for precise temperature control of sensor systems operating at cryogenic temperatures. Although fixed conductance heat pipes using monogroove designs have been tested for use on other programs, up until now no one had demonstrated that the variable conductance technique could work for systems operating at approximately 220K. The technology could be useful for cryogenic cooling of space-based antenna arrays and infrared sensor systems, reducing by 50 to 70 percent the mass, volume, and fuel consumption of their cooling systems, and eliminating the vibration problems often created by mechanical cryocoolers.

Heat pipes provide a big advantage over mechanical cryocoolers because the vibration associated with pumps is eliminated. The advantage of the monogroove design over one with axial grooves is that a single groove provides maximal heat transport with minimal fluid charge, thereby reducing ambient pipe pressure.

There is a catch, however. A two-phase thermal loop must be very precisely controlled, or it suffers dryout and stops working. The combination of materials—the pipes themselves and the fluid being used as the coolant—is critical.

When ETA engineers first tested their trial equipment, they noticed that the results didn't match with their predictions. They were getting dryout. Puzzled, they discovered the grooves were not very precisely milled. Debris had collected in the grooves like leaves in a gutter, disrupting or blocking the flow of coolant and reducing or eliminating the effectiveness of the heat pipes.

A combination of methods including doing "double pass cutting" and using lubricant to carry away debris as it formed solved the problem. At that point, they ran some tests again and demonstrated that a simulated transmit/receive module could be maintained within a ±3K temperature band under varying environmental and heat load conditions. A second monogroove VCHP test article was built and tested; it was designed to transport about 4.6 watts in the 30 to 40K range using neon as the working fluid in a stainless steel envelope.

In 1996, BMDO awarded an SBIR Phase I contract to ETA to examine the use of VCHP technology for cryogenic applications where temperature control of sensitive components (such as IR sensors) was required. In 1997, BMDO awarded a new SBIR Phase I contract to the company to prove that several cryocoolers could effectively operate on one heat pipe circuit, with overall cooling system weight savings. In 1998 these two ideas were combined, and BMDO awarded the company a single Phase II contract to prove that multiple VCHP modules could effectively cool two demonstration systems, a 220K active aperture radar antenna and a 35K IR sensor.

What's a VCHP good for? In the future, satellites and other space-based platforms hosting cameras and telescopes, as well as ground-based sensor arrays, will be even more powerful. They will need both low vibration and improved thermal management within a very narrow operating range of temperatures. The variable conductance aspect of a heat pipe is what makes it a desirable design choice to provide near constant temperatures even with the high heat flux loads of modern electronics.

—A. Gruen

### CONTACT INFORMATION:

Joseph Alario
ETA, LLC
17 Holiday Park Drive
Hauppauge, NY 11788
Tel: (631) 361-6967
Fax: (631) 361-6034
E-mail: joea21@optonline.net

FEATURE

Light Years Ahead from page 1

The OSP will support four U.S. astronauts and contingency cargo and be safer than the space shuttle or the Russian Soyuz. It should allow for more in-orbit maneuverability, be easier to process, launch, and land, operate autonomously, and minimize operations and life cycle costs.

MDA and NASA funded SLI to develop a cryogen system that can store a variety of fluids at different temperatures for a long period of time with zero boiloff. MDA had plans to use the system in the Space-Based Laser (SBL) program, but that project has since stalled.

Currently, SLI is developing a system for NASA's OSP. SLI's system will store propellants as densified cryogenic liquids, which reduce the size and weight of the storage system needed to hold them. SLI's cryogen system increases the density of cryogen liquids for maximum storage and delivery performance in zero gravity. Normally, cryogenic fluids in space are stored at normal boiling point temperature, which is still cold but it can be colder. SLI found that when the density of the fluids is increased, more can be stored onboard, and the whole system gets smaller and lighter—important benefits when mass is at a premium.

The system enables higher delivery rates by virtue of the increased density of the cryogen. Using SLI's densified cryogen storage system also enables the propellants to fire longer. The densified cryogen propellants allow for the use of 20- to 50-pound per square inch (psi) tanks, which are safer especially with highly toxic propellants, instead of 6,000-psi tanks. A patented sensor system, Cryo-Tracker™, operates inside the storage tanks to simultaneously gauge the fluid amount and temperatures and ensures there is no boiloff.

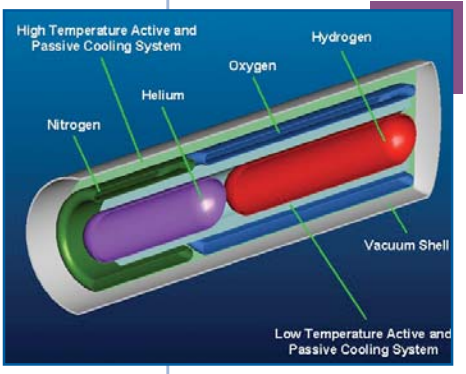
SLI's system is capable of minimizing environmental heat leakage and eliminating boiloff in a zero-gravity environment, representing a significant cost savings and a reduced environmental impact. A wide variety of current and future aerospace vehicles, orbital platforms, orbit transfer vehicles, lunar/Mars missions, and other missions requiring long-term storage and utilization of cryogenic liquids can benefit from SLI's system. SLI needs funding to build a testbed of specific configurations to test the cryocooler system. The company would also like to offer the testbed to the aerospace community for testing a variety of different cryocooler concepts.

### Making propellant systems lighter

While it will not be shuttling people to the moon, MDA also needs advanced, cost-saving space technologies. Thus, it funded MER to develop lower cost materials for propulsion systems.

MER has developed two low-cost composite materials—carbon-carbon (C-C) and carbon-silicon carbide (C-SiC)—for use in rocket propulsion systems. The company is using its low-cost, high thermal conductivity composites to replace much more expensive needled composites currently used in propulsion systems.

Currently, several aerospace companies are developing high-temperature components for missile propulsion systems using MER's complex carbon shapes. The material costs an order of magnitude less than those currently used in missile nozzle and attitude divert systems in missiles.




***Space saver.*** *Sierra Lobo's densified cryogen storage system holds more propellant in smaller tanks. As a result, the entire system is smaller and lighter—important benefits when mass is at a premium.*

MER uses two different processes to create its composites. In the first process, using P30X, which is a pitch-based fiber, MER creates a phenolic resin by applying its proprietary matrix formulations. The company then uses the resin to develop carbon phenolic composites, which are subjected to a heightened pyrolysis yielding a carbon-carbon composite. Because MER uses a liquid-based process to develop the composites with the P30X material, the company is able to bypass the extremely complicated and very expensive chemical vapor infiltration process, thereby enabling the fabrication of low-cost C-C composites even in small quantities.

The second process uses a stretch-broken fabric called 2.5D, which is made by the carbon fiber manufacturer Zoltek. Conventional stretch-broken composites are only 1.5-inches thick. By applying its proprietary matrix formulations, MER creates C-C composites that are up to 6-inches thick with high thermal conductivity throughout. The minimal variation of properties throughout the material is a key advantage. This trait allows for very thick section composites that do not exhibit

Continued on page 16

MDA Update
FALL 2003



Missile Defense Agency
c/o National Technology Transfer Center
Washington Operations
2121 Eisenhower Avenue, Suite 400
Alexandria, Virginia 22314
www.mdatechnology.net

**Address Service Requested**

*In addition to rocket propulsion systems, MER's composite materials can be used in semiconductor and vacuum-brazing furnaces.*

Light Years Ahead from page 15

a significant variation of properties. Typically, thick section composites have a huge density variation, which prevents subsequent densification and renders the composite almost useless for making parts.

The different fibers yield different densities. The composites with the P30X fiber have a density of 1.9 grams per centimeter cubed (g/cm$^3$), and the composites with the 2.5D fiber have a density of 1.65 g/cm$^3$.

MER is using polymer, liquid-based metals to add a functionally grated SiC surface to a C-C composite. The process begins with pure SiC on the surface and then the material slowly grows into a carbon. The C-SiC composite can be used in temperatures up to 3000ºF. Using the liquid-based precursor allows the company to create a variety of different sized composites and scale up the C-SiC composite by forming a mixture of a SiC and hafnium-carbide matrix inside the carbon matrix. This capability is unique to MER. The competing chemical vapor infiltration propulsion technology is not known to have scale-up capability.

Hafnium-carbide can produce thin-section composites that can withstand temperatures up to 4500ºF in an oxidizing environment for missile applications. It is the only material available with this capability. Currently, uncoated carbon, which erodes, is used.

MER's composite materials also have ground-based applications, especially in semiconductor manufacturing. The company is selling materials to this industry but needs more connections to further propel its technology beyond space-based applications.

### Contact Information:

Mark Haberbusch
Sierra Lobo, Inc.
11401 Hoover Road
Milan, Ohio 44846
Tel: (419) 499-9653
Fax: (419) 499-7700
E-mail: howl@sierralobo.com
Web: www.sierralobo.com

Dr. Witold Kowbel
Materials and Electrochemical Research Corporation
7960 South Kolb Road
Tucson, AZ 85706
Tel: (520) 574-1980, ext. 122
Fax: (520) 574-1983
E-mail: kowbel@mercorp.com
Web: www.mercorp.com