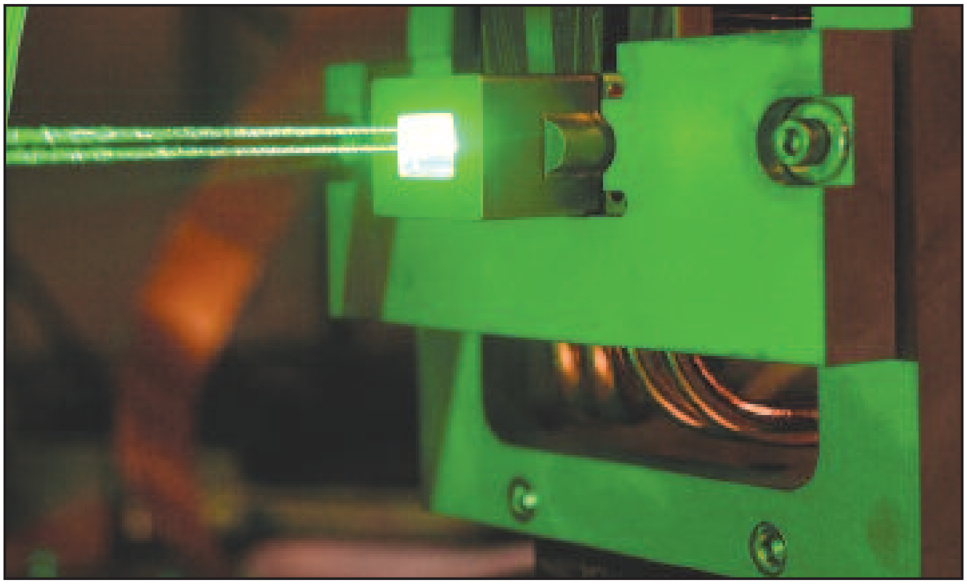
Missile Defense Agency

TechUpdate

A Quarterly Newsletter for MDA Technology Transfer

INSIDE



▲ Lasers such as those produced by Novalux, Inc., should result in TVs with improved image quality and fewer bulky components. An MDA predecessor funded the original technology used by the company.

Laser Televisions Promise More Vibrant Images

Will your next TV say 'NECSEL Inside'?

by Lindsey Aitcheson

Five years from now, the television you own will have an image produced by three lasers that are each less than one cubic centimeter in size and that are literally a million times brighter than current state-of-the-art light-emitting diodes (LEDs). They will provide sharper, crisper, more brilliant pictures than you have ever seen. And this new television will cost less to produce than the television you own now.

That is the vision of Novalux, Inc. (Sunnyvale, CA), which has developed the Novalux extended-cavity surface-emitting laser (NECSEL™) for use in high-definition (HD) rear-projection televisions (RPTVs).

Laser RPTVs differ greatly from typical televisions on the market today. They offer many advantages compared with the LED and ultra-high-performance lamp RPTVs that currently occupy the shelf space at your local big-box electronics store. The red, green, and blue lasers and accompanying components, which when combined are smaller than a matchbox, render bulky lamp televisions obsolete, as they eliminate the need for fans, lamps, color wheels, and beam-shaping optics.

Projection and illumination optics for laser televisions will cost less than those of either lamps or LEDs, resulting in a lower

continued on page 9

Beyond Stones and Shields

New report focuses on missile defense history, technology, and commercial successes.

by L. Scott Tillett/stillett@nttc.edu

At some point in prehistory, a caveman threw a stone at another caveman, and thus began a long history of defense—the building of shields, walls, and fortifications.

Over the years, the projectiles changed—from stones to spears to arrows to bullets to rockets to missiles. But the defense philosophy stayed the same: Make sure that those projectiles collide with something else instead of us.

And that philosophy is still the same today—even though the era of ballistic missiles has brought into play the potential for intercontinental theaters of battle, the possibility of long-lasting nuclear devastation, and hundreds of new and vastly complex defense technologies. A wall, a shield, a piece of armor—none of these simple items, quite obviously, is sufficient against a fast-moving ballistic missile bearing multiple warheads (some of them armed, some possibly not). Instead, an entire system of technologies—from sensors to communications networks to interceptors made with new super-materials—is needed. And one of the most dynamic periods in the development of those new defense technologies has occurred over the last two and a half decades.

What began as an idea of former President Ronald Reagan has grown into a very real and functional missile defense system—a "shield" based on new materials, software, sensors, communications protocols, and manufacturing processes. Today, there are multiple U.S. missile interceptors at the ready, prepared to hit an incoming projectile before it hits American soil.

Since 1992, the Technology Applications program's newsletter has been chronicling the rise of technologies that have been researched and developed in an effort to build and improve a missile defense system. Specifically, we have focused on technologies that, although originally developed for missile defense, can also be used commercially. If you were to read every archived issue, you would start to get a pretty good picture of how commercial successes have arisen amid an ever-changing landscape sculpted by world events, policy decisions, and continuing development of the missile defense system. But you don't have to do that.

A new report released by the MDA Technology Applications (TA) program outlines the evolution of missile defense technology—its role in military applications as well as its applicability beyond missile defense. The report, titled *Defining Moments: Selected Highlights from 25 Years of Missile Defense Technology Development & Transfer*, is available on our Web site, www.mdatechnology.net, and is also available in print. This special publication helps tell a tale that, although based on the simple and millennia-old premise of stopping projectiles, represents one of the greatest technological challenges the United States has ever undertaken. The TA program also has published a timeline poster that serves as a companion piece to the online report, illustrating some of the key missile defense milestones over the past 25 years. (Send a request to techapps@nttc.edu if you would like a free copy of the poster, the report, or both.)

Editor L. Scott Tillett
Production Manager Lisa Hylton
Contributing Writers Michael Felton, Jeff Reynolds, L. Scott Tillett, Joan Zimmermann
Advisors Paul Carroll, Jeff Reynolds, Alan Sherwin, Duane Zieg
Layout Lan Crickman
Intern Lindsey Aitcheson

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

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 TechUpdate*
Tel: (703) 518-8800 x500, Fax: (703) 518-8986
E-mail: stillett@nttc.edu
Web sites: www.mdatechnology.net, www.mda.mil/mdalink/html/mdalink.html

CONTENTS

Old Array, New Tricks

Imaging technique aids quality control for pharmaceuticals.

by Joan Zimmermann/jzimmermann@nttc.edu

Once destined for MDA's Exoatmospheric Kill Vehicle, a focal plane array instead helped a scientist see farther into the infrared spectrum.

Because today's tablet formulations often have a timed-release component that is entirely dependent on how and where the active ingredient is distributed inside the tablet, it is critical for a pharmaceutical manufacturer to test its properties before packaging. Manufacturers perform dissolution testing, which requires destruction of the tablet in a series of complex experimental steps. In addition, this sort of "wet chemistry" analysis depends on sampling, with findings for a limited amount of product being extrapolated to other products in the same lot.

However, with spectral imaging, a drug manufacturer can visualize the heterogeneity profile of multiple tablets with confidence and accuracy, and without the limitations, time-consuming effort, and expense of destructive testing. The technology behind this imaging technique has had numerous progenitors, but one array in particular helped yield some insight into the problem.

A new focus

"Dual-use" was still a popular buzzword when NIH researcher E. Neil Lewis picked up a mercury-cadmium-telluride (MCT) array from NIST colleague Ted Heilweil and placed it on the step-scanner of his infrared microscope. Lewis, a world-recognized expert in infrared imaging and recipient of numerous technology awards, used the array to extend the range of a microscope he had been refining for a number of years.

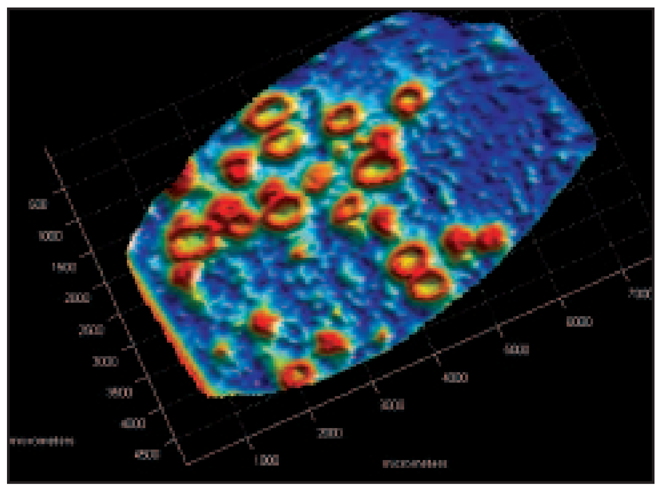
The MCT substrate had been meant for installation on a subsystem of the Exoatmospheric Kill Vehicle, but a few dead pixels disqualified it from use. For Dr. Lewis, it provided a better window into the infrared (to approximately 11,000 nanometers) through which his spectroscopic microscope could peer.

The subject of Lewis' interest at the time was to utilize the technology as a biodiagnostic tool for disease detection. The microscope could present this information in two ways: by location in an image plane and by wavelength in a spectrum, all contained in a three-dimensional space called a "hypercube." This allows pinpointing the location of a molecule of interest as well as the type of molecule present.

Dr. Lewis and his group developed highly specialized computer algorithms to decipher the large quantity of data in the hypercube, allowing the operator to locate a single pixel in the space of interest and view its spectral signature. With time and maturation of the focal-plane-array technology sector, arrays became larger, more robust, and affordable, leading the way to a new venture.

Assuring quality

In 1999, Dr. Lewis helped to found Spectral Dimensions, Inc. (Olney, MD), where this same chemical-imaging technology has now achieved a sophistication that has proven invaluable for the pharmaceutical industry. In a fine stroke of fortune for the company, the Food and Drug Administration recently rolled out an effort called the Process Analytical



▲ A near-infrared image of heartburn medication shows the architecture and spatial distribution of chemicals in a tablet, which would allow a manufacturer to evaluate its quality.

Technology (PAT) initiative, encouraging the pharmaceutical industry to use objective techniques wherever possible in the quality assurance sluice of the product pipeline. Spectral Dimension's rugged spectrometer, the Sapphire™ Near-Infrared Chemical Imaging System, provides the high-fidelity, high-throughput spectral imaging that is just the ticket for the sort of testing the PAT initiative demands.

In major laboratories such as Johnson & Johnson, Merck, Pfizer, Astra-Zeneca, and Bristol-Myers Squibb, the Sapphire rapidly provides information about quality and performance parameters. Some industrial users of the technology advocate that it may ultimately replace the traditional dissolution analysis.

continued on page 10

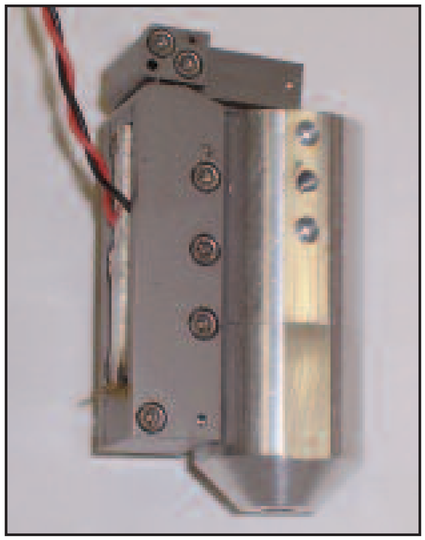
Amplifying Small Motions

Enhanced piezoelectric actuator allows for proportional valve control.

by Jeff Reynolds/jreynolds@nttc.edu

A team of engineers at Dynamic Structures and Materials, LLC (DSM; Franklin, TN) has used MDA SBIR Phase II funding to squeeze an actuator system—a piezoelectric actuator, sensors, and associated electronics—into a small package that provides improved control for missile actuation systems relative to baseline electromagnetic actuators. The novel piezoelectric actuator system's features include the use of low-voltage piezo material that is capable of operating in more extreme temperatures than electromagnetic systems.

If incorporated into missile valve systems, DSM's technology would be used to control the flow of hot gases in miniature kill vehicles. This type of actuator system could also improve the performance of cold-flow propulsion systems like those that are used in an astronaut's manned maneuvering unit (MMU) for extra-vehicular activities (EVAs) or "space walks."



▲ DSM's actuator technology boasts speed, temperature, and power advantages over competing systems.

A piezoelectric material changes shape when an electrical field is applied. The resulting electric charge in the piezo element causes it to extend in subnanometer increments at a minimum and by approximately 70 to 80 microns at a maximum (less than the width of a human hair) in DSM's valve actuator.

Stacking piezo elements adds incrementally to the displacement range, but to achieve significantly more displacement, the team designed a multihinged (flexured) metal composite housing—call it an "exoskeleton"—to bind the piezo elements together and mechanically amplify the piezo element's output. DSM has produced a range of valve actuators with mechanical amplification ratios of 5 to 100 times—producing strokes from 100 microns to 10 millimeters (mm). In the MDA valve application, the stroke is proportionally controlled to a fine degree over the range of 0 to 1.5 mm, which is the amount necessary for proportional control of many miniature missile valve applications.

Because of the choice of piezo material, the actuator system doesn't require much voltage: just 60 to 200 volts, which is generated onboard DSM's drive electronics from the missile platform's 28-volt battery source. In contrast, typical single-crystal piezo materials, which are considered to be "super" types of ceramics, generally require a substantially higher operational voltage. In addition, the lower voltage range used in DSM's actuator systems enables the use of a much broader selection of associated drive electronic components for miniaturization objectives.

But how does this stoked-up piezo stack up against the baseline electromechanical actuators already in use in missile systems? Compared to electromechanical actuators, DSM's product also has a power advantage.

"We've learned from users in the field that electromechanical actuators have a couple of drawbacks such as backlash and overshoot which can lead to slower move and settle times," explained Murray Johns, DSM's vice president. "Traditional electromechanical systems require up to 10 to 20 milliseconds to move and settle into position, while we've shown our piezo systems require less than 5 milliseconds," said Johns. "Moreover, electromechanical systems use a significant amount of power during hold maneuvers to maintain an electric field and, thereby, to hold position. The capacitive nature of the piezoelectric load means that our actuators do not use any power to hold position," Johns said.

Its composition and features also ensure that the actuator can withstand extremely low temperatures. At the opposite end of the temperature scale, the actuator is equally impressive. For example, although a standard piezo material starts to lose its piezoelectric properties above 100°C, the material and electrical connections used in DSM's design help it to operate reliably at up to 250°C.

The most difficult part of building the technology was reducing the size of the system—the actuator, drive electronics and sensor packaging size—to offer higher power density (power per unit mass) relative to electromagnetic systems. Simultaneously, DSM's efforts have focused on increasing the technology's "Technology Readiness Level" for future insertion into MDA platforms. The team has yet to perform hot-gas testing but has performed cold-flow testing to simulate the application and achieved very stable results, Johns said.

continued on page 10

Stacking Up

Barrier technology protects layers in memory materials for smart cards.

by L. Scott Tillett/stillett@nttc.edu

Some memory materials have great potential for use in devices with embedded logic—everything from smart cards to radio-frequency identification tags. But putting together the layers needed to make the memory materials can sometimes prove a challenge.

In trying to create a dense but thin material for robust applications, various layers of metals need to be stacked on top of one another. The approach requires layers of dielectric materials in between the metals to protect them from hydrogen. During the high-temperature production process, hydrogen can degrade the quality of the dielectric materials and ultimately result in end products that are less reliable.

MDA-funded Structured Materials, Inc. (SMI; Piscataway, NJ), has developed a method to put a barrier layer in the memory materials to keep hydrogen from degrading the dielectrics. The company already has developed a commercially available tool for building the barrier. And SMI Vice President Joe Cuchiaro said the company could take several routes to commercialization. The company could license its technology or use its tool to provide in-house services for customers. An additional possibility is that the company could produce and market the tool on a broad scale. At the heart of SMI's tool is a metal-organic chemical-vapor-deposition (MOCVD) process for hydrogen barriers based on aluminum-oxide materials.

The technology was awarded an SBIR Phase II contract from MDA, which funded SMI to develop barrier technology for reliable, high-density ferroelectric memories for applications that involve radiation. Ferroelectric materials are memory materials that can be "trained" with an electric field to store binary information—similar to the way a piece of iron can be switched with a magnetic field to develop north and south poles. The advantage to the materials is that it is a physical storage method, meaning that electrons won't leak off of components such as electrodes and destroy the memory.

Beyond MDA, the barrier technology should prove useful to commercial users who require reliable ferroelectric memories in robust applications—in which data need to be written and read quickly and often. Eventually, SMI's technology also could prove useful in making highly reliable memories for commonplace applications such as USB thumb drives or other portable memory devices—possibly facilitating the creation of devices that operate an order of magnitude faster. "Right now, the price point is not right," said Cuchiaro, referring to products now on the market. "That's why this technology is so important. It allows people to build it [memory] vertically so that they can start to integrate toward those densities. Without a technology like this, the price point will never be matched."

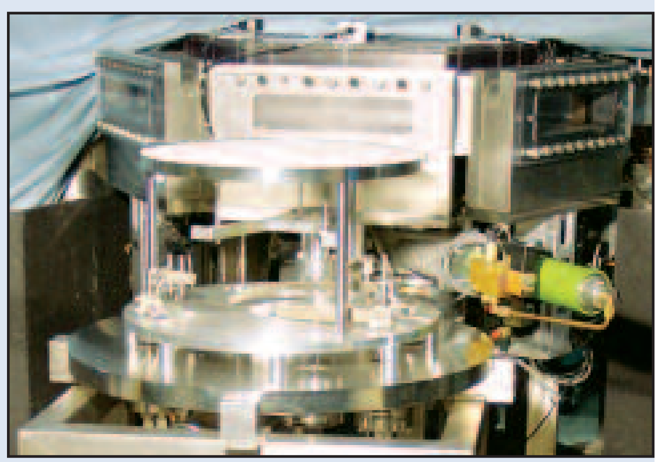
Cuchiaro said other encapsulating or hydrogen barrier technologies exist for ferroelectric memories, but he said so far SMI's technology appears to be the only one demonstrating consistent, 100-percent effectiveness.

A recent experiment involving memory materials by Ramtron International Corporation showed a 500-nanometer aluminum-oxide barrier layer deposited by SMI's technology was 100-percent effective in protecting a lead-zirconium-titanium capacitor from being "attacked" by hydrogen under test conditions.

Cuchiaro said the company continues to look for potential investors that will allow SMI to commercialize the tool and the process. The biggest challenge for the company remains transitioning from a small business to a major tool supplier, according to Cuchiaro, who estimated the market for the barrier technology to be in the hundreds of millions of dollars.

CONTACT INFO

Joe Cuchiaro
Structured Materials, Inc.
Tel: (719) 260-9589
E-mail: jcuchiaro@aol.com
Web: www.structuredmaterials.com



▲ SMI's tool uses a metal-organic chemical-vapor-deposition process to produce barriers based on aluminum-oxide materials.

Collaborating Across the Pond

UK's alternative optics help MDA mission.

by Joan Zimmermann/jzimmermann@nttc.edu

Telecommunications and biotechnology both stand to benefit from better optical fibers.

While MDA is decidedly American in origin, the defense interests of the United States are also inextricably bound with our allies across the pond. Our closest ally in recent years has been the United Kingdom. And in the spirit of collaboration, advanced research in optics and photonic fibers has been conducted in that country through the efforts of MDA's Advanced Technology Deputate.

As Innovation Team Leader at MDA, Mr. Paul Koskey worked with the UK's Ministry of Defence (MOD) and Defence Science and Technology Laboratory (DSTL) to fund innovative efforts in optical transmission for the Multiple Kill Vehicle (MKV) program. MKV's ladar range finder required new approaches for optical fibers capable of transmitting high-power, high-quality laser light, and the UK was exploring such alternatives at a timely point in this search.

Through MOD, MDA funded QinetiQ, Ltd. (Hampshire, UK), a British company with a presence in the United States, aiding in its production of a hollow waveguide. The waveguide is "the optical equivalent of an electronic printed circuit board," according to Dr. Michael Jenkins, a developer of the technology. In this case, QinetiQ developed a solid-state waveguide, increasing its ruggedness and decreasing its cost—requisite qualities for one of MKV's components, a high-powered lidar system. Using computer-controlled milling and deep reactive-ion etching (DRIE) techniques, QinetiQ has produced and demonstrated waveguides that operate from 1.5 to 10.6 microns, and has tested one of its waveguides in trials at the Army Missile Optical Range in Huntsville, AL.

QinetiQ's hollow waveguide has numerous potential applications in the marketplace, chief among them optical telecommunications systems, where it can function in switches, multiplexing/demultiplexing modules, and amplifiers. In the fast-growing lab-on-a-chip arena, the waveguide can be used to probe (identify) liquids flowing through microfluidic channels to act as an applied biosensor or analytic research tool.

The monolithic waveguide design was derived from QinetiQ's previous work in hollow-core, carbon dioxide waveguide lasers, extending the concept to a total system, after which the company patented the integrated optics concept underlying the waveguide. Compared with solid-core waveguides, the hollow-core version exhibits less loss, a broader wavelength range, higher power transmission, and low polarization-dependent loss.

QinetiQ is commercializing its technology for insertion into markets on both sides of the Atlantic.

MDA also helped fund an ongoing effort to develop novel optical fibers at the University of Bath (Bath, UK). Optical fibers with traditional cladding material are subject to failure under high-power conditions, so Bath University Professor J.C. Knight, a physicist, tackled the problem by examining a new type of photonic bandgap fiber. Instead of using the principle of total internal reflection, as that conferred by conventional cladding materials, the glass fiber has a hollow core surrounded by much smaller holes that run the length of the core. The surrounding air holes form a two-dimensional structure that directs the optical beam, "convincing" the light to stay in the hollow core.

Knight and his group set out with a parallel approach involving a nonoptimized fiber model and a fabrication scheme. The fiber is produced by first building its structure at a relatively large scale; it is then pulled through a furnace at speeds of 60 to 100 meters per minute, into its requisite ultra-slim dimensions. The fabrication is especially tricky, as the fiber's total diameter is shrunken by a factor of a thousand during the process, to a final diameter of 20 micrometers for the hollow core, and about 2 micrometers' diameter for each surrounding "hole." The size of the central hole and thickness of the core wall are a crucial part of the design and must be uniformly thin. The properties of the pulled fiber are then characterized with an electron microscope and a laser source and fed back into the model for further improvement. Having demonstrated proof of principle and some sample fibers, Knight continues with refinement of both model and method.

CONTACT INFO

Professor J.C. Knight
Bath University
Tel: +44 (0) 1225 388 388
E-mail: j.c.knight@bath.ac.uk
Web: www.bath.ac.uk

Dr. R. Michael Jenkins
QinetiQ, Ltd.
Tel: +44 (0) 8700 100 942
E-mail: rmjenkins@qinetiq.com
Web: www.qinetiq.com

An Ounce of Prevention

Space algorithms that came down to Earth are now preventing a major cancer.

by Joan Zimmermann/jzimmermann@nttc.edu

Most people have bitten the inside of their cheek, or burned the roof of their mouth eating pizza, and thus most people have experience with seeing a fair number of red or white spots in their mouth. Small white or red oral spots are extremely common and are typically harmless; however, they sometimes contain cells that may become cancerous if they are not removed.

Oral cancer is a major source of morbidity and mortality in the United States and virtually all other developed countries. It is one of the largest sources of cancer death throughout Asia and is the single largest cause of cancer death in India. In the United States, oral cancer kills more people than either melanoma (skin cancer) or cervical cancer and is as common as all forms of leukemia combined. In both the United States and Europe, oral cancer is rising sharply among women, young people, and nonsmokers. More than 25 percent of U.S. oral cancer victims have no identifiable risk factors and do not use tobacco or abuse alcohol.

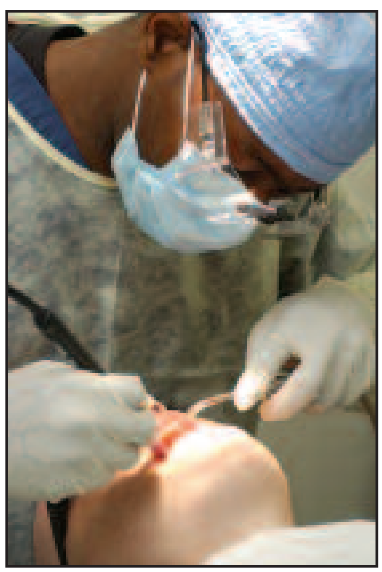
OralCDx—a technology that had its roots in DOD's Strategic Defense Initiative and is now being used by over 30,000 U.S. dentists—has made oral cancer a potentially preventable disease.

OralCDx can prevent oral cancer by facilitating routine painless testing of the common, small white and red areas in the mouth that appear in about 10 percent of the adult population. Several years before oral cancer can start, the patient develops a very small, painless, white or red spot that appears identical to a common benign oral spot but that contains pre-cancerous cells. While most oral spots are harmless, up to 4 percent may contain pre-cancerous (dysplastic) cells. When these pre-cancerous cells are detected by OralCDx, the spot can then be easily removed, thus preventing the development of oral cancer years before it can even start.

From Research to Application

In the early 1980s, Mark Rutenberg, CEO and founder of CDx Laboratories (Suffern, NY), was a pioneering neural network researcher in the nascent field of missile defense. The algorithms developed in the course of this research, originally meant for identifying objects embedded in mystifying clutter, eventually proved invaluable for medical diagnostic applications. The first such successful application of Rutenberg's work resulted in the widely used computer-aided test called PAPNET, which added greater accuracy to the common Papanicolau or "Pap" test for cervical cancer. Derivative systems now marketed as FocalPoint™ by TriPath Imaging continue to be valuable adjunct tools in women's health. CDx Laboratories has combined these imaging algorithms with a new tool in this latest technology, the OralCDx computer-assisted brush biopsy.

The patented OralCDx brush biopsy instrument quickly and painlessly extracts a complete tissue sample from the full thickness of the epithelium underlying the oral spot being tested. This unique tissue specimen is then analyzed by CDx Laboratories. It is at the computer interface at CDx labs where the "Star Wars" imaging algorithms perform their computations and quickly yield a result. The accuracy of OralCDx testing was successfully demonstrated in one of the largest clinical trials ever conducted in oral medicine. The results were published as a cover article in the Journal of the American Dental Association and have since been duplicated in numerous independent U.S. and European studies. OralCDx is now taught as standard practice in the majority of U.S. dental schools. By detecting oral lesions that were about to become cancerous, OralCDx has already been credited with saving thousands of lives.



▲ CDx Laboratories is marketing an oral-cancer-detection biopsy brush that can be used during routine dental visits. Dentists can use the brush to collect tissue samples for testing.

Gaining Acceptance

All necessary FDA, EU, and other regulatory approvals required to provide OralCDx worldwide have been received. OralCDx testing is a covered benefit by Delta Dental, Cigna Dental, many other dental insurance plans, Medicare, Medicaid, and virtually all other government and private medical health insurance in the United States and abroad.

CDx Laboratories is also in the process of extending this technology's reach into the larynx and esophagus to detect cancers of the upper airway and digestive tract. The same principles underlying OralCDx (sampling by biopsy brush and computer-aided diagnosis) can be applied to these

continued on page 10

Faster Than Flash

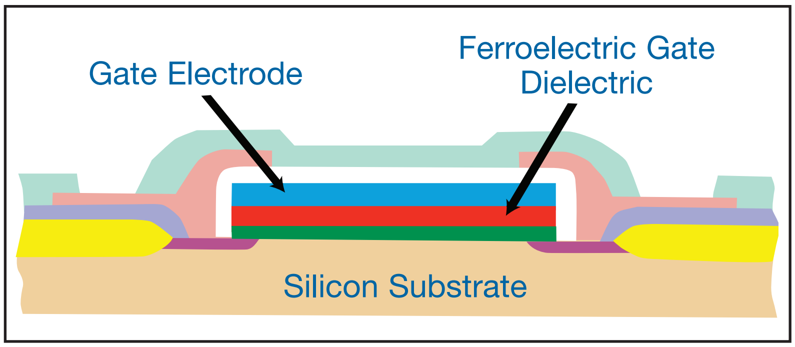
Next-generation nonvolatile memory may give flash memory a run for its money.

by Michael J. Felton

Memory storage in our digital cameras, MP3 players, USB drives, and even cell phones are all made possible using a kind of nonvolatile memory called flash. But flash has many drawbacks, so many companies, including COVA Technologies, Inc. (Colorado Springs, CO), are looking for next-generation nonvolatile memories.

Nonvolatile memory means that information won't be lost when the power is turned off, i.e., your cell phone can retain your contact information even when the battery is dead. Although flash has enabled all sorts of devices, it is far from perfect. It uses high voltages, which complicates design, and it is not radiation-hard, which is important for military and space uses.

Several alternatives to flash are being researched, including magnetic random access memory (RAM), phase-change memories, and ferroelectric memories. In the 1990s COVA began work, as part of an MDA SBIR Phase I project, to develop a transistor-based ferroelectric memory. Previous uses of ferroelectric materials had created functioning memories, but they could only retain data for short amounts of time.



▲ A diagram shows the architecture of a ferroelectric cell, the main building block of COVA's nonvolatile memory.

COVA began by searching for the right ferroelectric material to replace the dielectric layer in normal CMOS transistors. The company settled on rare-earth manganites and, eventually, on yttrium manganite ($YMNO_3$). During SBIR Phase II work, company researchers showed that, using the ferroelectric layer, they could change the threshold voltage of the transistor and the transistor would remain in the selected state.

The threshold voltage determines a transistor's on or off state. When voltage lower than the transistor's threshold is applied, the transistor does nothing, and current does not flow. If a higher voltage is applied (i.e., a voltage higher than the threshold), the transistor opens, and current flows. "In a regular transistor, the threshold is always the same; there is no meaning to it," said Fred Gnadinger, president and CEO of COVA. "But if you can switch it [the threshold voltage] between two values, then you can store information." When the threshold can be chosen, the transistor can later be asked whether it has a high or low threshold, which equates to whether it is a 1 or a 0. This is accomplished by sending a signal—to the transistor—that has a voltage between the high and low threshold voltages. If current flows, it must have had a low threshold. And if no current flows, it must have had a high voltage threshold.

There was one problem with COVA's ferroelectric transistor memory: It only held the new threshold, and therefore the data, for about one month. However, at the end of the Phase II project, there was a breakthrough. "We discovered by accident a totally different mode of operation for this device, and we call that device CT RAM for 'charge tunnel RAM,'" Gnadinger said. The researchers were operating the transistor so that when they wanted to store information, they would polarize the ferroelectric so it would have either a low or high threshold. But the polarization was being gradually reduced by other electric fields in the device. And in some samples in which they thought there were errors, they noticed that another phenomenon was at work.

Under certain conditions, instead of polarizing the ferroelectric, the ferroelectric was acting as a charge trap. Charges were tunneling from the silicon through the ferroelectric and then were trapped, affecting the threshold voltage of the transistor.

Altering the operation proved relatively simple, and simulations have shown that the transistor can store information for more than 10 years.

COVA is currently in a joint venture with NEC Corporation to further develop the CT RAM. The memory is much smaller than current flash memories, and the performance is as good or better than flash. And unlike another next-generation favorite, MRAM, CT RAM is also smaller and is compatible with CMOS fabrication methods, resulting in potential cost savings.

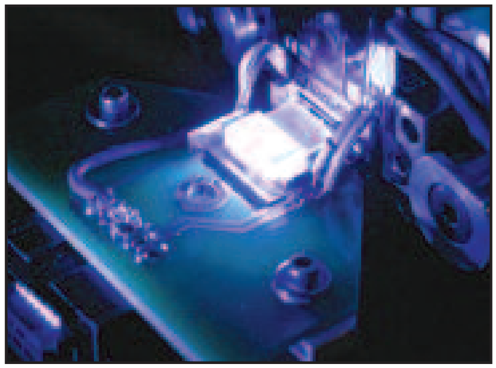
The privately held company already has some financing but is looking for more investors. Although COVA does not

continued on page 10

Laser Televisions . . . from page 1

price for the entire system. Novalux estimates that a 50-inch laser television will cost significantly less than $1,000, a figure that sharply contrasts with the $3,000-15,000 price tags on lamp and LED displays today.

Laser televisions will provide speckle-free images that have more contrast and better color coverage than their unwieldy, expensive counterparts. They also use 60 percent less power and have a lifespan more than 10 times as long as lamp televisions. And unlike LED televisions, laser televisions have incredible longevity without giving way to distracting color shifts over time.



▲ Novalux's NECSEL technology could serve as a main component in laser televisions, which manufacturers should start introducing in 2007.

Micracor (Acton, MA) in 1994 developed the technology behind this device, not for use in televisions, but to enable durable, lightweight micro-lasers for optical communications in space by the Strategic Devense Initiative Organization (SDIO), an MDA predecesor. Dr. Aram Mooradian, the founder and principal investigator for Micracor, developed the optically pumped surface-emitting semiconductor laser that was later acquired by Coherent, Inc. After leaving Micracor and founding Novalux, he patented and produced an electrically pumped version that was simpler and more cost-effective. Now, eight years later, he is revolutionizing the world of lasers.

A typical laser consists of a cavity filled with a gain medium. The cavity has a mirror at each end, one of which is partially reflective. An energy source excites the particles in the medium to release light energy, with all the photons having the same phase frequency and direction of travel. The light bounces back and forth between the mirrors before escaping as a laser beam through the partially reflective mirror.

The pinhead-sized NECSEL has a gallium-arsenide semiconductor medium. Novalux modified the traditional structure of the surface-emitting laser by reducing the reflectivity of one of the epitaxial mirrors and adding another partially reflective mirror outside the body of the laser. This extra mirror, separated by a few centimeters from the laser die, leaves sufficient space for intracavity optics. Novalux put a nonlinear optical crystal in that gap. The crystal enables the doubling of the frequency of the light as the beam passes through it, and this shift in frequency makes visible the colors that produce the television's brilliant display.

When Novalux first demonstrated the NECSEL in 1999, the results stunned even the inventor. "When it lased, the brightness was so high it hit the CCD camera and flared it so that on the TV screen it looked like a star pattern, which was exactly the logo for the company that I put down on Day One," Mooradian said. "I thought, 'My goodness, this is a sign of biblical proportions.'"

In recent months, Novalux has been busy. In March it announced a major joint development and license agreement with Seiko Epson Corporation that will result in the use of NECSEL-based illumination devices in microdisplay-based lasers. In June it secured $21.7 million in financing and joined forces with Unaxis Optics, a Switzerland-based company, with further hopes of using NECSELs in projection displays. In addition, Novalux is also pursuing several other deals with major television manufacturers.

Novalux created a stir at the 2006 International Consumer Electronics Show in Las Vegas when Insight Media bestowed on it a "Best Buzz" award, recognizing its surface-emitting lasers as the "Best New Enabling Technology."

Company officials hope the company gets an even better buzz in December 2007 when the first laser televisions roll off the assembly line. Users should see Novalux's lasers in the future, and not just in their televisions. Within the display market, they have potential for use in movie theater projectors, heads-up displays, and car dashboards. Novalux is also planning to market its lasers in cell phone pico-projectors—devices that will allow consumers to project large, sharp, radiant images directly onto walls and screens using portable, hand-held laser displays built into their cell phones.

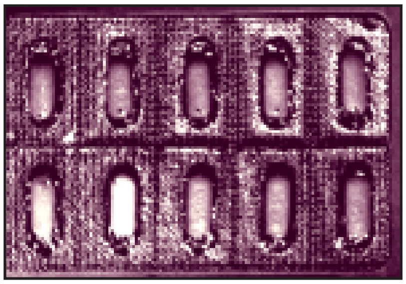
Beyond displays, NECSELs have a wide range of applications, from medicine to telecommunications to military functions. They may one day serve in the treatment of cancer, and they have potential for use in intricate heart and eye surgeries. They can boost signals sent over optical telephone, computer, or television lines, making telecommunications lightning-fast. Their potential for use in range finders, target designators, and sensors for detecting chemical and biological agents renders them useful in a wide range of military operations in addition to the space-based applications for which they were originally funded.

There are virtually limitless applications for NECSELs, and Novalux seeks to license its technology. Company officials hope that, by doing so, they can get NECSELs into more applications. Their vision is one in which the tiny NECSEL—a laser the size of a pinhead—will enhance a vast array of devices that can make medical care more accurate, businesses more productive, and the country safer.

CONTACT INFO
Gregory Niven
Novalux, Inc.
Tel: (408) 730-3433
E-mail: gniven@novalux.com
Web: http://www.novalux.com

Old Array, New Tricks from page 3

Spectral Dimensions' Sapphire NIR Chemical Imaging System operates on a cooled indium-antimonide-based focal plane array, with a wavelength range of 1,200 to 2,450 nanometers and a scan time of about two minutes. Sapphire features an open, accessible sample area and a variable field of view, from square millimeters to square inches. The unit is Spectral Dimensions' speediest system yet, and operates with ISys® hyperspectral data manipulation and visualization software. It is tailor-made for characterizing solid-dosage forms or, to use a less technical term, pills.



▲ Tablets in a blister pack would all look the same to the naked eye, but this near-infrared image shows that one tablet (the white tablet) has a different chemical composition from the others.

Where a larger field of view and greater depth of penetration is desired, Spectral Dimensions offers the MatrixNIR™ system, based on an indium-gallium-arsenide array. Whereas Sapphire is used primarily in pharmaceutical applications, the Matrix is often preferred for food and agricultural analyses, such as crop-seed viability.

Beyond these current applications, Spectral Dimensions is also in the process of pilot-testing its chemical-imaging system for the detection of animal protein in livestock feed. While the spread of bovine spongiform encephalopathy (mad cow disease) has largely been halted due to better industry oversight, the presence of nervous-system tissue in animal feed still represents a threat and is being monitored. Once again, spectrometry could provide a faster and possibly more accurate alternative to wet chemistry techniques. The company has units in Japan, Korea, and some European countries to test this concept.

Malvern Instruments acquired Spectral Dimensions in June 2006. It is a major instrumentation company with expertise in particle characterization, including imaging. Joining the strengths of the two companies will expedite the core mission of providing a complete suite of turnkey imaging systems, now including chemical imaging, for a variety of applications while helping clients maintain compliance with industry standards such as cGMP (current good manufacturing practices).

CONTACT INFO

E. Neil Lewis
Malvern Instruments
Tel: (301) 260-0290
E-mail: neil.lewis@malvern.com
Web: www.spectraldimensions.com or www.malvern.com

Amplifying Small Motions from page 4

DSM is continuing to pursue its unique miniaturization process on several fronts including material selection and system stiffness/control analysis. "We would also like to conduct hot-flow high-fidelity testing on a missile platform test bed in Phase III of our development process," Johns added.

The company, which is focusing largely on the piezo system's military and space-related applications, has also obtained additional funding from commercial sources to continue developing these technologies for related applications.

CONTACT INFO

Murray Johns
Dynamic Structures and Materials, LLC
Tel: (615) 595-6665
E-mail: mjohns@dynamic-structures.com
Web: www.dynamic-structures.com

An Ounce of Prevention from page 7

areas. In this application, the product is called EndoCDx and is designed for use in endoscopic examinations for the diagnosis of esophageal cancers, Barrett's esophagus (a pre-cancerous condition), and cancerous and pre-cancerous lesions of the upper airway.

CONTACT INFO

Mark Rutenberg
CDx Laboratories
Tel: (845) 369-7096
E-mail: mrutenberg@cdxlabs.com
Web: www.oralcdx.com

Faster Than Flash from page 8

have memory devices for sale, it sees opportunities in the defense sector. "We do have working devices, and although commercial customers may need more than 256K [of memory], within the DOD there are dozens of needs for smaller densities," Gnadinger said.

CONTACT INFO

Dr. Fred Gnadinger
COVA Technologies, Inc.
Tel: (719) 540 8504
E-mail: fred@covatech.com
Web: www.covatech.com

A Counterintuitive Way to Make Money

Licensing to your competition could bring benefits.

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

Having been a panel member on the MDA Technology Application Reviews for almost 10 years, I have a deep appreciation for the efforts that MDA-funded companies are making to develop the novel, unique technologies that MDA will need in the future. A key element in company plans is how to commercialize their technologies prior to MDA use. While the usual path is developing the capability to produce and/or provide services based on the technologies, at issue often is how to generate sufficient cash flow to nurture the business.

In many cases, company representatives indicate that their plan includes licensing out the technologies to selected noncompeting firms. I would like to propose a "counterintuitive" concept—i.e., licensing to competitors. But there is a key caveat. You should not do so until your company has established a clear advantage in the marketplace. This is another way of saying that your out-licensing has to be consistent with the basic business of the company; so "advantage" may take the form of:

- Market-share gain as a result of using the technology in a product or process.
- Recognized leadership in that technology sphere.

Now let's look at reasons why:

1. **Everything being equal, your competitor has to pay more for the technology.**
   Simply stated, the competitor has to pay a royalty for the right to use the technology. Assuming roughly equal manufacturing costs or purchase costs, then the royalty results in the competitor incurring a cost penalty.

2. **It keeps competitors from designing around your company's invention.**
   Licensing out your technology to a competitor or an industry supplier generally discourages your competitor from conducting its own in-house R&D to design around your intellectual property (IP). The implications are that your company then gains control over the technology, and it decreases any likelihood that your competitor could "leapfrog" your company's technology. Additionally, you also can try to negotiate a "grant-back" clause whereby any improvements made by your licensee either would belong to or would be licensed royalty-free to your company. In effect, this would make your competitor a product-development source for your company.

3. **It promotes new inventive efforts from your people—to work on a next-generation or complementary technology.**
   Once a competitor has gained the rights to use your company's selected IP, it often provides an incentive for your company's employees to develop the next generation—and thereby helps your company recapture technological leadership.

4. **It can establish an industry standard.**
   If an industry has certain technology standards, then advanced efforts to license out your company's technology to competitors can establish both a *de facto* standard and become the basis for a "real" standard—based on your own technology.

5. **Licensing out a technology can promote economies of scale.**
   For technologies that may provide only a small competitive advantage (or no competitive advantage), licensing out to competitors through industry suppliers can yield substantial increases in shareholder value. At Ford, for example, in working with suppliers we found that we could create "win-win" deals that generated new sources of revenue through earned royalties. But, perhaps more importantly, the deals reduced part or system costs by allowing suppliers to leverage the company's technology and increase their business—while providing a means for the suppliers to increase their profits.

6. **It minimizes the risk of employee raids.**
   Finally, it would be considerably less costly for a firm to recruit a key employee or employees from your company versus starting up from ground zero to develop a technology your company is successfully utilizing. By licensing your competitor, you remove the incentive to make such a raid.

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

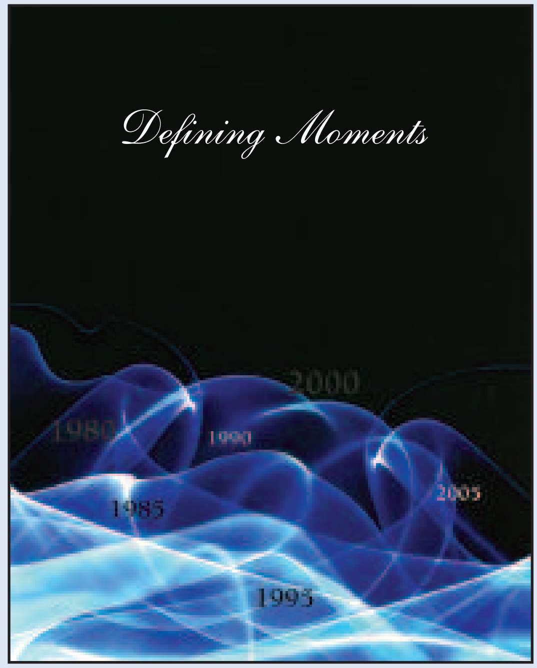
Special Report on Missile Defense History

The latest special report from the MDA Technology Applications program is available online and in print.

The report, titled *Defining Moments: Selected Highlights from 25 Years of Missile Defense Technology Development & Transfer*, offers historical perspectives on U.S. missile defense and technology commercialization.

You can find the publication in the Special Reports section of our Web site, www.mdatechnology.net.

Or, to receive a free copy of the print version, e-mail your name and address to techapps@nttc.edu, or call (703) 518-8800, extension 239, to request a copy.



Missile Defense Agency
TechUpdate
Fall 2006

PreSrt Std
U.S. Postage
PAID
Permit #1112
Merrifield, VA

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

Address Service Requested