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MDA Update

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

Focusing on More Powerful Lasers —by L. Scott Tillett

Researchers hope a beam combiner and a more efficient laser will have widespread commercial appeal.

Lasers serve as one of the latest and greatest methods for gathering and distributing information. Their potential for sensing compounds and for carrying signals offers new ways to collect and share data in environments where traditional methods of communication and information gathering might not be practical.

Lasers aren't just tools for blasting undesirable objects into nonexistence—one of their potential military applications. A laser also can serve as a line of communication across open, inhospitable terrain. And lasers can serve as the heart of devices for gathering information on the composition of an object or for collecting radar data.

Tapping into the full potential of lasers in some cases, however, requires building more powerful lasers. Many companies developing laser technology have received funding from BMDO, now MDA. And at least two of those companies have focused their efforts specifically on surpassing existing technology by developing stronger lasers with commercial potential.

One from many

From the standpoint of Digital Optics Technologies, Inc. (DOT; Rolling Meadows, IL), the more lasers, the better.

Sometimes, one laser just doesn't offer the strength that a user needs. So combining several lasers into one beam becomes a possible solution.

The more lasers combined, the more powerful the beam. But the challenge lies in getting the individual wavelengths in the combined beam close enough together to be effective. Within a single aperture, the more space (or wavelength separation) between individual lasers, the less useful the combined beam. More tightly spaced lasers within a combined beam, therefore, result in a more powerful and functional beam—one that could burn holes through thick walls or one that could boost the performance of optical communications networks, for example.

Researchers at DOT have overcome the spacing challenge and are packing lasers tightly together. They have developed a device for combining off-the-shelf laser beams with as little as 0.01 nanometer between them. Competing beam combiners meanwhile have about 1 nanometer of separation among individual lasers, according to the company.

The DOT beam combiner, therefore, can combine 20 lasers within a single aperture, while other beam combiners might combine only five lasers. And DOT can combine even more than 20 lasers if the company employs laser cascading techniques to create a combined beam.

The technology at the heart of beam combining involves



Analyze this. Applying techniques involved in beam combining, DOT developed a spectrum analyzer to test signals used in communications or sensing equipment. The device works like a beam combiner operating in reverse, taking one spectral source and breaking it down into many sources.

holography. The company's technique involves creating several patterns, or gratings, within a block of reflective polymeric material. As much as 100 kilowatts of continuous laser power can be directed

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MDA Update

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TOP 10 REASONS TO VISIT OUR WEB SITE

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1. *Search for innovative technology solutions.* Our site features 200+ abstracts of MDA-funded technologies available for commercialization. Each abstract contains descriptions of the technology, its MDA applications, its potential civilian and other military applications, and the developer's commercialization activities. Point-of-contact information is also included. To make it easier for you to find technology solutions, the abstracts are searchable!
2. *Get the latest MDA-funded technology and company news.* The site provides hyperlinks to press releases about MDA-funded technologies and companies. Missed last month's news? Don't worry. Browse through our archive to locate the information.
3. *Get the latest program news.* Whether its a new technology transfer publication or technology transfer demonstration, you can read all program news bulletins from the MDA Office of Technology Applications on the site.
4. *View the MDA Update.* Read the latest issue of the newsletter online. Or, browse through our newsletter archive, which includes all previous issues since Winter 1994.
5. *View and print special reports.* Using Adobe Acrobat®,

you can download and read our special reports on MDA-funded technologies with biomedical, counter-terrorism, environmental, telecommunications, and utility applications, among others. Yearly reports featuring technology transfer success stories can also be viewed.

6. *Sign up to receive the MDA Update.* Simply fill out a short form and click on the Submit button. It's that easy and takes less than a minute to complete.

7. *Sign up to receive the Media Tip Sheet.* If you're a media representative, you can sign up to receive our Media Tip Sheet delivered via e-mail at least three weeks BEFORE the *MDA Update* is printed and distributed.

8. *Browse the calendar of events.* Find out what industry trade shows and meetings MDA's Office of Technology Applications will be attending, sponsoring, and/or supporting.

9. *Locate other helpful resources.* Hyperlinks are provided to other Web sites that offer information about technology transfer and MDA. You can also find hyperlinks to business development resources for high-tech startups and other suggested reading.

10. *Find contact information.* Need to reach us? Whether its by e-mail, fax, phone, or mail, you can find all of our contact information on the site.

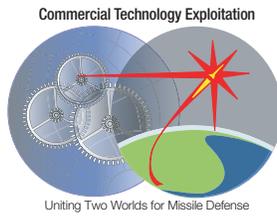
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NEW MDA PROGRAM SEEKS NON-DEFENSE TECHNOLOGIES

The Missile Defense Agency is sponsoring a new technology transfer demonstration project called the Commercial Technology Exploitation Initiative. Managed by the National Technology Transfer Center-Washington Operations, the project hopes to identify commercial, non-defense technologies that can enhance ballistic missile defense capabilities and forge relationships between MDA Program Elements and commercial industry. The first kick-off meeting was held in late October 2002, and the project findings will be reported by Spring 2003.

“MDA is interested in technology capabilities wherever they may reside,” commented Paul Koskey, Director of Technology Transition and Exploitation for MDA’s

Advanced Systems. “We are making a special effort to seek technologies already developed by commercial corporations that normally do not do business with the U.S. Department of Defense because we feel these



companies may have capabilities that could lend themselves to protecting the Nation, its troops, and its friends and allies against missile attacks.”

To this end, the project will encourage the use of the “Other Transactions” procurement option for research and

prototype projects to lure commercial industries to participate with MDA Program Elements. This vehicle waives compliance to Federal Acquisition Regulation (FAR) accounting and auditing requirements for traditionally non-defense contractors. It also allows them to negotiate their intellectual property.

The challenge for the project will be to fully understand and prioritize key capability enhancements suitable for such a demonstration and translate them in a way for non-defense industry experts to be effective. If all goes well, successes could provide significant savings in research, development, and scale-up costs while providing a better performing solution.



Press releases inform the public about company news. On its home page, mdatechnology.net provides hyperlinks to press releases issued by MDA technology developers. The next time your company issues a press release, let us know about it! Send an e-mail with the URL address of the press release to techapps@nttc.edu.

SBIR's LITTLE SISTER GROWS BIGGER

Technology developers doing joint research in conjunction with universities may want to consider proposing to MDA’s Small Business Technology Transfer Research (STTR) program. Sometimes regarded as SBIR’s little sister, STTR is a congressionally mandated program that requires all agencies with more than \$100 million in research and development to set aside 0.3 percent of their extramural RDT&E budget for joint research between small businesses and universities or Federally funded research and development centers (FFRDCs) beginning in FY ’04. The program operates

similarly to the SBIR in that contracts are awarded in two phases, with Phase I providing up to \$100,000 for a design concept, and Phase II providing up to \$500,000 for prototype development (increasing to \$750,000 in FY ’04).

STTR is ideal for university researchers who are spinning out small businesses to commercialize their intellectual property. “In addition to that,” commented Mr. Frank Rucky, the MDA SBIR/STTR program manager, “the program is also useful for partnerships with FFRDCs. Many people do not realize that STTR goes beyond the scope of universities and

allows small businesses an avenue for working with FFRDCs, which include centers like MIT’s Lincoln Laboratory and NASA’s Jet Propulsion Laboratory.”

STTR, through Congressional language, was recently raised in FY ’04 from 0.15 percent of an Agency’s R&D budget to 0.3, so although it is still the little sister, it has grown significantly for MDA to roughly \$15 million. The MDA solicitation for proposals, different than SBIR, is planned to be released in early January and can be accessed through www.sbirstr.com at that time.

BULK GALLIUM NITRIDE SUBSTRATES NOW AVAILABLE

ATMI (Danbury, CT) is manufacturing gallium nitride (GaN) substrates using a



process called hydride vapor phase epitaxy (HVPE). The company has already sold GaN substrates to major consumer electronics manufacturers, has

a contract with the Defense Advanced Research Projects Agency (DARPA) to explore radar applications, and is researching the benefits of use to the ultra-violet light-emitting diode (UV LED) industry. BMDO, now MDA, originally funded ATMI to develop GaN substrates for radar applications.

ATMI began selling GaN substrates to consumer electronics manufacturers in 2002. Consumer electronics manufacturers are investigating using the GaN substrates in their blue laser diodes, which are used primarily for storage applications. GaN devices can emit light at shorter wavelengths, allowing from 27 to 120 gigabytes of information to be stored on a single disc, depending on the method used to write the data. Imagine watching the entire *Godfather* and *Star Wars* trilogies without having to change the DVDs or videotapes. GaN substrates can make it possible by enabling you to save five to seven of your favorite DVDs onto one disc.

DARPA's Wide-Bandgap Semiconductor Technology Initiative awarded ATMI a contract to further develop materials, specifically the GaN substrates and epitaxy, for high-power, high-frequency radar applications. GaN is capable of transmitting at frequencies of more than 30 GHz and may offer the best combination of frequency and power performance. This will enable radar systems to see twice as far allowing a longer period of time to react. Wide bandgap semiconductors also do not require as much cooling, which means the radar device can be more compact and mobile.

ATMI is beginning to explore the value of its GaN substrate to the UV LED market. The value of the GaN substrate to that market depends on the degree to which dislocation and other crystalline imperfections impact or reduce light output. UV LEDs are typically used for solid-state white lighting applications. The UV LED industry may also find applications in sterilization and disinfectant devices, detection systems, and novel communication technology.

Inside a hot-walled HVPE reactor, ATMI is growing GaN boules at a rate in excess of 100 microns per hour. The GaN boules are originally grown on sapphire, which is then separated from the GaN. Once grown, the GaN boules are fabricated into GaN wafers using conventional tech-

niques. A chemical-mechanical polishing process is used to remove any damage created during fabrication. Instead of using sapphire again, ATMI selects the best GaN wafer as a seed to grow the next GaN boule. This process is repeated until 2-inch-diameter GaN wafers are fabricated and processed into devices. With DARPA funding, ATMI is developing four-inch GaN wafers. GaN substrates allow manufacturers to use the same material in the substrate as the epitaxial layer creating a smaller dislocation density, which improves device performance and yield. ATMI is interested in collaborating with other companies pursuing GaN technology.

—T. Spitzer

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Now available. Using a process called hydride vapor phase epitaxy, ATMI is growing GaN boules and manufacturing GaN substrates, which are currently being sold to consumer electronics manufacturers.

Looking to ramp up production and lower manufacturing costs, ATMI is developing a four-inch diameter GaN wafer.

"He can who thinks he can, and he can't who thinks he can't. This is an inexorable, indisputable law."

—Henry Ford

POLYMER OFFERS DISPLAY ALTERNATIVE TO INDIUM TIN OXIDE

Conductive polymer coatings are emerging as a more robust and flexible alternative to indium tin oxide (ITO) for liquid crystal displays.

Fractal Systems, Inc. (Tampa, FL), has developed transparent polymer coatings with copper-like conductivity. Although there are a variety of commercial and military applications for this technology, entering the liquid crystal display market is the ultimate goal of the company. Currently, Fractal is pursuing applications in solid-state lighting, optical device coatings, and electromagnetic shielding. BMDO, now MDA, funded Fractal to develop multi-functional conductive polymers for broad-frequency radiation hardening applications.

Fractal's polymer films can be used in conjunction with or to replace ITO, the current display industry standard. The copper-like conductivity of Fractal's polymer is three to four orders of magnitude higher than existing conductive coatings. The polymer is applied using traditional chemical processes at atmospheric conditions, which costs less than conventional methods. ITO is applied using an evaporation process, which results in pinholes in the ITO thin films. Correcting this problem requires laying down thick layers of ITO, resulting in lower transparency to visible light, limiting the devices' tolerance to mechanical stress and flexibility. Fractal can obtain a very homogenous polymer film without pinholes at sub micron-level thickness,

increasing robustness and flexibility. Creating a liquid crystal display is a difficult process that involves layering polymers, dividing it into pixels with high resolution, and developing circuitries that connect each pixel with a transistor. A possible beginning for Fractal is the small display market, such as cell phones and telephones, because there are not as many pixels and resolution is not as important.

Fractal is working with investors on another application of its polymer technology: solid-state lighting. Fractal's thin-film polymer is more efficient in lighting applications because it is nearly 100 percent transparent. Conventional thin films are still too thick to allow complete transparency. Solid-state lighting is also a low-power application because the light can run on just a few volts of electricity.

The coating capability of Fractal's polymer has generated interest in the defense industry as well. The company is currently talking to a defense contractor about using the polymer to hard-coat optical devices. Fractal's polymer is capable of being transparent in the visible through the infrared (IR). Many of the military's optical devices operate on the mid-wave IR range; therefore the coatings that protect the lenses must transmit IR. Currently, the military uses an ultra-violet (UV) filter and hardening coat—both absorb IR making the signals weak. Fractal can eliminate the need for conventional hardening and UV coatings with its polymer, which can achieve

more than 90 percent transmittance of the IR signal.

Another military application that is being discussed is using the polymer to shield the optics on military weapons, such as missiles, from electromagnetic signals. A window in the weapon transmits the IR signal to the electronics, but a destructive electromagnetic signal can enter as well. The conductivity of Fractal's polymer will shield the electronics from electromagnetic pulses while allowing the IR signals to pass through.

Fractal is poised for growth and ready to hire more employees in the next year. The company is interested in obtaining partners in device manufacturing to expand on applications of its polymer.

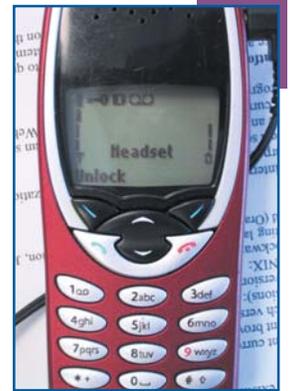
—T. Spitzer

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"Only those who risk going far will ever know how far they can go."

—Anonymous



Small display. Fractal's polymer films are ideal for small displays, such as those in cell phones, where fewer pixels and lower resolutions are tolerated.

Fractal's thin-film polymer is more efficient in lighting applications because it is nearly 100 percent transparent.

SIMPLIFYING FLUID DYNAMICS

Computational fluid dynamics (CFD) software is daunting—enough to make even the most brilliant engineers roll their eyes and groan. Tetra Research Corporation (Huntsville, AL) has developed new software called Tetrex that is easier to use than conventional CFD programs.

Tetrex allows aerospace engineers and other personnel to enter data and determine the jet interaction (JI) control of a missile. JI is used to guide missiles that do not have control surfaces such as fins. There are many competing factors affecting the JI control of a missile—placement of the jets on the missile, the type of combustible gas used to fire those jets, and the density of the air through which the missile will be flying.

Tetra partnered with Pointwise, Intelligent Light, and SGI Federal to develop Tetrex, which calculates all of the factors of JI control. It is an all-inclusive package that will handle geometry, turbulence, and chemistry data in a single code. BMDO, now MDA, funded Tetra in 1998 to develop JI controls, which will help develop faster, lighter, more maneuverable, and more accurate missile interceptors and achieve highly effective control authority across large portions of the battlespace.

The primary differentiating feature in Tetrex is the use of an unstructured grid to create the CFD model, which allows for greater flexibility, ease of

use, and generality. The grid encompasses multiple volumetric elements, including hexahedra, tetrahedra, prisms, and pyramids to accurately represent the geometry of the object in the flow field.

Tetra recently completed work for the U.S. Army's Theater High Altitude Area Defense (THAAD) program. The THAAD system is being developed to intercept short- and medium-range ballistic missiles inside and outside Earth's atmosphere. Tetra used its Tetrex software to compute JI and analyze basic aerodynamics as well as to gather information about the fluid flow around certain areas of the missile.

The company is researching two new U.S. Army programs, Compact Kinetic Energy Missile (CKEM) and Low Cost Interceptor (LCI), for possible applications of its Tetrex software. CKEM is planned to be a smaller, lighter version of the Line-of-Sight Anti-Tank Missile and may be incorporated into the Future Combat System

(FCS), which is a combination of manned and unmanned vehicles that will operate independently on multiple platforms. The LCI program is intended to demonstrate that a long-range, low-cost missile interceptor system can be developed using current capabilities and existing components.

Tetra is primarily focused on government projects related to missile defense. With additional funding, however, the software can be altered to calculate commercial applications. The computational algorithms of the program can be altered to solve low-density, low-speed flow problems making it applicable to process modeling in areas such as chemical vapor deposition and spray combustion.

—T. Spitzer

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Supercomputers

optional. Tetrex software operates on the U.S. Army's Space and Missile Defense Command supercomputers, but it can also run on powerful personal computers or corporate networks.

MDA TECHNOLOGY NEWS ON LINE

Is the information below news to you?

- Sensors Unlimited purchases assets from Finisar Corporation.
- Frontier Technology and Advantys merge to form stronger information technology business.
- EMCORE sells E300 GaNzilla™ MOCVD to EpiPlus.
- CoreTek optical unit, acquired by Nortel Networks, plans to shut down.
- T/J Technologies and McKenzie Bay agree to form new company to sell ultracapacitors for UPS applications.
- NP Photonics unveils optical spectrum analyzer engine.
- Neocera raises \$13.3 million in second-round venture financing.
- SY Technology is acquired by L-3 Communications.
- Templex Technology is acquired by Intel Corporation.

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

FORECASTING SOFTWARE RAISES THE BAR ON ACCURACY

Is a crystal ball more accurate than your current forecasting software? Knowledge Based Systems, Inc. (KBSI; College Station, TX), has developed a new software tool containing six forecasting methods that can be configured in 16 different combinations. This capability significantly increases forecasting accuracy.

Integrated Data Experimentation and Fusion System (IDEFS) is data mining and fusion software that leverages many sources of information and integrates it to make an informed decision. BMDO, now MDA, funded its development to increase the use of data fusion technology. IDEFS contains different forecasting methods such as artificial neural networks, fuzzy logic, expert systems, and genetic algorithms. The fusion of these methods can create a more accurate inventory of parts in a U.S. Army depot, correctly predict corrosion in piping systems on Navy ships, dependably manage cash in financial institutions, and generate precise threat assessments at airports.

Using its IDEFS technology, KBSI developed software to improve the U.S. Army's Rotary Wing Aircraft Sustainment Process at the Corpus Christi Airport Depot (CCAD). The Kit Content History Report (KCHR) tool allows personnel to maintain an online inventory of parts from disassembled aircraft or track ordered parts in real time. Mechanics can learn the location and availability of a part by typing the part number into KCHR. KBSI streamlined helicopter maintenance by analyzing the shop floor

mechanics' process for repairs, integrated new technology and information delivery, and prioritized the work schedule. Despite a larger workload, CCAD has enabled a 400 percent increase in throughput and a 39 percent reduction in cycle time for aircraft repair.

In addition to the CCAD contract, KBSI also worked on a contract for the U.S. Navy to develop a multi-fusion software system to monitor corrosion and improve maintenance of military machinery. Seawater is used for numerous applications and systems aboard ship. A major maintenance problem is checking the piping systems for corrosion caused by the seawater. The only way to monitor the corrosion was to physically take the pipes apart and visually inspect them, which was costing the U.S. Navy up to \$1 billion annually for a 200-ship fleet. KBSI developed condition based maintenance (CBM) software, based on IDEFS, to detect the onset of crevice corrosion.

KBSI is currently exploring applications of its IDEFS technology in cash management. Financial institutions such as banks and casinos can use Cash InfoMart™, available in early 2003, to forecast the amount of cash needed daily and how to manage it by quickly identifying business trends. For example, assume one branch of a bank maintains a cash balance of \$400,000 but typically only uses around \$200,000—an excess amount of 50 percent. If the Federal interest rate is five percent, the branch could have saved \$10,000 annually by not having so much extra cash. Using

those figures, if the bank contains 400 branches that would calculate to approximately \$4 million annually in savings. The software can also improve customer service by ensuring that cash will not run out prematurely.

Recently, KBSI developed two IDEFS technology systems to counter terrorism in airports: Pattern Characterization and Analysis System (PCAS) and Integrated Port of Entry Security Screening (IPSS). PCAS can monitor travel patterns and create profiles of normal and suspicious behavior that are compared with individuals or emerging situations to generate real-time threat estimates. IPSS integrates passenger profile information with baggage threat assessment and utilizes intelligent information processing algorithms to create real-time risk evaluation at the baggage-screening checkpoint. Both of these systems are currently available.

KBSI is in need of additional funding to continue the progress made with the IDEFS technology. The company is also interested in obtaining more government contracts.

—T. Spitzer



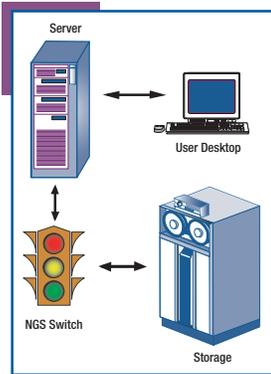
Maintenance reform.
Using KBSI's software technology, Corpus Christi Airport Depot increased throughput by 400 percent and reduced cycle time by 39 percent, greatly improving military helicopter maintenance.

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SMART TOOLS TO MANAGE DATA NETWORKS —by L. Scott Tillett

New technologies eliminate the guesswork associated with managing bandwidth and monitoring system failures.



Storage structure.

NGS's switching technology works as sort of a traffic cop sitting between servers and data-storage devices such as tape drives.

As people rely more on information networks and automated devices to run their businesses, the need to monitor and manage the health of those networks becomes critical.

A clog in a data pipeline used to process customer transactions could lead to dissatisfaction and lost business. Or failure to detect a bad connection to hardware running on the network could leave businesses operating at less than maximum capacity.

Meanwhile, in an effort to eliminate guesswork from their jobs, the users and the ultimate beneficiaries of information networks are demanding more these days. They want data immediately, and they want to be able to get to it easily. They want to be able to sort through the minute details on how their networks are operating, but they don't have the time to monitor all of the details.

New automation tools should take some of the guesswork, as well as some of the drudgework, out of the network management picture. And two companies funded with help from the SBIR program of BMDO, now MDA, are rapidly developing information technologies that take aim at the problems.

Storage networking

One company, Next Generation Systems, Inc. (NGS; Dayton, OH), has developed technology that adds new functionality to existing commercial data-storage technology.

The development involves storage area networks (SANs),

which serve as the information foundations of many large automated enterprises—from health care companies to banks to government agencies. SANs include a series of interconnected devices such as disk arrays and tape drives that hold massive amounts of data. The SANs supply data to servers that process the data for office applications, for electronic business transactions, and for Web-based queries—for virtually every information function in an organization.

Increasingly, the users of SANs are turning toward an architecture known as “fibre channel” to network together their data storage devices. The fibre-channel architecture relies on optical fiber to transmit stored data and operates at one of two industry-standardized speeds: 1 gigabit per second or 2 gigabits per second.

A key element of fibre-channel architecture is switching—the hardware and software that distributes data flowing over a SAN. But fibre-channel switches, while a ripe and widely used technology, still have room for improvement, according to NGS.

So NGS has developed fibre-channel switching hardware and software that allows storage users to apportion the bandwidth for their storage networks dynamically, devoting more resources to critical data tasks as needed. For missile-defense applications, the technology has been envisioned as a way to increase the efficiency of data management in avionics systems.

The new approach developed by NGS gives users guaranteed bandwidth (the amount of data that can be transmitted within a specific window of time) and guaranteed latency (or individual data-packet speed) for their storage networks. The two guarantees so far have been lacking in the fibre-channel SAN industry, according to NGS.

The technology also should bring new functionality to service providers on which storage users rely. Many storage users often turn to third-party vendors to help manage their networks, hammering out service-level agreements with the vendors as a way to oversee the billing process. The agreements long have allowed storage users to see how much storage they use and on which storage devices they use it. But the new technology from NGS now should allow users to oversee details on data rates or bandwidth—not just storage amounts and location.

The ability to drill down into the details of storage network bandwidth should allow users to make sure they are getting what they pay for from vendors. It also should allow users to manage data demands better within their organizations. Without the NGS switch, an end user within an organization might get data rates of 100 megabytes per second one day and 10 megabytes per second another day. The NGS switch allows network managers effectively to meter the data traffic and allocate band-

Continued on page 9

Smart Tools . . . from page 8

width ad hoc to the most critical business tasks.

NGS officials say the bandwidth-management features of their new switching technology also can help eliminate the need for two corporate networks—one for smaller data packets and one for large data packets. In missiles, aircraft, and other vessels, having such a singular, unified network instead of two networks could cut down on a craft's weight by reducing the amount of wiring and hardware needed. In addition to teaming with three initial strategic sales partners, NGS continues to negotiate more relationships with systems integrators and resellers.

Network monitoring

For some organizations, a network serves as the medium to manage many devices, such as security cameras, sensors, or other pieces of machinery. The more complex the web of devices being run by a network, the more challenging the job of the network manager. The challenge also increases dramatically with each additional network that a manager oversees. So a failed connection somewhere along the network could easily escape detection by a network manager. Or the manager might not become aware of a potential network problem until after a failure on one of the nodes of the network has occurred.

IPITEK (Carlsbad, CA), the result of a merger between BMDO-funded TACAN Corp. and Tetra Tech Data Systems in the late 1990s, has developed a solution to the network-management problem. The solution, a combination of software

and hardware, allows network managers to monitor information such as power-supply status for devices on a network; chassis and circuit temperatures; signal levels; and video and audio quality. The system regularly monitors the health of a network, and a user interface displays color-coded alarms, with different colors representing different levels of severity. The system also can automatically switch the devices or nodes on a network to use new network paths if one path fails.

The IPITEK solution includes fuzzy cognitive mapping (FCM) technology, a mathematical modeling tool akin to artificial intelligence, as well as expert systems and neural networks. BMDO funded the FCM technology through TACAN, with an eye toward using the technology to enhance the decision-making processes of information systems involved in missile defense.

The FCM technology was used in the development of IPITEK's NodeWizard® software. The technology provides the mechanism for determining status and prioritizing alarms managed by NodeWizard, which works with IPITEK's HBR-2500 hardware. The hardware is used to manage data streams in multiple formats.

The company already has clients that include a South American mining operation, which uses the system to monitor mining equipment and cameras. The system also would apply well to industries, such as telecommunications and cable television, in which companies must manage a net-

work of devices scattered across many locations. In addition, the technology could help cable companies monitor the infrastructure needed to deliver movies on demand to subscribers' homes.

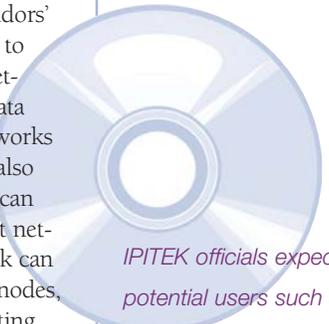
What distinguishes the system from competing vendors' technologies is its ability to manage not just voice networks and high-speed data networks, but video networks as well. IPITEK officials also boast that their solution can monitor as many as eight networks. And each network can include as many as 256 nodes, more nodes than competing products.

IPITEK continues to search for new customers, and company officials say they are especially eager to do business with companies working on missile defense systems, offering perhaps a chance for the FCM technology to spin back into MDA systems.

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IPITEK officials expect potential users such as businesses or government agencies to take a keener interest in IPITEK's NodeWizard® software as the focus on security grows and larger networks of devices, such as video cameras, sophisticated inspection equipment, or electronically controlled doorways, are built.

NEW CAMERA SPOTS GAS LEAKS

Half a billion dollars in natural gas is lost every year to leaks. Now, a new camera helps



Shooting the breeze.
Pacific Advanced Technology's camera spots natural gas leaks from a distance.

find them quickly and efficiently, using technology originally developed to detect missile launch plumes.

Pacific Advanced Technology, Inc. (PAT; Santa Ynez, CA), has

filed a patent on a camera that detects the presence of methane, propane, or other gas leaks by comparing their spectral signatures (infrared absorption) against a normal background. A unit can be handheld by a technician or mounted in an aircraft and operates in real-time as a combination of camera and computer.

In 1998 BMDO, now MDA, was interested in developing accurate sensors that could quickly detect gas plumes and awarded an SBIR contract to PAT to develop non-uniformity correction technology that would attach directly to a focal plane array (FPA). In 1999, BMDO awarded a Phase II contract to PAT to build a complete "smart" system including non-uniformity correction, image stabilization, and two-color ratios directly on the FPA chip. The electronics that PAT developed were uniquely low-noise and highly accurate.

Those electronics found a new life in PAT's gas-leak-detection camera. An FPA consists of approximately 65,000 pixels bonded to a multiplexer. The signals coming off the array have to be collected, processed, and corrected for error 60 times per second for video-rate imaging. This creates a backlog of chip processing and slows things down, even for the fastest chips available. The electronics package enables on-chip processing and signal amplification and compensates for distortion.

PAT's camera—a combination of image spectrometer, a cooled "sensor engine" supplied by Indigo Systems Corporation, and a viewer—is of great interest to corporations that have gas pipelines or refining and processing facilities. British Petroleum worked in tandem with the Gas Technology Institute to provide funding and facilities for testing the equipment. Shell Petroleum, N.V. and a corporation in Sweden have also expressed interest in this technology.

Sensitivity testing for the camera is scheduled for February 2003 at BP facilities. PAT anticipates being able to have a production unit ready for sale by April 2003 at a cost of between \$40,000 and \$80,000, depending on quantities manufactured. If the U.S. Environmental Protection Agency were to accept spectral surveys in lieu of the current Method 21 (which involves a painstaking method of physically applying solutions to facility components to find leaks), the mar-

ket demand for gas-detection cameras would significantly and rapidly increase.

Any gas that absorbs infrared radiation either in the midwave range (3 to 5 microns) or long wave range (8 to 12 microns) provides clues for an image spectrometer. SF-6 (sulphur hexafluoride), for example, which has a spectral signature in these ranges, is a very powerful greenhouse gas used as a transformer insulator in the electric utility industry. So a PAT camera would have an application not only to detect propane or methane leaks, but greenhouse gas emissions as well. The technology could also be applied to detect chemical and biological warfare agents.

The company is confident about its ability to manufacture as many cameras as necessary to meet customer demand, but has not yet settled on a definitive marketing strategy. They invite inquiries from interested parties who may be able to help with marketing the product.

—A. Gruen

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ADVANCED NANOPositionERS LEAD TO PRECISION IN MINIATURIZATION

The trend in small technology is infiltrating fields like biotechnology and atomic force microscopy (AFM), which is increasing the demand for positioners that enable placement and measurement with nanometer resolution.

To address the need for precise motion control, nPoint, Inc. (Madison, WI), began selling complete, calibrated nanopositioning systems one year ago. The company's integrated motion control systems can be used wherever nanoscale positioning is required over a limited range of motion. BMDO, now MDA, funded nPoint to develop advanced nanopositioners to improve measurement, positioning, and machining.

nPoint's positioners are currently being used as scanning stages for atomic force microscopy, which allows researchers to study the topography of surfaces. Most atomic force microscopes use open-loop scanners that have limited accuracy due to non-linearity of the piezoelectric material and do not allow researchers to make reliable measurements. nPoint is currently working with the AFM industry to convert from open-loop to closed-loop scanners, which offer typical accuracy and resolution values of 5 nm and 1 nm, respectively.

Currently, nPoint is manufacturing nanopositioning systems for several original equipment manufacturers. In addition to the AFM industry,

nPoint is working with the semiconductor and biotechnology industries to fulfill their requirements. The semiconductor industry needs accuracy and precision from its nanopositioners. nPoint's nanopositioners offer an out-of-plane motion less than 5 nm for a 100 micron x 100 micron scanning stage.

Biotechnology is an emerging market for nanopositioners. For instance, the biotech industry is manufacturing DNA chips that can monitor an entire genome on a single chip. DNA chip manufacturing does not require the resolution that nPoint offers. A growing need does exist, however, for nanopositioning stages with increased range of motion. nPoint is collaborating with biotechnology companies to develop them. In fact, nPoint is finding that many biotechnology companies want medium range stages that have 2 mm x 2 mm motion with nanometer resolution. The company is currently developing a design that will accommodate these specifications.

The capabilities of nPoint's nanopositioners are derived from some unique design characteristics. With Defense Advanced Research Projects Agency funding, nPoint designed a capacitance micrometer, which allows closed loop operation. This capacitance micrometer has a displacement resolution that is less than the diameter of an atom and is integrated into the design of the positioning stage, eliminating the need for

externally mounted feedback devices. nPoint also uses high-end piezoelectric elements that allow

increased travel for a given positioner size. The nanopositioners feature high resonant frequencies, enabling high-speed movement, and the

mounting holes feature unique flexures that decouple the strain and stress in the stage body maintaining the accuracy and stability of the stage position. nPoint's sophisticated design methods permit them to produce a family of standard, off-the-shelf nanopositioners with scanning ranges of up to 200 microns.

nPoint is currently trying to obtain venture funding for continued product development. The company was formerly known as Piezomax Technologies.

—T. Spitzer



Positioned for success. Using sophisticated design methods, nPoint has developed a family of standard, off-the-shelf nanopositioners as well as unique positioning systems for several original equipment manufacturers.

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REAPING THE EVANESCENT FIELD

Modern fiber-optic cable, despite its gigabit-per-second capacity, is still just a big pipe carrying light that is switched and routed by some other mechanism. No longer; the fiber can do



Coming soon. IFOS intends to sell *FyberSpace™* couplers and other products after their reliability has been proven.

its own switching now at the speed of light. Intelligent Fiber Optic Systems (IFOS; Sunnyvale, CA) has developed products that could mark the transition to true all-optical communications, computing, and sensing. IFO takes conventional fiber-optic cable and, using patented designs and processes called *FyberSpace™*, modifies both the core and the cladding. The result is fiber that performs

integrated functions outside of simple transport such as add-drop multiplexing, variable attenuation, filtering, modulation, and switching.

Optical processing within a fiber-optic cable provides more capacity within a smaller housing and eliminates the burden of electronic components. BMDO, now MDA, was interested in supporting IFOS research and awarded the company a Phase I SBIR contract in 1998 and a Phase II contract in the last quarter of 1999. In Phase I, IFOS successfully fabricated and proved optical add-drop multiplexing. In Phase II, the company showed that conventional fiber could be modified cost-effectively and packaged to be attractive to potential

customers in the photonics industry. IFOS is now evaluating the performance and reliability of the product at both the device and network levels.

The heart of IFOS technology is the ability to manipulate what is called the evanescent field. Light travels as an electromagnetic wave through the core of a fiber called a waveguide. Most of the energy of the wave is propagated through the waveguide, but a small “tail” of energy—the evanescent field—extends a few microns outside the guide and into the less dense cladding. If two waveguides are brought into close proximity such that the evanescent fields overlap, under special conditions of separation and interaction length, the energy can switch back and forth between the waveguides.

By thinning fiber cladding very precisely and optically contacting the thinned faces of two strands, IFOS takes advantage of a phenomenon known as evanescent wave coupling to create a coupling mechanism. Light passes through or is redirected from one fiber strand to another. Modifying fiber with micron-level precision for high performance device applications would be impossible without the help of sophisticated simulation software.

IFOS technology can be either passive or active. Using fiber gratings, IFOS technology can perform static network routing and management functions. Using active optical materials as the activation mechanism, it would be possible for a network operator to “reprogram” the fiber to perform a different specific function.

Whether something works in the laboratory and again in the field under harsh conditions are two different questions. The reliability of “intelligent” fiber needs to be proven before network providers will deploy it. IFOS is manufacturing batch samples for testing to standards established by Telcordia Technologies, which industry engineers recognize for performance qualification. After testing, the company intends to ship products to customers for direct use in deploying new or replacement fiber-optic networks. IFOS is closely working with customers to optimize products for specific applications.

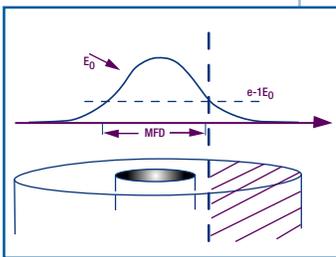
Optical sensors also benefit from IFOS *FyberSpace* technology and products, which need no distributed electronics. The company claims that any mechanism or structure that benefits now from sensors could substitute IFOS fiber for sensors and save on cost and weight.

The company seeks approximately \$5 million in investment funding to purchase manufacturing equipment that would enable them to quickly and efficiently meet anticipated demand over the next few years. The company also welcomes inquiries on new research projects based on *FyberSpace* technology that need funding.

—A. Gruen

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Catch a lightwave by the tail. The energy of a wave of light travels mostly through a waveguide (center), but an evanescent tail (right) extends outside the waveguide and into the surrounding cladding.

ELECTRO-OPTIC POLYMERS COME OF AGE

Organic technology is a science-fiction staple. No longer; it's entered the realm of fact.

Lumera Corporation (Bothell, WA) has developed a prototype for an electro-opto-polymer-based 10-gigabit modulator that will run reliably, in room temperature, at more than 100 GHz. Devices made with this new material should run at higher operational speeds, with lower optical losses, lower power consumption, and lower cost of fabrication than existing devices using inorganic materials.

As early as 1994 under the Innovative Science and Technology (IS&T) Program, BMDO, now MDA, supported research into electro-optic polymers by Dr. Larry Dalton and others at the Loker Hydrocarbon Research Institute at the University of Southern California. Thermal and optical stability of the early polymers was a key issue that Dalton continued to investigate after he moved to the University of Washington. Lumera is partially funding, and has acquired an exclusive license to use, professor Dalton's research at the University of Washington. The company recently signed a licensing and consulting agreement with Arizona Microsystems giving Lumera licensing rights to the electro-optic work at the University of Arizona and Caltech.

The magic behind Lumera's electro-opto-polymer-based modulator is a molecule called a chromophore. Chromophores are

organic molecules that are specially engineered to control the propagation of light by means of an applied electric field. The current industry standard for use in electro-optic modulators is the inorganic (or crystalline) ferroelectric material lithium niobate. But lithium niobate has physical limits for maximum speed, requires high drive voltage, and does not easily adhere to other surfaces. In contrast, chromophores (set within a thermoset polymer matrix) offer much higher speeds and lower drive voltages, and integrate well with other polymer-based optic technologies.

Capitalizing on these advantages, Lumera has designed a modulator that can operate at 100 GHz (instead of 10 or 40 GHz) at roughly half the voltage of existing modulators, for less cost. The company is testing the thermal stability of its electro-optic polymer for up to 2,000 hours at 85°C. It plans to ship engineering samples of a 10-gigabit modulator to selected customers including Cisco (a major investor in Lumera), before the end of 2002. Lumera thinks it can manufacture units for significantly less than the \$6,000 to \$15,000 price tag of existing electro-optic modulators. By the second quarter of 2004, the company hopes to introduce an even more powerful 40-gigabit device, and equally hopes to reduce costs down to \$1,000 per unit by that time.

A series of electro-opto-polymer-based modulators could be packed into a small space with negligible crosstalk

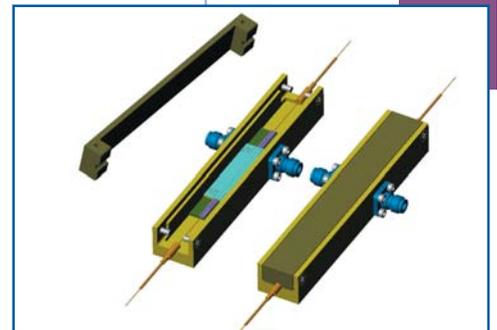
interference. This offers the promise of compact, multi-channel optical communications links in a small space with very low

losses, something that manufacturers of lithium niobate-based modulators cannot hope to match. With a Class 100 clean room of its own inside an 11,500-square-foot facility, Lumera intends to maintain manufacturing control of its own materials and does not plan to license the technology.

While optical communications is the first market that Lumera has chosen to enter, it is not the only segment of the photonics industry that might benefit. Electro-opto-polymers might profitably be deployed in displays, sensors, and optical computing.

The company, which is majority-owned by Microvision, seeks \$20 million in additional funding to build a full-scale manufacturing facility and market the new products.

—A. Gruen



10-gigabit modulator: Based on organic technology, the prototype runs at room temperature at more than 100 GHz.

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ION POWER

It's more powerful than a standard rechargeable lithium ion battery, weighs less, lasts longer, provides lower voltage, and might even cost less to manufacture than traditional rechargeables.



Thin is in. A thin-film lithium-ion polymer battery, developed by Lithium Power Technologies with BMDO SBIR funding, can power cell phones and other small electronic devices at low voltage over long periods.

Lithium Power Technologies, Inc. (LPT; Manvel, TX), has created and applied for a patent on a thin-film lithium-ion polymer electrolyte battery that has the potential to offer an energy density of up to 250 watt-hours per kilogram (Wh/kg). The most efficient batteries sold today have energy densities from 130 to 185 Wh/kg. "The majority of cell phone batteries are around 165," said LPT president Dr. Zafar A. Munshi. "Advances in new cathode chemistries are allowing energy densities as high as 185 Wh/kg. However, a lower voltage lithium-ion battery with greater than 200 Wh/kg does not exist today, and we know we can do it." The LPT thin-film battery combines elements of both battery and capacitor technology and is lighter and cheaper to manufacture because the battery consists mostly of polymer rather than metal.

BMDO, now MDA, awarded a Phase I SBIR contract to LPT in 1998 to investigate the possibility of developing a hybrid power source based on metallized thin-film capacitors and polymer electrolyte batteries that could operate reliably and efficiently

at room temperature. BMDO awarded a follow-on Phase II contract in 1999 to test the different cells LPT produced for durability and other properties.

The key to LPT's breakthrough product is combining the best of both battery and capacitor worlds. Metallized film capacitors have neither high energy density nor lengthy storage capability, but they are easy to manufacture using a high-speed, large surface area, thin-film process. Solid polymer electrolytes do not conduct well at room temperature, but lithium-ion gel has excellent conductivity. By using a very small amount of solvent, LPT imparts room temperature conductivity to a solid gel by giving it some liquid properties. The process of creating the hybrid metal/polymer cell is similar to spray-painting a shag rug where only the tips of each individual polymer strand need be metallized. The aluminum or copper coating on the polymer is durable, and the result is a thin, low-voltage (2 V to 3 V) battery that can be mass-produced.

Supplying power for medical devices is a promising short-term application. A leading world class medical device company has placed a small prototype cell order with Lithium Power Technologies. If these cells are approved, the medical company may place an order for an improved battery with the possibility of placing a 10,000 unit order thereafter.

The wearable computing and consumer electronics industries are always looking

for low-voltage, lightweight batteries. In theory, electric vehicles, aircraft, and missiles could also benefit from LPT's technology which, being thin, can take advantage of a large surface area to supply electricity in a weight-sensitive design environment.

LPT currently manufactures cells in small batches to supply potential customers with samples, but sees no obstacle to increasing production. The main hurdle that remains is finding a cost-effective process for testing and maintaining quality control. The company needs three to five million dollars to buy pilot plant equipment and to start the first phase of production. It seeks private investment in return for equity in the company.

—A. Gruen

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"A lower voltage lithium-ion battery with greater than 200 Wh/kg does not exist today, and we know we can do it"

—Dr. Zafar Munshi
Lithium Power Technology

Focusing on . . . from page 1

into a centimeter-square area of the material without damaging it. Each grating reflects only one individual laser, having a unique angle of incidence. But all the gratings in a block of the material are designed to direct the individual lasers in the same direction.

Since each individual laser acquired from a commercial vendor might not have the exact color or wavelength desired by someone combining beams, DOT's beam combiner includes a feedback mechanism designed to tweak an individual laser to the appropriate wavelength. The feedback mechanism involves using partial reflectors to transmit light of one wavelength while deflecting light of another wavelength.

Beams produced by DOT's beam combiner could prove useful in laser radars, printers, fiber-optic communications, and even cancer treatment, according to company officials. Since the beam combiner works as a demultiplexer, taking many spectral sources and merging them into one source, the technology also proves useful in multiplexing applications, taking one spectral source and breaking it down into many sources. As a result, the same technology used for combining the beams can be used for spectrum analysis, allowing would-be customers to use the technology to test the signals used in communications or sensing equipment.

DOT received funding for its holographic beam combiner through BMDO's SBIR program. The agency funded the technology in part for its potential in laser radar systems for missile guidance.

DOT is aiming its initial commercial thrust toward spectrum analysis, as well as toward a beam combiner for laser radars. The company already has developed a spectrum analysis product that it intends to market in coming months. It continues to seek vendor collaboration to market the spectrum analyzer and also is keeping its door open to potential aid from venture capitalists. Company executives place the initial customer cost for the analyzer at \$3,000. Other commercial spectrum analyzers with similar capabilities on the market now cost close to \$20,000, according to the company.

More bang for the beam

While some laser researchers see combining lasers as an avenue to greater functionality, other scientists are focusing on how to squeeze more power and performance out of existing lasers.

Maxion Technologies, Inc. (Hyattsville, MD), develops mid-infrared semiconductor lasers for wireless optical communications, chemical sensing, and infrared countermeasures and has received BMDO funding to develop distributed feedback interband cascade lasers for military applications such as wireless communications systems and chemical sensing.

The distributed feedback technique uses a grating structure along the entire length of the laser that feeds back only a specific, desired wavelength into the laser's final output. The interband cascade laser design advanced by Maxion meanwhile involves cascading electrons to produce multiple pho-

tons as the electrons move between the energy bands, or levels, of the multi-layered semiconductor structure used for the laser.

The result is a very efficient laser—one that has advantages over similar lasers such as the intersubband quantum cascade laser according to Maxion officials. "The bottom line is that Maxion's laser has all of the advantages of the intersubband laser that arise from the cascade design, along with a big efficiency advantage that comes from cascading interband active regions together," said Maxion Chief Technology Officer John Bruno.

Common mid-infrared diode lasers have power efficiencies as small as 3 percent, with 97 percent of their input power wasted as heat, according to Bruno. But the Maxion lasers—mid-infrared lasers based on indium-arsenide, gallium-antimonide, and aluminum-antimonide materials—can operate in continuous-wave (CW) mode at 80 Kelvin with power efficiencies higher than 17 percent. The result is that a Maxion laser can operate much more efficiently than comparable lasers and, with further development, may operate at room temperature under CW conditions.

Maxion's laser technology not only boasts greater efficiency than current lasers; it also boasts greater power. Bruno said the company had demonstrated at 80 Kelvin a continuous-wave laser with power levels around 160 milliwatts. That power compares



Laser layout. A magnified image of Maxion's 4-micron interband cascade laser bar is pictured above. The bar measures 1 mm by 6 mm. Eight lasers (each 15-microns wide and 1-mm long) as well as a ground contact are wired to the pins on the bar.

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Maxion lasers are being tested for potential use in portable chemical sensors.

Focusing on . . . from page 15
with continuous-wave lead-salt lasers that generally generate less than about 1 milliwatt of power, he said.

Maxion envisions its technology as valuable for “free-space” optical (wireless) communications, chemical sensing, and infrared countermeasures. The company has agreements with two organizations that are testing its lasers in chemical-sensing applications for potential use in portable chemical sensors, according to Maxion.

With free-space communications, some challenges will remain. Fog is almost always an issue in free-space optical communications, weakening signals as they travel through the air. In a light fog, 3.5-micron beams, such as those produced by Maxion’s lasers, can propagate almost as well as

10-micron beams. But in a dense fog, a 10-micron beam does better.

The benefits of a 10-micron beam in a dense fog, however, are more than offset by a disadvantage, according to Maxion. “Even though the fog would reduce the transmission of the 10-micron beam less, the available detectors at 10 microns are noisy,” Bruno said. “The detector noise is so large that the propagation advantage at 10 microns is lost in a high-bandwidth optical link unless one resorts to a cryogenically cooled detector—a commercially unreasonable solution.” For this reason, Bruno said he viewed 3.5-micron beams as having the greatest commercial potential. “It is not perfect as far as fog propagation goes, but it’s so much better than the 1.55-micron [beam] that’s now being

used that we think it’s going to make the difference.”

Maxion officials plan to continue their research and are searching for government R&D funding that will carry the company into the next few years. Bruno said the company might seek venture capital funding in 2003.

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