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September / 2009

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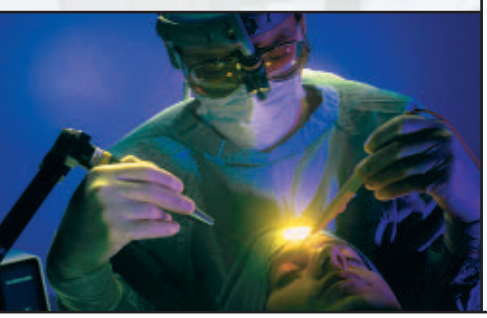

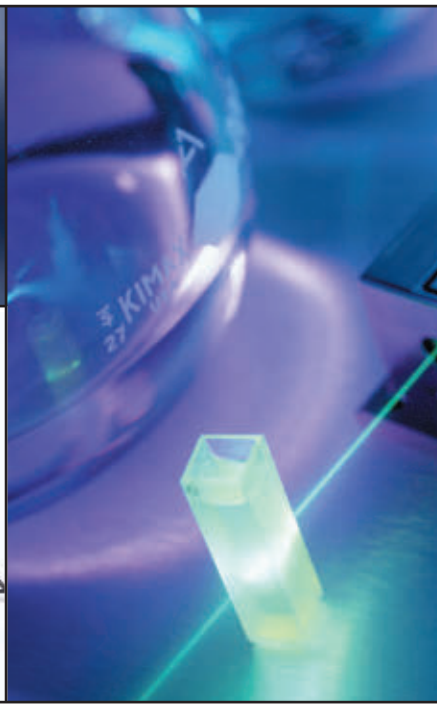

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E measurement (testing, quality control or safety)
F other engineering or science function (please specify) _____

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H engineering/technical
J manufacturing or production
K purchasing
L other management function (please specify) _____

Other

M consultant
N educator
P other functions (please specify) _____

2 ☐ Please indicate the primary end product or service of your company at this location. (Please insert one letter/number only.)

A aerospace/aviation systems
B agriculture, food, forestry & mining
C analytical, test or measurement instrumentation
D automotive or transportation
E cable TV/video/broadcasting
F cameras, detectors, sensors & electro-optical components
G chemical or pharmaceutical products
H communications equipment or services (incl. telcos, RBOC & other carriers)
J computer displays, peripherals, office & business equipment
K consumer electronics & appliances
L electronics, semiconductors & IC
M environmental monitoring
N fiber optic components or systems
P hospital/medical university or office
Q industrial control systems & robotics
R laboratory, government
S laboratory, industrial
T lasers/laser systems
U manufacturing equipment, machinery or metal products
V medical & biotechnology equipment
W military equipment
X navigation & guidance systems or equipment
Y optical components, materials or systems
Z plastics, polymers, rubber
1 printing, publishing, graphic arts
2 university/institution/college
3 utilities, energy, petroleum & coal
4 government personnel not classified elsewhere
5 industrial company or commercial user incorporating photonic products not classified elsewhere
6 other _____

Principal Product or Service _____

3 Which of the following publications do you read regularly? (Please check all that apply.)

A ☐ Advanced Imaging
H ☐ Laser Focus World
K ☐ Lightwave
M ☐ NASA Tech Briefs
N ☐ Nature
P ☐ OLE
R ☐ Physics Today
S ☐ Science
T ☐ Semiconductor International
V ☐ Vision Systems Design
X ☐ None of the above

4 ☐ The number of employees at this location is: (Please insert one letter only.)

A 1-10
B 11-25
C 26-50
D 51-100
E 101-500
F 501-1000
G 1001-5000
H over 5000

5 Which of the following technologies/sciences do you and/or your organization work with? (Please check all that apply.)

A.
A ☐ aerospace/aviation
C ☐ astronomy
D ☐ automotive
E ☐ biotechnology
G ☐ chemistry, chemical engineering
J ☐ chromatography
L ☐ communications
N ☐ computer engineering
P ☐ displays
R ☐ environmental monitoring/sensing
T ☐ forensic science
V ☐ holography
W ☐ lighting/illumination
X ☐ imaging
Z ☐ inspection/identification

B.
A ☐ machine vision
C ☐ materials processing/production
E ☐ materials research
G ☐ medical/biomedical
J ☐ microscopy
L ☐ military/tactical
N ☐ nondestructive testing
P ☐ optical character recognition
R ☐ optical computing/data storage
T ☐ photonic component mfg.
V ☐ process control
X ☐ quality control
Z ☐ remote sensing/lidar

C.
A ☐ reprographics/printing
C ☐ robotics
E ☐ semiconductor processing
G ☐ simulation/modeling
J ☐ signal processing
L ☐ spectroscopy
N ☐ test & measurement
P ☐ ultrafast/time-resolution studies
R ☐ other _____

6 Which of the following products do you buy, use, recommend and/or specify? (Please check all that apply.)

A. Optical Components & Software
A ☐ coatings
C ☐ filters & beamsplitters
E ☐ gratings
G ☐ infrared optics
J ☐ laser optics
L ☐ lenses
N ☐ mirrors & reflectors
P ☐ optical design software
R ☐ polarizing optics
T ☐ prisms
V ☐ ultraviolet optics
X ☐ windows & domes

B. Lasers
A ☐ semiconductor, diode
C ☐ solid-state, diode-pumped
E ☐ solid-state, Nd:YAG
G ☐ solid-state, Ti:sapphire
J ☐ solid-state, tunable
L ☐ solid-state, VCSELs
M ☐ fiber lasers
N ☐ gas lasers, CO_2
P ☐ gas lasers, excimer
R ☐ gas lasers, HeNe
T ☐ gas lasers, ion
V ☐ gas lasers, other
X ☐ dye
Z ☐ other lasers _____

C. Laser Systems
A ☐ biometric/forensic
C ☐ biotechnology
E ☐ communications
G ☐ industrial (cutting/welding/marking)
J ☐ entertainment
L ☐ environmental monitoring
N ☐ holography
P ☐ materials processing
R ☐ medical
T ☐ military
V ☐ remote sensing
X ☐ reprographics (printing/graphic arts)
Z ☐ spectroscopy & photochemical analysis

D. Fiber Optics
A ☐ cables
C ☐ communications lasers
E ☐ connectors or couplers
G ☐ detectors or receivers
H ☐ fiber
K ☐ gratings
M ☐ lightguides
N ☐ network components
O ☐ optical amplifiers
Q ☐ optical switches
S ☐ splicing & polishing equipment
U ☐ test equipment
W ☐ transmitters
Y ☐ WDM or DWDM
Z ☐ other fiber optic components _____

E. Cameras
A ☐ CCD or CID
C ☐ CMOS
E ☐ high speed
G ☐ infrared
J ☐ line scan
L ☐ other camera _____

F. Detectors/Sensors
A ☐ CCD or CID
C ☐ CMOS
E ☐ detector arrays
G ☐ infrared
J ☐ photodiodes
L ☐ photomultipliers
N ☐ semiconductor

G. Imaging Equipment & Software
A ☐ frame grabbers
C ☐ image intensifiers
E ☐ imaging software
G ☐ infrared imagers
J ☐ illumination equipment
L ☐ vision systems
N ☐ x-ray imaging

H. Manufacturing Equipment for Photonic Components
A ☐ assembly or packaging equipment
C ☐ cleanroom equipment
E ☐ coating equipment
G ☐ cooling & cryogenic equipment
J ☐ diamond machining equipment
L ☐ grinding & polishing equipment
N ☐ optical design software
P ☐ photonics test equipment
R ☐ vacuum equipment
T ☐ other manufacturing equipment _____

J. Positioning/Vibration Isolation Equipment
A ☐ benches, rails & slides
C ☐ micropositioners
E ☐ mounts for photonic components
G ☐ positioning equipment
J ☐ position-sensing equip.
L ☐ stepper motors & drivers
N ☐ tables, optical
P ☐ vibration-isolation equipment

K. LEDs and Displays
A ☐ CRTs
C ☐ flat panel
E ☐ LCDs
G ☐ LEDs
J ☐ light valves
L ☐ OLEDs
N ☐ plasma

L. Test & Analysis Equipment
A ☐ interferometers
C ☐ microscopes, optical
E ☐ microscopes, other
G ☐ monochromators
J ☐ optics testing equipment
L ☐ power/energy meters/wavelength meters
N ☐ radiometers/photometers
P ☐ spectroscopy equipment
R ☐ spectrum analyzers
T ☐ telescopes

M. Electronics & Signal-Analysis Equipment
A ☐ amplifiers
C ☐ oscilloscopes
E ☐ power supplies
G ☐ pulse & signal generators
J ☐ signal analyzers
L ☐ time-delay generators

N. Laser Accessories
A ☐ beam analysis
C ☐ flashlamps
E ☐ laser chillers
G ☐ laser dyes, gases or rods
J ☐ laser power & energy meters
L ☐ laser power supplies
N ☐ laser safety
P ☐ laser scanners

P. Light Sources
A ☐ arc sources
C ☐ flashlamps
E ☐ infrared
G ☐ LEDs
J ☐ ultraviolet

Q. Materials & Chemicals
A ☐ cements, adhesives & epoxies
C ☐ coating materials
E ☐ crystals
G ☐ grinding & polishing materials
J ☐ transmissive materials, IR
L ☐ transmissive materials, UV
N ☐ transmissive materials, visible

R. Computers & Software
A ☐ computer hardware (PCs, servers, workstations, mainframes)
C ☐ data acquisition
E ☐ scientific/engineering software

S. Nanophotonics
A ☐ microscopes
C ☐ nanophotonic devices
E ☐ nanophotonic materials
G ☐ quantum dots

T. A ☐ Other _____

X. ☐ None of the above (6A-6S inclusive)

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THE COVER
This month's cover was inspired by the flat screen display feature on page 56; designed by Art Director Lisa N. Comstock.

PHOTONICS: The technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. The range of applications of photonics extends from energy generation to detection to communications and information processing.

Volume 43 | Issue 9
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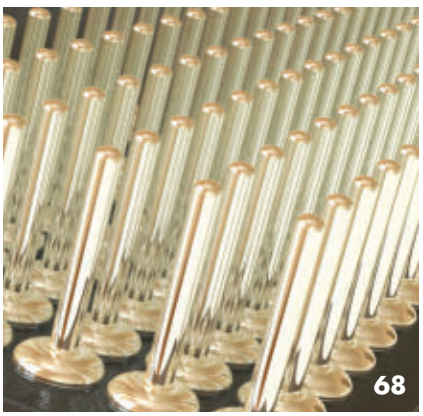

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A Great Loss

Diane M. Laurin, group publisher for Laurin Publishing's slate of international trade magazines, died unexpectedly Aug. 3. She was 57.

Diane's mother, Teddi C. Laurin, founded *Optical Spectra*, later *Photonics Spectra*, magazine in 1967, and Diane began her career with Laurin Publishing shortly after graduating from Russell Sage College in 1973. Diane left the company in July 1991, becoming vice president of public relations for Winstanley Associates, an advertising/marketing communications agency based in Lenox, Mass.

Diane returned to Laurin Publishing in early 2008 to assist me, her brother, in managing the business. As group publisher, she spearheaded a rebranding and refocusing of the company's three magazines – the flagship publication *Photonics Spectra*, *BioPhotonics* and *EuroPhotonics* – and a completely new online Photonics Directory. Her ambitious goal was to reinvigorate industry pride and to position Laurin Publishing for the 21st century, and one of her first accomplishments was giving the company a new identity: "Photonics Media – The pulse of the industry," to describe its full suite of print and online media. She embraced new media ventures and led Laurin's foray into social networking sites such as Twitter and Facebook.

Diane was happy to reconnect with her many friends and colleagues in the photonics industry by attending several trade shows over the past two years. She also was instrumental in founding the world-class Prism Awards for Photonics Innovation, which recognize the most innovative photonic products, conceived in partnership with SPIE and awarded for the first time in January 2009.

Diane also re-energized the staff of all three magazines, who considered her both a mentor and a dear friend.

On a personal note, I would like to add that I worked with Diane in her early years at Laurin and when she came back in the spring of last year. She was more than a colleague, she was a dear friend, whom I – and everyone else here – will miss greatly. Diane was one of the brightest and most versatile people I've ever met. She worked and played hard, and enjoyed life to its fullest. Her passing leaves a huge void – professionally and personally.

Tom Laurin

Thomas F. Laurin
President

Although I grieve as only a mother can when losing a child, I am confident that the company will continue the thoughts and dreams that have been put into place. And though it was only for a short year and half, I know that Tom was excited to work hand in hand with his sister to grow the company and make efforts to head it in the right direction. For Diane, I am proud of my staff because it embraced her efforts and followed her passion.

At this time, we may have to pause and reflect upon our loss, but in the next moment, we know that we must still go forward. This is what we have been doing for more than 50 years as a family business. When Diane left the company 17 years ago to join a marketing firm, the company continued to grow and prosper. And while she is no longer with us today, her spirit is. And with her spirit alive, we will continue to grow and prosper in the years to come.

Teddi C. Laurin

Teddi C. Laurin
Chairman/CEO

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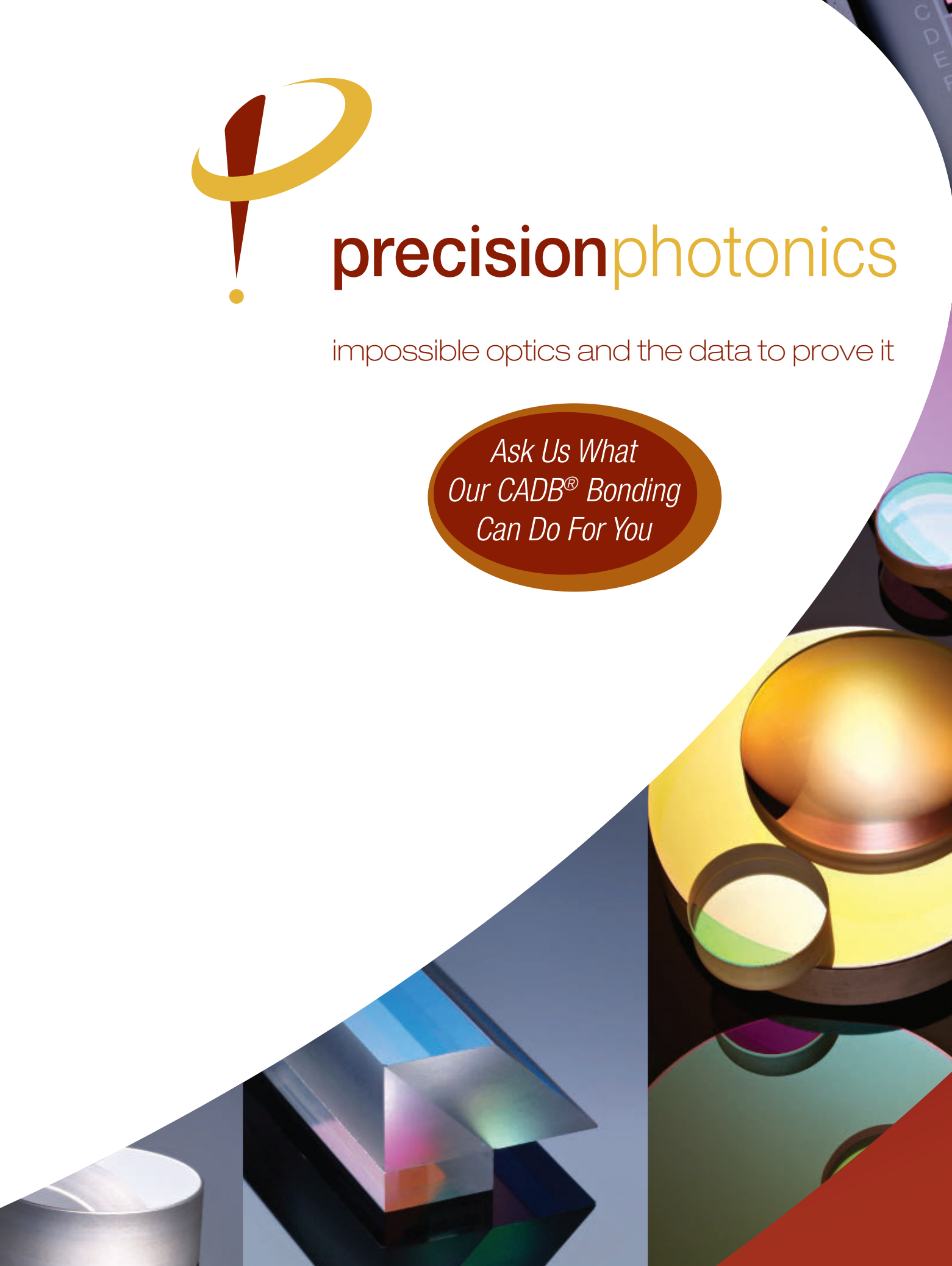

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White Elephant in Space?

Many view the International Space Station ("Solar-powered space station," *Photonics Spectra*, July, p. 36), as a $150 billion "white elephant" in space that has sucked resources from many other more worthwhile programs – construction that was said to have been created in part to provide jobs for out-of-work ex-Soviet nuclear scientists so they would not run off and give atom bombs to rogue states.

That it needs 32,800 solar cells is no brag. The same job could have been done with a plutonium energy cell the size of a home computer box, and it would not be relying on the sun to function.

Richard Anderson
Toronto

A solar fraud?

In the July issue of *Photonics Spectra* I read "Solar from space" (page 35). This concept is a complete fraud to get money for nonsense.

First, why is it so necessary to send power to Earth from space? Do we not have enough from fossils or other sources? One reason given is that it is often cloudy, so solar power plants cannot generate enough power.

If you look at pictures of the globe sent from a Meteo geostationary satellite, you can easily see that only about one-eighth of the half-globe is covered by clouds. This means that the remaining seven-eighths has unlimited solar irradiation, and we have terrestrial power networks to transport the generated power around the globe.

Next, consider that solar cells are quite inefficient; today's best are at about 15 percent, and they age in space. Satellite designers know better. In my opinion, heating water is more efficient, and it is done in California, Arizona, Spain, Japan and elsewhere without rocket technology.

Then there's the issue of energy loss as power is transmitted to Earth. Anyone who has heard about electromagnetic waves knows that the power decreases due to propagation in proportion to inverse square. In a power distribution, a "good" efficiency is more than 80 percent. The experts claim that the power will be focused and collected by huge antennas. A typical good satellite antenna has about 50 percent efficiency. And the free-space power loss at 2.45 GHz over 35,000 km is ~190 dB, otherwise 10^{20}. What kind of power efficiency can you expect?

Finally, I have asked some of the experts how to get those wonderful antennas that amplify power. I would use them in microwave and millimeter-wave communication systems. Nobody has responded. All this is a hoax and pure fantasy, and moreover not based on natural laws. Those space solar concepts are pure nonsense.

Jiri Polivka
Santa Barbara, Calif.

Editor's response:

As a science writer, I cover subjects that I think will be of interest to our readers and make no claims as to the success of a technology or marketing concept. We do, however, appreciate readers keeping us informed of the many issues surrounding such a controversial topic.

Thin-film question

I read with great interest Caren B. Les' article in the July issue on p. 28: "Image sensor market: Looking forward to better times." I am curious about a statement in your article: "A third generation of devices based on polymeric thin films … also could be developed."

Are there companies or start-ups in this space?

Erik Bodegom
Professor of Physics
Chairman, Department of Physics
Portland State University
Portland, Ore.

Response:

I'm not sure of any companies that might be involved, but think PARC [Palo Alto Research Center] and the University of California, Santa Barbara, might be working on polymer-based image sensors.

Charles E. Spear
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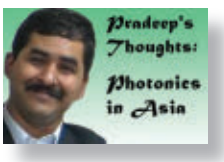

Pradeep's Thoughts
– a regular column by blogger Pradeep Chakraborty detailing the photonics industry in Asia. Pradeep is a semi-con/telecom consultant at PC Mediaworks.

WEB EXCLUSIVES:
Recent Developments in Photoconductive IR Arrays
Brian Elias, director of engineering at Cal Sensors, takes a closer look at the application of several established technologies that have been applied to make lead sulphide (PbS) and lead selenide (PbSe) arrays compatible with modern infrared array applications. In this article, an implementation will be shown that takes advantage of these techniques to produce a second-generation array.

Check out a sample of the new digital version of *Photonics Spectra* magazine at www.photonics.com/DigitalSample. It's a whole new world of information for people in the global photonics industry.

Plus all the latest news, products and industry information you need each day.

In the October issue of Photonics Spectra …

Instant Revenue – Marketing & Mergers
Industry expert Milton Chang gives advice on quick revenue generation in the current economy, focusing on the benefits of advertising and pooling resources.

It's the Humidity
The humidity surrounding optical components can affect performance, especially in systems exposed to the elements, such as cars. Multisorb Technologies explains the benefits of incorporating desiccants early in the optical design process.

Who Are You, Really?
Security ID systems use a variety of techniques, many of which make use of photonic sensors and light sources. In an increasingly cyber-physical world, those systems also are used to control access to computers, databases and cyberspace.

Whalespotting
Whales are usually difficult to find. A *EuroPhotonics* article will introduce a thermal imaging camera now in testing that could support research projects on whale population or help ships avoid collisions with the large mammals.

Staring into the sun
Stories in GreenLight will focus on high-tech sun catchers, developments in "personalized energy" that involve storing solar energy in hydrogen fuel cells, the global photovoltaics market and the Desertec Industrial Initiative, a huge solar installation that intends to send solar power from the Sahara Desert to Europe.

Plus all the news that affects your industry, from tech trends and market reports to the latest products and media.

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Baking powder or anthrax? Ask the Ceeker

CHRISTCHURCH, New Zealand – These days, anyone who comes across a strange white powder might like to know – as quickly and as accurately as possible – whether it is benign baking powder or deadly anthrax.

The Ceeker can help.

Pronounced "seeker," the handheld gadget was created by Veritide Ltd., which develops biological identification and detection devices. It analyzes a suspicious sample and, within minutes, can reveal whether it contains bacterial spores. First responders such as police and firefighters, HazMat personnel, airport security, postal workers and military units would benefit most from the tool because they are more likely than the general populace to encounter hazardous materials on the job.

"At the very beginning, when we came up with the technology … it was very clear to us … it was something that would help a lot of people," said Lou Reinisch, professor of physics and head of the physical and Earth sciences department at Jacksonville State University in Alabama. Reinisch is the inventor of the technology behind the device.

Drs. Andrew Rudge (left), CEO of Veritide Ltd., and Lou Reinisch (right), inventor of the Ceeker's optical technology with the device.

With a push of a button, Veritide Ltd.'s Ceeker can accurately analyze a sample in 10 minutes. Traditional methods involve sending the sample to a laboratory, where it takes two to three days before scientists can determine whether the substance is anthrax or not. Images courtesy of Veritide Ltd.

Singling out spores

With just a push of a button, operators can identify a substance. The equipment uses fluorescence – ultraviolet light near 350 nm – to measure instances of dipicolinic acid (DPA), a chemical compound that makes up 5 to 15 percent of the dry weight of bacterial spores. "This particular compound is unique to all bacterial spores," Reinisch said.

Both DPA and calcium-DPA (CaDPA) complex, which constitutes about 80 percent of DPA, can be identified with the UV light. However, both composites are weakly fluorescing, and photochemistry must be applied to verify the presence of hazardous matter. Because of this, a shorter wavelength of light, near 250 nm, is used to illuminate the sample, prompting photodissociation of a slight amount of DPA and CaDPA. The exposure causes the DPA to lose a carboxylic group and to convert into picolinic acid – a more fluorescing fluorophore.

Another fluorescence test then is carried out at 350 nm. This time, the Ceeker's software looks at and compares both results to determine whether DPA and picolinic acid are present. "This gives the absolute certainty that DPA was detected and indicates that bacterial spores are present," Reinisch said.

Because there is no wet chemistry involved in the process, and no heat or ultrasound testing, the sample avoids damage, and examination can continue. The equipment also can be tested for additional substances without delay. Each result is stored for future reference, along with the equipment's operational factors during testing. "All information is archived in the device and can be downloaded at a later date," he said.

After a brief 10-minute analysis, a yes or no answer is displayed on an LCD screen positioned at the top of the device. Current methods involve sending the sample to a laboratory, which can take up to a few days for scientists to confirm the presence of toxins. The delay can negatively affect a business because it must be shut down during the investigation.

Nowhere to hide

During a two-week independent test run at Midwest Research Institute in Palm Bay, Fla., the detector accurately identified 100 percent of bacterial spores and 95 percent of hoax substances. Veritide said that a sample size of only 3000 spores is required for an accurate readout, while other detectors require at least 10,000 to 10 million spores for a valid result.

"Our detection level is well below the estimated 10,000 spores (LD50) [lethal dose 50 percent] it takes to infect someone," Reinisch said. Furthermore, the Ceeker can identify bacterial spores in wet or dry samples, even if the substance is mixed with contaminants such as dust or dirt.

He noted that anthrax threats or "white powder incidents" occur in the US at least 20,000 times a year – or about 55 per day. The Ceeker's reliability and meticulousness may help to alleviate the threat in many of these situations by immediately informing first responders as to whether a substance is anthrax or not.

Veritide is working on incorporating the same technology to identify both Ricin toxin, a white powder or liquid protein extracted from castor beans, and Botulinum toxin, produced by the bacterium *Clostridium botulinum*. The two also are frequently used as biological weapons.

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Glasses provide information in the blink of an eye

DRESDEN, Germany – In the James Bond film *Die Another Day*, the titular hero trains for his upcoming mission using virtual reality sunglasses. Researchers at the Fraunhofer Institute for Photonic Microsystems (IPMS) are developing a bona fide interactive display on a pair of glasses that they hope will be worthy of the fictional spy.

A user of the Fraunhofer glasses will be able to look at his surroundings and the display at the same time. Technically, this combination of a virtual reality display and the ability to see the surrounding environment is referred to as augmented reality.

Although virtual and augmented reality head-mounted displays have been around a long time, historically they showed information only passively and were bulky to wear on the head. The Fraunhofer glasses are lightweight and interactive.

Researchers at Fraunhofer IPMS created these interactive glasses. Courtesy of Fraunhofer-Gesellschaft.

The researchers are developing an eye-tracking feature that will enable wearers to influence the content of the display by scrolling with their eyes or by fixing their eyes on a point to select a menu option. A separate group of researchers, at Fraunhofer Institute for Information and Data Processing in Karlsruhe, Germany, is working on eye-tracking algorithms that can distinguish between intended eye movements and random ones such as blinking.

This eye-tracking feature will be useful for anyone needing to work with his hands while using the display, including surgeons, civil engineers and technicians. This option will allow surgeons to operate while viewing x-ray images, or building engineers to look at plans while working on a project. The glasses also connect to a personal digital assistant that can be used for handheld control.

The interactive display consists of organic LEDs on top of a 19.3 × 17-mm CMOS chip, a lightweight combination. In the prototype model, the chip is just behind the hinge on the temple of the glasses, and the bidirectional display projects onto the retina of the wearer so that it appears to be viewed from 1 m away.

The eyeglasses' final model may have additional optics. According to Michael Scholles, the business unit manager at Fraunhofer IPMS, "The challenge is to find an optics design that can be used both for generating the virtual image display and the eye tracking."

Until spring 2011, the product's development will be funded by the Fraunhofer central administration under the iStar project. The project has an industry advisory board that includes companies such as EADS, Daimler and T-Systems, which are pilot users of the system.

"We think that first applications will be for professional use (assembly, maintenance, medical). However, within the mentioned iStar project, also a touristy prototype application will be developed. So, yes, we believe that the interactive eyeglasses will be available to the greater public, but only as a second step," Scholles said.

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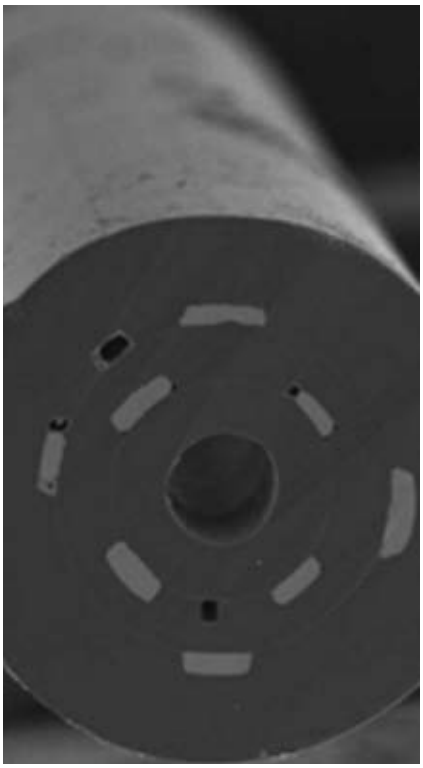
Multitasking fibers weave a new story for imaging systems



A group at MIT has developed a multimaterial optical fiber that can detect the components of any light that strikes it. Woven together, the fibers make a flexible, lensless camera. Courtesy of Fabien Sorin, MIT.

CAMBRIDGE, Mass. – Imagine walking to work one day and, for no obvious reason, you get a feeling that everyone is looking at you. You ignore the feeling for a while, but it persists, despite the fact that none of the people bustling around nearby are casting a single glance at you and you've gotten used to the growing number of surveillance cameras filling every city block. Now you feel silly, perhaps even a little paranoid. But you might not be wrong – a new imaging technology has begun to weave itself into the fabric of everyday life.

In the lab of professor Yoel Fink of the materials science and engineering department at MIT reside swaths of woven strands of optical fibers. Not off-the-roll fibers ordered from a catalog, but custom lines drawn from a preform crafted by Fink's group. Interwoven like a patch of cloth, the fibers combine to form a lensless, flexible camera.

The researchers made the fiber using polyethersulfone as the base material and alternating layers of semiconducting $As_{40}Se_{60}$ or $As_{40}Se_{54}Te_6$. Contacts made of tin were attached to the semiconductor rings. After deposition, the layers were rolled together onto a tube. After making a series of these tubes, the engineers stacked them, joined the ends by heating them and drew them out into their final fiber diameter (see figure). The preforms were about 3 cm in diameter, while the processed fibers ranged from 100 µm to 1 mm in diameter.

When an external electric field is applied to the contacts, which act as electrodes, the semiconductor layers become responsive to light via the photocurrent effect. A single layer of the material can discriminate the incoming light's angle of incidence; a second layer distinguishes wavelength. A third layer, in theory, would add RGB information to the mix.

According to Fabien Sorin, a member of Fink's group representing MIT's electronics lab, the semiconductor bandgap can be adjusted so that wavelengths from the UV to the visible to the IR can be detected.

The investigators tested the fiber's ability to form an imaging system by arranging them into a 32 × 32 grid, with about 1 cm between each pair of strands. Powered up, the optical fiber "fabric" patch could image an object with features as small as 100 nm.

"The size [of the grid] was limited for convenience of use in the lab," Sorin said, "but could be made much larger, with smaller spacing between fibers." That would significantly improve image resolution.

Fink's group sees strong potential for this technology – which its members have dubbed "multimaterial fibers" – in such applications as large-area medical imaging, remote sensing, industrial control and intelligent fabrics.

It may even show up as watchful sew-on patches on clothes and baseball caps, giving their wearers an extra eye with which to watch the world and you something to be wary of on your walk to work.

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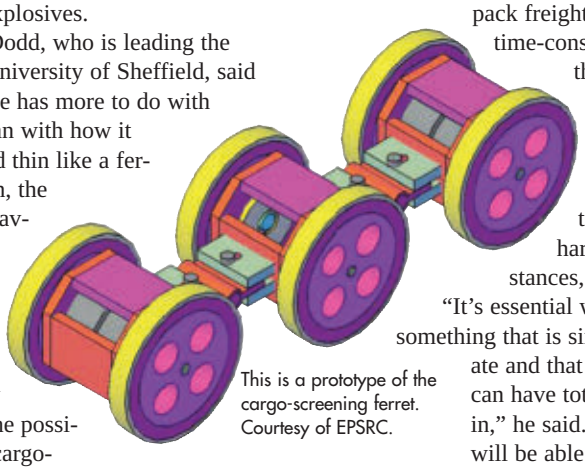
Robo-weasel could sniff out contraband

SHEFFIELD, UK – A sophisticated robot with a suite of laser and fiber optic-based sensors is being developed to detect illicit substances concealed in cargo containers at airports and seaports.

The 30-cm-long robot, dubbed the "cargo-screening ferret," would be the world's first to operate inside standard freight containers and the first designed to detect illegal immigrants and all kinds of illicit substances, including drugs, weapons and explosives.

Dr. Tony J. Dodd, who is leading the project at the University of Sheffield, said the robot's name has more to do with what it does than with how it looks. Long and thin like a ferret, or its cousin, the weasel, it can navigate through small spaces, emulating the animal's slinky movements.



This is a prototype of the cargo-screening ferret. Courtesy of EPSRC.

"We are very excited about the possibilities for the cargo-screening ferret. We believe the robot will enhance the ability of border agents to detect contraband in cargo and will act as a deterrent to smugglers," Dodd said. "We hope the ferret robot will form part of a team of robotic detection systems for the UK Border Agency."

Current methods for screening cargo rely largely on sniffer dogs and external scanners that provide information only about the shape and density of objects or substances within the containers. The ferret, on the other hand, will house sensors that will be able to detect not only the tiniest traces of illicit substances found in drugs and explosives but also the smallest amounts of carbon dioxide, indicating human presence.

When placed inside a steel freight container, the ferret will attach itself to the top. Magnetic wheels will allow it to move about in search of contraband, all the while sending a steady stream of information back to the controller.

Dodd said that the design of the magnetic wheels has proved more challenging than anticipated. The original design, which consisted of a solid cylindrical magnet for the wheel, proved too expensive. With the hope of maximizing the magnetic force while keeping costs down, the researchers plan to redesign the wheels using a ring of small magnets. They are currently seeking an expert to help with the design, which they deem critical to the project.

A key benefit to the cargo-screening ferret is that it will reduce the need for customs and security officials to enter or unpack freight containers, a time-consuming job that exposes officers to potential danger or to contamination from harmful substances, Dodd said. "It's essential we develop something that is simple to operate and that border agents can have total confidence in," he said. "The ferret will be able to drop small probes down through the cargo and, so, pinpoint exactly where contraband is concealed."

Because the current design is based on the robot clinging magnetically to the sides or ceiling of the container, the possibility that newly manufactured containers could be constructed of nonferrous materials could prove challenging. Although Dodd admits that this could be troublesome, he emphasizes that the many millions of steel containers in the world will continue to be used for many years.

The three-year project, which began in October 2008, is being funded by the Engineering and Physical Sciences Research Council (EPSRC) and also involves the University of Glasgow, Loughborough University, City University (London) and defense and security specialist QinetiQ Inc.

Working prototypes of the cargo-screening ferret could be ready for testing within two years and for deployment within five years.

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Brighter days ahead for LEDs in signage

UPPER LAKE, Calif. – Valued at $1.17 billion in 2008, the global consumption of packaged LED chips (component-level LED bulbs) used in commercial/professional signage applications is projected to rise to $1.49 billion in 2013, according to studies conducted by ElectroniCast Consultants, a market analysis company based in Upper Lake, Calif.

The studies encompass the current worldwide consumption of standard packaged LED chips and high-brightness single- and multiple-chip packaged (single-bulb and multiple-chip/bulb single-chip/bulb or device package) LEDs, which are used in digital LED display panels/signage, channel letter signage and retail display light boxes.

The Fremont Street Experience in Las Vegas uses LED displays for the Viva Vision "A Tribute to Queen.

In 2008, the Americas region, consisting of North, Central and South America, represented a 43 percent share of the worldwide consumption of LEDS used in signage and professional displays. The company projects that, in 2013, the Americas' share will have increased to 46 percent, with a value of $686.85 million. In 2008, Europe, consisting of Western and Eastern Europe, and the Middle Eastern countries, represented a 24 percent share of the market. The company projects that the Asia-Pacific region share will increase in value from $384.27 million in 2008 to $487.91 million in 2013.

The company recently published two reports: *LEDS Used in Signage & Professional Displays Global Market Forecast (2008-2013)* and *LEDS Used in Solid-State Lighting/Illumination Global Market Forecast* – the latter of which includes data on LEDs used in channel lettering signs and in retail display light boxes.

As a result of the economic downturn, slower sales in consumer and commercial markets across multiple industries worldwide are expected, including some segments of the LED industry, through most of 2009, according to Stephen Montgomery, president of the Asia-Pacific region at ElectroniCast Consultants.

Display panels: standard vs. high-brightness LEDs

The global consumption value of LEDs used in commercial/professional digital LED display panels in 2008 was $1.141 billion and is forecast to rise to $1.278 billion in 2013, Montgomery said. In 2008, high-brightness LEDs represented a 55 percent share of this global consumption value. By 2013, this share is expected to rise to 60 percent and to increase in value to $767.11 million versus $625.15 million in 2008. The global consumption value of standard or conventional LEDs used in commercial/professional digital LED display panels is forecasted to decrease in value from $515.46 million (45 percent of the market share) in 2008 to $511.12 million (40 percent of the market share) in 2013, he said.

LED-based electronic billboards enable multiple advertising messages to share the same sign space, and they allow the delivery of messages in real time, which is important for public emergency announcements and other information.

The company says that, based on its observations at technical conferences over the years, much basic research is still being pursued in this industry, mainly in university, government and other non-commercial laboratories. This is viewed as an indicator that there are many more years of vigorous growth ahead for LED advancement.

The company focuses on the consumption of signage and professional LED display panels, such as surface-mount device types, and conventional types, which use discrete LEDs. Most outdoor screens, as well as some indoor ones, are built around discrete LEDs, also known as individually mounted LEDs.

High-brightness visible LED lamps are typically used in outdoor applications such as traffic signals, changeable message signs, large-area visible displays and automotive exterior lighting, while conventional low-power visible LEDs are commonly used as solid-state indicator lights in cameras, appliances, dashboards, instrument panels, telephone dials and computer terminals, and as light sources for numeric and alphanumeric displays.

Display cases and channel letters

The global value of LEDs used in channel letter signage and retail light box applications is expected to rise from $30.43 million in 2008 to $208.92 million in 2013, according to the company.

"The standard light box technology used to display merchandise in the retail industry soon could become yesterday's

news," Montgomery said. New developments in the technology and the demand for more sophisticated and energy-efficient display box lighting are bringing about change in this market, he said.

For the retail industry, LED/solid-state lighting has the potential to bring about significant reductions in energy consumption and maintenance costs, thinner light boxes that save space, brighter and more even illumination, and greater compliance with consumer and regulatory demands for environmentally friendly retailing.

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Changing of the guard

PITTSFIELD, Mass. – Michael T. Houk, co-founder and vice president of technology at Bristol Instruments Inc. in Victor, N.Y., has joined the Editorial Advisory Board of *Photonics Spectra*. He replaces longtime member William Gornall, a respected industry consultant, who has retired.

Houk's current research interests focus on novel wavelength measurement methods, laser frequency stabilization and Fourier-based spectral analysis.

Before helping to found Bristol Instruments, a developer of optical interferometer-based laser wavelength meters and laser spectrum analyzers, he was a project manager and senior optical engineer for Exfo Burleigh Products Group Inc., also in Victor. There, he participated in the development of more than 20 interferometer-based products.

Houk earned a doctorate in optical engineering from the Institute of Optics at the University of Rochester in New York, where he studied the design, fabrication and testing of index gradients in fluoride materials. He also holds a bachelor's degree in physics from Kalamazoo College in Michigan.

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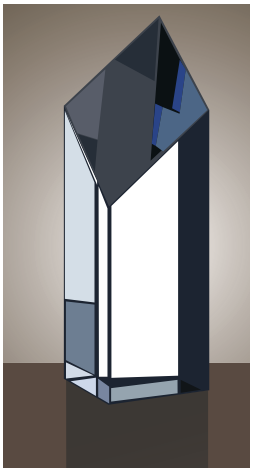
The Prism Awards Call for Entries

PITTSFIELD, Mass., and BELLINGHAM, Wash. – Laurin Publishing, producer of *Photonics Spectra*, and SPIE, the international society for optics and photonics, are accepting entries for the 2009 Prism Awards for Photonics Innovation until Sept. 22, 2009.

The Prism Awards, introduced for the first time in 2008, recognize the best innovative technology in the photonics industry. A panel of 26 independent judges, all considered industry experts, will select finalists in nine product categories as follows: optics; lasers; other light sources; detectors, sensing and imaging systems; analytical, test and measurement; photonics systems; photonics processes; sustainable/green technology; and life sciences.

"Photonics technologies affect nearly every aspect of life – energy production and distribution, communications, consumer electronics, medicine, biotechnology, manufacturing, analysis of climate change, and security, to mention a few," said Eugene Arthurs, CEO of SPIE. "The Prism Awards program is one way we are helping to accelerate innovation and move technology to market. We are pleased to honor and promote the technological creativity and vision represented by these entries."



Last year 130 entries were submitted, of which 67 were tapped as finalists for the global competition. Ultimately, 10 winners representing three nations were chosen, and the awards were presented at Photon-

ics West 2009, North America's premier event for the photonics and optics industry.

"The overwhelming global response to the Prism Awards demonstrates that even during this grim economic downturn, the industry is very much alive and increasingly relevant," said Thomas F. Laurin, president of Laurin Publishing. "We look forward to seeing this year's exciting world-class innovations from our industry leaders and experts."

The winners of this year's Prism Awards for Photonics Innovation will be announced at Photonics West 2010 in San Francisco.

Entries can be submitted at www.photonicsprismaward.com; contact innovation@spie.org with questions.

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Dome Award Optimax Systems Inc., headquartered in Ontario, N.Y., a manufacturing company that provides prototyping of precision optical components, has been awarded a Phase II Small Business Innovative Research grant. The award will enable the company to create a polished transparent aerodynamic infrared tangent ogive dome out of polycrystalline alumina.

Certification Received In Pavilion, N.Y., Syntec Optics has received ISO 9001:2000 certification. The custom polymer optics manufacturer plans to leverage the qualification to reach global markets where strict process control is required to meet cost and schedule restrictions.

Funding Optics The Optical Society of America (OSA) Foundation has announced the programs it will be funding next year. It will offer grants for optics education, for OSA student member activities and for student travel to OSA-sponsored events. The foundation's goals are to improve science education, provide optics instruction and resources to underserved populations, and offer career and professional development support to the optics community.

Semiconductor Collaboration An agreement to expand access to the 3M Wafer Support System equipment has been signed by 3M of St. Paul, Minn., and Suss MicroTec of Garching, Germany. The German company will become an authorized equipment supplier for the 3M system, which temporarily bonds the ultrathin wafers required for 3-D packaging. Suss MicroTec also will manufacture and sell wafer bonders designed to use 3M's materials.

New View In Ulm, Germany, WiTec GmbH has moved to its new headquarters. The facility provides about 1900 sq m of space and contains customized production facilities, seminar rooms and office space. The company believes that the building will enable it to meet the demand for its high-resolution nanoanalytical microscopy solutions.

SSL Opportunities The US Department of Energy (DoE) is seeking applications for three solid-state lighting (SSL) funding opportunities. Under funding from the American Recovery and Reinvestment Act, the DoE will provide support for projects focusing on core technology research, product development and manufacturing.

Million-Dollar Order Ceramics and metals manufacturer SCI Engineered Materials Inc. of Columbus, Ohio, has received an order for thin-film solar products worth $1 million. The products are expected to be manufactured and shipped during the latter half of this year.

Chapter 11 Citing the recession and a 2007 federal raid on the business, Rocky Mountain Instrument (RMI) Co. of Lafayette, Colo., a manufacturer of full spectrum optical components, has filed for Chapter 11 bankruptcy. The company owes between $1 million and $10 million to as many as 49 creditors. RMI has

asked the court for permission to use $1 million of its lines of credit to support the business and fulfill orders while it reorganizes, as well as for permission to use cash to retain its workforce.

Expanded Distribution AMS Technologies AG of Munich, Germany, and Laser Operations LLC of Sylmar, Calif., have agreed to expand their distribution agreement. The German company will sell and support its partner's products, including the QPC Lasers line – which it has been distributing for several years – in the UK, Ireland, France and Spain.

Large Hadron Collider Restart According to CERN, the European Organization for Nuclear Research, in Geneva, repairs and upgrades to the Large Hadron Collider are on schedule for a restart this fall, although two to three weeks later than originally planned. A new quench protection system, designed to prevent failures such as the one that occurred last year, should be fully tested by late summer.

More IR ULIS of Veurey-Voroize, France, a manufacturer of infrared detectors for low-cost IR cameras, has quadrupled the production capacity of its microbolometers to 200,000 units per year. The company expects to see large-scale orders resulting from three market drivers: the trend of adding IR to visible surveillance cameras, government mandates for improved safety, and new regulations in energy conservation and building compliance.

Shifting Subsidiaries Coastal Optical Systems Inc. of West Palm Beach, Fla., and Liebmann Optical Co. of Easthampton, Mass., have merged. Both subsidiaries of Jenoptik AG of Jena, Germany, they will be known as Jenoptik Optical Systems Inc. and will be based in Jupiter, Fla. The new company will offer design and manufacturing capabilities for prototype optical assemblies as well as high-volume component manufacturing.

Investment Funding Pyreos Ltd. of Edinburgh, UK, a supplier of infrared components, has secured another round of funding, £750,000, from Noble Venture Finance of London. The funds will be used to expand the company's global sales and commercial operations.

Investing in Telecommunications In France, 3S Photonics of Nozay has raised funds totaling nearly €13 million from three investment groups. The company, which manufactures optical and optoelectronic components for telecommunications networks, received €450,000 from Midi Capital of Toulouse, €2.5 million from Alto Invest of Le Chesnay and a promise of €10 million from France's Strategic Investment Fund, €5 million of which has been provided so far.

Metrology Research FEI Co. of Hillsboro, Ore., a provider of atomic-scale imaging and analysis systems, has joined the Advanced Metrology Development Program at the College of Nanoscale Science and Engineering at the University at Albany-State University of New York. The program is run by Sematech, a global consortium of chipmakers. The company will collaborate with metrology experts to create tools for high-resolution imaging and compositional data at the nanometer scale for use in defect analysis.

Energy-Harvesting Expansion Nextreme Thermal Solutions of Durham, N.C., has raised another $8 million in Series B financing from undisclosed investors, increasing its total to $21 million. The latest funding will be used to expand the company's energy-harvesting presence and products as well as its thermal management products.

Applications Laboratory BaySpec Inc. of Fremont, Calif., has established a Systems & Field Sales Div. to promote its optical spectral engine systems. The new applications laboratory will provide customers with demonstrations of the company's full range of products, including optical spectrum analyzers, microscopes and fiber accessories.

SPIE AND LAURIN PUBLISHING PRESENT THE 2009

Prism Awards

FOR PHOTONICS INNOVATION

The second Annual Prism Awards are presented in recognition of the Best in Innovative Products and Processes for the Photonics Industry Worldwide.

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SPIE's Photonics West, North America's largest commercial exhibition on optics, lasers, biomedical optics, optoelectronic components and imaging technologies.

Call for Entries

Please join us in participating in the 2009 Prism Awards competition honoring the best in innovative photonics technology for 2009. This global competition will be judged by a distinguished panel of acknowledged technology experts in their respective fields.

Competition Categories:

Optics

Lasers

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Detectors, Sensing & Imaging Systems

Analytical, Test & Measurement

Photonics Systems

Photonics Processes

Sustainable/Green Technology

Life Sciences

Call for Entries Deadline: September 22, 2009

Please visit www.PhotonicsPrismAwards.com for Award regulations and entry forms.

SPIE

PHOTONICS MEDIA

THE PULSE OF THE INDUSTRY

Understanding the "sex gap" in science and math

Study focuses on relationship between implicit stereotypes and academic achievement

BY GARY BOAS
CONTRIBUTING EDITOR

The assumption that boys are naturally drawn to – and inherently skilled at – math and science while girls are predisposed to the more liberal arts is deeply embedded in our culture. And it is continually reinforced and perpetuated by observations that boys do in fact do better in these areas.

There is evidence, however, that this so-called "sex gap" is shaped by sociocultural factors. A recent report found, for example, that differences in math performance have been declining over time. Another revealed correlations between the size of the gap and national indicators of gender egalitarianism. If aptitude for math and science were somehow intrinsic to boys and not to girls, we probably would not see such variability across time and place.

Brian A. Nosek, an associate professor of psychology at the University of Virginia in Charlottesville, and colleagues decided to explore the influence of sociocultural factors, looking specifically at the role of implicit, or unconscious, stereotypes about gender and science. "Stereotypes have often been implicated in contributing to the sex gap, but the evidence for self-reported stereotypes predicting such outcomes is mixed. We thought that implicit stereotype measures might be more effective predictors because they do not require self-awareness of possessing them, and they can exist in people's minds even if they are consciously rejected," he explained.

Nosek serves as director of Project Implicit, which seeks to uncover the differences between conscious and unconscious attitudes through administration of Implicit Association Tests (IATs). Visitors to the Project Implicit Web site (http://implicit.harvard.edu/) can complete tests covering a range of topics: measuring association strengths, for example, between gender (male, female) and academics (science, liberal arts). Those who participated in the gender-science component completed the test, a short questionnaire that measured beliefs and attitudes, and math and science and demographics questionnaires.

For a study published in the June 30 issue of *PNAS*, Nosek and a number of colleagues from across the globe looked at IAT data collected between May 2000 and July 2008. More than half a million IATs were completed during this time. The researchers focused specifically on the nearly 300,000 tests completed by citizens of the 34 countries covered by the 2003 Trends in International Mathematics and Science Study (TIMSS). This facilitated comparison with the results of that study, in which standardized exams of math and science achievement were administered to samples of eighth-graders.

They reported three main findings: (1) The implicit association tests confirmed the existence of implicit stereotypes associating males with science much more so than females. (2) The investigators found that nation-level implicit stereotypes predict nation-level sex differences in achievement in eighth-grade science and math. And finally, (3) they noted that self-reported (that is, conscious) stereotypes do not predict differences in achievement.

So what does this tell us? First, on some unconscious level, many people still assume that males have greater aptitude for math and science than females – even if they have convinced themselves that they believe otherwise. The *PNAS* study shows that more than 70 percent of the 500,000+ IAT respondents were more apt to associate males with science and females with liberal arts than the reverse. That said, the extent to which people make such assumptions varies considerably, both across individuals and across cultures.

Which brings us to the second take-home lesson: There is a strong correlation between how well people think males and females will do in math and science and how well they actually do, as recorded by the TIMSS. Nosek and colleagues avoid the obvious and unanswerable chicken-and-egg question here, but they note that implicit gender stereotypes and sex gaps are mutually reinforcing. Because they are exposed to the stereotypes pretty much from birth, girls often show less interest than boys in science and math, and as a result they may not perform as well in these areas. This serves to reinforce the belief that boys are more inherently skilled in math and science. And so on.

While governments around the world are working to close the sex gap in science and math, it is not yet clear which interventions have been the most or the least effective. Researchers and policy makers will want to know, however. "Those questions are highly important and surely among the next issues to investigate in this research," Nosek said.

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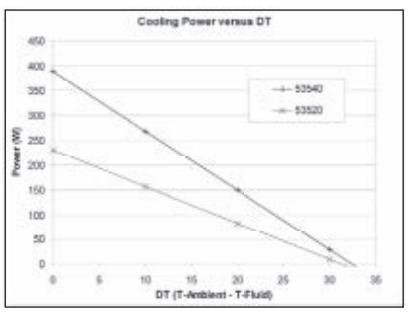

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GreenLight

Back to green school

BY ANNE L. FISCHER
SENIOR EDITOR

Renewable energy technologies are everywhere, but nowhere are they more prevalent than on college and university campuses around the globe. Sustainability is the name of the game when it comes to curriculum development, research funding, student initiatives and much more, including even the overall design of the campuses themselves.

The Association of University Leaders for a Sustainable Future supports sustainability in all of these areas and maintains a list of those who have signed the Talloires Declaration, a 10-point action plan for incorporating sustainability and environmental literacy into teaching, research, operations and outreach at colleges and universities. More than 350 university presidents and chancellors in 40 countries have signed on to the program.

In this issue's GreenLight section, we look at green endeavors at the college level across the globe. Perhaps the greatest display of photonics-related green activity is the Solar Decathlon, which pits 20 colleges and universities in a competition to build a home that is powered fully by solar energy.

Sustainable initiatives take other approaches on campuses as well. Industry/university partnerships are working to advance solar technology, examples of which are the Arizona State/Advent Solar partnership and a unique project in the Netherlands.

As campuses worldwide commit not only to teaching green but to being green, solar is springing up all over, with projects at Butte College in Oroville, Calif., and at McMaster University in Hamilton, Ontario, Canada, both of which are leading by example.

In other cases, cutting-edge research on materials and production techniques is rapidly advancing solar technology and manufacturing, as is the case with a new approach to copper indium gallium selenide production at the University of California, Los Angeles.

This section just skims the surface of sustainability on campuses around the world. We look forward to bringing you more examples, and we welcome your examples of cases where the sciences offer real solutions to today's environmental issues.

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Zero-net energy on the Washington Mall

The 2009 Solar Decathlon will take place Oct. 9-18 on the National Mall in Washington, where 20 university teams from the US, Canada, Spain and Germany each will build a self-sufficient 800-sq-ft solar home. They compete in 10 contests proving that the solar design is producing enough electricity and hot water to perform the normal functions of a home. Added to this year's competition is a net-metering contest, which will test each home's ability to produce its own energy.

Twenty 800-sq-ft solar-powered homes will be transported to the Washington Mall in October, where they'll be competing in 10 contests. Some entries, such as the one pictured here from the University of Puerto Rico, come from overseas. Photo courtesy of the University of Puerto Rico.

Each team is made up of students and advisers from multiple disciplines, with the majority focusing on architecture and engineering. Team Boston is mostly architecture students from Boston Architectural College (BAC) and Tufts University. Regardless of their fields of study, all teams divvy up the responsibilities of fundraising, marketing, lighting design, construction and more. To achieve this end, according to Jeff Stein, dean of BAC, the students have created "collaborative design studios with interior designers, landscape architects, engineers; they have brought consultants into their classrooms – like folks from the Biomimicry Institute, modular builders, HVAC [heating, ventilation and air conditioning] consultants, fundraisers, Web designers, Autodesk computer programmers … . In addition, they are working with high school students on the issues of design that they confront. This is an experience rarely afforded to students of high school age, yet Stein is certain of their capabilities.

One of the many tasks that may be unrelated to what the students are studying in school is transportation logistics. Mostly, the students are concerned with designing the most energy-efficient off-the-grid home, but they have to get it to Washington – undamaged. Logistics is, therefore, supremely important, especially

for those not on the continental US. Two years ago, the University of Darmstadt in Germany traveled across the ocean to take first place. Joining the Darmstadt team from abroad this year will be contenders from Universidad Politécnica de Madrid in Spain and the University of Puerto Rico.

The role of the sun

Each team takes its own unique approach to solar design. Virginia Tech, for example, uses bifacial building-integrated photovoltaic panels on its house (dubbed "Lumenhaus"), meaning that a tilting mechanism that adjusts the arrays allows both sides of the panels to produce electricity. The house also has photovoltaic wafers within the skylight in the bathroom.

The University of Puerto Rico's home is called "CASH," for Caribbean Affordable Solar House, and its solar and structural design takes the hot and humid climate into consideration. The roof has 34 crystalline-silicon solar panels for electricity, evacuated-tube solar collectors for hot water, a radiant ceiling system of piped hot or cold water, an air conditioner and a dehumidifier.

Members of Team Boston, which includes students from Boston Architectural College and Tufts University, are shown tacking insulation onto their solar home. Photo by Erin Baldassari.

Competing with light

Lighting design is one of the 10 contests, and it is judged by a jury of lighting designers and industry experts who look for things like quality of electric lighting and daylighting, ease of operation, flexibility, energy efficiency and building integration. At Iowa State, a class called "File to Fabrication," which merges lighting and computer design, was altered somewhat to better prepare students to participate in the Decathlon, according to associate professor Mikesch Muecke, who teaches the course. Jennie Retke is one student who took the course and also participated in the

Refract House, the entry for Team California (Santa Clara University and California College of the Arts), is shown at night illuminated by LEDs.

solar decathlon workshop. According to Muecke, "From participating in the workshop, she knew the specs we needed to work with, the size and type of lights." He added that, as a result, "She took a lead role in the lighting design."

The amount of background work that goes into lighting design for any Decathlon entry is far more than meets the eye. For example, John George, a third-year master of architecture student at Iowa State, took a summer course designed to study energy consumption of the Decathlon project. The course included overall energy performance, thermal loads, diurnal shifts and mechanical system responses. During the course, participants realized that their lighting strategy greatly affected energy performance. "If our daylighting approach didn't work as planned, we would have to turn more lights on, thus changing our projected energy consumption." Lighting analysis is required in the rules of the Solar Decathlon, so John created an independent study course to look at the quantitative analysis of both the daylighting electric lighting design and the strategies. Using software from AGi32 of Littleton, Colo., he modeled the sunlight for different times of day and sky conditions, which provided information on how much artificial lighting would be needed, and when.

When asked what he had gained from the project that could be used in a future career, George was quick to point out that his role was "minimal compared to many others who have worked longer and more intensely." He added that his role as "checker" is one that's rarely addressed in academic settings, but it's important in any project, and he hopes it will translate to applicable experience in the working world.

GreenLight

Competing for market

Lighting, solar energy and self-sufficiency are important aspects of the competition, but also critical is how the design will fare on the market, and the houses are judged on that as well. In addition to trying to win in marketability, some teams already have plans for the homes after they are hauled back to campus. The Rice University team's home, called the "Ze-Row House," was designed to be replicable and to fit into a neighborhood of row houses in Houston. Knowing that the home would have to be comfortable for a family in Houston's high-heat, high-humidity climate added challenge to the team's engineering efforts.

The students gain much from participating in the Solar Decathlon, but nothing more significant, according to BAC's Stein, than an understanding of the consequences of our own actions. He points to the Nike slogan, "Just Do It," which he said students have come to oppose. Instead they've learned that what works in terms of designing places for people to live is to "just think about it, just consider its consequences, just work out its funding, just understand how to construct it, just imagine how people will feel around it for the next few generations, [and] just imagine how to solve for the future."

The competition takes place every two years and is sponsored by the US Department of Energy, which awards $100,000 to each team for design and construction costs. A European Solar Decathlon will take place in Madrid, Spain, in 2010.

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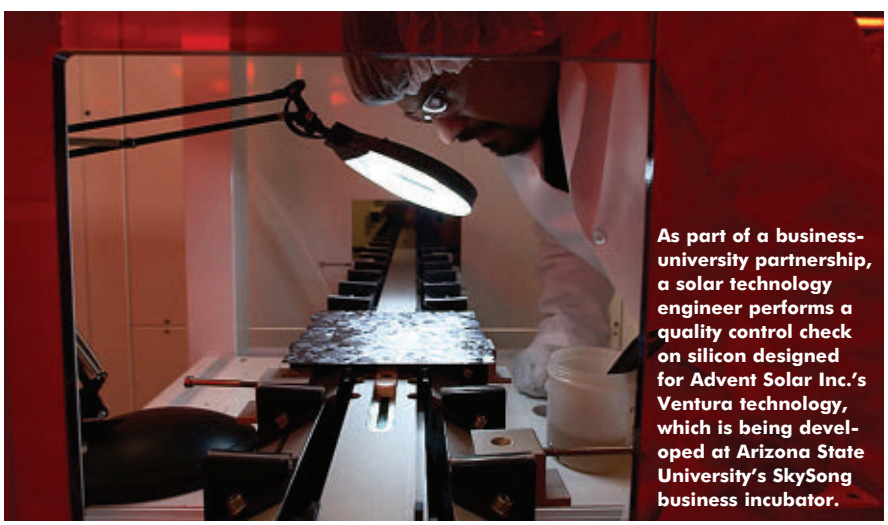
PV partnership in Arizona



As part of a business-university partnership, a solar technology engineer performs a quality control check on silicon designed for Advent Solar Inc.'s Ventura technology, which is being developed at Arizona State University's SkySong business incubator.

A partnership between graduate-level engineering students and a solar energy business is working on advancing the efficiency of photovoltaics.

In New Mexico, Advent Solar Inc. of Albuquerque has found a home within SkySong, Arizona State University's business incubator in Scottsdale. At SkySong, alongside ASU engineering students, the company's own engineers are working on Advent Solar's Ventura technology, which puts an emitter wrap-through back-contact cell into a monolithic module assembly. The module uses low-cost manufacturing techniques from the semiconductor industry, noted Peter Green, president and CEO of Advent Solar. The cell-to-module architecture means that the function of a single cell now can be addressed. Green explained, "If one cell is shaded or impacted, we can address it at the individual cell level."

The team is developing the module and the software control, which will monitor its function without human interface.

Green is confident in his partnership with ASU. "They're quite a sustainability engine," he said, noting that the university offers what was the nation's first degree program in sustainability.

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California community college commitment

Butte College of Oroville, Calif., is on a sustainability mission. One goal is to be grid-positive by 2012, and another is to be carbon-neutral by 2015. Well on its way toward achieving those goals, the college recently installed on a campus parking garage more than 2000 solar modules that will produce 545,400 kWh each year.

Mike Miller, director of facilities, predicts that the campus will produce nearly all of the electricity it needs by 2012. In fact, it's already producing nearly 50 percent of its electricity from solar.

Besides generating energy, the campus has been saving energy by installing LED lighting and occupancy sensors, and it has taken steps toward water conservation. According to Miller, "The metrics are interesting" because even though recent building construction has added about 50 percent more square footage, the college has managed to decrease energy use and cost by 30 percent.

Teaching the talk

At Butte, it's not just about practicing sustainability; it's about teaching it. The school offers a green building construction program and various sustainability degrees, and it is involved with a program that retrains construction workers in solar installation. Miller said that the facilities department, although it is not integrated into the official curriculum, is involved with student orientation, showing students the solar photovoltaics and other sustainable initiatives on campus right from day one. Four kiosks demonstrate energy production on a screen. Miller said these work really well, "and are so sensitive that if a cloud goes over, you see a drop in production." In August, the school hosted its third annual conference focusing on institutional sustainability and energy projects for colleges, and it offered group tours of its solar setup. So at Butte, sustainability teaching extends far beyond the campus community.

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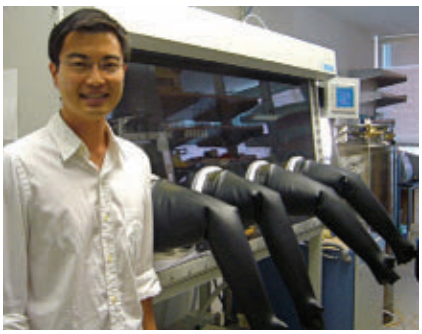
In California, Butte College of Oroville has taken giant steps toward grid independence while also teaching solar installation and other green skills.

Dissolving CIGS for flexible application

Solar cell designs traditionally are based on crystalline silicon, but not only has that material been in short supply, the silicon-solar process is relatively expensive. And as the solar industry strives to decrease the cost to make it a viable alternative to fossil fuels, many are turning an eye toward panels with copper indium gallium selenide (CIGS) as an alternative.

Although CIGS cells have proved efficient and have the potential to cost less, a low-cost production method has eluded the industry. Researchers at Henry Samueli School of Engineering and Applied Science at the University of California, Los Angeles (UCLA), are aiming to change that by developing a low-cost production method for solar cells based on CIGS.

The group, led by Yang Yang, a professor in the department of materials science and engineering, recently published a study in the journal *Thin Solid Films* that describes a low-cost method for manufacturing on a large scale. The study reports the efficiency at 7.5 percent, but the team has surpassed that, improving to 9.3 percent.



Doctoral candidate William Hou works with the UCLA team that is developing a low-cost production method for CIGS solar cells.

The dissolution method

Key to the method is the fact that it does not use a vacuum evaporation process. Most CIGS solar cells are produced by heating each of the active elements and depositing them onto a surface in a vacuum. This "co-evaporation" method can be costly and time-consuming, Yang said. Instead, the investigators dissolved the materials into a liquid, applied it onto a substrate and baked it. They had been dissolving organic materials for both LED and solar cell applications, and it was only recently that they applied this concept to inorganic materials such as CIGS.

They used hydrazine to dissolve the copper sulfide and indium selenide to form the constituents for the copper indium sulfur selenide. According to Yang, they also can dissolve gallium, but they left if out to simplify the material system for research purposes. He also said gallium may be replaced by sulfur because of cost, adding that gallium costs 500 times more than sulfur.

Not only did they find their method of liquefying the materials cheaper and easier than the vacuum method, but the materials can be applied to various surfaces, including film that can be manufactured in a roll-to-roll process.

Yang said that, even though the material system is unchanged, "the quality of the material is very different between the conventional methods and our process." The challenges have been in understanding the type of defects that result from the solution-processing method "and to either eliminate or passivate the defects."

As far as efficiency goes, he said they are seeing an increase of about 1 percent every two months and expect to reach 15 to 20 percent within a few years. Currently, the best CIGS method achieves about 20 percent but is more costly and challenging to produce and cannot be applied to the range of surfaces that the new UCLA method can.

A flexible future

The significance of this work is the potential of using a flexible insulating material such as polyimide, which cannot tolerate the traditional method of processing CIGS. "Most demonstrations of flexible CIGS solar cells are done on metal foils," Yang explained, adding that "this creates various problems." The low-temperature process offers a way to fabricate CIGS on polyimide without serious degradation, he said.

Yang expects to see commercial products based on this method in three or four years.

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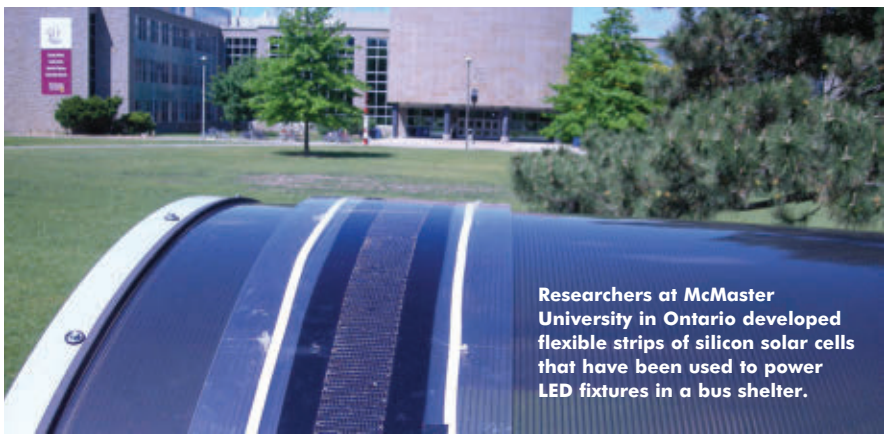
Flexible solar from Canada

Small buildings with few electrical demands are prime targets for stand-alone solar power units. That's the thought behind new solar technology applied to a bus shelter on the campus of McMaster University in Hamilton, Ontario, Canada. The flexible solar design was developed by a group of researchers at the school.

Silicon solar cells were custom-fabricated for this purpose and mounted on a sheet of flexible material. Much of the development work went into the method of connecting the cells "reliably and effectively," according to Adrian Kitai, a professor on the faculty of engineering. The result is two flexible strips, each measuring 90 × 12 cm and comprising 720 solar cells measuring 1 × 1 cm each. Each strip can generate up to 4.5 W of power. The energy generated during the day is stored in batteries to light the shelter for eight hours at night.

Each of the two LED fixtures that light the shelter uses 600 mW of power and produces about the same light output as a 3-W regular tungsten bulb – equivalent to a small night-light. The solar power in storage is more than enough to run the two lights throughout the night, so even if it's a cloudy day or there's snow on the roof, backup power is there, Kitai explained. He added, though, that the researchers have not yet made observations with 2 ft of snow on the roof, so they are not sure what the results of such long-term shading would be.



Researchers at McMaster University in Ontario developed flexible strips of silicon solar cells that have been used to power LED fixtures in a bus shelter.

Building on their experience with flexible solar design, the McMaster team members are building integrated projects, anticipating commercial success in the not-too-distant future.

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Solar infusion in the Netherlands

Several solar projects have received hefty subsidies as part of the Joint Solar Programme (JSP), which aims to promote research into photovoltaic solar energy in the Netherlands. JSP is funded by the Netherlands Organization for Scientific Research and by the Amsterdam-based company NV Nuon Energy.

Several universities also are participating in the program. Utrecht University received funding for projects involving solar concentrators based on luminescent-doped nanocrystals, on quantum-dot-based thin-film silicon cells and on low-cost luminescent concentrators, and for another project done in conjunction with Delft University of Technology that focuses on quantum-dot superlattice solar cells.

Also, Nuon Helianthos, a subsidiary of NV Nuon Energy, which recently merged with Vattenfall AB, a Swedish government-owned energy group, has opened a test factory in Arnhem to produce a thin, flexible foil material for solar cells. Development of the technology began in 1996 with an invention made by industrial researchers at Utrecht University. Three years ago, Nuon acquired the solar cell foil producer Helianthos and, since that time, has been active in developing the technology.

Production facility planned

Once the tests are successfully completed, a production facility is planned in Arnhem that will manufacture 1 million square meters of solar laminate a year. One advance demonstrated at the test factory is the ability to produce a 120-cm-wide laminate, four times the width of previous production.

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A researcher working with Nuon Helianthos in the Netherlands is overseeing the sputtering process, which is applying the reflective back contact of the solar cells.

Flat Screens Go Deep – and More

BY HANK HOGAN
CONTRIBUTING EDITOR

The Duchess of Windsor was half right, at least as far as displays are concerned: They really never can be too *thin*, as evidenced by the rise of flat screens of all varieties and of displays that can be virtually anywhere. But as for being too *rich*, she was partially wrong. On the one hand, displays can definitely be too expensive, in either initial cost or ongoing energy consumption. However, they can never do too much, as shown by screens that accept input via multifinger touch.

Recent advances promise to help displays on all of these fronts. Some of the applications that will result from these technological innovations will be fairly standard, noted Paul Drzaic. He's president of the Society for Information Display, the professional organization for those in display research, design, manufacturing, applications and marketing.

But some of the new uses enabled by the novel display technologies are anything but the norm, Drzaic said. "There are new application areas, brand-new things people haven't seen before. 3-D displays would fall into that category."

A look reveals recent advances in display technology, as well as ongoing trends. Together they show what may be coming soon to a screen near you.

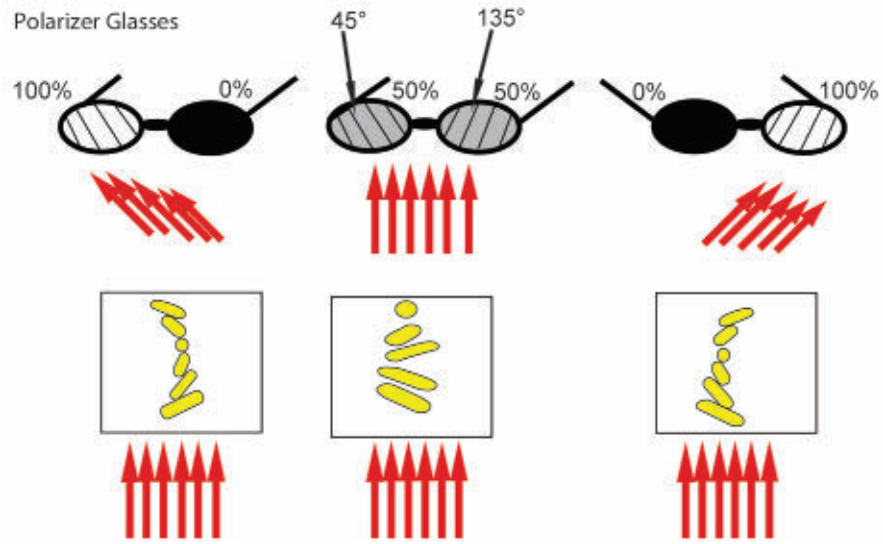
Soon in three dimensions

One of the biggest emerging trends involves something that promises to bring displays into the real world. Despite what can be seen on screens, the world isn't flat. Although attempts that date back decades have been made to correct this, the third dimension has been missing. Displays today present videos, still pictures and everything else in 2-D.

That is about to change. Advances in technology have made viewing and generation of 3-D content easier and less expensive than ever. That, in turn, is expected to drive the deployment of 3-D movies, games, photos and television. The arrival sequence is expected to be in roughly that order because of two intertwined requirements, according to Jennifer Colegrove, director of display technologies at DisplaySearch. The Austin, Texas-based firm tracks flat panel display markets and technologies.

As she explained when talking about the last category, "3-D TV relies on several factors. One, is the display technology available? Another, is there 3-D content on the TV or DVD?"

On the content side, she noted that 3-D movies already exist, with perhaps a dozen in the pipeline and expected to premiere over the next 12 to 18 months. Television broadcasts in 3-D, however, are so



Polarizing glasses and liquid crystal are pushing 3-D technologies. Dynamic polarization management presents different images to the right and left eyes, producing one with depth [top right image]. This is done using a modified flat panel [below right] display and could soon be the norm for gaming systems and eventually for TV. Courtesy of iZ3D.

rare as to be almost nonexistent in the US, although there was a 3-D movie trailer shown during this year's Super Bowl.

On the technology side, 3-D displays have to present two slightly different 2-D images, one for the right eye and another for the left. The two are then interpreted by the brain as a single 3-D image.

These distinct and separate images can be displayed in a number of ways, but the most common for larger, shared screens is through the use of glasses. In one implementation, the display polarizes the images, and polarized material in the glasses ensures that the proper image gets to the correct eye. In another, the glasses are used as shutters, synchronized with the changing images on the display so that each eye sees only the appropriate image.

The first approach is more demanding of the display but easier on the glasses, which are passive devices and can therefore be light and inexpensive. The second is easier on the display, although it does require that it be fast enough to switch quickly between images. The active glasses, however, are more complex and tend to be heavier and more expensive than passive ones.

The 3-D market is at present very small, but Colegrove thinks the technology is ready.

Fun and games

Games are expected to go 3-D before television does for a number of reasons. One is that hard-core gamers are willing to spend money, and they tend to be early adopters of technology, characteristics that make them a potential market. Another is the result of a decision made years ago by game developers in response to another

attempt to deliver 3-D game content.

"Most of the games have 3-D information embedded in their 2-D versions," said Thomas Striegler, president and CEO of iZ3D. The San Diego-based start-up company offers a 3-D monitor for gamers. Introduced last year, it uses the inherent characteristic of liquid crystals to dynamically change the polarization on a pixel-by-pixel basis. Combined with linearly polarized viewing glasses, this allows left and right image information to end up in the correct eye.

The monitor is about 50 percent more expensive than a similarly sized 2-D one, largely because it has a second LCD layer that controls the polarization and thereby produces images with depth. The 3-D monitor also has to have a brighter backlight than a 2-D one because of the two LCD layers that must be transited instead of the one found in a 2-D monitor.

Striegler said that a polarization approach, which uses passive glasses and not ones with a shutter in them, offers the advantage of minimizing visual and mental strain on the viewer. Polarization-based techniques are used in 3-D movies, although circular polarization is the focus, not the linear polarization used by iZ3D.

The company plans to go both big and small with its monitors. The larger ones will be for high-definition home entertainment, either broadcast or recorded. The smaller ones will show up in phones and other handheld devices. In that case, the implementation may be different because there are other technologies than LCDs that could be used.

Displays will be seen everywhere, thanks to recent technical advances. A micromirror chip set, like the one shown left, embedded in a cell phone could allow virtually any flat surface to be a display, even a 3-D one. Courtesy of Texas Instruments.

Going deep on small screens

For example, Qualcomm MEMS Technologies of San Diego has a reflective display technology that works by using electrostatics to change an air gap in a minuscule subpixel microelectromechanical systems (MEMS) element, thereby turning the element on or off. Different air gaps lead to different colors when the element is on.

Because the company is a subsidiary of cell phone chip maker Qualcomm, it's no surprise that its products show up in handsets, in part because they consume very little power when displaying unchanging pixels.

Displays will become ubiquitous input devices, like the one shown here with a 10-finger touch screen. Courtesy of 3M.

Texas Instruments of Dallas has a micromirror-based digital light processor (DLP) chip set small enough to be embedded in a cell phone. The chip works by reflecting light from a source, such as an LED. Frank Moizio, DLP emerging markets business manager, noted that the technology allows for a 20-in. projected image to be visible in ambient light.

Doing so would allow the display on a cell phone to be shared anywhere there's a suitable surface, such as a wall, with the inherent switching speed enabling high contrast, a wide color range, sharp images and more, Moizio said. "In addition, it allows for advanced features like 3-D imaging using stereoscopic techniques."

For those who don't care about sharing images, a third 3-D variation involves miniature displays mounted in the glasses themselves. These small displays act as virtual larger ones, thus providing the visual cues needed for 3-D imagery. There are also ways to achieve 3-D effects without glasses, but today most flat panels that do this are limited in size for cost reasons. These autostereoscopic approaches also don't work as well, at present, as other methods when fast-moving images are involved.

The right touch

While 3-D may be attracting attention, another strong theme is screens that do more than just display information, they also act as input devices through the use of touch or other means. Methuen, Mass.-based 3M Touch Systems, a 3M subsidiary, recently released a 10-finger multitouch developer kit that Kelly Devin, marketing manager for the company, said is based on projected capacitive technol-

ogy. She noted that the company's multitouch capability does not demand a high-end computer.

"We use standard business PCs, nothing fantastic," she said. "To track all 10 fingers at one time gives you roughly a 15-ms response time. So we're processing the inputs quite quickly."

As for where multitouch displays might show up, classrooms are a possibility, as are conference rooms, where collaboration is needed, and home entertainment systems. Smaller screens, such as those found on cell phones, will be limited in the number of touch inputs that can be effectively used because of finger size.

According to figures from DisplaySearch, the market for multitouch displays is expected to grow quickly. The total touch-screen module market stood at an estimated $3.6 billion in 2008, with multitouch accounting for about 25 percent of that. By 2015, the total touch-screen module market is forecast to be $9 billion. Of that, $4.2 billion will be multitouch.

There are applications, such as the kiosks used for airline check-in or specialized registers in restaurants, where single-touch is fine. Those settings are unlikely to switch to more expensive multitouch technology.

Boosting brightness while cutting power

Finally, there are enhancements that promise to bring high-brightness yet thin and low-power displays to televisions and mobile devices. Some of these can be found in the backlight that sits behind every LCD. Switching to LEDs can cut power by as much as 30 percent and can result in sharper images, both courtesy of the ability to rapidly modulate the output from an LED.

That same ability could prove useful in other areas, as there have been demonstrations where a modulated backlight has been used as a communication channel. One possibility would be to have the display communicate with a cell phone or computer pointed at it, like a TV remote in reverse.

Other improvements involve the liquid crystals themselves. The next generation of displays could employ the polymer-stabilized vertical alignment material developed by Merck KGaA of Darmstadt, Germany. Thanks to an additional polymer layer, the molecules in the display material are pre-aligned in a particular direction. As a result, contrast is improved, switching times are faster, and transmission of the light through the medium is increased.

The last, in turn, means that the backlight brightness can be significantly reduced. Since the backlight is the major energy sink in an LCD, the material cuts the power consumed by such things as TVs and extends battery life in mobile devices. Roman Maisch, senior vice president of marketing and sales in Merck's liquid crystals division, noted that the new material is already being put to use in LCD TVs.

In summing up the material demands of tomorrow's displays, he also outlined where the overall display market is heading, noting, "Faster switching times will be also for the future a key driver for the development of liquid crystal materials. Another factor which drives the development of liquid crystal materials is the trend for green products."

For information on projection technology, see "Pico Boom" on page 76.

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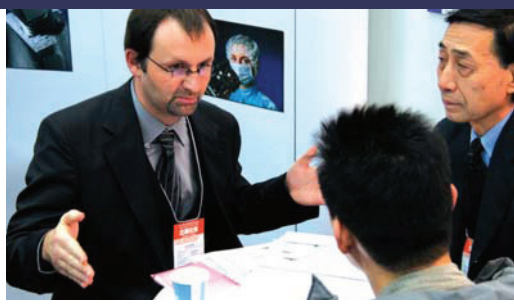

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Reflecting on the Past

Applying Ancient Technologies to Modern Photonics

BY JAMIE KNAPP
NEWPORT CORP. – CORION OPTICAL FILTERS

One source rarely considered when addressing photonics issues is our ancestors: Great technological discoveries from many millennia ago may lead to modern day solutions.

A recent example of this involves optimizing gold-based infrared reflectors commonly employed for defense and aerospace instrumentation, imaging optics and Fourier transform infrared (FTIR) spectroscopy (environmental monitoring).[1] In the latter case, light is transmitted through the volume of air to be analyzed. The light is reflected – via gold retroreflector arrays – back into appropriate analysis instrumentation, where optical absorption is used to evaluate pollutant content. Open-path environmental FTIR spectroscopy is used to monitor CO, CO_2, NO and SO_2 (absorption peaks are in the range of 1580 to 15,000 nm). HF, HCl, H_2S, NH_3, CH_4, CO_2, HCN, C_2H_4 and C_2H_2 are measured using tunable diode laser spectroscopy in the 1300- to 1700-nm range.

In the open environment, such mirrors inevitably become soiled and dulled. When cleaned, the soft gold surfaces are damaged. Current conventional gold mirrors, which are deposited upon polished substrates, are therefore oftentimes produced with protective overcoats – common thermal and electron beam-deposited films include silicon monoxide, zinc sulfide and silicon. Such technologies mandate the use of elevated temperatures; e.g., approximately 300 °C. For conventional metal mirrors, these manufacturing techniques are routine.[2]

An alternative to costly front-surface mirrors is replication, a well-established technology employed to produce high-quality mirrors at a significantly lower cost. These mirrors, however, consist of a critical epoxy layer that is sensitive to elevated temperatures above approximately 105 °C. Standard techniques normally employed to create "hardened" gold mirrors therefore cannot be used.

Unless deposited at elevated temperatures, many protective thin films exhibit poor adherence to the underlying gold and have a porous, columnar micromorphology, limiting their protective properties.[3] There is a critical need, therefore, to develop hard, durable, replicated gold mirrors using means that do not involve the elevation of temperature. Such a product must maintain an adequate infrared reflectivity, particularly in the critical 1300- to 1700-nm and 1580- to 15,000-nm ranges.

To address this, one may turn to the Ancients. Mating metallurgical discoveries of almost 2600 years ago, together with state-of-the-art low-temperature thin-film deposition methods, allows for development of the desired hardened replicated infrared reflectors.

History

Introduced almost three millennia ago, coins are an integral part of daily life. From generation to generation, rulers, cities and states have issued a countless number of coins.

Around 670 BC, the ancient Greeks of Ionia and Lydia – now located in modern-day western Turkey – experimented with producing standardized preweighed lumps of electrum, a natural gold and silver alloy found in local river beds.[4] To minimize counterfeiting, the lumps were struck with a chisel to expose their inner core; counterfeits were produced by metal-plating electrum onto low-value bronze (Figure1).

Unfortunately, this did not slow the innovative counterfeiters who managed to produce bronze-cored clones. The first true coin, a piece of metal certified to be of a guaranteed designated monetary value by a recognized governmental authority, was created by King Alyattes of Lydia in 610 BC. The king's official emblem of the lion acted as a deterrent to counterfeiters.

Electrum, however, suffers from a variable alloy composition – gold content varied from 45 to 55 percent. Exchange values from coin to coin, therefore, could vary. To address this, under the rule of the legendary King Croesus of Lydia, circa

Figure 1. A typical electrum trite from circa 610 BC bears the emblem of King Alyattes of Lydia. Images courtesy of Newport Corp.

Figure 2. The gold daric, named for King Darius of Persia, was created after the defeat of Croesus in 540 BC. This coin bears the image of the king and was fashioned from a wear-resistant gold alloy.

570 BC, metallurgists developed a means to divide and purify the gold and silver from raw electrum.[5] Separate gold and silver coins – 99 percent purity – formed the first "bi-metallic" currency.

The resultant wealth of this Greek region became too much of a temptation to the neighboring ancient Persians. In 540 BC, Croesus was defeated and his empire destroyed. Afterward, King Darius of Persia began striking his new coin (Figure 2).

Known as a gold "daric," this important coin featured the king's image, so it was vital that it not suffer wear, as was common in Croesus' previous pure-gold issues. Persian metallurgists created an alloy that not only maintained the desired visual brilliance of the coin but that significantly added to its hardness and wear resistance.

X-ray fluorescence

To unlock the secrets of Darius' coins, the nondestructive method of energy-dispersive x-ray fluorescence spectrometry (XRF) was employed. With this technique, the sample is irradiated with x-rays, and re-emitted x-rays have wavelengths that

are characteristic of the sample composition.[6] Using XRF, the average metallic composition of the Persian daric was found to be 95.1 percent gold, 2.8 percent copper and 2.1 percent silver.

Alloy-replicated mirrors

Replicated mirrors were produced using Darius' alloy. The intent was to comparatively characterize the surface hardness and wear resistance of this unique alloy against virgin gold and to spectrophotometrically measure its infrared reflectivity. If improved hardness was evident, then the alloy might be an ideal candidate for further surface hardening using a room-temperature deposited protective film.

For comparative hardness measurements, the moderate abrasion methods per MIL-M-13508C were used by abrading dry cheesecloth across a mirror's surfaces using a 1-lb force. Virgin gold suffered visual damage after one test stroke; Darius' alloy survived eight to 12 strokes.

Reflectivity was measured on Perkin-Elmer Lambda 950 UV/VIS and Lambda 983 infrared spectrophotometers. In the 1300- to 15,000-nm region, alloy mirrors were basically indistinguishable from virgin gold (>99 percent reflectivity).

These alloy-replicated mirrors therefore were excellent candidates for further surface modifications.

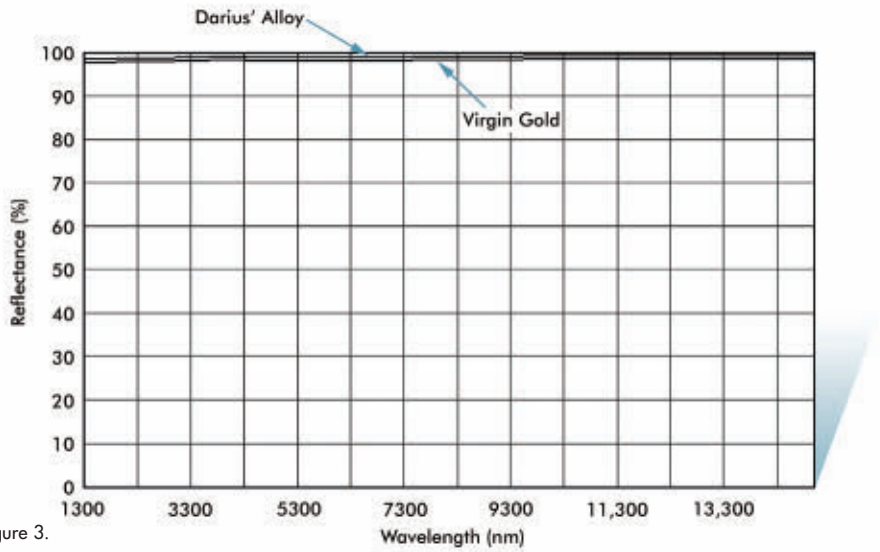

Figure 3.

Reactive ion plating deposition

Established as a means to produce high-quality optical filters, Newport's Stabilife Reactive Low Voltage Ion Plating (RLVIP) process was used to deposit hard adherent silicon protective films upon the alloy mirror's surfaces.[7] The process produces optical thin films possessing the physical density, amorphous microstructure and optical properties approaching those of bulk materials. These homogeneous films are free of the physical pores and columnar structure typically seen in

coatings created by other means. Of prime importance is that deposition takes place at room temperature.[8]

Using atomic force microscopy[9] (AFM), Figure 4 shows the surface micromorphology of a 2-µm-thick silicon film deposited by conventional thermal evaporation at room temperature. The resultant film morphology exhibits a rough, poorly nucleated, nonadherent columnar porous film.

Figure 5 is an AFM evaluation of a 2-µm silicon film created at room temperature by the reactive ion plating. In this case, the film is fully adherent, smooth and featureless, indicative of a fully densified bulklike thin-film structure.

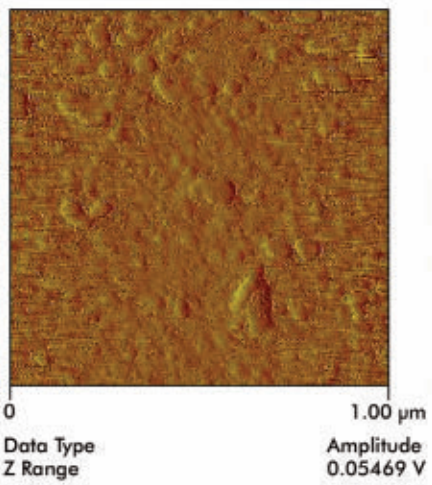

Figure 4. This AFM image shows the surface micromorphology of a 2-µm-thick silicon film deposited by conventional thermal evaporation at room temperature.

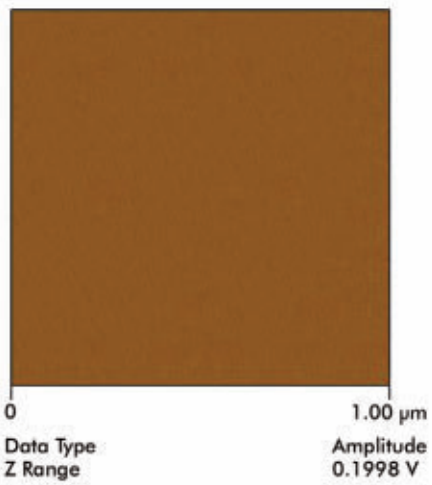

Figure 5. An AFM evaluation of a 2-µm silicon film was created at room temperature by Newport's patented Reactive Low Voltage Ion Plating process.

Protected gold alloy-replicated mirrors

Replicated mirrors produced with Darius' alloy subsequently were coated with elemental silicon at room temperature using RLVIP. A film thickness of 70 nm was employed to tune the optimal spectral performance for the desired 1580- to 15,000-nm spectral region. A silicon film thickness of 160 nm was used for creating mirrors for the alternative 1300- to 1700-nm band. The resultant measured reflectances demonstrate that these surface-modified replicated mirrors are indeed well suited to critical infrared instrumentation applications (Figures 6 and 7).

For a comparative measurement of surface hardness and abrasion resistance, the moderate abrasion methods as described in MIL-M-13508C were re-employed. In both of the above cases, RLVIP-protected replicated gold alloy mirrors survived beyond 350 strokes without visible evidence of any surface abrasions.

Learning from the past

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methods were created many millennia ago, many of which still offer rare insights when developing new technologies.

In this current case, the successes of ancient metallurgists became key in developing an improved cost-effective replicated gold-based infrared reflector. The ancient Greeks and Persians were not merely scientific theoreticians; a multitude of discoveries were transformed into practical applications.

Meet the author

Jamie Knapp is director of engineering at Newport Corp. – Corion Optical Filters in Franklin, Mass.; e-mail: jamie.knapp@newport.com.

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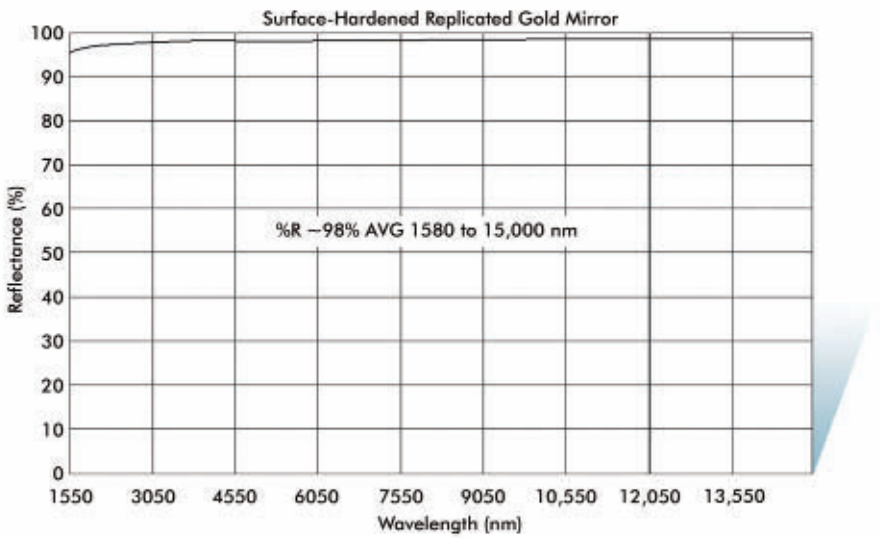
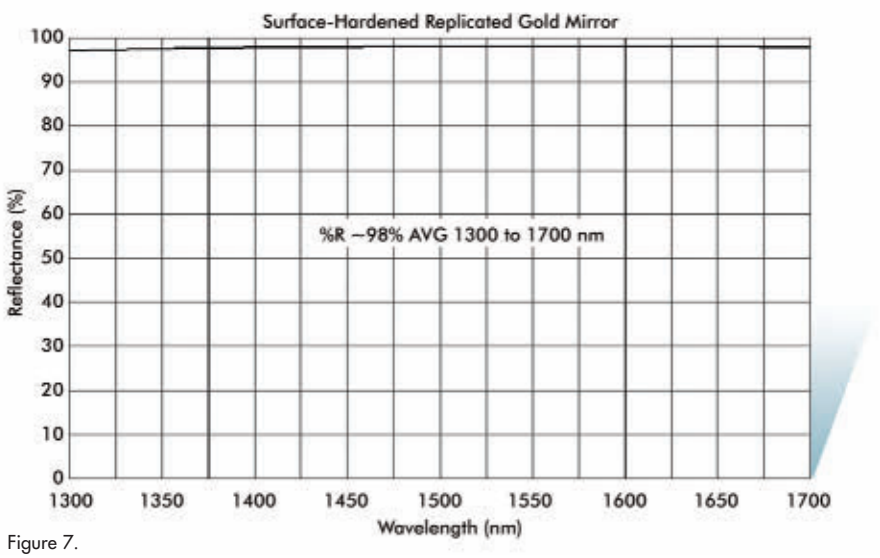


Figure 6.



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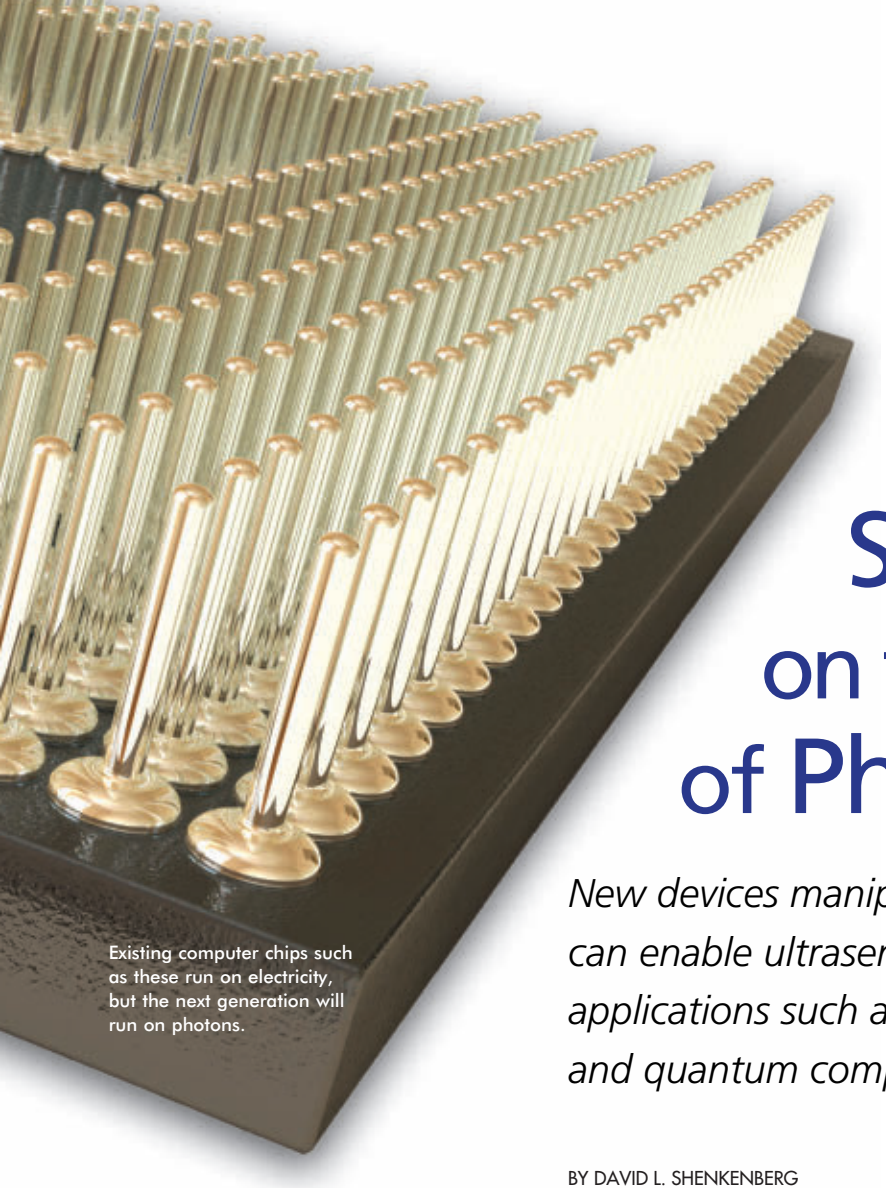

Existing computer chips such as these run on electricity, but the next generation will run on photons.

Sensors on the Frontiers of Physics

New devices manipulate light in unusual ways that can enable ultrasensitive detection, leading to applications such as quantum communication and quantum computing.

BY DAVID L. SHENKENBERG
FEATURES EDITOR

Computer chips based on light as opposed to electricity have only been theorized, but now researchers are actually developing computer chips that will use light for computer functions.

At Yale University in New Haven, Conn., members of Hong Tang's lab are already taking development of these photonic computer chips a step further. They are using light to power nanomachines built from computer chips, and these nanomachines could have numerous applications, including sensing molecules and even smaller particles.

The photonic nanomachines are similar to micro- and nanomachines that are powered by electricity, which are formally called micro- and nanoelectromechanical systems, or MEMS and NEMS, respectively. Far from a lab curiosity, MEMS devices have been deployed in automobile airbag sensors, ink-jet printers and even the motion sensors in Nintendo Wii controllers.

The researchers in the Tang lab have found an optical force that behaves like the Casimir force found in tiny electrical machines. This force is usually weak but becomes significant in micro- and nanodevices. The photonic chip will enable them to study this weak force, as well as to develop applications.

This force is different from the radiation pressure that is used by optical tweezers to move particles. "The new force that we have investigated actually kicks to the side of that light flow," Tang said.

Enter the matrix

The researchers have used the optical force to move 10 tiny cantilevers on a CMOS chip. Tang said, "The significance of our CMOS platform is that our device is fully compatible with many other devices. You can cascade them, put them in parallel, multiplex, scale up the production."

As described in the April 26, 2009, issue of *Nature Nanotechnology*, the light goes through the hollow bore of each nanocantilever and is collected on-chip. The nanocantilevers are of different lengths and therefore resonate at different frequencies, like keys on a xylophone. The system can detect particles $\frac{1}{10,000}$ the size of an atom, or 0.0001 angstroms. The detection mechanism is based on the deflection of the cantilevers.

The system can operate with inexpensive LEDs as opposed to more expensive laser systems, and at room temperature as opposed to extreme cold – major advantages over detectors with comparable sensitivity, according to the researchers.

In the July 13, 2009, issue of *Nature Photonics*, they reported that the optical force can be repulsive as well as attractive, a feature that could be used as a routing mechanism for communication between devices that contain computer chips.

In particular, this device possibly could be used as a router for quantum communication, which promises faster and more efficient communication between devices

that contain computer chips as well as extremely strong encryption of computer data, which is called quantum cryptography.

Quantum communication, cryptography and computing all are based on the concept that quantum particles such as photons can be in more than one physical state at the same time. Electricity, by contrast, is either on or off – one or the other, but not both. By existing in more than one state at the same time, photons can hasten computer-to-computer communication and make smarter computers that can come up with complex encryption that foreign spies and wanton hackers cannot break.

Holding an ion

Another device that can be used both for sensing and for quantum communication was developed by researchers at the National Institute of Standards and Technology (NIST) in Bolder, Colo., and their colleagues at the University of Erlangen-Nuremberg in Germany. It can trap and hold individual ions above three cylindrical steel electrodes with hollow bores protruding from the device. They call it a "stylus trap" because the steel cylinders trap the ion, and each cylinder reminds the researchers of a stylus.

Laser light and cold temperatures were used to trap the ions using techniques that have been demonstrated previously. The fact that the ions are held above the electrodes is unique. This architecture allows for greater access to the ions.

Using the ion as a probe for electromagnetic fields, the device can be used to measure forces, especially those oscillating between approximately 100 kHz and 10 MHz. It is about a million times more sensitive than the mechanical sensitivity of a cantilever of an atomic force microscope. Individual photons theoretically could be transferred to the trapped ions with 95 percent efficiency for quantum cryptography, and fluorescent light emitted by the ions could be used in quantum computing. This device is detailed in the June 28, 2009, issue of *Nature Physics* by senior author David Wineland of NIST and his colleagues.

Ripping a nanozipper

An even more exotic-looking force-sensing device was created by the Oskar Painter group at Caltech. The device consists of two nanoscale strands of silicon with periodic oval holes down the length of the strands. Connected side by side, the strands reminded the researchers of a zipper found on a piece of clothing. The zipper strands even opened up like a zipper when the scientists focused a laser beam down the center of the strands.

However, the researchers said that the zipper does not open as a result of the beam's path straight down the center. The mechanism is more exotic than that. Some of the photons enter and circulate in the periodic oval holes, and this circulation is what ultimately opens the zipper cavity.

The zipper strands could be used in force sensing; for example, two molecules could be attached to opposite strands, and the force required to open the strands and thereby pull the molecules apart could be calculated from there. The strands also could be used for photonic communication and photonic circuits, as well as for studying fundamental forces.

Applications aside, the cavity is also a marvel of physics. The force of a single photon traveling straight through the cavity is comparable to a force 10 times that of gravity.

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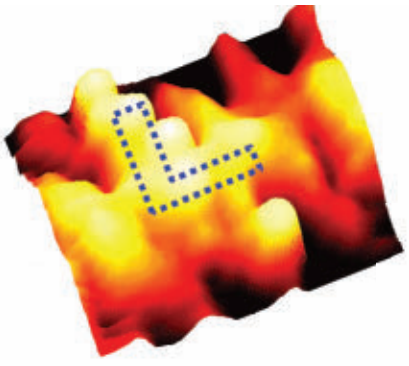


It's Two, Two, Two Tools in One

Technique enables simultaneous imaging and laser surgery without mechanical scanning.

BY LAURA S. MARSHALL
MANAGING EDITOR

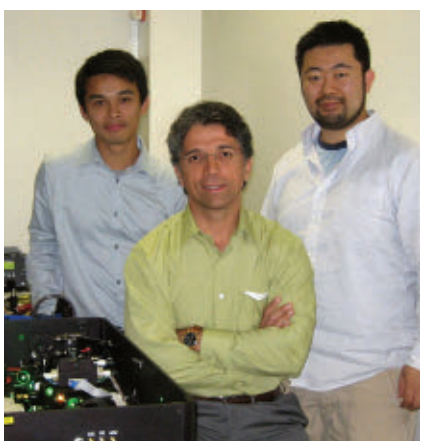
If a surgeon is about to use a probe in the brain, the patient is sure to want that probe to be as small as possible. And three University of California, Los Angeles (UCLA), researchers have developed technology that could lead to tinier probes that can perform both endoscopic imaging and laser microsurgery at the same time.

The technique, called "spectrally encoded confocal microscopy and microsurgery" – SECOMM for short – uses light for both functions. And it's the first of its kind that does not require mechanical scanning for either.

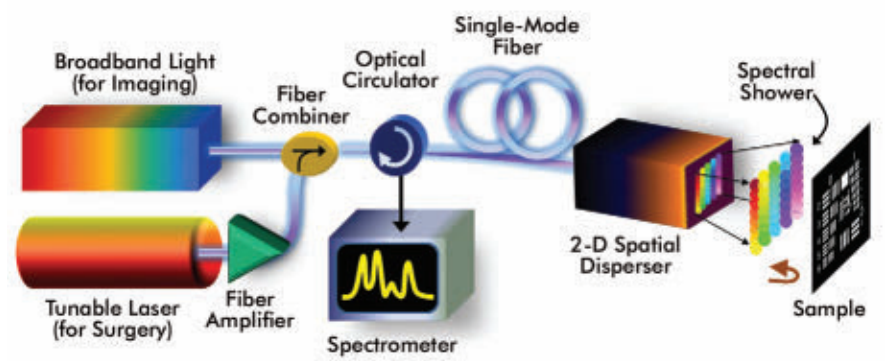
Mechanical scanning is useful because it enables acquisition of multidimensional images. But it has its downsides in endoscopy.

"Fluctuations in mechanical scanning introduce image noise and artifacts," said recent PhD graduate Kevin Kin-Man Tsia, now an assistant professor in the department of electrical and electronic engineering at the University of Hong Kong. He added that endoscopic probes using microelectromechanical systems (MEMS) scanners are similarly limited. And MEMS scanners in miniaturized endoscopic probes require a large probe size, up to ~1 cm, which limits their usefulness in clinical settings.

But SECOMM doesn't have that problem.



UCLA researchers Dr. Kevin Kin-Man Tsia, left, professor Bahram Jalali, center, and Dr. Keisuke Goda have developed an endoscope-compatible single-fiber-based device capable of simultaneous imaging and high-precision laser microsurgery.



With the SECOMM method, a fiber combiner takes a broadband light source (for imaging) and combines it with a wavelength-tunable continuous-wave laser followed by a fiber amplifier (for laser ablation). The 2-D spatial disperser generates a "spectral shower," and the spatial information about the sample is encoded into the spectrum of the back-reflected spectral shower. The optical circulator routes the back-reflected spectral shower to the spectrometer. Images courtesy of Kevin Kin-Man Tsia.

How it works

"The heart of SECOMM," Tsia said, "is an optical diffractive component: a two-dimensional spatial disperser which diffracts the different wavelengths of incident light into 2-D space, creating a 1:1 map between 2-D spatial coordinates and the optical wavelengths."

He said the 2-D spatial disperser delivers broadband light for imaging and wavelength-tunable light for laser surgery. Two optical diffractive elements make this happen: a virtually imaged phase array (VIPA) and a diffraction grating. The figure below, left illustrates the SECOMM design.

"Both the broadband light and high-power tunable laser are coupled into the same single fiber and the same 2-D spatial disperser to perform simultaneous imaging and high-precision laser microsurgery," Tsia said.

The disperser transforms an incident broadband light beam from a supercontinuum pulse laser or an incoherent broadband light source into a 2-D spatial spectral pattern resembling a spectral shower, which is used to illuminate the sample.

The sample's 2-D spatial information is encoded into the back-reflected "spectral shower," which is transmitted back to the "nondispersed" – but image-encoded – beam by the same 2-D spatial disperser.

The single-mode fiber re-collects the beam, allowing transmission of 2-D images of the sample, and a spectrometer detects the image-encoded spectrum.

"Such imaging is essentially a confocal microscope," Tsia noted, "as the aperture of the fiber that captures the reflection from the sample rejects the scattered light from out-of-focus axial planes."

Folding the 1-D spectral data into a 2-D matrix that represents the image allows for digital reconstruction of the sample's image.

Tsia said that a high-power wavelength-tunable laser beam will follow the same

wavelength-to-spatial-coordinate mapping as the spectral shower performing the imaging if it is coupled with the imaging optics via a beam combiner and passes through the same spatial disperser.

"By tuning the wavelength of the laser," he said, "the beam can be directed to any arbitrary position on the sample to perform laser surgery [ablation], without any mechanical movement of the probe to steer the laser beam or the movement of the sample.

"Hence, high-precision microsurgery can be performed by computer-controlled tuning of the laser wavelength according to a preprogrammed pattern."

Advantages and challenges

Most currently employed endoscopes rely on a CCD or a fiber bundle to capture images, sometimes combined with a scal pel or other surgical instrument to provide simultaneous imaging and surgery.

For minimally invasive procedures, an endoscope must be very flexible, and it must have a very small diameter. "In CCD-based probes, the size of the chip placed at the distal tip limits the minimum diameter to about a few millimeters," Tsia noted, "and their electrical cables limit their flexibility." He added that fiber-bundle technology is limited because obtaining a high pixel count requires a large number of fibers, resulting in mechanical rigidity. Because SECOMM uses a single fiber, it is both small and flexible.

Right now, SECOMM is hindered by its spatial resolution – around 4 to 10 µm – and by the number of pixels it can capture.

"Nevertheless," Tsia said, "these are not the inherent limitations of this technique because the number of pixels can significantly be increased by using an optical source with larger bandwidth or a spectrometer with higher spectral resolution."

First of its kind

Others have been working on designing similar probes in recent years. A Harvard Medical School group demonstrated a 1-D spectrally encoded endoscope, but the technique requires mechanical scanning to capture a whole 2-D image. Another group demonstrated an endoscopic probe capable of both imaging and laser surgery through the use of MEMS scanners for beam steering. "SECOMM has the advantages over such endoscopic probes," Tsia said, "as it eliminates the need for mechanical scanning."

Grating-VIPA arrangements have been used in the past for demultiplexing in telecom applications and for spectroscopy, he added. But his team used the 2-D spatial disperser for imaging and microsurgery.

A winning team

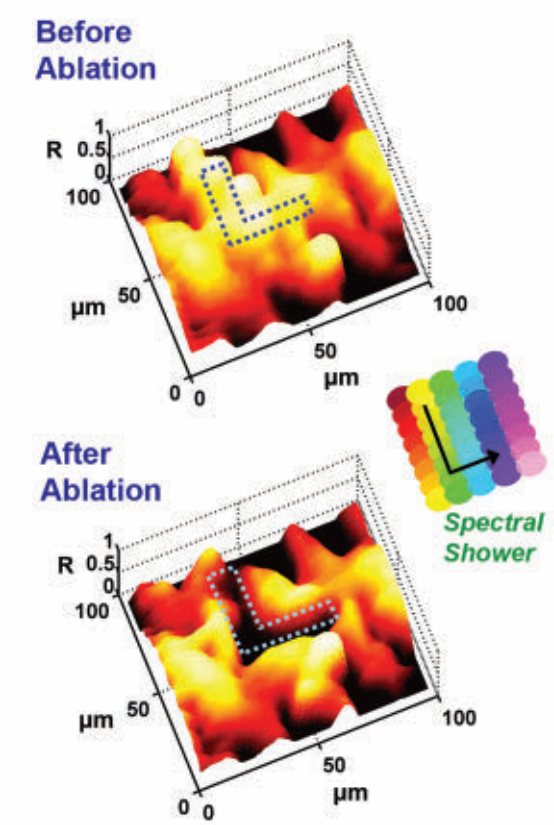
Tsia worked on the SECOMM project with Keisuke Goda, a postdoctoral researcher in the electrical engineering department at UCLA, and with Bahram Jalali, a professor of electrical engineering at the university.

These same three researchers recently made headlines when they developed "the fastest camera in the world." That camera is known as STEAM, which stands for "serial time-encoded amplified microscopy." It allows real-time imaging with up to 6 million fps, thanks to ultrashort laser pulses; "optical" image gain enables high detection sensitivity. STEAM, according to Tsia, can overcome the trade-off between speed and sensitivity that occurs in existing CCD/CMOS cameras. And its speed makes it useful for capturing rapid biological processes and events such as the firing of a neuron. It also can be used with SECOMM for laser surgery.

In fact, Tsia said, SECOMM originated from the work they did on STEAM.

"One of the key features in STEAM is spectrally encoded imaging, which maps the spatial information onto the spectrum of an ultrashort laser pulse. We borrowed this idea for SECOMM and realized that laser surgery can also benefit from the same wavelength-space mapping idea."

The two can be combined to perform simultaneous ultrafast real-time imaging and laser surgery. "This is particularly useful to monitoring the laser ablation dynamic in the tissue," Tsia said. "The optical amplification feature in STEAM can also be applied to SECOMM, in which the detection sensitivity can be greatly enhanced."



This demonstration of SECOMM's ability to perform laser microsurgery and simultaneous monitoring shows the images captured (a) before and (b) after performing laser ablation on a bovine tissue sample. The "L" pattern (outlined in dots) is carved out of the tissue by tuning the wavelength of the CW laser in the manner shown in the inset of the figure (see arrow). The Z-axis represents the normalized reflectivity of the sample.

Concept proved

The next step for the SECOMM project is to design and build the miniaturized SECOMM probe. This will consist of off-the-shelf miniaturized optics, including a diffraction grating and a gradient-index lens.

The preliminary design showed that SECOMM can be miniaturized into a submillimeter-diameter probe with spatial resolution of 1.4 × 2 µm, with a field of view of 280 × 70 mm. "The present imaging technique can also be further extended to three-dimensional volumetric imaging by employing an interferometric configuration, which enables the acquisition of the depth information of the sample," Tsia said, which will be good news for future patients undergoing delicate procedures.

"SECOMM can be applicable to any area where high-precision, small and flexible probes are required, such as brain tumor, pediatric and endovascular surgeries," he said.

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Mid-IR Tunable Lasers Probe

Hydrocarbon Molecules

BY ANGUS HENDERSON
LOCKHEED MARTIN ACULIGHT

Infrared laser spectroscopy is a powerful technique that allows unique identification of chemical species as well as study of their properties. Measuring absorption as a function of wavelength enables chemists to obtain spectra of compounds that are a unique reflection of their molecular structure.

The wavelength region between 3.0 and 3.7 µm (2750 cm^{-1} and 3300 cm^{-1} in frequency) is particularly important because it contains virtually all the characteristic stretching frequencies of molecules containing carbon-hydrogen bonds. The strength of the fundamental absorptions in this so-called "C-H stretch" region can be orders of magnitude higher than overtone absorptions of the same molecules in the near-infrared (<2-µm wavelength). For example, the absorption of methane at 3.3 µm is more than 100 times stronger than in its overtone band at 1.65 µm (Figure 1). As a result, narrowband tunable lasers operating in the C-H stretch region can be used to perform highly sensitive detection of hydrocarbon species, as well as more fundamental investigations of molecular structure and chemical reactions.

Such sensitive hydrocarbon molecule detection could enhance capabilities in many applications. Potential applications for mid-infrared laser-based detection of organic molecules include analysis of human breath for medical diagnostics, detection of impurities in industrial process gases (e.g., in semiconductor wafer manufacture), airborne natural gas pipeline leak detection and monitoring industrial greenhouse gas emissions. Implementation of these techniques is showing promise, as new mid-infrared laser sources are proving themselves useful and robust spectroscopic tools in the research laboratory.

Lasers for spectroscopy

Currently, mature tunable laser technology exists primarily in the near-infrared region, with emission wavelengths below 2 µm. Titanium-sapphire and dye lasers[1] provide high power (watts) and wide tunability (hundreds of nanometers) in the 400- to 1000-nm range. External-cavity diode lasers provide widely tunable, lower power output (milliwatts) covering wavelengths up to approximately 2 µm. Above 4 µm, external cavity quantum cascade lasers[2] now are being offered commercially and are opening up new possibilities for spectroscopy in the long-wavelength infrared "fingerprint region."

However, in the 3- to 4-µm range, there are as yet no commercial semiconductor sources that provide wide tunability. Although interband cascade lasers show promise,[3] currently the growth of this kind of semiconductor material remains challenging. To date, the most capable tunable lasers in this spectral region have been color center lasers. These use alkali halide or oxide crystals as gain media, and they provide output in the 2.4- to 3.6-µm range. They operate at cryogenic temperatures with typical output powers of tens of milliwatts and are pumped using a krypton ion laser. Although the color center laser has provided substantial capability for spectroscopy, the size, complexity and difficulty with maintenance have been substantial drawbacks, and they are no longer available commercially.

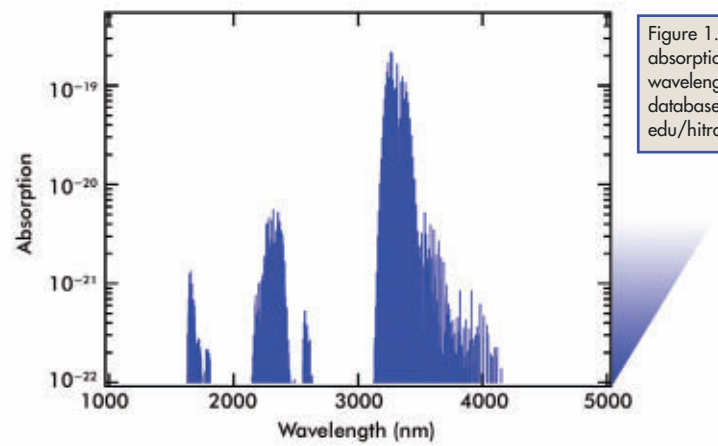

Figure 1. Methane absorption strength vs. wavelength (HITRAN database: www.cfa.harvard.edu/hitran/).

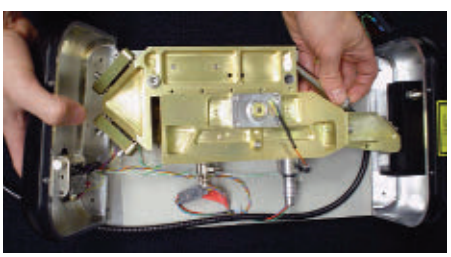

Figure 2. Aculight Argos OPO modules consist of a quasi-monolithic resonant OPO cavity mounted on a pump laser pointing unit. Here the fiber laser collimator is shown being inserted into the pointing unit.

CW OPOs fill the 3- to 4-µm gap

In addition to lasers directly emitting within the 3- to 4-µm region, widely tunable emission in this range is also possible by nonlinear frequency conversion of more mature near-infrared sources. Products based on difference frequency generation between two distributed feedback diode lasers have been offered commercially. These devices typically produce submilliwatt output and tuning of approximately 100 nm per device.[4]

Optical parametric oscillators (OPOs), by contrast, provide a pathway to much wider tuning and higher power output in this spectral region. Although the first CW OPOs have been commercially available since 2000, the emergence of fiber lasers as pump sources has transformed OPO capabilities. The most important advance is that the pump power level is sufficient to

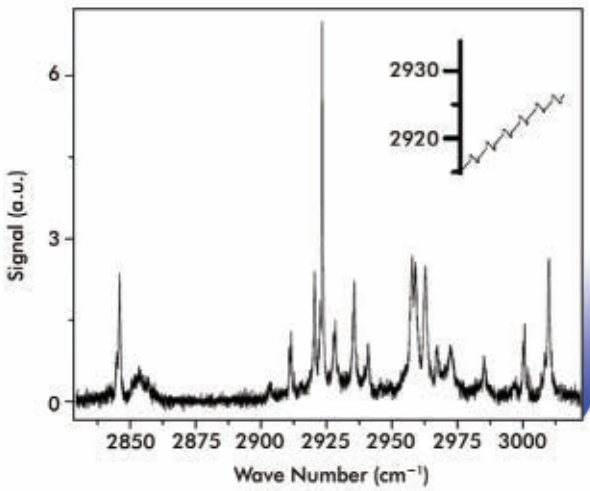

Figure 3. Shown is a depletion spectrum of methanol, recorded using a helium nanodroplet spectrometer in combination with a CW OPO. The inset shows the wavelength meter reading for part of the computer-controlled scan, made up of overlapping 50-GHz mode-hop-free scans. After acquisition, data is reconstructed and plotted via a LabView program. Courtesy of the University of Georgia.

operate the OPO as a singly resonant oscillator, where only one of the three interacting wavelengths is resonant. This allows straightforward monotonic tuning.

Lockheed Martin Aculight's Argos, launched in 2007, is the first truly singly resonant CW OPO product. The Argos systems provide multiwatt output powers at both signal and idler wavelengths, linewidth of <1 MHz and mode-hop-free tunability of >50 GHz. They are configured as quasi-monolithic resonant cavities (Figure 2) with a keyed fiber input collimator acting as a connector to a prealigned OPO module. Three interchangeable OPO modules tune from 1.46 to 3.9 µm. The fiber-coupled pump source and monolithic OPO design make the system turnkey, so no "tweaking" is required to maintain alignment. As a result, these OPO systems are finding wide application in major research laboratories around the world for a variety of spectroscopic investigations.

Applications in chemistry

At the University of Georgia in Athens, Gary Douberly's research group uses high-resolution infrared laser spectroscopy to study novel molecular species isolated in cold 0.4-K helium nanodroplets. Low-temperature helium droplets provide a unique environment in which to probe the structural properties of the isolated molecules. The group is using an Aculight Argos CW OPO system in combination with a helium nanodroplet instrument to make the spectroscopic measurements. The researchers have added additional controls to a standard OPO system, allowing them to collect wide-range spectra. Synchronizing the fine- and coarse-tuning control mechanisms via a PC allows the OPO to collect high-resolution spectra over hundreds of nanometers (Figure 3).

These wide scans allow the group to investigate the evolution of the infrared spectra of hydrocarbon molecules after they undergo reactions with various metal clusters within the helium droplets. Reactions between metal clusters and molecular species such as methane, ethylene and acetylene show up as qualitative changes in the infrared spectra. Full automation of the OPO's tuning enables exceptionally wide, high-resolution measurement of the entire C-H stretching range (approximately 300 nm) characteristic of hydrocarbon molecules in about 3 h, with no user intervention.

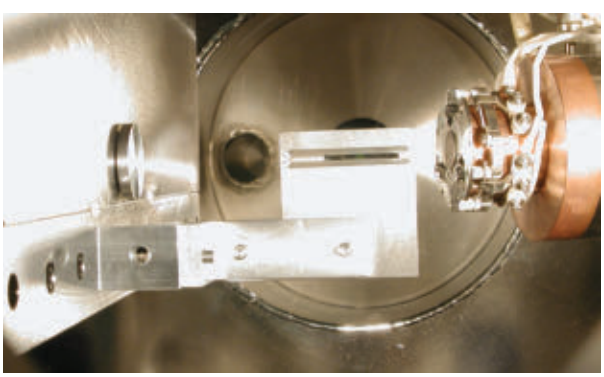

Figure 4. Shown is an École Polytechnique Fédérale de Lausanne (EPFL) surface science apparatus. The molecular beam exits the aperture (left), traverses the alignment tool (center), where laser excitation takes place, and collides with the single crystal metal surface mounted in the center of the sample holder (right).

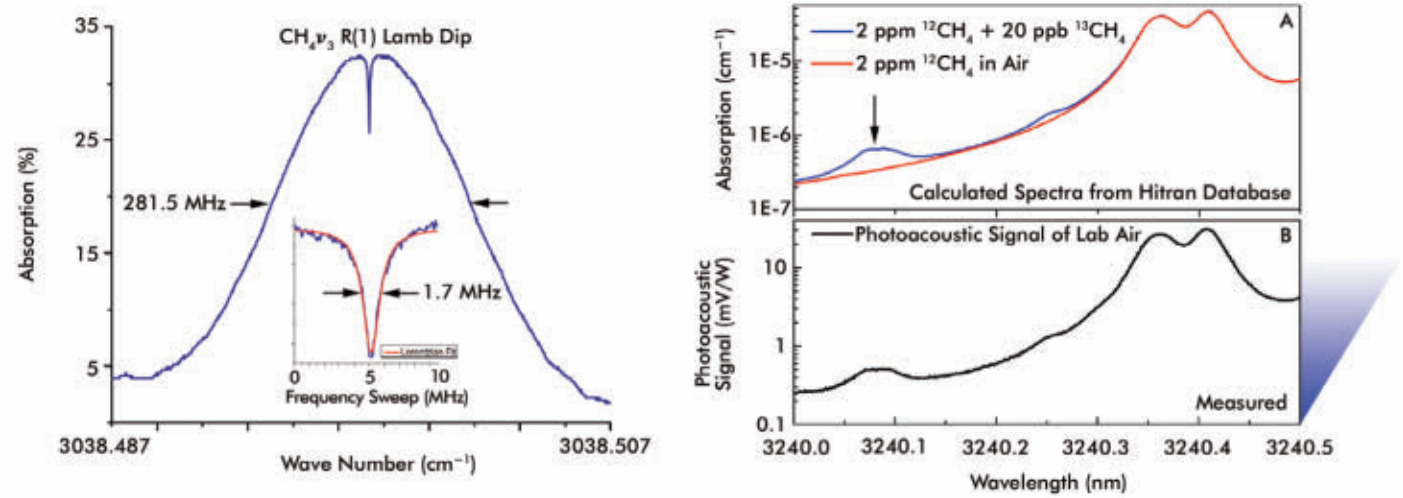

Figure 5. (left) This graph shows methane spectra calculated from a Hitran database. The arrow indicates the ^{13}C peak used for measurements. (right) This chart illustrates the photoacoustic spectra of laboratory air. Courtesy of Radboud University.

At the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, professor Rainer Beck and his research group are studying chemical reactions between gas molecules and solid surfaces. Processes in surface chemistry such as heterogeneous catalysis and chemical vapor deposition are important in many industrial implementations, such as catalytic conversion in automobiles and semiconductor growth in the electronics industry. In Beck's laboratory, researchers are studying the effects of laser excitation in such processes. The results of these experiments provide stringent tests for theoretical models of gas-surface chemistry.

The group is currently using an Aculight Argos CW OPO to study the reaction of methane with a nickel catalyst. The OPO prepares a beam of methane molecules in a specific excited state. To preserve the molecules in this state, the preparation is performed under collision-free conditions in a molecular beam (Figure 4), whereby the absorption feature is reduced to less than a few megahertz in width. The high spectral resolution and

high power of the OPO allow vibrational transitions to be excited into saturation (Figure 4) where approximately 50 percent of the molecules are in a single quantum state. The wide tunability of the OPO makes it a highly versatile source for this study, and the researchers anticipate using it in the future to extend their studies to a variety of molecular species and absorption features.

Applications in chemical sensing

Professor Frans Harren leads the Life Science Trace Gas Facility at Radboud University Nijmegen in the Netherlands. The group has developed state-of-the-art laser-based trace gas detectors that are used for research in areas from plant physiology to medicine and human health. Harren and his colleagues use a variety of lasers combination with sensitive detection schemes, including photoacoustic spectroscopy and cavity ring-down spectroscopy.

The team's recent experiments have challenged the findings of a published study that asserted that emission of significant amounts of methane from plants may play a significant role in the global atmospheric concentration of this powerful greenhouse gas.

By growing plant samples in the presence of carbon dioxide molecules based on the stable isotope of carbon ^{13}C, any methane emitted by the plants could be identified by the presence of this isotope in the methane molecule. Researchers performed trace methane detection with the photoacoustic technique using a singly resonant CW OPO pumped by a diode-pumped solid-state laser operating at approximately 3.24 µm (Figure 5). The OPO's high power level allowed a $^{13}CH_4$ detection limit of three parts per billion to be attained using the OPO spectrometer. This is well below the naturally occurring level of $^{13}CH_4$ in the atmosphere. Monitoring the $^{13}CH_4$ level showed that there was not a statistically significant level of methane emission from the plants, contradicting the original published finding.

Looking ahead

It appears likely that, with time, new types of semiconductor lasers may emerge as the lowest cost pathway for laser emission in the 3- to 4-µm region. However, the high power, wide tuning and robust physical characteristics of OPOs, especially those pumped by fiber lasers, make these sources important spectroscopic tools in today's research laboratories. These same attributes also make OPOs promising for in-the-field applications in industry, medicine and sensing.

Meet the author

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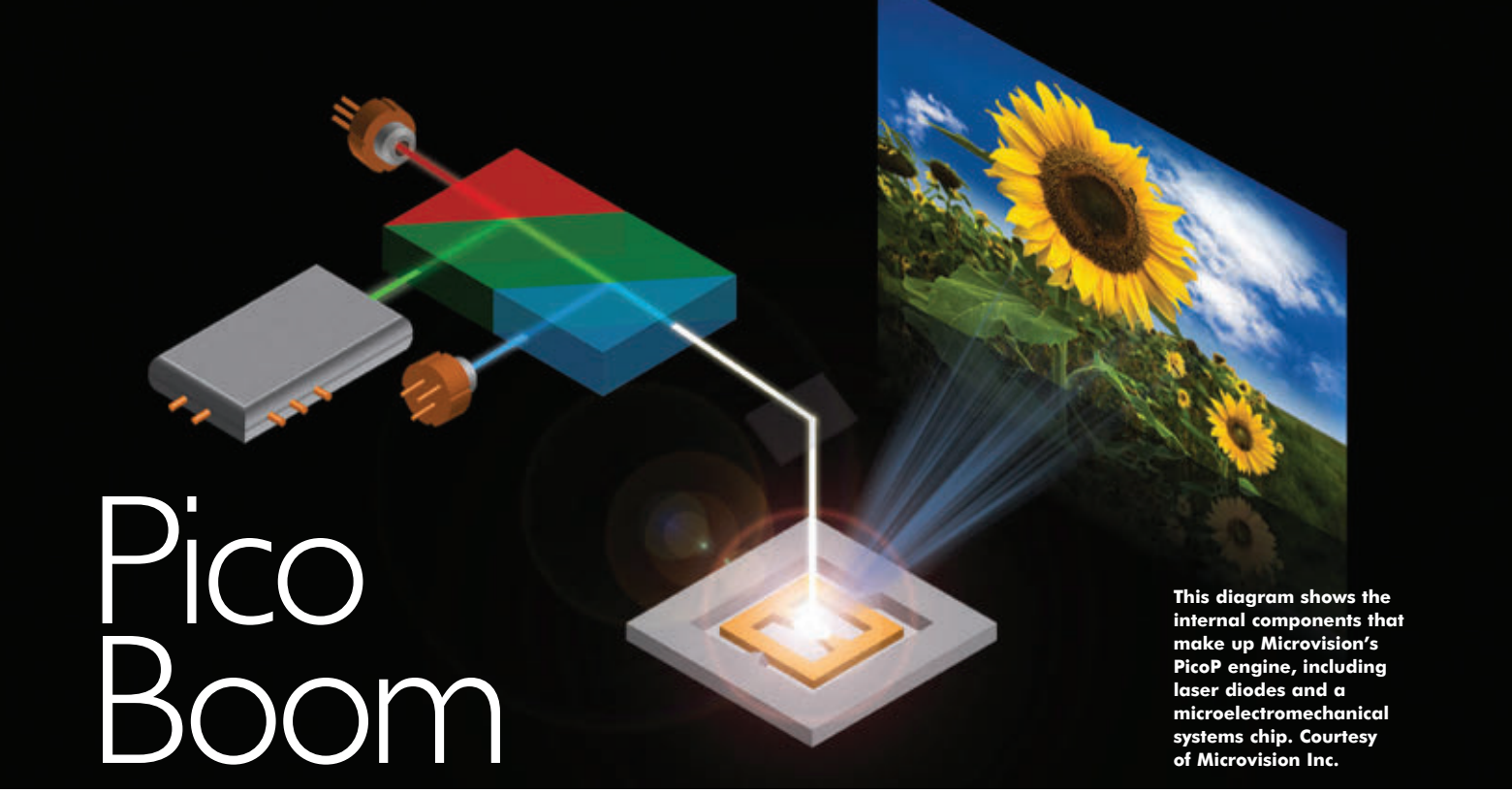


Pico Boom

This diagram shows the internal components that make up Microvision's PicoP engine, including laser diodes and a microelectromechanical systems chip. Courtesy of Microvision Inc.

Pocket projectors are poised to explode, but will lasers or LEDs be the pre-eminent light source?

BY MELINDA ROSE
SENIOR EDITOR

Tiny projectors, known as pico or pocket projectors, are on the cusp of becoming the next big thing as they shrink to sizes practical for embedding into ever-smaller cell phones and other mobile devices as well as head-up displays for the military and auto industries. As these projectors continue to shrink, a battle is growing between LEDs and lasers to become the pre-eminent pico light source.

The lamps first used as light sources for tabletop projectors or rear-projection televisions are large and power hungry, and they generate enormous amounts of heat, so manufacturers have turned increasingly to LEDs and, more recently, to lasers as better choices.

The Show, the first smart phone to include a pico projector, currently is sold only in South Korea. Courtesy of Samsung Electronics Co. Ltd.

Pico projectors are driven by three major technologies: digital light processing (DLP), liquid crystal on silicon (LCoS) and laser beam steering (LBS).

Texas Instruments (TI) of Dallas pioneered the DLP projection system in 1987. DLP technology is driven by a small chip containing up to 2 million hinge-mounted micromirrors. The chip switches each mirror on and off several thousand times per second, generating light or dark pixels.

"DLP can work with lasers or LEDs and is poised to take advantage of either LED or laser technology," said Frank J. Moizio, DLP emerging markets manager at TI. "DLP products today ship with lasers."

One such product is the 65-in. laser TV, LaserVue, from Mitsubishi Electric of Tokyo, which appeared on the market in October 2008 for $7000. Mitsubishi said the lasers give the TV about twice the color range of other high-definition TVs, while consuming as much as 75 percent less power than LCD and plasma panels.

LCoS uses liquid crystal instead of mirrors to control the amount of light each pixel receives. Its light source has shifted in recent years from high-intensity lamps to LEDs, but lasers also can be used.

LBS systems use optics to combine RGB (red, green, blue) laser beams and then guide them with a mirror to create an image.

Show me the market

With the worldwide economy in a slump, diode makers are looking to sell their product however they can. The worldwide mobile phone market, with one billion units sold last year, is an attractive one: Even a 2 percent slice translates to sales of 20 million to 30 million diodes.

Pico projector prototypes with a resolution similar to a DVD were featured at the Consumer Electronics Show in Las Vegas in 2008 and 2009 and have been trickling onto the market.

The MPro110 from 3M of St. Paul, Minn., has an LED light source and LCoS imager. The Pico, a handheld projector made by Optoma Technology of Milpitas, Calif., and featuring TI's DLP, began shipping at the end of 2008.

Samsung Electronics Co. Ltd. of Seoul, South Korea, unveiled its Show, the first smart phone to include a pico projector, at the Consumer Electronics Show in January. Show also features TI's DLP and is currently available only in South Korea.

According to industry analyst iSuppli Corp. of El Segundo, Calif., the market for pico projectors will explode by nearly 6000 percent over the next four years, growing from fewer than 50,000 units this

year to more than three million in 2013.

Sanju Khatri, principal analyst for signage/projection at iSuppli, said tiny displays have been a major obstacle, preventing smart phones and small laptops from becoming primary platforms for computing and Internet access.

"The growth potential for embedded pico projectors will be limited during the next few years due to challenges in areas including power consumption, size and manufacturing," she said. "As these issues are resolved, pico projectors will appear in many more mobile electronics devices."

That might make microprojectors the hot accessory, possibly as soon as this Christmas. The upside: You could soon project bigger versions of the photos or videos from mobile devices onto virtually any surface without having to download them first. The downside: There may be no escaping a slide show of Uncle Phil's two weeks in Branson, Mo.

Self-contained pico projectors now are about the size of a garage-door opener, but the trend is to embed them into portable things, such as a cell phone, an MP3 player or a digital camera.

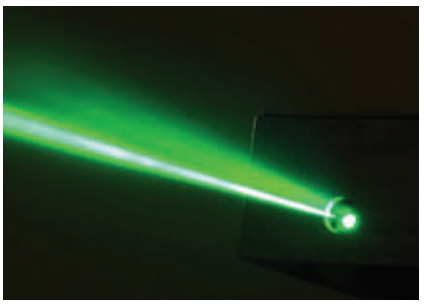
Pico projectors with laser light sources are expected on the market sometime this year as consumers demand smaller devices. Diode manufacturers have been busy building diodes that lase at shorter and shorter wavelengths because the shorter the wavelength, the less power they use and the brighter the image is to the human eye.

"We are still planning to begin initial shipments of SHOWWX later this summer," said Matt Nichols, director of communications for the Redmond, Wash.-based Microvision. SHOWWX is a handheld pico projector driven by the laser-based PicoP display engine. (For more information on projection technology, see "Microdisplays: Coming Soon to an Eye Near You?" September 2008, p. 68, and, in this issue, "Flat Screens Go Deep – and More," p. 56.)

Seeing red

High-power red laser diodes emitting at 660 nm are standard in devices such as recordable DVD players, but that wavelength appears relatively dark to the human eye, making the diodes ill-suited for compact projectors equipped with RGB lasers.

Mitsubishi Electric said it solved that problem with its new red series – diodes that emit at 638 nm – which provide the brightness needed for pico projectors.



A green laser emits from an oscillator. Courtesy of Sumitomo Electric Industries Ltd.

The company introduced the red diodes at Laser World of Photonics in Munich in June, saying they appear much brighter than 660 nm or even the commonly used 645-nm diodes at the same output power.

Blue (450 to 480 nm) diodes showed up about 15 years ago and are used now in Blu-ray disc players. In January at Photonics West 2009, Osram Opto Semiconductors GmbH of Regensburg, Germany, announced a blue laser with a wavelength of 450 nm and an output of 50 mW that it said is the smallest in its class.

It ain't easy beamin' green

One hurdle that laser makers have had to overcome is with the green wavelength, which stretches from 520 to 570 nm, with 532 considered optimal for displays.

Green lasers have been achieved through frequency conversion of infrared lasers but have been unable to directly emit green light. Recently, engineers have been inching closer to pure green emitters by producing wavelengths in the blue-green spectrum.

In February, researchers at Rohm Co. Ltd. in Kyoto, Japan, said they had pushed a gallium nitride (GaN) diode to the longest recorded wavelength yet produced, 499.8 nm, but said their technique is not suitable for mass production. Later that month, Osram Opto Semiconductors Inc., whose North American headquarters is in Sunnyvale, Calif., published a paper in Applied Physics Letters describing an electrically pumped 500-nm-emitting diode based on its blue technology. In May, in an Applied Physics Express paper, Nichia Corp. of Tokushima, Japan, said it had created a 515-nm device. (At press time, Osram Opto announced it achieved a direct-emitting green indium GaN laser at 515 nm.)

Then in July, Sumitomo Electric Industries Ltd. of Osaka, Japan, announced that it had created the first direct-emitting green laser at 531 nm. The company said it overcame a problem with GaN semiconductors (used commercially for blue LEDs), in which the material's luminance efficiency rapidly declines as the wavelength increases, by developing a GaN crystal that inhibits the efficiency drop. The result was room-temperature pulse operation of a laser diode emitting in the pure-green region at 531 nm. Sumitomo has applied for 60 patents on the technology.

Spectralus Corp. of Santa Clara, Calif., is reporting this month at the Eurodisplay 2009 conference on its developments in green laser efficiency. In June, it announced a milestone in shrinking green lasers: an eight-pin butterfly package for its 100-mW green laser. It also said that the lasers demonstrated 30 percent optical-to-optical (808- into 532-nm wavelength) conversion efficiency levels.

The company said in a statement that it is preparing a mass-production package tailored for pico and embedded projectors for the fourth quarter of 2009.

Microvision signed a supply deal with Corning Inc. of Rochester, N.Y., in May for its G-1000 synthetic green lasers and an agreement with Osram Opto for its blue and green lasers, to ensure an ample supply of diodes as it prepares to begin commercial production of the SHOWWX.

Nichols said he expects quantities to be in the thousands for the remainder of this year, constrained more by supply than by

Shown is Microvision's pico projector, the SHOWWX. Courtesy of Microvision Inc.

demand, with production ramping up to more than 100,000 next year.

Lasers vs. LEDs

Laser diode makers say using lasers means that the projected images will be focus-free, will deliver a wide range of bright, vibrant colors, and will consume less power, while downplaying their major disadvantages, speckle noise – black dots that make the image appear grainy – and cost.

LED manufacturers have been making inroads into increasing the power, brightness (HB-LEDs) and efficiency of their products, which are long-lived and less expensive than lasers. They have been criticized for a lack of brightness under normal lighting conditions and for having limited focus.

Moizio said the first pico prototype DLP shown in 2007 used a pico DLP chip and three lasers. "Feedback from customers and the market were that lasers were too expensive and had associated speckle and safety issues. It was the choice of brands and manufacturers to use LEDs instead of lasers, due to their maturity, safety and cost."

If lasers can exceed LEDs in terms of cost, performance and safety, he added, "DLP customers and manufacturers would likely take advantage of this and use lasers."

Alexander Mönchmeier, senior product marketing engineer of opto components for Mitsubishi Electric, said that, over the next three to five years, laser diode makers will work to overcome problems such as thermal expansion and price to integrate RGB onto one submount. Red lasers are very inexpensive, about $10 to $15 apiece, because they are made in high quantities – about 15 million a month – for the DVD market. But blue lasers are expensive, as high as $1000 for one.

He said that having an RGB engine-driven pico projector could add about 15 percent to the cost of an already expensive multimedia phone.

"Demand from the consumer may be there, but what price are they willing to pay?" Mönchmeier asked.

Nikon's Coolpix S1000PJ, hitting the market this month, is the first camera equipped with a pico projector. Courtesy of Nikon Corp.

The next big thing for little things

Nikon Corp. of Tokyo is expected to ship its first camera equipped with a pico projector, the Coolpix S1000PJ, this month. Featuring an organic LED screen, it is being touted as one of the first combination digital cameras and LCoS pico pro-

jectors and is expected to retail for about $430.

Light Blue Optics (LBO), a startup in Cambridge, UK, recently secured another $15 million in funding for its holographic laser projection technology. With its system, a diffraction pattern of the desired 2-D image is calculated using patented holographic algorithms, then shown on an LCoS microdisplay. When illuminated by coherent laser light, the desired 2-D image is projected. Three techniques, two proprietary, are used to remove speckle and improve the image.

LBO's "cool" factor lies in its ability to turn the projected image into a touch screen via an infrared beam – invisible to the eye, superimposed over the projected image – and a sensor that detects when and where the image is touched.

LBO announced in June that its first product will be released to OEM customers in the fourth quarter of 2009.

The WWW.Brighter.Eu (World Wide Welfare: High Brightness Semiconductor Lasers for Generic Use) Project aims to push the limits of current laser diode technology toward high brightness for health care, telecommunications and displays such as mobile projectors, head-up displays and rear-projection TVs. The €16.2 million program, a consortium of 23 companies and research institutions, began in 2006 with €9.7 million in European Union funding. It is scheduled to end in January 2010.

Light Blue Optics' laser technology turns the projected image into a touch screen. Courtesy of Light Blue Optics Ltd.

Over the course of the project, Brighter announced a series of firsts in lab-based records for red, infrared and green lasers. In the coming months, the red and green laser modules will be tested for display application feasibility. The goal is to create devices featuring the technology over the next two to five years.

Late last year TI began selling a DLP Pico projector development kit, called DLP Discovery, that allows developers to incorporate DLP into emerging applications.

"The open source community is using the Pico kit in a variety of interesting ways: for example, 3-D optical measurement systems and augmented reality overlay of information," said Arun Chhabra, business development manager of DLP Embedded at TI. Based on feedback from developers, he said, "We plan to introduce kits that are targeted at more specific application areas" to accelerate experimentation-to-development time.

"Stay tuned over the next six months for exciting developments on this front," he added.

Microvision also is working with OEMs to design products that embed its PicoP, which is about the size of an Andes chocolate mint. Those products might be introduced in 2010 or 2011, Nichols said.

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Northern Lights: The Photonics Industry in Canada

BY LAURA S. MARSHALL
MANAGING EDITOR

Canada is a pretty big place: Its surface area is 9,984,670 km^2, which means that only Russia and Antarctica are bigger. And photonics is pretty big in Canada, too.

The country is strong in a wide variety of photonic areas, according to a January 2009 survey by the Canadian Photonics Consortium (CPC). These include research capability and infrastructure; industry-academic cluster activity, especially in Ontario and Québec; systems integration; optical communications; image sensors and vision systems; short-pulse laser technology; and emerging biophotonics capability.

Canadian photonics technologies are used worldwide in defense and security; health and medicine; manufacturing; energy and lighting; communications; consumer goods; environmental protection; sensing and measurement in the oil, gas, paper and forestry industries; and even entertainment.

The nearly 400 photonics companies in Canada employ a total of more than 20,000 people, collectively generating close to 4.4 billion CAD per year, according to the CPC report. Approximately 85 percent of that revenue comes from exports, and 50 percent of those exports head to the US.

In a country with so much space, clusters are only natural. The province of Ontario is known for biophotonics, according to the CPC, while Québec is known for sensing, although both regions have plenty going on in all photonics disciplines. Activity is more scattered in the western provinces.

Ontario

"Ontario has a strong track record of excellence in photonics," said Don Wilford, managing director of the Centre for Photonics, part of the Ontario Centres of Excellence (OCE), which supports research commercialization and connects academe with industry. "The industry sector is mature and successful, including globally competitive large firms, nimble small and medium enterprises, and a small but vibrant start-up community."

The Ottawa area, traditionally the focal point of Ontario photonics, is home to communications companies such as Nortel, JDS Uniphase Corp., Cisco Systems Inc. and Alcatel-Lucent Canada Inc. "This created a strong ecosystem focused on communications," said John Fielding, a director of business development at OCE.

But that all changed in the early 2000s, when the telecom bubble burst. "One of the effects of the bubble," he said, "was that the technical and entrepreneurial people took their communications expertise and applied it to other technology sectors [including] biomedical, photovoltaics, industrial photonics and lighting."

Today, Ontario's photonics industry is fairly balanced across six market sectors, according to Fielding: information and communications technologies, health and life sciences, defense and security, lighting energy and environmental photonics, industrial photonics, and the entertainment and consumer segments. And although there is still significant activity in Ottawa, the industry distribution has spread to other cities, such as Toronto and Waterloo.

In Ontario, 41 percent of all photonics jobs are in the research-and-development area, according to a March 2009 report authored by Wilford. Nearly a third of jobs are in manufacturing, with the rest almost evenly divided between administration and small-/medium-business development.

More than three-quarters of photonics employees work for large companies with more than 250 workers; most are subsidiaries of US corporations, he reported. Small and medium enterprises employ nearly 20 percent of workers, while startups employ only 4 percent.

The Ontario Photonics Industry Network (OPIN), in which both Wilford and Fielding play key roles, works to promote photonics through various initiatives, from offering sponsorships to enable members of the industry to attend trade shows to compiling and distributing promotional materials on photonics in the province.

On the academic side, Ontario is home to university groups and world-class research institutes such as the Canadian Photonics Fabrication Centre in Ottawa, which Fielding described as a unique-to-Canada photonics fabrication facility that allows companies to do small fabrication runs.

"Ontario has developed a strong capability in biophotonics, principally at the University Health Network in Toronto," Wilford said. The network's Laboratory for Applied Biophotonics (LAB), he said, has partnered with the Centre for Biophotonics Science and Technology at the University of California, Davis. "LAB is a unique model – embedded within Canada's largest research hospital complex and seamlessly integrated with its biomedical research, clinical trials and medical delivery capacities."

Québec

Ontario isn't the only photonics hot spot in Canada. Industry and research are booming in Québec as well. Most of the companies are located in Montréal and Québec City; a few others can be found in the Sherbrooke and Gatineau areas.

"The key factors driving the photonics industry in the province of Québec," said

Dr. Michel Têtu, an emeritus professor from Université Laval in Québec City, "are the availability of highly qualified technical personnel, the presence of world-class research centers and institutes working closely with industry, the proximity to key markets in the US and Canada, a dynamic business environment and a strong commitment from governments to support the industry.

Québec City, the provincial capital, has taken special care to home in on photonics in its quest to build a tech-centered creative economy.

Local economic development agency Pôle Québec Chaudière-Appalaches works closely with Montréal-based Investissement Québec as well as area companies and institutions to ensure the success of photonics-related endeavors. Pôle does it all, from facilitating the formation of research and business partnerships between local entities to hosting events and conferences to promoting the area as a desirable spot for expanding foreign companies.

Nonprofit photonics advancement group Québec Photonic Network (QPN), of which Têtu also is president and CEO, serves as a networking and information hub, working to bring together companies, government departments and organizations involved in the area's optics-photonics industry.

Pôle and the QPN have a big job because there is so much going on with photonics in Québec.

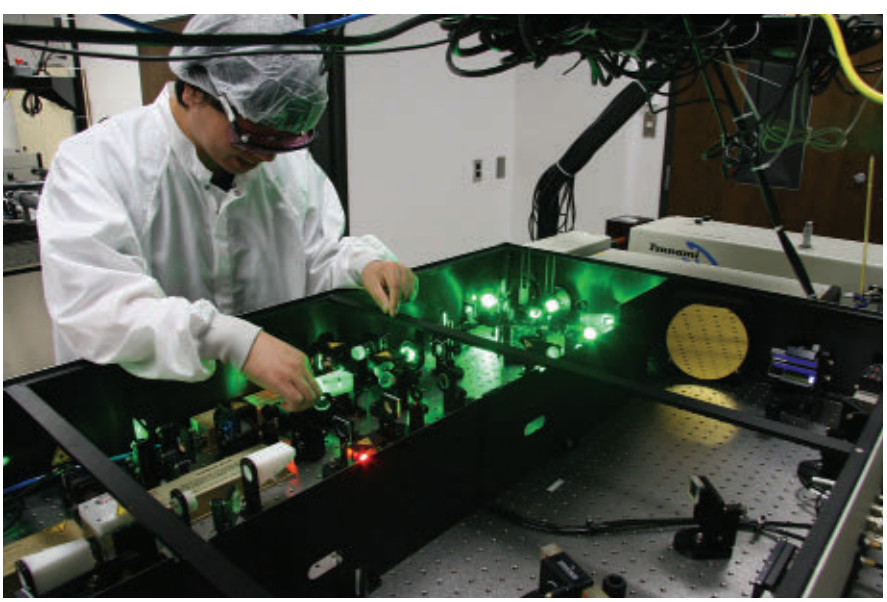
"We have a strong history in optics and photonics research activities dating back to the late forties, Têtu said. Research centers strive to innovate at the basic research and industrial levels; so do major companies such as test and measurement leader Exfo, health science and optoelectronics market powerhouse PerkinElmer, spectrometer maker ABB and laser beam testing equipment manufacturer Gentec-EO.

The Centre d'optique, photonique et laser (COPL) is Canada's largest university research center in optics/photonics. As a strategic cluster of optics/photonics researchers from a number of Québec province universities, COPL strives to perform both fundamental and applied research; to support industry; and to train the next generation of optics/photonics scientists. Other Québec research institutions with wide-ranging interests include the National Optics Institute, a design and development firm based in Québec City, and the Defence R&D Canada facility in Valcartier, Québec.

"The photonics industry in Québec province is mainly small and medium enterprises which are very diverse, covering many application domains," said Robert Corriveau, president and CEO of the Québec City-based Canadian Institute for Photonic Innovations (CIPI), part of the national Network of Centres of Excellence. CIPI fosters interaction among Canadian scientists from universities, government and industry through research and networking programs.

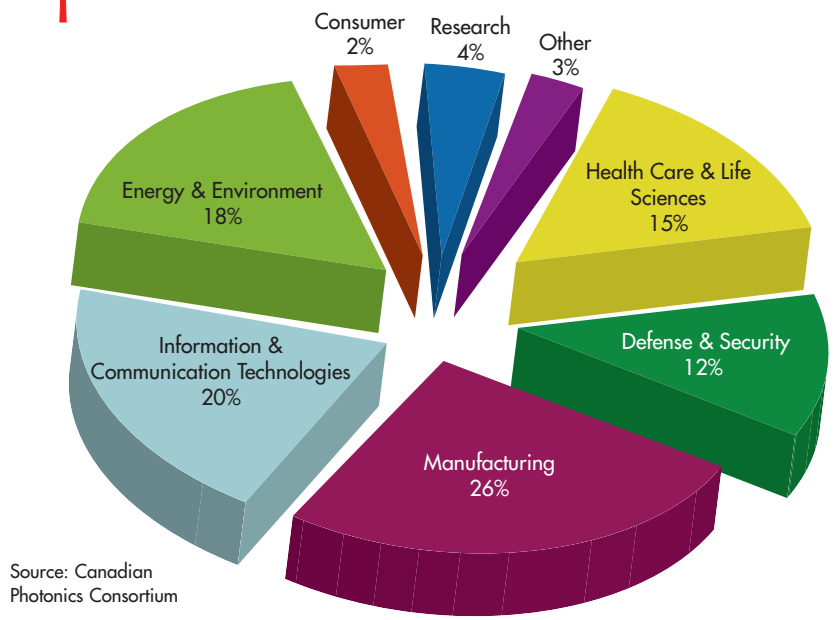
More than 100 companies in the province generate nearly 5000 jobs; in 2007, 1685 of those jobs fell into the research category. Sixty-nine percent of Québec photonics companies employ

The Pavilion of Optics and Photonics (POP), which opened in 2006 at Université Laval in Québec City, is the home of the Centre d'optique, photonique et laser and the administrative office of the Canadian Institute for Photonic Innovations. Courtesy of Pierre Bolduc.



POP is equipped with state-of-the-art laboratory systems and devices. Courtesy of Pierre Bolduc.

Québec City is a hot spot for photonics innovation in Canada.



Source: Canadian Photonics Consortium

fewer than 50 employees, according to a May 2007 report produced by the QPN; only 3 percent employ more than 300. But companies with more than 300 employees offer 27 percent of the jobs; companies that employ more than 100 and fewer than 300 workers make up 38 percent of the job market.

Corriveau said that, because Québec's photonics companies tend to be smaller, as opposed to mass-production companies, "they were less affected by the economic crisis."

Québec has a striking spirit of cooperation between researchers and businesses – even those competing for the same funding and the same customer base seem to have little difficulty pooling resources to develop photonic solutions.

"Québec City is spread over a relatively small area with a tightly knit society. So the members of the scientific and engineering community know each other or/and they have common contacts. The same can also be said for the commercial community and others," Têtu said. "That's probably why we can more easily partner on a collaborative effort. This being said, we also recognize that the market is international, and the competition is international. So we have to join efforts to face the challenge of being competitive at the international level."

Elsewhere in Canada

Other regions of Canada are a little less organized than Québec and Ontario in their efforts to take advantage of photonics, but that doesn't mean there aren't glimmers of activity.

The prairie provinces – Alberta, Saskatchewan and Manitoba – have 95 photonics companies, employing almost 3000 people among the three of them. In British Columbia, there are 50 companies, creating more than 2000 jobs.

And even the Atlantic provinces, which are made up of Nova Scotia, New Brunswick, Newfoundland and Prince Edward Island, have a total of eight companies that employ more than 300 people among them. Collectively, the prairies, the Atlantic provinces and British Columbia generate 796 million CAD, far less than the 3.6 billion CAD raked in by Ontario and Québec. There do not appear to be any photonics companies in the Northwest Territories, the Yukon Territory or Nunavut.

Several glimmers of photonics activity outside Ontario and Québec are occurring at institutions such as the University of Alberta in Edmonton and the National Research Council's National Institute of Nanotechnology, which also is in Edmonton and is affiliated with the university. There also are photonics groups and projects at other universities, including the University of Victoria in British Columbia, the University of British Columbia in Vancouver and the University of Calgary in Alberta. The University of Saskatchewan in Saskatoon is home to the Canadian Light Source, the national center for synchrotron research.

Because Ontario and Québec have done so well with the cluster model, the CPC has encouraged the other provinces to develop a focused plan and a dedicated cluster to support and promote photonics innovation.

Education

A number of Canadian universities have photonics groups or centers. Algonquin College in Ottawa offers diploma and bachelor's degree programs, while Laval students can earn a master's degree in biophotonics. McMaster University in Hamilton, Ontario, has a bachelor's degree in applied engineering in photonics, and the University of Waterloo in Ontario offers a certificate in education for photonics professionals. Brock College in St. Catharines, Ontario, even offers a graduate certificate in lasers.

Around the world, photonics as a field has been suffering from a general lack of trained engineers and technicians, and the CPC reports that this is the case in Canada as well. "Apart from the university education, there is not much exposure to photonics for students at the primary- and secondary-school levels," Têtu noted.

But organizations such as the Ontario Photonics Education and Training Association, which was founded by another OCE director of business development, Marc Nantel, and the QPN have adopted the cause of building up the number of Canadian photonics engineers and technicians and of attracting younger students to science and technology careers.

Outlook and goals

As big as photonics is in Canada, there is always room for growth.

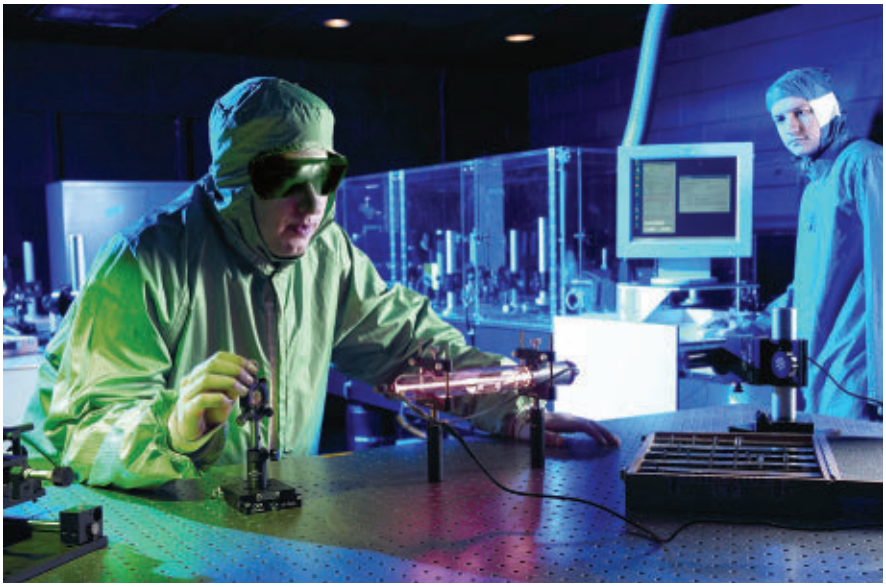
The CPC has outlined some strategies for general success: Photonics companies should be more proactive about reaching out to customers, to ensure the development of photonic solutions that will fit their needs. Clusters and national photonics organizations should establish information portals to facilitate knowledge exchange between companies and researchers. Canadian technology should be increasingly commercialized, perhaps via interagency programs using alternative financing and technology transfer methods, to ensure that technological developments are exploited to the maximum. R&D efforts, the group advised, should focus on areas of strategic importance to Canada.

laura.marshall@laurin.com

Photonics in Canada: By the Numbers

Province/Region	Companies	Employees	Revenues
Québec	104	4750	600M CAD
Ontario	117	10,200	3.0B CAD
Prairies	95	2990	330M CAD
British Columbia	50	2010	430M CAD
Atlantic	8	310	36M CAD
Totals	**374**	**20,260**	**4.4B CAD**

Source: "Making Light Work for Canada," Canadian Photonics Consortium



Niagara College's Welland campus in Ontario has a photonics lab with a cleanroom for laser research. Courtesy of Niagara College.

TeamPatent: A building block for developing a patent application

A new online patent application drafting program may provide inventors with an easy-to-use application developer that automates much of the process.

Professional patent filers and inventors can now set up their applications quickly in an application skeleton that organizes and associates claim terms, part numbers and drawings. The program, called TeamPatent, enhances productivity and quality by reducing errors, by reducing the cost of employing an attorney to assess the finished application and by eliminating the need for a draftsman to interpret the drawings.

Formulated in 2005 by Rocky Kahn, an experienced patent filer, the system was made available to the public in April. Kahn, who heads TeamPatent LLC, has written 23 patents, including a modern optical mouse for a handheld solid-state scanner. He believes that the program, which is funded by the National Science Foundation, is due for an easier and updated service provider that will help when applying for a patent.

"While filing patent applications using MSWord and a drawing program such as Visio or Canvas, I've found the process incredibly expensive, tedious and archaic," he said. To overcome these problems, he devised an economical, motivating word processor.

"TeamPatent has streamlined my work flow," said Barry Rabin, CEO of Sage Technology & Development LLC and a developer of four patents using the system. He said it has allowed him "to focus on the technical aspects of creating a new patent application rather than having to worry about the tedious tasks of formatting the document or worrying about whether claim terms have been properly supported."

Design scheme

There is no software to be downloaded because the program works entirely online. Clients can create a user name and a password-protected account that keeps all documents secure, and all communication on the server is encrypted. The Web address is www.teampatent.com.

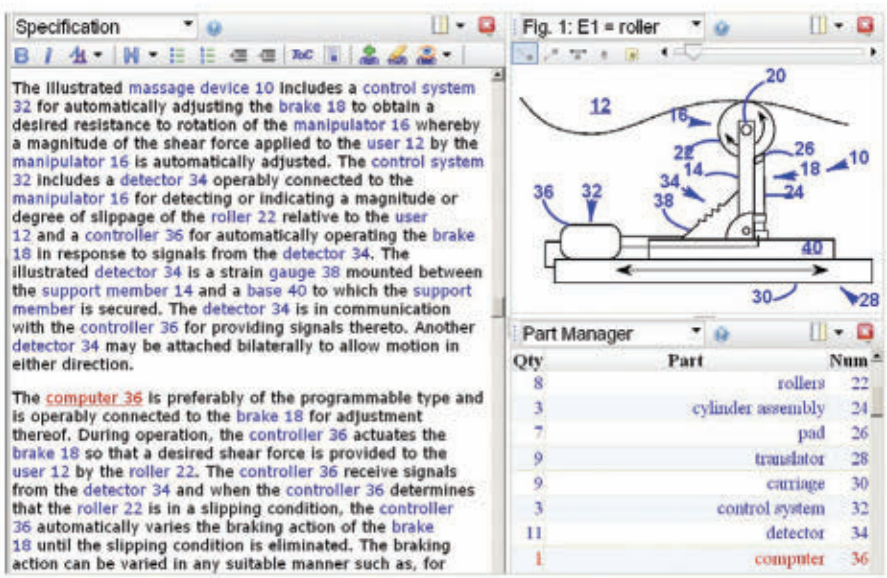
The first step of the process is to either integrate an existing application document into an application skeleton or to build one from scratch on the Web site. Inventors are prompted to include the title of the product, an abstract and summary, any federally sponsored research, prior art, claims, advantages of the product and descriptions of figures.

Images can be uploaded into the system, and a drawing editor enables users to place call-outs – numbered labels to identify specific components – for each individual part. By clicking on a call-out, users can move from a drawing to the part reference located in the text. A part-manager pane, which shows a complete list of all components, allows for easier detection of a component within the text and drawings.

After incorporating the text, the system automatically identifies part and figure references by marking them blue for valid, supported items, or red for invalid, inconsistent items. When a part reference is red, it may mean that two part names conflict – e.g., coil 15 and heater 15 – letting users know that they can rename or renumber one of the references. If both items are the same part – e.g., optical amplifier 15 and amplifier 15 – the user can change the name of one of the items to make them synonymous.

Other facets of the site include a claims outline for easier reading and editing, a figure manager for viewing all drawings and part references, and a preview menu that illustrates what the final application will look like. When the application is completed, inventors can export the file into MSWord or Adobe Acrobat as a pdf version.

Once an inventor has learned how to use it, it can really speed things up, according to Erin-Michael Gill, a former patent examiner and author of the IP man-



Visitors to TeamPatent LLC's Web site can examine their patent application before using the company's drafting program. Presented is a specifications pane (left), which comprises a detailed report of an uploaded drawing of the invention (in this example, a massager). A figure manager pane (top right) shows the actual drawing of the referred description, and a part manager (bottom right) lists each part called out in the drawing. Part references that are valid – having supported and consistent names – are automatically displayed in blue, while invalid terms are in red, notifying the user to rename or renumber the components.

agement blog e^(ip) at www.gillip.com. "But, it does take some time. You're not just going to walk into it and use it as a normal text editor."

Collaborators at work

Once an application has been developed, it's time for an attorney to review the text, which can be a long and expensive process. Being able to establish inconsistencies or errors and to precisely denote a relationship between a part and the location in which it appears in the claims beforehand enable faster evaluation and lower cost.

Gill said professional patent drafting can cost from $300 to $900 an hour. "The more time that [inventors] spend on tools like TeamPatent, fleshing out their invention, improving the description, carefully mapping it to the drawings and getting their application ready for a patent professional, overall the application should cost significantly less to prepare."

Inventors will have access to their files the entire time the application is being analyzed, enabling last-minute changes and simultaneous follow-up with collaborators in separate locations. "TeamPatent allows multiple inventors to participate more fully throughout the process," Gill said.

Upgrades

Kahn plans to extend TeamPatent's editor for third-party developers, including those who handle academic papers, electronic medical health records, user manuals and software wire frames.

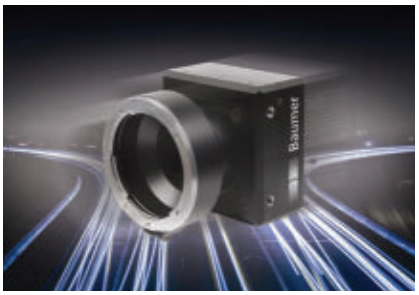
He hopes that TeamPatent will become a vital application processor for inventors around the world, with the US and foreign patent and trademark offices using the site to reduce the time needed to examine patent applications.

"At some point, it will be considered malpractice not to run a patent filing through a system like TeamPatent," he said.

Amanda D. Francoeur
amanda.francoeur@laurin.com

BRIGHT IDEAS

High-Speed Cameras



Cameras in the HX series introduced by Baumer Ltd. capture 1.3-megapixel images at rates of up to 500 fps and are suitable for use in ultrafast machine vision applications. The CMOS cameras produce 1280 × 1024-pixel resolution and can deliver up to 120,000 fps by restricting image data to one, two or three regions of interest within the full frame. They support the Camera Link standard and offer multiexposure capability and a data transfer rate of up to 680 MB/s. Available in monochrome and color versions and housed in a compact and lightweight aluminum housing, the cameras have a dynamic range of up to 90 dB.
Baumer
sales.us@baumergroup.com

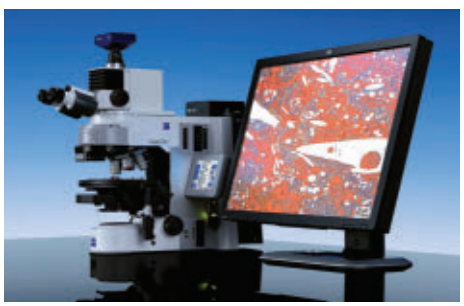
Nanopositioning Stage

The PK line of X-Y nanopositioning and nanoscanning stages unveiled by piezosystem jena Inc. offers 100 × 100-mm clearance, flatness, parallel kinematics and configurability. Measuring 15 mm high, the stages achieve subnanometer positioning accuracy. Actuation can be performed with any of the company's PX or nanoX elements, and the stroke range goes up to 700 µm. Built with a frame-in-frame support, the stage has an inner frame that is suspended in the outer one, resulting in dual guidance. The stages have two kinds of optionally integrated metrology, and the company offers a number of options for materials, including nonmagnetic.
piezosystem jena
sales@piezojena.com

Frame Grabber

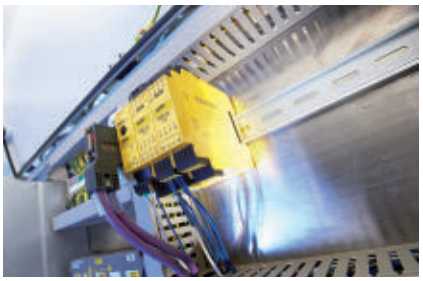
The Xcelera-CL LX1 Base frame grabber announced by Dalsa Corp. is for use with Camera Link Base cameras. The company says that the board is easy to set up and use, delivers reliable image acquisition and offers extensive software support. Designed for the PCI Express x1 interface, the frame grabber can acquire images from a variety of multitap area- and line-scan, color and monochrome cameras. Camera Link is supported up to 85 MHz, and the device is Power Over Camera Link-compliant. The included Sapera Essential software features 1-/2-D bar codes, optical character recognition, pattern finding, color and blob analysis, and lens correction tools.
Dalsa
sales.americas@dalsa.com

Microscope System



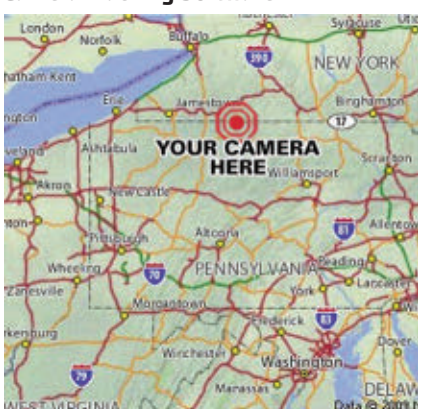
Carl Zeiss MicroImaging Inc. has launched the second generation of its Axio Imager microscope system for use in materials microscopy applications. The optical system provides information about the sample in bright- and dark-field, and in confocal and differential interference contrast techniques. The M2m and Z2m models have motorized focus and reflected-light beam paths, and the latter offers automatic component recognition. All models feature the ability to combine reflected and transmitted light, access to the luminous field and aperture diaphragms in the reflected-light beam path, exchangeability of the fine-drive knob and the fine-drive disk, and a redesigned transmitted-light beam path for homogeneous illumination, even at low objective magnifications.
Carl Zeiss MicroImaging
ksalerno@zeiss.com

Safety Controller



Sick Inc. has unveiled the FX3 Flexi Soft modular safety controller. Designed for adaptation to safety applications for small- to medium-size machines, the controller is expandable from 12 to 144 inputs/outputs. It is software-programmable and offers features to increase the response time of the machine as well as an enhanced functional interface. Hardware and software configuration for the system is done using a drag-and-drop feature.
Sick
info@sick.com

Camera Tracking Software



ThermaTrak, introduced by Flir Systems Inc., is a high-tech service for locating missing or stolen infrared cameras and thermal imagers. Developed with GadgetTrak Inc., it uses recovery software that pinpoints the geographic location of lost, stolen or missing cameras. The ThermaTrak software embedded in the camera tracks the Internet protocol address, the host name and the Internet service provider being used after the camera has been lost or stolen and then connected to the Internet. It also is used for asset management when multiple cameras are deployed in the field. When tracking is activated, each time a camera is connected to a computer with Internet access, an e-mail is sent to the owner with a link to an updated location report.
Flir Systems
sales@flir.com

Cooled Camera

The Alta U16M high-performance cooled camera system from Apogee Instruments Inc. has a 16-megapixel full-frame sensor with a 4096 × 4096 array size. The system offers microlensing and blooming gates, making it useful for applications in astrophotography, sky surveys, radiology, and optical and nondestructive testing. It has 32 MB of camera memory and a USB 2.0 interface, and it can be cooled to between 45 and 70 °C below ambient, depending on the housing selected. The dynamic range is 79 dB, and anti-blooming is >100×. ActiveX drivers are included with each system.
Apogee Instruments
sales@multipix.com

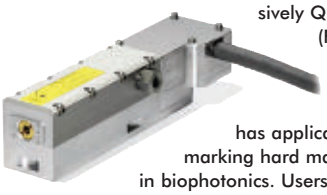
Laser Processing Machine

Jenoptik Laserdiode GmbH's Lasers & Material Processing Div. has released the Jenoptik-Votan Solas 1800, a laser system that drills within 1 s up to 100 tiny through holes into crystalline solar cells for back-side contacts via metal or emitter wrap-through technology. Available as a stand-alone system or as a module for integration into existing production environments, it has a disk laser that creates <10-µm holes without microcracks or debris. The laser beam is delivered by a scanner, with positioning accuracy of ±10 µm. Wafer sizes of 100, 125 and 156 mm can be accommodated, as can wafer thickness from 150 to 300 µm. Up to 1800 solar cells can be processed per hour.
Jenoptik Laserdiode
jold@jenoptik.com

Joulemeter Probes

Spectrum Detector Inc.'s two new models of the "delta" joulemeter probes are compatible with its delta-DPM USB-based digital power module. Model DPJ-25-OB features a black absorbing coating for flat spectral response across the spectrum, while model DPJ-25-DC has a fast, diffuse metallic coating and is capable of pulsed measurements at >40,000 pps. Both versions have an aperture diameter of 23 mm and a spectral range of 0.25 to 15 µm.
Spectrum Detector
info@spectrumdetector.com

PQS Lasers



The 1064-nm passively Q-switched (PQS) laser series from Teem Photonics SA has applications in marking hard materials and in biophotonics. Users have the option to vary the lasers' average output power. The SNP-400P provides 400 mW of average power, the SNP-30E delivers more than 30 µJ per pulse, and the SNP-7PW, 21 µJ per pulse and 350 mW.
Teem Photonics
sales@teemphotonics.com

b BRIGHT IDEAS

Temperature Control

ILX Lightwave Corp. has released the LDT-53500 series laser diode thermoelectric chillers. The two models available offer 185- and 370-W cooling capacities as well as temperature control over the range of −5 to 45 °C. The heat exchanger design and optimized PID control loop constants provide temperature stability of ±0.1 °C at the water outlet. The devices are equipped with multiple interlocks, a removable front panel, external temperature sensing and a USB interface.
ILX Lightwave
sales@ilxlightwave.com

Epoxy Compound

The 20-3001 NC noncrystallizing epoxy potting and encapsulating resin introduced by Epoxies Etc. is a low-viscosity system that forms a bubble-free glasslike finish when cured. Containing no solvents or fillers, it is available in black or clear and in 50-, 75-, 200- and 400-ml dual-barrel syringes, or in quarts, gallons and 5-gallon pails. Mix ratio by volume is 1:1 and by weight, 100:83. Operating temperature is from –50 to 150 °C, and tensile strength is 5700 psi.
Epoxies Etc.
sales@epoxies.com

Spectrophotometer

Majantys has unveiled the Probe4Light, a handheld spectrophotometer for spectral and color characterization of LEDs and other light sources. It comprises a miniaturized spectrometer-based sensor and all necessary electronics, and it connects to a PC through a USB port. The Windows software graphical user interface provides access to the spectrum and to color parameters such as color coordinates, dominant wavelength, correlated temperature and color rendering index. Spectral range is 360 to 830 nm, measurement time is adjustable from 1 ms to 1 s, and focal length is 20 mm.

Majantys
contact@majantys.com

Evaluation Kit

The 2D MEMS EVK (evaluation kit) released by Opus Microsystems Corp. is a flexible control board for the company's 2-D MEMS scanning mirror that lets users evaluate mirror performance by setting up scanning frequencies, duty ratios and phase difference of driving signals through an RS-232 graphical user interface. Maximum input current is <100 mA, maximum power consumption is <500 mW, operating temperature is

from 10 to 40 °C, output frequency is from 320 to 50,000 Hz, output duty ratio is 10% to 50%, and output duty ratio resolution is 1%. The kit measures 86 × 60 × 13.7 mm.
Opus Microsystems
sales@opusmicro.com.tw

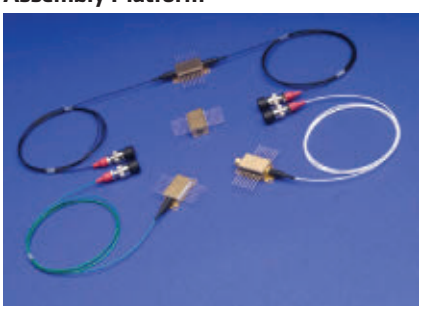
DC/DC Converters

Murata Power Solutions has expanded its Okami family of nonisolated point-of-load DC/DC converters with four 10-A and four 16-A output current surface-mount modules. The OKY-T/10 and -T/16 modules are available with either positive or negative on/off logic control, as are the OKY2-T/10 and -T/16 devices, which also feature a sequence/tracking function whereby the output voltage will track an input signal to enable power sequencing. Input voltage ranges from 8.3 to 14 VDC, and output voltage is programmable from 0.75 to 5.5 VDC. The converters are fully compatible with distributed-power Open Standards Alliance specifications.
Murata Power Solutions
sales@murata-ps.com

Fiber Inspection

A system for inspection of fibers between 100 and 1000 µm in diameter has been released by Arden Photonics Ltd. The VF-20 Trio has three user-selectable settings with 150-, 500- and 1000-µm-diameter fields of view and operates in "inspect" and "interferometric" modes, eliminating the need for separate inspection equipment for checking end-face quality and flatness. Analog and digital outputs enable use with a video monitor or computer, and the system also is suitable for use with Vytran and other splicer holders.
Arden Photonics
sales@ardenphotonics.com

Assembly Platform



Optocap Ltd. has announced its turnkey packaging platform for fiber coupling of optoelectronic devices. Available are 14-pin butterfly

packages and TO-cans, and polarization-maintaining, single- and multimode, polycrystalline and high-temperature fibers. A high-quality antireflection coating with a variety of lens designs maximizes coupling efficiency. The platform provides solutions for devices including distributed feedback and distributed Bragg reflector lasers, semiconductor optical amplifiers, superluminescent diodes, vertical-cavity surface-emitting lasers, photodiodes and quantum cascade lasers.

Optocap
info@optocap.com

XGA LVS Display

The CyberDisplay XGA LVS display manufactured by Kopin Corp. and driven by the proprietary A251 driver application-specific integrated circuit produces full-color 1024 × 768-pixel resolution and has 3.75 × 11.25-µm color dots. It is suitable for use in emerging high-end applications such as virtual reality and 3-D high-definition gaming. The images shown in the 0.57-in.-diagonal display can be magnified by optics to provide large cinemalike pictures.

Kopin
cyberdisplay@kopin.com

Video Decoding

The VDA-1164 video decoding accelerator manufactured by Matrox Graphics Inc. is designed for use in workstations running Video Management System software, and it supports simultaneous decoding of multiple video streams at multiple resolutions from a variety of cameras and codecs. It comprises an information processing video decoder board and a full high-definition (HD) quad-output board. The former offloads video decoding from the host CPU, enabling it to focus on access control, system configuration and situation management. The output board displays multiple individual streams in native resolution at full frame rates on up to four HD displays.

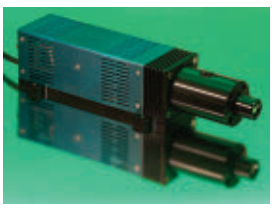
Matrox Graphics
graphics@matrox.com

Beam-Steering Scanner

Along with a KTN scanner chip, NTT Advanced Technologies has introduced a KTN (potassium tantalite niobate) module that is a fully adjustable multidirectional beam-steering scanner. The 2 × 3 × 6-cm scanner contains no moving parts because the deflection stems from electron redistribution induced by applying an external voltage, resulting in operating speeds of up to 1 MHz. Wavelength range is from 532 to 4000 nm, beam diameter is <1 mm, and deflection angle is 10° ±5°. Applications include laser processing, 3-D measurement, optical communications and recording, displays, imaging, sensing, printing and copying.

NTT Advanced Technologies
ktn@ntt-at.co.jp

Green Laser



The Lasiris Green Power-Line 532-nm laser manufactured by StockerYale Inc. has a thermoelectric system and fan that maintain a constant laser diode temperature to improve wavelength, power and pointing stabilities. Available with 50, 100, 150 and 200 mW of output power, it is suitable for use in hot steel and glass inspection, positioning, and research and development. The TEM_{00} beam has a Gaussian profile and typical M^2 of 1.6. Polarization ratio is 4:1, bore sighting is <3 mrad, and operating temperature is from –20 to 45 °C.

StockerYale
lasers@stockeryale.com

Metrology Systems

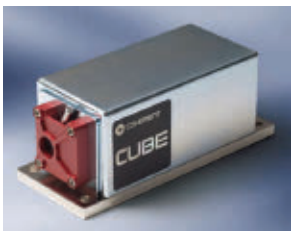
Lehighton Electronics Inc. has enhanced its 1800 series devices for characterizing solar cells, flat panel displays, wafers up to 450 mm in diameter and coated glass panels. The systems are suitable for in-line integration into the manufacturing of solar products, semiconductors, architectural and automotive glass, microwave food susceptors and plastic substrate products. Sensor heads are used for in-line monitoring, and automated conveyor models monitor the uniformity of indium tin oxide, transparent conductive oxide, thin films and other coatings on nonconductive substrates. Optional statistical process control software provides a warning when uniformity or sheet-resistance measurements are out of the desired range.
Lehighton Electronics
salesinfo@lehighton.com

Fiber Lasers

Rofin-Baasel UK Ltd. has announced the FL series high-power fiber lasers. The FL x75 and FL 010 output 750 and 1000 W, respectively. The beam can be coupled with 50- to 600-µm-diameter fiber optics, resulting in beam quality of 2.5 to 30 mm × mrad. The lasers can be used to weld small parts with low thermal distortion

and minimal heat-affected zones, and steel and aluminum can be joined with welding depths of several millimeters. The optional beam switch and energy-share modules enable a single laser to be used in up to four work cells.
Rofin-Baasel
sales@rofin-baasel.co.uk

Diode Laser



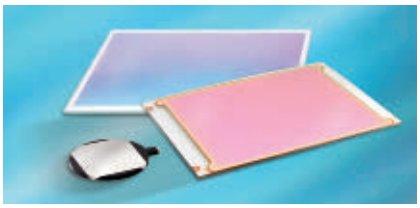
Coherent Inc. has introduced a high-power 640-nm red diode laser module for use in flow cytometry and drug discovery. The single-emitter-based turnkey Cube 640-100 produces 100 mW of continuous-wave output in a 1-mm-diameter beam with M^2 <1.5. The company says that the laser delivers a higher scan rate and a better signal-to-noise ratio than HeNe models. Maximum output wavelength is 644 nm, ensuring high transmission through the laser emission bandpass filters used in cytometry instruments and good blocking by commonly used detector filters. USB, RS-232 and analog interfaces facilitate system integration.
Coherent
tech.sales@coherent.com

Mirror Switch

The QuickSwitch 6288 is a microelectromechanical systems-based fiber optic mirror A/B switch designed by Electro Standards Laboratories. The device enables users to access two separate devices on ports A and B via connection through the common port by manual front-panel push button or over RS-232 serial data remote control of the switch. If power is lost, the 1300-nm switch will default to the A position and continue to transmit data. It supports a gigabyte data rate and is transparent to data format and speed. All fiber optic ports are duplex multimode ST with a fiber size of 62.5/125 µm. LEDs display the switch position and power status.
Electro Standards Laboratories
eslab@electrostandards.com

Optical Coatings

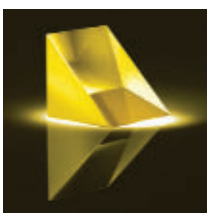
New optical thin-film coatings from Deposition Sciences Inc. can be deposited on materials in-



cluding Ultem, Zeonex and a variety of polycarbonate plastics. They operate from the visible through the infrared and are suitable for use in LED lighting, medical devices, unmanned aerial vehicle optics and photovoltaic solar systems. The coatings include bandpass filters, dichroics, high reflectors and various metals. Proprietary MicroDyn sputtering deposition technology yields high-performance multilayer thin-film coatings for optics, microelectromechanical systems and other thin-film nanotechnologies.
Deposition Sciences
solutions@depsci.com

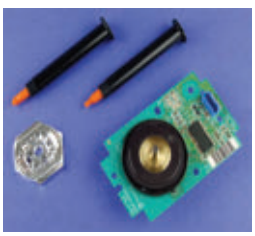
IR Right-Angle Prisms

Edmund Optics Inc.'s infrared right-angle prisms are used to achieve a 90° light path bend. They are available in three substrates. Calcium fluoride provides good transmission



from 190 nm to 7 µm and is suitable for applications throughout the ultraviolet, visible and infrared regions. Germanium's high index of refraction suits applications in the 3- to 12-µm region, and zinc selenide features high transmission from 1 to 16 µm. The uncoated prisms are suitable for use with well-collimated light sources. The calcium fluoride prisms are available in 12.7-, 25.4- and 38.1-mm sizes. The germanium and zinc selenide ones are supplied in 12.7 and 25.4 mm.
Edmund Optics
medmund@edmundoptics.com

UV-Curable Epoxy



Master Bond Inc.'s UV22 nanosilica-reinforced UV-curable epoxy system cures rapidly upon exposure to UV light at room temperatures. The <50-nm filler provides high abrasion resistance and optical clarity, low shrinkage, good physical strength and viscosity of 4000 cycles per second. The tensile strength of the cured epoxy is >4600 lb/sq in. (psi), and its tensile modulus is >500,000 psi. The single-component system requires no mixing, has a low coefficient of thermal expansion and is a good electrical insulator. Post curing at 90 to 125 °C for 30 min yields a glass transition temperature of >120 °C.
Master Bond
technical@masterbond.com

Micropositioning System

The Hexapod from Newport Corp. is a six-axis micropositioning system driven by six actuators that accommodate the requirements of parallel kinematic systems. The antifriction-coated spherical joint design provides high rigidity and load capacity. The XPS electronic controller masters the synchronized transformations from Cartesian input coordinates to the motion of the Hexapod kinematic members. It features instrument-grade input/output, hardware-based input triggers, event triggers, high-speed on-the-fly data acquisition and fast transmission control protocol/Internet protocol communication. It has a freely definable virtual pivot point that offers flexibility in relocating the pivot point and the entire coordinate system through advanced motion algorithms.
Newport
beda.espinoza@newport.com

HAPPENINGS

PAPERS

ODF'10 (April 19-21) Yokohama, Japan
Deadline: abstracts, October 20
Papers are encouraged for the Seventh International Conference on Optics-photonics Design & Fabrication, which is collocated with Lens Expo 2010. Organizers of ODF'10 will accept a limited number of original papers for presentation. Subject areas to be considered include simulation, photonic crystals, near-field optics, thin films, biomedical optics, and optical components and systems. Contact Tsuyoshi Hayashi, Proactive Inc., +81 78 332 2505; odf10@odf.jp; www.odf.jp

SPIE Photonics Europe (April 12-16) Brussels, Belgium
Deadline: abstracts, November 9
Organizers of SPIE Photonics Europe invite researchers to contribute their recent findings in areas including sensors, nanometrology, metamaterials, microelectromechanical systems, silicon and organic photonics, and semiconductor and solid-state laser technology in applications such as automotives, biophotonics and image processing. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; www.spie.org.

Speckle 2010 (September 6-9) Rosario, Argentina
Deadline: abstracts, November 15
Both novice and senior researchers involved in speckle and its applications are invited to present their current work at this international conference. Recent theories, techniques and data analysis approaches as well as the various applications of the speckle effect in areas such as optical testing, materials science and experimental mechanics are among the areas to be considered. Contact Guillermo Kaufmann, Instituto de Fisica de Rosario, speckle2010@ifir-conicet.gov.ar; www.speckle2010.com.ar.

OCTOBER

OFS-20: 20th International Conference on Optical Fiber Sensors 2009 (Oct. 5-9) Edinburgh, UK. Contact Jenny Bremner, OFS-20 Secretariat, Institute of Physics, +44 20 7470 4908; ofs20@iop.org; www.ofs20.org.

OPTO 2009 (Oct. 6-8) Paris. Contact Nadège Venet, GL Events, +33 1 44 31 82 57; nadege.venet@gl-events.com; www.forum4s.com.

SEMICON Europa 2009 (Oct. 6-8) Dresden, Germany. Contact Kelli Torres, SEMI Global Headquarters, +1 (408) 943-6979; ktorres@semi.org; www.semiconeuropa.org.

11th Asian Symposium on Information Display (Oct. 7-10) Guangzhou, China. Contact ASID '09 Secretariat, c/o Biyun Chen, +86 20 8411 0916; asid09@mail.sysu.edu.cn; www.asid09.org.cn.

Frontiers in Optics 2009/Laser Science XXV (Oct. 11-15) San Jose, Calif. Collocated with the Fall OSA Optics & Photonics Congress, which includes the meetings Advances in Optical Materials (AIOM); Adaptive Optics: Methods, Analysis and Applications (AO); Computational Optical Sensing and Imaging (COSI); Femtosecond Laser Microfabrication (LM); and Signal Recovery and Synthesis (SRS). Contact The Optical Society, +1 (202) 416-1907; custserv@osa.org; www.frontiersinoptics.com.

Image Sensors 2009 (Oct. 12-14) San Diego. Contact Derek Mitchell, IntertechPira, +1 (207) 781-9615; derek.mitchell@pira-international.com; www.intertechpira.com.

High Power Diode Laser & Systems Meeting (Oct. 14) Coventry, UK. Contact Barbara Neat, Enlighten Meetings Administration, +44 1372

HAPPENINGS

750 555; info@enlightenmeetings.com; www.xmarkmedia.com.

Photonex 2009 (Oct. 14-15) Coventry, UK. Contact Laurence Devereux, Xmark Media Ltd., +44 1372 750 555; ld@photonex.org; www.photonex.org.

Third Boston Workshop on Advanced TCSPC Techniques (Oct. 15-16) Boston. Contact Becker & Hickl GmbH, +49 30 787 56 32; info@becker-hickl.com.

Neuroscience 2009 (Oct. 17-21) Chicago. Contact Society for Neuroscience, +1 (202) 962-4000; info@sfn.org; www.sfn.org.

LEDs 2009 (Oct. 20-22) San Diego. Contact Brian Santos, IntertechPira, +1 (207) 781-9618; brian.santos@pira-international.com.

MOC '09: 15th Microoptics Conference (Oct. 25-28) Tokyo. Contact Registration Desk, Event & Convention House Inc., +81 3 3831 2601; regdesk@moc2009.com; www.moc2009.com.

PECS '09: Ninth International Symposium on Photon Echo and Coherent Spectroscopy (Oct. 26-31) Kazan, Russia. Contact Vitaly V. Samartsev, samartsev@kfti.knc.ru; www.osa.org.

Automotive Testing Expo 2009 North America (Oct. 27-29) Novi, Mich. Contact Renata Lengui, UKIP Media & Events Ltd., +44 1306 743 744; www.testing-expo.com.

Second International Workshop on Theoretical and Computational Nano-Photonics (TaCoNa-Photonics) (Oct. 28-30) Bad Honnef, Germany. Contact Dmitry N. Chigrin, Bergische Universität Wuppertal, +49 202 439 1452; chigrin@uni-wuppertal.de; www.tacona-photonics.org.

International Conference on Optics & Photonics (ICOP-2009) (Oct. 30-Nov. 1) Chandigarh, India. Contact N.S. Mehla, +91 172 265 9951; icop2009@gmail.com; www.csio.res.in.

Sixth International Symposium on Multispectral Image Processing & Pattern Recognition (Oct. 30-Nov. 1) Yichang, China. Contact Fa-xiong Zhang, +86 27 8754 0131; mippr09@gmail.com; www.mippr.cn.

NOVEMBER

Introduction to Illumination Design Using LightTools Course (Nov. 2-4) Pasadena, Calif. Contact Optical Research Associates, +1 (626) 795-9101; service@opticalres.com; www.opticalres.com.

ICALEO 2009 (Nov. 2-5) Orlando, Fla. 28th International Congress on Applications of Lasers & Electro-Optics. Contact Laser Institute of America, +1 (800) 345-2737; www.laserinstitute.org.

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An Artist's Secrets?
Projection and Photoluminescence

More than 200 years before the camera was invented, Italian Renaissance artist Caravaggio (1571-1610) employed photographic techniques to develop his renowned light and shadow paintings, according to Roberta Lapucci, a teacher and researcher at Studio Art Centers International (SACI) in Florence, Italy.

There is evidence to suggest that the 16th-century artist and his contemporaries to some extent experimented with optics – including lenses, the concave mirror and the camera obscura – as aids in their creative process, Lapucci said. Caravaggio, for example, is known to have worked in a darkened room and to have illuminated his models through a hole in the ceiling, and he did not use preliminary drawings, she added.

Lapucci's recent research, which she presented at the Brera Museum in Milan in February 2009 and at the Collegio Ghislieri in Pavia in January 2009, both in Italy, provides evidence that Caravaggio may have projected images onto a canvas and used photosensitive materials to fix their outlines. The process may have helped him to better portray the relationships between the models in a dramatic scene.

By the use of photosensitive materials such as mercury salts, a permanent image could be produced within the darkened studio, which functioned as a camera obscura, Lapucci said. "After the projection of the image, a luminous monochromatic simulacrum could remain visible on the canvas, similar to a black-and-white photograph, for about 40 minutes to two hours – only in darkness; a light exposure could have made it vanish," she explained. "During this time, within the darkened room, the painter could have fixed, with a luminescent white paint, a monochrome (brown priming and white paint) sketch of the projected figures."

"To trace the main shapes of the highlights in his composition, Caravaggio used a lead white sketch, which seems to confirm his attempts to block a snapshot composition on the canvas before it vanished, or to assemble more figures together in a sort of patchwork," Lapucci said, adding, "To fix the poses of his models, he always traced some scoring."

Lapucci said that there is a "Venetian white" paint that was available in the 17th century that was made of 50 percent lead white and 50 percent barium sulfate. "Its use by the Venetian artists and by Caravaggio could be connected to the camera obscura and should be viewed in this new perspective: as a fluorescent material which allowed the artist to paint in the dark within the camera obscura," Lapucci said.

Light-sensitive and photoluminescent substances were mentioned in the field of natural science by Giovan Battista Della Porta, a 16th-century Italian scholar, scientist and playwright, according to Lapucci.

These photoluminescent substances could be magnesium, silver, mercury or arsenic, in combination with chlorine, sulfur and iodide. She added that salts of these substances could be vaporized, nebulized or mixed to the priming components (usually based on gypsum, animal glue, oil or pigment). She said that nondestructive tests have been used to try to identify these substances in the artwork but that these tests are limited: X-ray fluorescence, for example, identifies only heavy metals and cannot recognize iodide, arsenic or sulfur.

"X-ray fluorescence did not find magnesium in Caravaggio's artwork, and only a small amount of silver, but it did detect mercury everywhere," Lapucci said.

Lapucci said that, consequently, it can be supposed that mercury is located in the priming layer. However, to position mercury with certainty, cross sections (requiring destructive testing) or a new kind of analysis would be needed – a sort of x-ray fluorescence that scans for the presence of the element micron by micron to understand where the mercury is located and, consequently, whether the artist exposed the primed canvas to mercury vapors (such as mercury iodide), or mixed the materials with the priming components, or applied these materials over the priming as jelly emulsions.

Caren B. Les
caren.les@laurin.com

Shown is an x-ray image of Caravaggio's painting *The Beheading of St. John the Baptist* and cross-section analyses taken from the artwork.

Background: Art historian Roberta Lapucci noted that there is a higher than average number of left-handed models in works painted by Caravaggio during an early stage of his career. This observation suggests that he may have been unable to reverse the projected image from left to right with the system he used at the time, she said. The photo represents Caravaggio's painting of St. Catherine.

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THE PHOTONICS SPECTRUM REFERENCE WALL CHART

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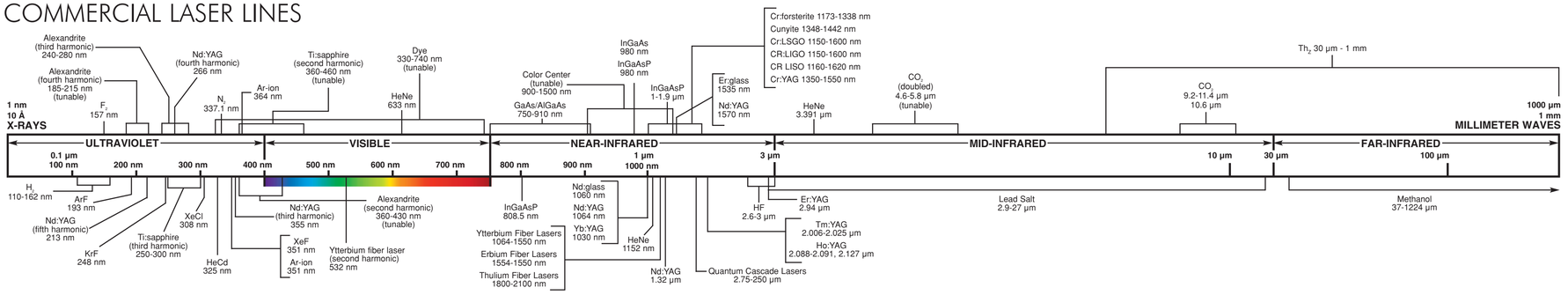
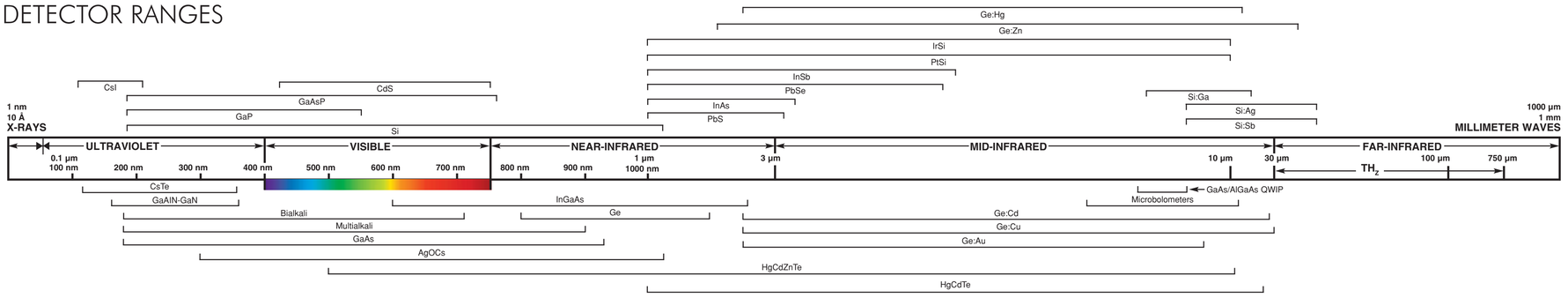
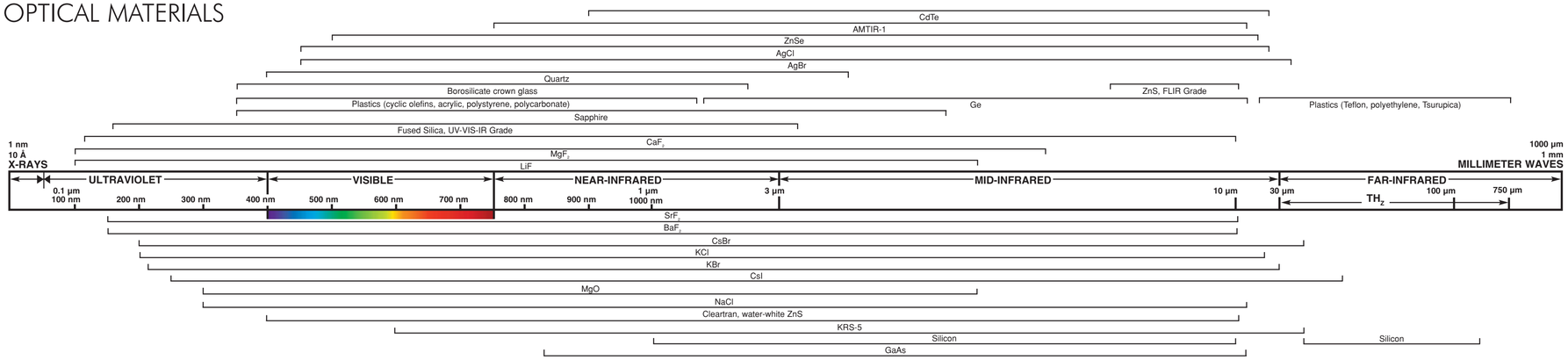


DETECTOR RANGES



OPTICAL MATERIALS



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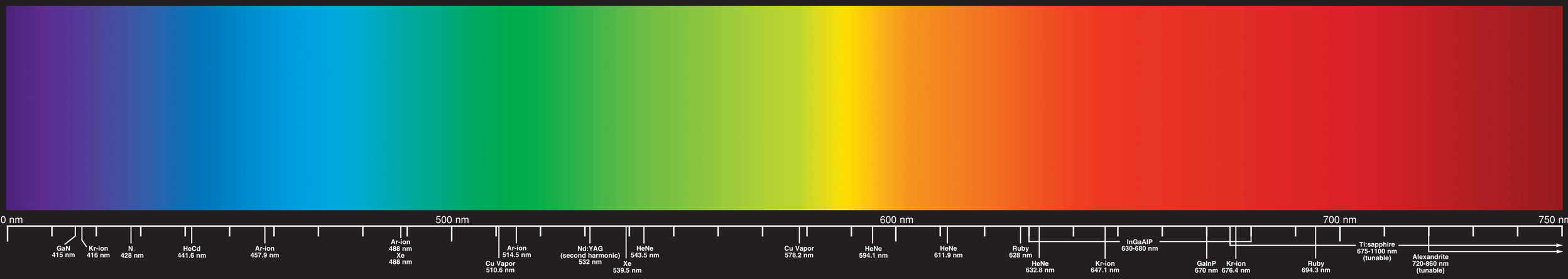

The photonic spectrum wall chart displays the major commercial laser lines, detectors and optical materials in the ultraviolet to the far-infrared and beyond. Space limitations make it impossible to include all available lasing media, and, particularly in the crowded areas of the visible spectrum and the near-infrared, we were forced to limit their multiple secondary lines to the more familiar. In drawing the full spectrum band, legibility received a higher priority than accurate scale or proportion.

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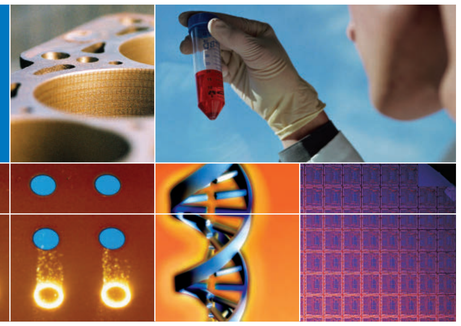

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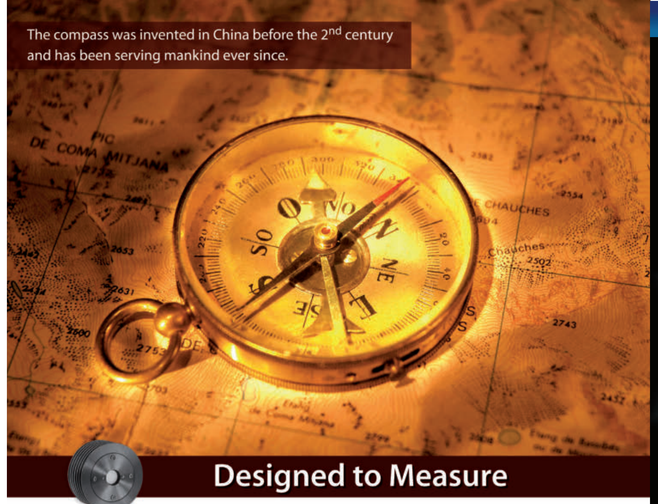

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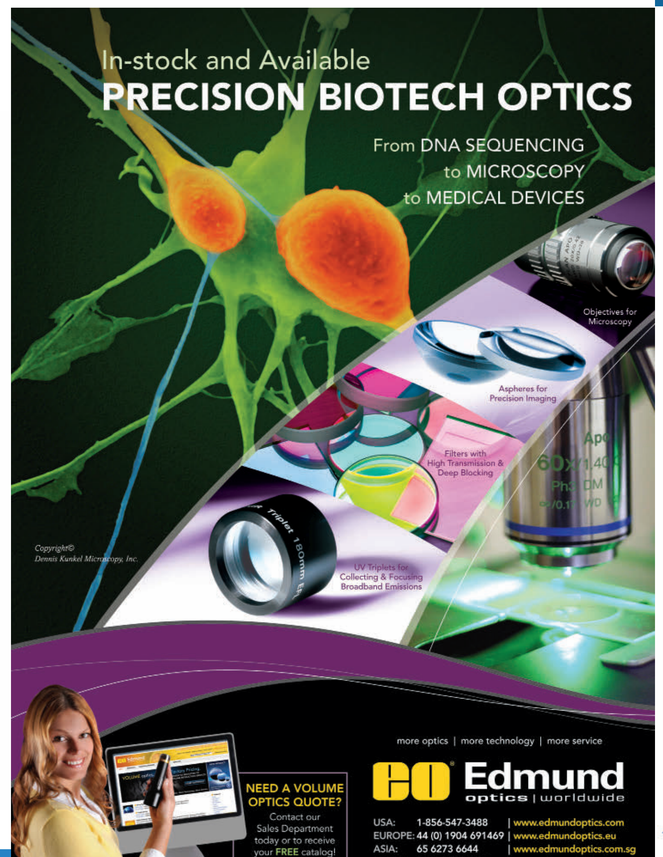

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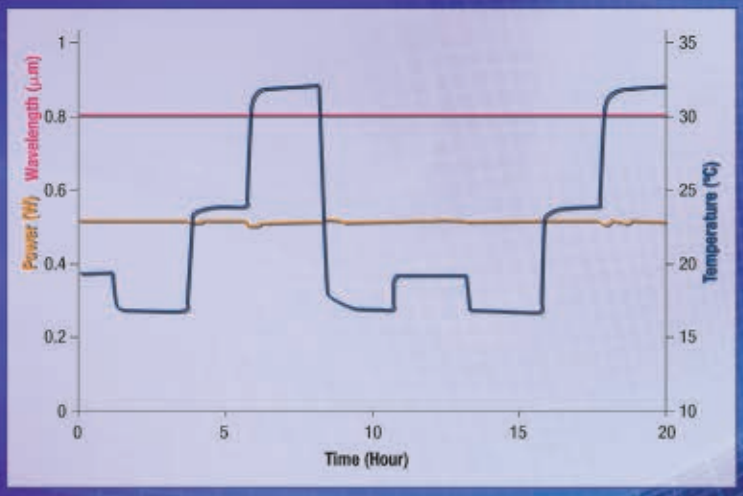

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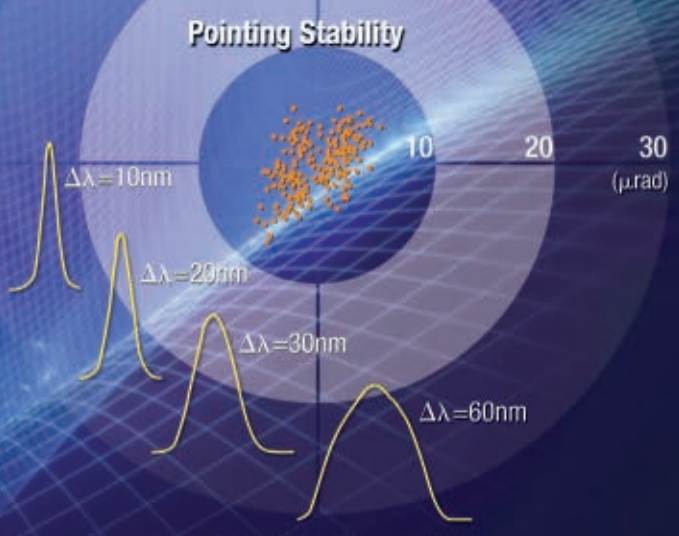

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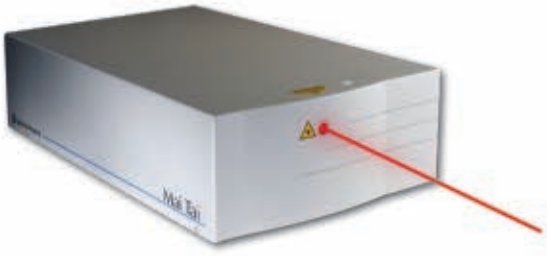

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