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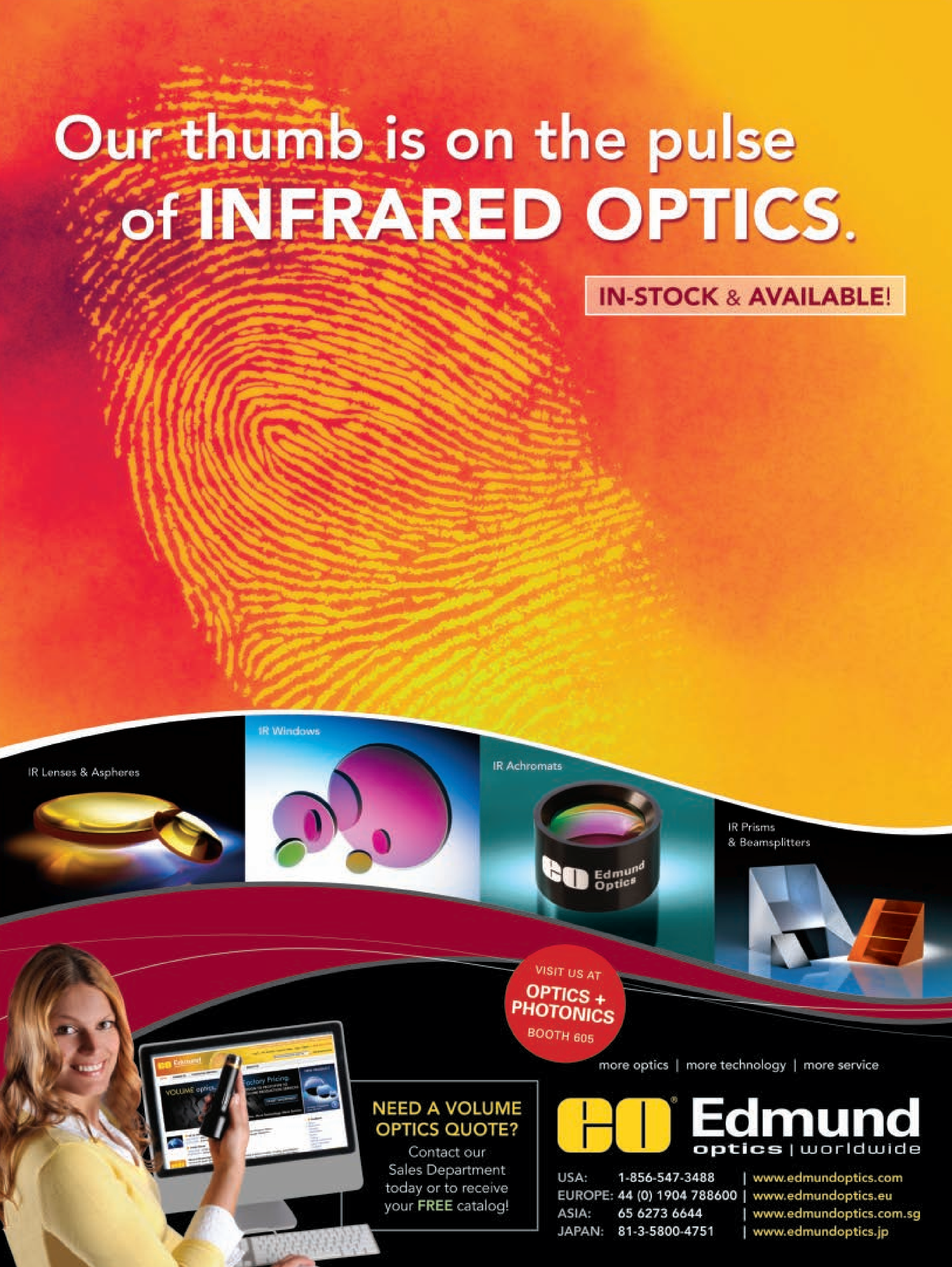
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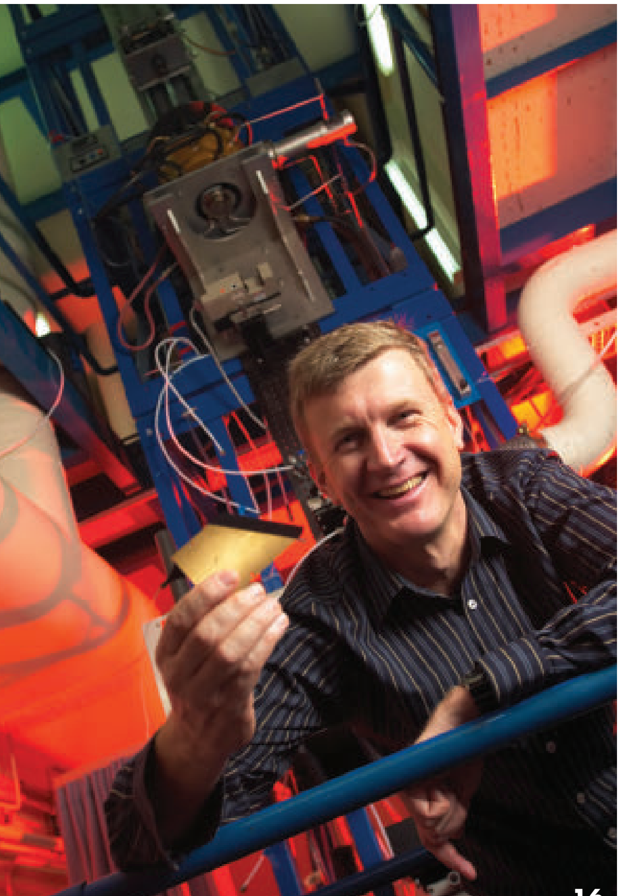

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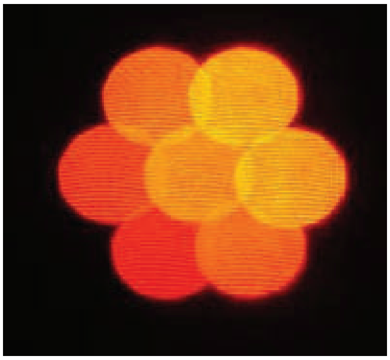

DEPARTMENTS

THE COVER
The strength and flexibility of Gorilla glass from Corning Inc. are demonstrated. (Photo courtesy of Corning.) See related article on displays beginning on page 28. The cover was designed by Art Director Lisa N. Comstock.

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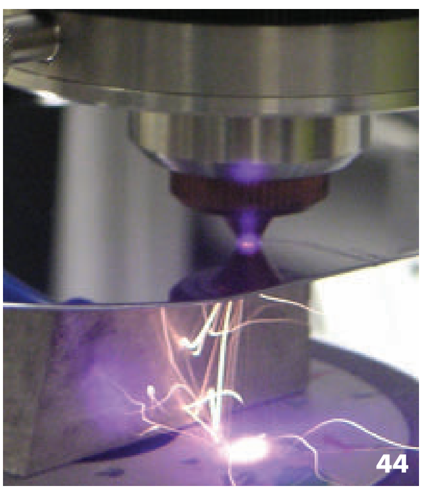
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LASERS AT 50

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Laser history goes on and on

This issue of *Photonics Spectra* may be the final installment of our three-month special feature article celebration of the laser's 50th anniversary, but the party isn't over.

This month's laser features include an article by Spectra-Physics about the development of the Ti:sapphire laser and its applications; a walk through the history of the Laser Institute of America (LIA); editor Hank Hogan's examination of fiber lasers for industrial uses; and Trumpf's predictions for what the next 50 years will bring. And "Creating Art with Light," a Web exclusive on Photonics.com, explores the ways in which lasers have contributed to the arts, from laser animation to audience scanning, from holographic sculptures to works of art that use laser beams to create patterns.

You can relive high points from the laser's history anytime you like at www.lasertimeline.com, an interactive timeline that allows you to scroll through the years and click on milestones for more details.

And we have launched a new reference, too: www.laserlookup.com, where you can easily find a wide array of laser types, applications and manufacturers. We are excited about this and hope you are, too. We would love your feedback on these two new initiatives. Please contact our senior Web editor, Melinda Rose, at melinda.rose@photonics.com.

But we at Photonics Media aren't the only ones still celebrating.

LIA announced last month that it will present its first Lifetime Achievement Award to laser pioneer Dr. Charles Townes, 94, who won the 1964 Nobel Prize in physics "for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle." The award will be presented during the 29th International Congress on Applications of Lasers and Electro-Optics at the end of September in Anaheim, Calif.

An exhibit called LaserLab, developed by Trumpf Inc. and mechanical engineering students from the Stuttgart University of Cooperative Education in Germany, offers visitors to the Connecticut Science Center in Hartford a chance to get hands-on with lasers. In the process, of course, they can learn all about what lasers do, how they do it and how they touch our lives every day.

And LaserFest is still in full swing, with events and exhibits around the country at trade shows, conferences and science festivals through the end of the year. Late this month, Spectra the Original Laser Superhero will make her Comic-Con debut in San Diego. The comic book series was developed by the American Physical Society to teach kids about lasers.

But we don't only celebrate the laser's history with special events – we celebrate it by using the technology every day, and by working continually to explore and expand its potential.


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Solar array size important

In Anne L. Fischer's interesting article titled "Solar-heated bridges, roads" (February 2010, p. 38), she did not comment on the size of the solar array that would be needed. Because the roadway itself is a solar collector, and that area is not enough, the area of the collector would have to be larger than that of the roadway.

She also did not mention the number of batteries needed. During a snowstorm, there is not much sunlight, so energy would have to have been saved from several days before.

Edwin Norbeck
Department of Physics and Astronomy
University of Iowa

Battle of the bulbs

I enjoyed reading about the analysis of various light devices conducted by University of Pittsburgh researchers in the May issue ("LED streetlights shine in cradle-to-grave study," p. 40). However, the investigators should have included incandescent bulbs in their comparison. Did they assume that incandescent bulbs are being mostly outlawed and are not politically correct? You included the rarely discussed environmental issues for manufacturing LED lights. LEDs are touted as the big solution, just as compact fluorescent lightbulbs (CFLs) were not so long ago. LEDs are not yet ready for widespread lighting, but are getting there.

There should be more discussion about the manufacturing process and disposal of all of these lighting products. My experience with CFLs and tubular fluorescent bulbs is that they do not last nearly as long as claimed, can require time-consuming and costly ballast replacement, and are difficult to properly discard. What is the cost in time, transportation, energy and emissions to get rid of one CFL or a pair of 40-W fluorescent tubes? Few facilities will accept them. The local garbage company won't pick them up.

The incandescent bulb (e.g., 60 W), although not the most efficient operational choice, is cheap, easily manufactured, uses simple and mostly recyclable material (glass and aluminum), is not hazardous or toxic, and will not generate radio-frequency emissions. The total cost and effects of ownership should be considered.

It is sad that the federal government does not allow people to make free choices in a free market. I am glad to see the city of Pittsburgh making a scientific

study rather than spending a large amount of money irrationally.

Oddly, carbon dioxide is treated as a harmful material, when it actually is the basis of life on Earth. Many people make that wrongful assumption and get on the bandwagon. This false idea will cost us huge amounts of money while some people gain huge amounts of money, for an infinitesimal change in the atmosphere. I believe that carbon dioxide is not a pollutant, but that its changing level in the atmosphere is a result of natural events.

Too many people blindly accept theories from a small number of researchers who use suspicious methods. Science should be used in an honest way, not as a selective tool to support selfish political agendas.

Dan Bosque
San Bruno, Calif.

Erratum

A "Bright Ideas" product listing on page 80 of the May issue featuring the Genesis CX355-250 from Coherent Inc. should have read as follows:

The Genesis CX355-250 from Coherent Inc., a solid-state CW ultraviolet laser, delivers more than 250 mW of output power. Its TEM_{00} output beam has an M^2 value of <1.2, enabling optimum collimation and/or refocusing to a diffraction-limited spot, and its optically pumped semiconductor technology provides <0.5% noise, enabling OEM instruments to achieve good signal-to-noise characteristics. Applications include flow cytometry of live cells such as eggs, fertilized egg sorting, fluorescence-based confocal microscopy and 3-D prototyping such as stereolithography.

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Photonics Media's industry-leading site showcases specific areas of interest, such as optics, imaging, displays and lasers.

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WEB EXCLUSIVE:
Life Without Lasers?

If you were offered $1000 to go an entire day without interacting with lasers or using anything built with the help of lasers, do you think you could do it? Doesn't sound too hard, but think again – if you lead a normal life, you inevitably come into contact with products that were created with or contain a laser. In a special Web Exclusive, Mark Bronski of Trumpf Inc. takes you on a journey through a typical day, where lasers greet you at every corner.

For more, visit: www.photonics.com/webexclusives

50th ANNIVERSARY OF THE LASER

Explore our interactive timeline of the history of the laser. See how laser pioneers have transformed our world over the past 50 years. From the invention of the maser to the first demonstration of the quantum dot laser, take a walk through decades of historic moments that shaped the world of photonics and optics.

To view the interactive timeline, visit: www.lasertimeline.com

In the August issue of Photonics Spectra …

Seeing Faces
An exploration of recent advances in optical image capture and processing technology for facial recognition applications in security and other areas.

Optical Lithography
For semiconductors, smaller is better. But getting there is increasingly difficult. Is optical lithography up to the task of turning out the chips of tomorrow – or the day after?

Lidar for Relief Work and More
Crucial lidar-based mapping of Port-au-Prince and the surrounding area in Haiti are providing earthquake survivors and aid workers with information about the ground on which they find themselves trying to pick up the pieces.

EMCCD for Lidar Applications
Electron multiplying CCDs are uniquely positioned for use in lidar applications, which mandate strict requirements for charge collection, temporal sampling and quantum efficiency at short wavelengths

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.

You'll also find all the news that affects your industry, from tech trends and market reports to the latest products and media.

High Power Laser Diode Drivers

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ILX Lightwave
Laser Diode Instrumentation & Test Systems

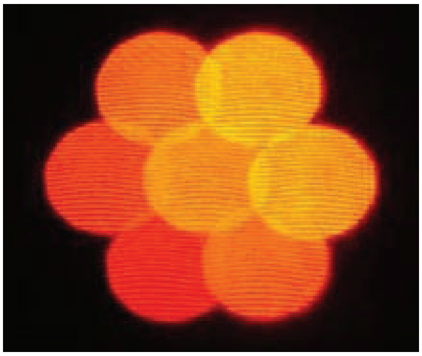
Holograms lighten the payload of unmanned aerial vehicles

ARLINGTON, Va. – US Air Force scientists have devised a way to make unmanned aerial vehicles (UAVs) better eyes in the sky, besides making them lighter and more efficient.

Also known as drones or pilotless aircraft, UAVs increasingly are being used for reconnaissance missions by both military and commercial operators. The aircraft can acquire intelligence on enemy combatants, locate terrorism suspects, measure instances of extreme weather, and inspect remote oil, gas and power lines, among many other uses.

In remote sensing and imaging operations, however, UAVs must peer through varying atmospheric conditions, most of which degrade the results. Adaptive optics systems, which are known chiefly for improving celestial images acquired by ground-based telescopes that also are subject to atmospheric distortions, would help, except that they are too bulky and heavy for practical use aboard UAVs.

Adaptive optics systems work by discerning errors in the wavefronts of light that reflects off imaging targets. Aside from the optics, which include a deformable mirror that uses tiny actuators to correct wavefront errors before the light is passed on to a CCD, these systems require a high-power computer to operate at high speeds. A significant portion of the weight and volume of an adaptive optics system belongs to the computer.



Using a holographic adaptive optics system permits computer-free operation of unmanned aerial vehicles for surveillance missions. Courtesy of the US Air Force Office of Scientific Research.

Dr. Geoff Andersen of the US Air Force's Laser and Optics Research Center in Colorado Springs, Colo., and his colleague, Dr. Kent Miller of the Air Force Office of Scientific Research in Arlington, tackled the problem by stripping out the computer. To perform the intensive calculations required, they replaced the computer with a holographic wavefront sensor technology upon which is recorded the individual responses of each actuator on the deformable mirror.

When the hologram containing the actuator response functions is used during imaging, wavefront errors are measured as intensity outputs from an array of fast photodetectors, then sent directly to the mirror's controller. This makes the system an all-optical closed loop that requires no external electronic computation.

"Adding the holographic wavefront sensor technology improves speed and functionality while also decreasing mass, volume and complexity," Andersen said. "By removing the computer, we can make the entire system smaller and lightweight and over 100 times faster."

The system, dubbed HALOS (Holographic Adaptive Laser Optics System), has been tested as a proof of concept. According to Andersen, he and Miller are now in the process of testing full autonomous operation of the technology. They will also be trying it with more sensitive detectors.

"The idea of incorporating adaptive optics into UAV surveillance systems is now a real possibility," he said. "This is not possible with current technologies."

Lynn Savage
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In focus near and far – at the same time

TORONTO – Researchers at the University of Toronto have developed a new distance-mapping principle that delivers automatic real-time focus of both near- and far-field images, simultaneously and in high resolution. Called the Omni-focus Video Camera, it is described as a "breakthrough in video camera design." The researchers say that this capability can be broadly applied in industry, including manufacturing, medicine, defense and security – and ultimately in the consumer market.

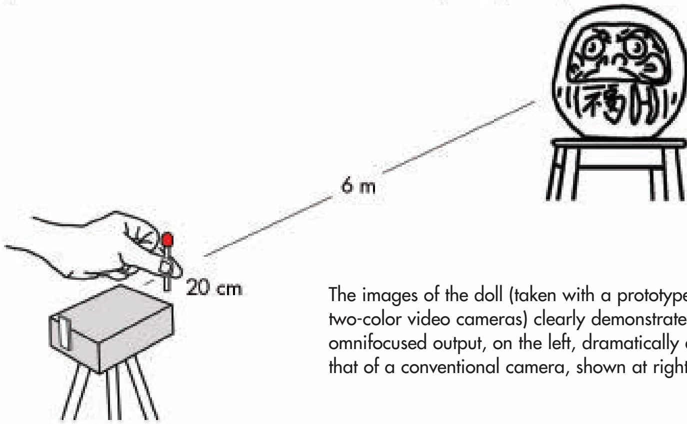
Inventor and principal investigator of the Omni-focus Video Camera, professor Keigo Iizuka of the Edward S. Rogers Sr. Department of Electrical and Computer Engineering explains that "the intensity of a point source decays with the inverse square of the distance of propagation. This variation with distance has proven to be large enough to provide depth mapping with high resolution. What's more, by using two point sources at different locations, the distance of the object can be determined without the influence of its surface texture." This principle led Iizuka to develop the Axi-Vision, a distance-mapping camera. Abbreviated "Divcam," the divergence-ratio camera is a key component of the new device.

The Omni-focus is produced in collaboration with consulting investigator Dr. David Wilkes, president of Wilkes Associates, a Canadian high-tech product development company. It contains an array of color video cameras, two Sony XC color cameras and an XCR150 IR camera, each focused at a different distance, and an integrated Divcam. The Divcam maps distance information for every pixel in the scene in real time. Iizuka said that the number of cameras can be increased using additional beamsplitters.

A software-based pixel correspondence utility, using prior intellectual property

By Omni-focus Video Camera

By Sony Handycam DCR-PC55



The images of the doll (taken with a prototype using two-color video cameras) clearly demonstrate how the omnifocused output, on the left, dramatically differs from that of a conventional camera, shown at right.

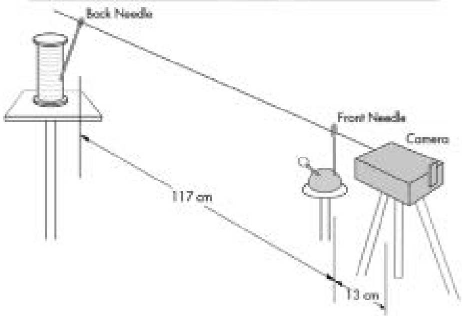
invented by Wilkes, employs the distance information to select individual pixels from the ensemble of outputs of the color video cameras to generate the final "omnifocused" single-video image.

"The Omni-focus Video Camera's ability to achieve simultaneous focus of all of the objects in a scene, near or far, multiple or single, without the usual physical movement of the camera's optics, represents a true advancement that is further distinguished in terms of high resolution, distance mapping, real-time operation, simplicity, compactness, lightweight portability and a projected low manufacturing cost," Wilkes said.

Iizuka predicts that the device, although still in the research phase, could have an impact on several industries, such as in the following applications:

TV studio cameras. One example is a musical concert that is being televised by a major network. Even though the singer is in sharp focus, band members in the background are invariably blurry. Conventional video cameras are unable to focus on both simultaneously, but the Omni-focus Video Camera would remove this limitation and allow higher-quality video images.

Medical applications. Iizuka said, "I'd



This image illustrates the Omni-focus Video Camera's high-pixel resolution. Although the two sewing needles were photographed approximately 1.2 m apart, both are in sharp focus. Note that the eye of the back needle is actually viewed through the eye of the front needle.

like to apply the principle of the Omnifocus Video Camera to the design of a laparoscope. It would help doctors at the operating table if they can see the entire view without touching optics of the laparoscope, especially if dealing with a large lesion." This would work "because the size of endoscopic cameras is shrinking, and not all of the components need to be on the shaft of the laparoscope."

Charles T. Troy
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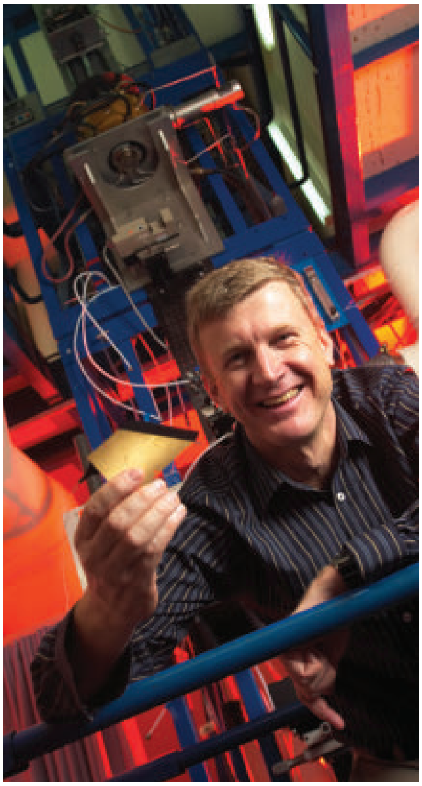
Microspectrographs enable deeper space exploration

SYDNEY, Australia – As telescopes get bigger and bigger – and more complex – engineers and astronomers recognize that simply scaling up existing technology would result in instruments that are limited by size and complexity. Integrated devices for multiobject spectroscopy could help, according to researchers at the University of Sydney.

The university's astrophotonics research group is working on a solution: an optical device with a variety of functions that can be produced on a chip as small as tens of millimeters. Several single-mode integrated optics systems have been shown to work with existing interferometers, the team reported, adding that these systems offer better interferometer resolution, increased flexibility, better instrument stability, easy installation, and reduced overall cost and complexity.

The group, led by professor Joss Bland-Hawthorn of the Sydney Institute of Astronomy in the School of Physics, also is part of the Institute for Photonics and Optical Science and the Consortium for Australian Astrophotonics, which includes the Anglo-Australian Observatory and Macquarie University.

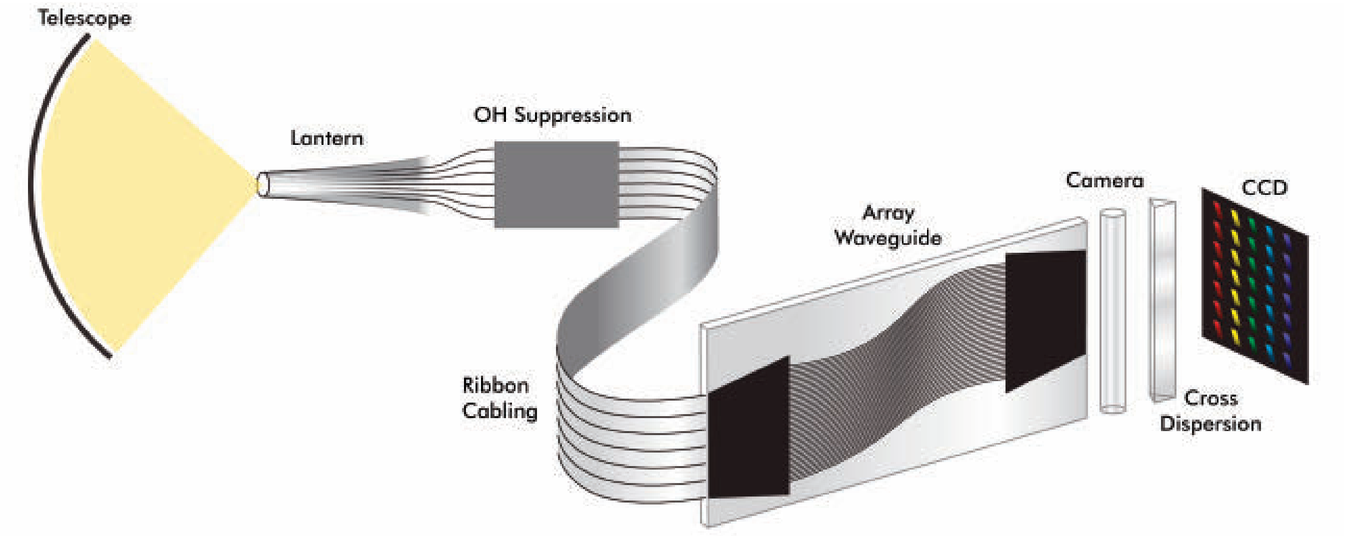


Joss Bland-Hawthorn holds a microspectrograph developed by his research group. He leads the astrophotonics team at the Institute of Astronomy in the School of Physics at the University of Sydney in Australia. Courtesy of Alison Muir, University of Sydney.

Bland-Hawthorn's team is investigating various devices, including ultrabroadband fiber Bragg gratings – 1050 to 1750 nm – that knock out approximately 200 narrow frequencies.

"These are by far the most complex filters ever demonstrated," he noted. Most filters simply isolate a region of the spectrum, but these filters go much further, he added. "They knock out hundreds of emission lines produced by the Earth's atmosphere so that the sky appears far darker."

The team also is working on multimode to single-mode converters (photonic lanterns) that allow single-mode action in a multimode fiber developed with the University of Bath. This is a world first,



This is a schematic drawing of the PIMMS#1 instrument concept. Courtesy of Joss Bland-Hawthorn, University of Sydney.

according to Bland-Hawthorn, who is also an Australian Research Council federation fellow.

"We are building an astronomical instrument called Gnosis based on this technology and incorporating the special filters," he said. "The instrument will allow Australian astronomers to peer much further into the universe and to detect the most distant galaxies in the early universe.

"We can feed these multimode converters into an array waveguide such that we can accurately disperse the input light from an incoherent multimoded source with a single-mode photonic grating; e.g., array waveguide grating. We call this device PIMMS#1 and are building a device to demo at the telescope. You end up with a microspectrograph which outperforms existing technologies."

The figure for one array waveguide illustrates this. "The telescope light is imaged onto the front face of the lantern, which splits the light into seven single-mode fibers (in practice, the output number can be much larger)," Bland-Hawthorn said. "The light from these single-mode fibers then passes through an array waveguide before being dispersed into little spectra at the detector.

"The truly remarkable feature of PIMMS#1 is that the instrument is diffraction-limited regardless of the illumination pattern falling onto the lantern." This means that it can be made very compact regardless of the size of the telescope with which it will be used. "With a little help from industry, the cost of instruments on the new generation of extremely large telescopes could be greatly reduced," he noted.

Bland-Hawthorn is excited about microspectrographs and their versatility. "One spectrograph fits all telescopes," he said, "and it's tiny compared to conventional instruments."

The PIMMS paradigm could lead to an array of possible future devices for a range of uses. The team is working to develop devices that will find wide application in oceanographic, atmospheric and space sciences. "In the area of remote sensing, we foresee arrays of small devices that can be carried by robots, nano-/microsatellites, dirigibles, balloons, submersibles and so forth," he said.

He believes that microspectrographs will allow smaller university departments and observatories to start designing and building their own instruments without relying as heavily on support from major observatories and associated funding streams, as they have in the past.

The researchers also are developing imaging fiber bundles with 90 percent fill fraction. "The best to date has been about 30 percent," Bland-Hawthorn said. "These will be moved around at the telescope with robots so that we can make images of hundreds of sources at a time."

Systems operating with multimode fibers are in development in various research groups, the team noted, and future integrated optics projects are expected to involve multipurpose devices that can handle spectroscopy and other applications.

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Optical sensors let gadgets point their own way

PITTSBURGH – With apologies to William Shakespeare, all the world's a pad and all devices merely mice. At least, that could be the case if researchers Chris Harrison and professor Scott E. Hudson of the Human-Computer Interaction Institute at Carnegie Mellon University have their way. The duo has shown how gadgets too small for ordinary input methods can function as their own pointing devices, thanks to the latest in inexpensive optical sensor technology.

The approach could make possible much smaller audio players, phones and other gear, Harrison said. "If we can get rid of screens and buttons, we could make devices that are the size of a couple of pennies."

Harrison, a graduate student, noted that getting information into electronic devices presents a fundamental challenge. Although electronic devices have gotten smaller, people have not. As a result, buttons and screens must be a certain size, placing a lower limit on the size of devices.

The solution devised by the Carnegie Mellon researchers is to change the input method. Conceptually, it is the same as turning a device into a mouse, with optical sensors mounted on the bottom of the device. With two sensors, this approach enables tracking X and Y movement, as well as rotation, on surfaces ranging from tabletops to shirtsleeves to the palm of a hand. Virtually any flat surface will work.

This tactic of turning devices into mice offers a number of advantages. One is that targeting with pixel-level accuracy is possible – something that cannot be done with comparatively fat fingers working a touch screen. Also, getting fingers off a screen improves the visibility of its output. A third plus is that it can transform a surface into a virtual control space, with some areas designated for functions such as horizontal or vertical scrolling.

The approach takes advantage of the sensor technology behind today's optical mice. Over the past few years, the cost of such technology has dropped significantly. So, too, has its size. At the same time, the precision of the sensors and their ability to pinpoint a location have remained high.

The sensors and associated technology have another attribute that makes them useful in a handheld or portable device, Harrison said. "They consume almost no power and are fantastically precise."

He noted that simply slapping sensors on a device isn't enough, however. The technology must be married to software, other hardware and the right interface to be effective. Harrison and Hudson presented a prototype at the April 2010 Association for Computing Machinery's annual Conference on Human Factors in Computing Systems in Atlanta.

In their prototype, they used the technology for gestures, with software that understood flicking and twisting. They demonstrated an audio player, with users able to scroll through a list, select a song and adjust the volume. All of this was done without the use of buttons.

Tests done with eight college-age subjects produced positive feedback. Certain motions, in particular those involving twisting, were particularly popular. The physical nature of the motion, such as flicking, also appealed to some of the testers.

As for the future, Harrison noted that talks with manufacturers to bring the technology to the mass market are under way. The approach could end up in a cell phone, which has the processing power to handle the interface.

With regard to the sensor technology itself, it's good enough for many applications today but could be improved, Harrison said. "Further miniaturization is always welcome."

Hank Hogan
hank.hogan@photonics.com

Optical sensor technology mounted on the bottom of a small device provides it with mouselike pointing ability that makes input easier. Courtesy of Chris Harrison, Carnegie Mellon University.

CVD process improves diamond quality for lasers

SYDNEY, Australia – Diamonds could become a laser's best friend, thanks to new methods of creating man-made versions of the gem.

Researchers have proved the principle that diamonds offer high efficiency for lasing; however, demonstrating this has been an issue because it requires pure diamond crystals. "Using natural diamonds … is problematic – the quality is not consistent and, as everybody knows, they're very expensive," said associate professor Richard P. Mildren of Macquarie University.

The new synthetic diamonds not only cost much less but also are grown to researchers' specifications using the process of chemical vapor deposition (CVD), a method that essentially creates a carbon crystal lattice by putting down atomic layers of carbon on a large, flat diamond crystal substrate. Today this allows cre-

Richard Mildren and his team at Macquarie University have been pushing the limits of diamond-based Raman lasers for several years. Now these devices have become mature enough to compete with other lasers, mainly due to the availability of good-quality synthetic diamonds and a better understanding of the laser's design. Courtesy of Macquarie University.

ation of diamonds up to 8 mm in length, weighing a bit under a carat. Last year, when the researchers set a new record efficiency of 63.5 percent (see "Diamonds sparkle in Raman application," *Photonics Spectra*, November 2009, p. 23), they used a 6.7-mm-long crystal and, going forward, "Diamonds larger than one centimeter are likely to be available very soon," Mildren said. Another benefit of CVD is that it is compatible with photonic integration processes, so that diamond lasers or waveguides can be included in future photonic integration efforts.

Over the past few years, researchers from Macquarie University have made tremendous progress introducing diamond as a very attractive laser material. Presenting recent findings on this relatively young laser variant in an invited talk at this year's CLEO/QELS conference, the scientists outlined the state of the art in Raman lasers based on undoped, single-crystal diamond, which typically uses an external cavity to generate nano- and picosecond pulses with high efficiency.

Aside from its outstanding efficiency – at least 40 percent higher than alternative Raman materials – diamond has two properties that make it attractive as a laser material. First, it offers very good heat conductivity; second, it is transparent over an extremely wide part of the optical spectrum. Localized heating is an unwanted side effect when building lasers with high power and/or when trying to make them small. Low absorption over a wide range is desired to give flexibility in terms of output wavelength.

For classical lasers, the choice of output wavelength is determined by the atomic or molecular energy levels and transitions available for lasing action. However, diamond lasers are Raman lasers: Unlike, say, diode lasers, they are optically rather than electrically pumped; the pump interacts with molecular or atomic vibrations in the material. These interactions make some of the pump photons lose or gain energy – i.e., the scattered light has a different wavelength. The laser action takes place with this secondary light, called Stokes or anti-Stokes, being amplified in an appropriate cavity while pumping energy into the system, resulting in coherent emission at the shifted wavelength.

Diamond not only transfers the pump energy more efficiently into the output but also enables a larger-than-usual shift, resulting in output light that is at a greater spectral distance from the pump. This means that, in combination with the wide window of transparency, diamond lasers can be made to lase at wavelengths between 225 nm in the ultraviolet and 100 µm in the far-infrared (with a gap between 3- and 6-µm wavelengths).

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Night vision: There's an app for that

GAINESVILLE, Fla. – A paper-thin device that uses energy-efficient organic LED technology similar to that found in flat-screen TV and laptop computer screens soon could be made into a night vision application for cell phone cameras.

"Really, this is a very inexpensive device," said Franky So, a University of Florida researcher and professor of materials science and engineering. "Incorporating it into a cell phone might not be a big deal."

Conventional night vision devices use massive amounts of electricity. The technology entails converting invisible infrared light photons into electrons via a photodiode. The electrons then are accelerated under high voltage and driven into a phosphorous screen, producing greenish images – the color to which the human eye is most sensitive – of objects not visible to the human eye in darkness. Turning photons into thousands of volts of electrons requires a vacuum tube similar to a cathode-ray tube. The vacuum tube is made of thick, heavy glass, which is why night vision goggles tend to be bulky and heavy.

As described in a recent issue of the journal *Advanced Materials*, So replaced the heavy glass with lighter, thinner plastic, eliminating the need for the vacuum tube. Co-author of the paper was Do Young Kim, a postdoctoral associate in materials science and engineering. The project was funded in part by DARPA.

The night vision device uses several layers of organic semiconductor thin-film materials and can range in diameter from a few millimeters to the size of a nickel.

"This device can convert any infrared image into a visible image and would weigh no more than a pair of eyeglasses," So said in an interview with *Discovery News*. "Ten years ago, when people talked about putting cameras in cell phones, people asked: Why would you want to do that? Now you cannot find a cell phone without a camera. In the future, you might not be able to find a cell phone without night vision."

So said that other applications could include night vision technology for car windshields or for standard eyeglasses for night use. He said his team plans to create cell phones that also can measure heat. A thermal vision application could, for example, check a patient's body temperature for a fever or, if applied to a windshield, could help a driver detect and avoid pedestrians crossing the street.

His research also was funded by Nanoholdings LLC, a Rowayton, Conn.-based company that licenses and develops nanoenergy discoveries in partnership with universities, scientists and DARPA.

A University of Florida startup, NirVision, a portfolio company of Nanoholdings, was formed recently to further develop and commercialize the technology, which is expected to take about 18 months for practical applications.

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Microprojectors spur development of green lasers

LYON, France – Picoprojectors will drive the green laser market – expected to reach about $500 million in revenue by 2016, up from an estimated $20 million in 2011 – with more than 45 million devices, according to a market analysis by Yole Développement sarl.

The emerging microprojector technology has applications in mobile phones, digital cameras, media players, personal digital assistants, head-mounted or head-up displays, laptop computers and other portable devices, enabling users to project the smaller image from their device onto a wall or other surface so that it may be easily viewed or shared in a larger format. The technology – stand-alone or embedded – requires delivery of a high-quality image and may allow the projection of movies, video games or even touch-screen menus.

In the microprojector market, lasers would be the ideal light-emitting device because of their ability to deliver highly saturated colors in the widest possible gamut, according to Yole's report, *Green Laser Market for Projection Devices*. Published in April 2010, it comprises a market analysis of direct- and indirect-emitting semiconductor green laser diodes in projection applications. Lasers offer focus-free operation and are expected to deliver improved wall-plug efficiency, which will affect the power consumption for battery operation, the company said.

There are three vastly different technologies battling for the heart of the pico-projector: liquid-crystal-on-silicon micro-displays, digital light processing devices and scanning mirror systems (also called laser beam-steering systems), according to an article in the May 2010 issue of *IEEE Spectrum* titled *March of the Pico Projectors* by Jacques Lincoln, global product manager for automotive displays at Microvision Inc. in Redmond, Wash. He wrote that the imagery of the scanning mirror systems is extremely sharp, has the highest contrast of the three technologies and potentially could be produced in the smallest package.

Red, green and blue lasers are required for the laser-based microprojector. The report from Yole notes that the light-engine module, including the light engine and the scanning device, is expected at a target price of $40 to $70, depending upon the application, implying a laser price target of $10 per color. Neither blue nor green lasers currently meet these price requirements, the report states.

Green lasers have niche applications in industry, medicine, defense and biomedical instrumentation, all of which can work with existing solid-state lasers or the more recent combinations of semiconductor lasers with nonlinear crystals, according to Yole. The company said that three green laser semiconductor-based technologies are frequency-doubled diode-pumped solid-state lasers, second-harmonic generation of semiconductor edge- and surface-emitting lasers, and direct-emission laser diodes. It indicated that the technology will undergo development from second-harmonic generation to direct-emission sources.

Green laser developments

Various companies have been developing green laser technology for applications in microprojection; e.g., a green laser employing quantum dot semiconductor crystals was developed by QD Laser Inc. of Tokyo in collaboration with Yasuhiko Arakawa of the University of Tokyo's Institute for Nano Quantum Information Electronics. QD Laser said in a September 2009 press release that the compact laser, which operates with low power consumption, is optimal for use in projectors that can be mounted on mobile phones or laptop computers.

The company said that it produced the green laser by applying distributed feedback laser technology to create a quantum dot semiconductor crystal laser operating at 1064 nm. The photon stream is then filtered through a nonlinear crystal via second-harmonic generation, forming photons with a 532-nm wavelength, half the original. The green laser can be housed in a generic TO-56 package operating from a 2-VDC supply.

Michael Usami, vice president of sales and marketing, said that the company is sampling the green laser by targeting mass production by the end of the year. He added that the green laser is suitable for any mobile projection system – especially for flying spot-type scanning systems, which require high-speed modulations – or for applications that require high beam quality.

Direct green InGaN-based laser emission with CW output of 50 mW is a milestone for mobile laser projection technology. Courtesy of Osram Opto Semiconductors.

"If green lasers can be mass-produced with reasonable pricing and enough manufacturing capacity, red-green-blue small-projection engines would be realized and would enable the creation of brand new applications. We would like to contribute them," Usami said.

As announced in an August 2009 press release, Osram Opto Semiconductors GmbH of Regensburg, Germany, achieved a direct-emitting green InGaN laser with 50 mW in its laboratory. Suitable for mobile laser projection, the diode emits a true green, defined by the spectral range of 515 to 535 nm.

The release also stated that, compared with semiconductor lasers that operate with frequency doubling based on current technology, direct emitting green lasers are more compact and easier to control, offer greater temperature stability and have higher modulation capability. The main advantages of a direct-emitting InGaN laser are a smaller form factor (similar to blue laser diodes), high modulation capabilities and long-term price potential (similar to the blue laser), it said.

Osram noted that the main challenges lie in the fact that the direct green laser must be competitive with its second-harmonic green laser. For example, mobile laser projection systems need single-mode operation, 50 mW of output power at 515 to 525 nm (this requires low threshold and good slope efficiency), comparable wall plug efficiency and sufficiently long lifetimes.

In a report titled *Progress of blue and green InGaN laser diodes* by Stephan Lutgen et al in the *Proceedings of SPIE*, Vol. 7616, Feb. 8, 2010, laser operation at 516 nm with more than 50 mW of output power in CW operation is described in combination with a wall plug efficiency of 2.7 percent.

In another report, *True green InGaN laser diodes* by Lutgen et al, published in *physica status solidi (a)* online in May 2010, research is presented on true-green InGaN ridge waveguide laser diodes at 520 nm on c-plane GaN substrates in pulse operation at room temperature.

Using an LED light source, it is necessary to refocus the projector each time the distance between the projector and screen changes. With laser light sources, refocusing is unnecessary, regardless of the distance. The Yole report indicated that, in 2009, the first LED-based picoprojectors were available commercially, but, perhaps because of their poor brightness and relatively high price, no more than 300,000 units were sold. However, LEDs and high-brightness LEDs are serious competitors to laser-based systems because some picoprojectors have already been announced with brightness up to 30 lm, Yole said.

Applications forecasts

Yole predicts that 10 to 20 percent of stand-alone projectors will be laser-based by 2011, and that the ratio could grow to 50 to 75 percent by 2016. It forecasts that laser-based projection systems gradually will enter the cell phone market, especially if direct-emission green lasers contribute to the small size requirement. LED technology is expected to dominate until at least 2016, however.

A boom in media players equipped with projection functionality is expected by 2012. Second-harmonic-generation green lasers are likely to dominate in this market initially while waiting for direct-emission technology to become compatible in price and performance, Yole said.

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LED Innovation In Grover Beach, Calif., Arroyo Instruments has completed a National Institute of Standards and Technology Phase 1 Small Business Innovation Research program for the development of a pulse/DC characterization system for LEDs. The goal of the project, which was met with the completion of a prototype device, was to develop a commercially viable solution to determine and maintain accurate LED junction temperature during characterization.

Wafer Processing Axus Technology and CMP Solutions have announced a partnership that expands the chemical mechanical polishing (CMP) and wafer thinning process for both companies. The agreement is anticipated to link the process development expertise of the latter company with the established CMP foundry and wafer processing capability of the former. Based in Chandler, Ariz., Axus Technology will continue also to provide direct foundry and development services to end users and consumables suppliers.

Solar Defense Cambrios Technologies Corp. of Sunnyvale, Calif., an electronic materials company, has announced that it has received a military contract to produce lightweight, flexible, cost-effective solar energy photovoltaics. Under a contract with the Department of Defense and in collaboration with Ascent Solar Technologies Inc., Cambrios will deliver flexible solar cells that incorporate its ClearOhm electrode layer. Featuring transparency and light handling capability, the cells are expected to be 1 to 3 percent more efficient than equivalent cells made with conventional transparent electrode material.

Fiber Optic Alternative Avago Technologies of Wetzlar, Germany, an analog interface components supplier, announced the release of an embedded fiber optic solution that eventually could replace copper for handling the high-speed data rate requirements of supercomputers. Designed in collaboration with IBM, the miniature 12-channel parallel optic transmitter and receiver modules can handle data rates up to 120 Gb/s.

$27 Million Military Order Display systems manufacturer Kopin Corp. of Taunton, Mass., has announced that it has received a $27 million follow-on production order for eyepieces for the US Army's Thermal Weapon Sight Bridge program. To be fulfilled over a two-year period, the order supports the continued production of an eyepiece that recently was fully qualified in the program after harsh testing in battlefield environments.

Microscopy Acquisition Carl Zeiss Ltd. has announced an agreement to acquire Imaging Associates (IMAS) Ltd. of Bicester, UK. As a distributor of Zeiss' materials microscopy products since 1992, IMAS has supported digital imaging platforms in research, clinical and industrial environments. The company, which will be fully integrated within Zeiss, will continue to support customers in industrial and other markets. Additionally, IMAS will contribute its software application development expertise and will support digital imaging platforms across Zeiss' microscopy portfolio.

Solar Partnership Santa Clara, Calif.-based Coherent Inc. and Beverly, Mass.-based SiOnyx Inc. have announced that they will partner to evaluate and develop SiOnyx's black silicon processing, which offers a number of advantages for the solar industry, including cost reduction, increased conversion efficiency and improved manufacturing yields, the companies said. The partnership is expected to provide both companies new opportunities in the photovoltaic industry.

Surgical Lighting Inroads LED manufacturer Enfis Ltd. of Swansea, UK, and Chinese medical lighting specialist C-THME of Chongqing have collaborated on new surgical lighting technology. Enfis has produced a tailored LED light engine that combines with a fixture designed by C-THME. The technology is anticipated to deliver efficient, widely tunable light with no color separation or shadowing.

LED Joint Venture Everlight Electronics Co. Ltd. of Taipei, Taiwan, an LED packaging company, has announced a joint venture in WeJiang City, China. The company will join LG Display Co. Ltd., an innovator in thin-film-transistor LCD technology, and AmTran Technology, a display manufacturer specializing in computer monitors and flat panel televisions, to form a new LED packaging company. The three companies will pool their strengths and resources to provide state-of-the-art LEDs for the backlit television market. The newly formed company is scheduled to start mass production by year's end with a capitalization of $30 million.

Thin-Film Company Formed In St. Petersburg, Fla., the establishment of Labtec Sales Partners LLC has been announced. The company was formed to provide sales and marketing expertise to companies that provide processing equipment to the thin-film research and development and manufacturing fields. It has a number of agreements in place with thin-film suppliers, including Forth-Rite Technologies LLC of Austin, Texas; JLS Designs Ltd. of Somerset, UK; Surface Science Integration of El Mirage, Ariz.; and V&N Advanced Automation Systems of Rockledge, Fla.

Assets Acquisition Ocean Optics Inc. of Dunedin, Fla., has acquired the assets of Sandhouse Design LLC, also of Dunedin, a manufacturer of modular mid-infrared spectrometers, LEDs, light sources and other photonic products. Over the past four years, Sandhouse Design has developed a line of high-power LED light sources for research and spectroscopy applications. The new product line will be manufactured at Ocean Optics' Winter Park facility and, starting immediately, Ocean Optics will handle all sales and support via its regional sales offices in the Americas, Europe and Asia.

$7.5 M Investment Oclaro Inc. of San Jose, Calif., an optical communications and laser solutions provider, has made a $7.5 million strategic investment in ClariPhy Communications of Irvine, Calif., a privately held fabless semiconductor company that focuses on digital signal processing and mixed-signal integrated circuits for high-speed, next-generation networks. The companies also have signed a marketing and development agreement that leverages ClariPhy's 40-nm single-chip products with Oclaro's optical technology.

Laser Co. Acquisition Precision laser measurement company Ophir Optronics of Jerusalem has added scanning-slit technology to its beam profiling product line through the acquisition of Photon Inc. Financial terms of the deal were not disclosed. The latter company, based in San Jose, Calif., provides a range of instruments for aligning and building laser optical systems, for collimating lasers, and for characterizing fiber optic beams, lasers and other light sources. The former company said the acquisition creates a diverse and powerful supplier of laser measurement equipment for industrial, medical, military and scientific/research applications for its Ophir-Spiricon group.

Contract Award Optical Surface Technologies (OST) has been awarded a contract with the Discovery Channel Telescope at Lowell Observatory to coat the 4.3-m primary mirror and to provide manufacturing support for the 1.4-m secondary mirror. The contract launched the Albuquerque, N.M.-based company's mobile coating capability by providing comprehensive on-site coating services at customer facilities. The service facilitates chamber outsourcing operations by using OST's staff to perform periodic cleaning and recoating activities. OST manufactures, tests and coats large custom optics, and its fabrication facility can produce mirrors and optical components up to 3 m in diameter.

Licensing Agreement Terahertz research company T-Ray Science Inc. has granted a licensing agreement to Toptica Photonics Inc. of Victor, N.Y., a terahertz source supplier. Under terms of the agreement, T-Ray will collect royalties on US sales of Toptica's terahertz standard package plus spectroscopy kit, which uses a coherent detection technique for continuous-wave terahertz signals. The former company's platform terahertz imaging technology is anticipated to have many applications, including homeland security; the detection of explosives and ceramic knives; process control in the paper, plastics, petrochemical and pharmaceutical industries; and medical imaging for the detection of skin and other cancers.

Worldwide Representative Schmitt Industries Inc., a laser-based surface measurement metrology equipment supplier, has named Lambda Research Corp. as worldwide representative for its SMS line of laser light scatter surface measurement services, the MicroScan portable surface measurement system and the CASI laser light scatterometer. Schmitt will couple its products and measurement services with Lambda's TracePro software, a software tool for modeling and analyzing the propagation of light in imaging and nonimaging optomechanical systems.

Sales Growth Physik Instrumente (PI) GmbH & Co. KG of Karlsruhe, Germany, has strengthened its European sales organization with new offices and employees. Strategically located near the UK's Cranfield University, the new office, at Trent House, Cranfield Technology Park, will provide room for further growth. PI France also recently relocated into a new office in the suburbs of Paris, close to the Boulevard Périphérique. The move will allow the piezo technology and motion control company to provide improved services with better customer proximity and to focus more directly on its core nanopositioning and piezo technology business.

ITAR Certification PhotoMachining Inc. of Pelham, N.H., has received certification from the US Department of State as an International Traffic in Arms Regulations (ITAR)-compliant manufacturer. Under registration code #M26561, this allows the company to significantly expand its efforts in the aerospace and defense fields with the use of lasers. The new status is expected to improve PhotoMachining's core capabilities in high-resolution laser materials processing in the medical device, microelectronics and renewable energy markets. The company engages in high-precision laser micromachining and custom laser systems integration.

GreenLight

Thermal cameras assist solar contractors

BY LISA BELL
FLIR COMMERCIAL SYSTEMS INC.

Solar service and installation companies have known for some time that high-performance thermal cameras, capable of detecting very small temperature differences and of creating crystal clear images or video of problem areas, had enormous potential to diagnose problems on solar installation sites.

Their drawback had been that they were prohibitively expensive for smaller businesses. The past few years, however, have seen the cost of high-quality thermal cameras drop dramatically, with models now available for less than $3000, greatly expanding their use in building and maintenance applications, including solar energy.

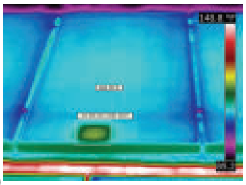
Innovative solar contractors are rapidly adding this tool to their diagnostic and preventive maintenance programs. Proactive thermal imaging surveys of solar modules can identify problem areas quickly and efficiently, preventing offline incidents and reducing operation costs.

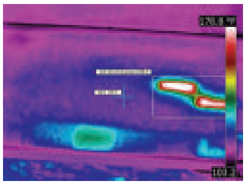
In addition, solar contractors report that adding thermal images and temperature data to inspection reports significantly increases the value of these reports and generates more work opportunities.

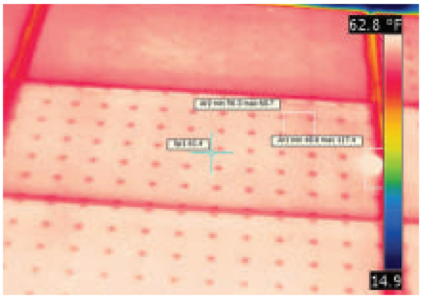
Halcyon Solar Construction of Cottonwood, Calif., installs, maintains and troubleshoots megawatt photovoltaic (PV) systems, both residential and commercial. Co-owner Andrew Begley has been using a thermal imager to identify problem areas in solar modules for more than a year – initially at the request of a client familiar with the technology.

After renting a handheld thermal camera for close to a year and becoming familiar with infrared technology and its possibilities, Begley was so pleased with the results that his company purchased a camera at the start of this year.

Thermal imaging is now a key component in Halcyon's preventive maintenance program. The camera, a Flir T300, offers extremely high quality images and advanced features in an affordable, lightweight, tough and versatile handheld package. Over the past three months, Halcyon has regularly used it to identify bad modules and to mitigate system risk.







Halcyon Solar Contractors in California uses a Flir T300 thermal imager to detect problems in solar cells. Top center, a hot solar cell is revealed by thermal imaging. Top right, a hot splice box is found at the back of a module where wires connect. Right, a solar module with broken glass and damaged cells is imaged. Images courtesy of Flir Commercial Systems Inc.

Begley uses the camera to create a composite electrical reading across the output curve of the entire solar module, to evaluate the quality of power output, to identify bad connections and to understand overall thermal patterns, including shading.

Thermal imagery can identify soiled or shaded individual cells within the systems as hotter areas of resistance. In a photovoltaic installation, efficiency is a function, in part, of temperature; cooler panels run more efficiently. As individual cells fail, they can begin to heat up, rather than collect energy, and this heat increase is easy to see with a thermal imaging device.

If a cell shows up hot in the thermal image but is not shaded or soiled, Begley can zoom in for a closer look to pinpoint the problem. Common defects in PV cells such as shunt or series resistance, or crystalline nonuniformities can reduce efficiency – even shut down an installation.

Begley uses other industry-standard measures to confirm the potential problems identified by the thermal imager, including current testing, voltage readings and IV curve tracing. If the cell is found to be defective, Halcyon can replace the solar module before it actually fails.

Halcyon's camera includes both a thermal imager and a daylight camera, with the onboard camera ability to fuse both types of images into a single composite image that clearly shows customers where and what the problem is.

Advanced in-camera algorithms and preset temperature triggers can quickly detect low and high temperatures as well as offer differential, or Delta-T, readings. All temperature data, object parameters, voice and text comments are stored with the infrared image, enabling advanced postprocessing and report writing.

Begley is particularly pleased with the data collection and reporting functionality software analysis tools that complement and extend the use of his thermal camera, including easy image organization tools and report templates. "I can quickly and easily generate a complete report with images to show a client that clearly identifies potential issues."

Solar is a clean source of renewable energy, with essentially free energy input and, as such, has tremendous environmental and political benefits. However, to become a truly viable alternative, solar installations must achieve the absolute maximum in production and performance. And as larger, more complex and more numerous installations become more common, thermal imaging can help the technology to reach its full potential.

Meet the author

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Displays
Add a Dimension, Durability

Courtesy of Microsoft.

Sony's battery-powered 3-D active shutter glasses work with its Bravia 3-D TVs. They retail for about $150. Courtesy of Sony.

BY MELINDA ROSE
SENIOR EDITOR

The rumblings about 3-D that began in 2009 are starting to hit the home display market in earnest, thanks in part to the overwhelming popularity of 3-D movies such as *Avatar*. Besides being visually more stimulating, new displays also are becoming more interactive through multitouch technology, and much thinner and lighter with the addition of LED backlights. Also, various types of organic LED (OLED) technology are gradually penetrating the display market, although currently only at small and medium screen sizes.

"Make no mistake about it – consumers are ready for 3-D," Sony Electronics President and Chief Operating Officer Stan Glasgow told a crowd at the business conference during the Society for Information Display's (SID) Display Week in Seattle in May.

Sony expects demand to be strong for its 3-D Bravia TVs this summer, he said, and predicts it will sell 100 million 3-D units globally over the next three years.

"There's a very bullish feeling at Panasonic on 3-D," said Peter Fannon, vice president of corporate and government affairs for Panasonic Corp. of North America, which released its first 3-D TV, a plasma display, in March.

Market research firm DisplaySearch has increased its 2010 forecast for 3-D-capable TV shipments and predicts that the market will grow from 2.5 million sets this year to 27 million in 2013.

"In 2009, we saw the first 3-D-capable TVs, with the market greatly accelerating at CES [Consumer Electronics Show] 2010. Now we are seeing the hype turning into real products," said Paul Gray, director of TV Electronics Research at DisplaySearch.

Companies such as LG, Panasonic, Samsung, Sony, Toshiba and Vizio have all introduced 3-D-capable TVs this year.

But will the consumers who are content to put on the glasses for a few hours during trips to the movie theater really want to watch TV like that at home?

"There are a lot of question marks about 3-D in general. This is very much a 'work the bugs out' year, and there will be a lot of bugs to work out," said Chris Chinnock, founder and president of market research firm Insight Media, at a Display Week 2010 press and analyst breakfast.

Shutter versus polarized

The 3-D TVs on the market today operate with either shutter-type or polarized glasses.

Shutter glasses are battery-powered, with the shutter opening and closing to show the image to one eye and then the other; polarized are just that – polarized in different directions to allow images to shift between eyes. Shutter glasses allow the images to be seen in full high-definition resolution, while polarizers show images at half the screen resolution. Shutter glasses are more expensive for the consumer but cheaper for the display manufacturer, because less cost is added to the TV when active shutter technology is used.

The problem with the glasses is that compatibility between brands can be an issue, and sets and glasses often aren't bundled together. Typically, consumers get only one pair included with a TV and have to pay extra for additional pairs. The quality of the glasses also can vary greatly.

Look, Ma, no glasses!

Some prototype sets on display at SID Display Week by companies such as LG Electronics and Samsung didn't require the use of any glasses to see the 3-D effect, although the images were far from perfect and the viewing angles extremely limited, so taking a mere step left or right of direct center could make the image blur.

During his keynote address, Steven Bathiche, director of research for Microsoft Corp.'s Applied Sciences Group, discussed the company's wedge optics, which could create a glasses-free stereoscopic 3-D effect for the user.

The wedge lens, about 11 mm thick at the top and tapering to 6 mm at the bottom, guides light provided by an LED backlight to the viewer's eyes. The technology uses a camera to send different images to a person's left and right eyes for a 3-D picture, or it can send two completely different 3-D images to two people watching the same display, allowing each person to have his own unique and private experience. Right now the system's viewing angle is only about 20°, Bathiche said, but he hopes to increase that to 40° by improving the lens design.

Also at Display Week, 3M of St. Paul, Minn., showed its field-sequential 3-D optical film, which allows 3-D autostereoscopic viewing without glasses on handheld devices such as mobile phones and gaming units.

Using directional backlight technology, left and right images are focused sequentially into the viewer's eyes, enabling a full-resolution display. The film, which requires one LCD panel operating at a 120-Hz refresh rate, can be integrated into the backlight module, the company said.

Where's the three-dimensional beef?

OK, so you've made the investment in a 3-D-capable set, you have the proper gear required by your cable or satellite provider, and you have your glasses. Now – what are you going to watch?

There's precious little programming available in 3-D these days. Gaming and sports, along with nature programs, are expected to be the big three in terms of future 3-D broadcast programming, according to industry analysts, but that programming is just beginning.

At the E3 Expo in Los Angeles in June, game makers such as Sony Computer Entertainment and Nintendo unveiled 3-D games. Sony games, which run on a Playstation 3 that has been updated to process stereoscopic 3-D graphics, require players to wear glasses. Nintendo's 3DS system is glasses-free.

Also at E3, Microsoft premiered its Kinect for Xbox 360, a controller-free gaming platform formerly known as Project Natal. Kinect's camera controller allows players to wirelessly use their entire bodies in game play.

On broadcast TV, April's 2010 Masters golf tournament was available in 3-D for the first time, as were 25 matches of the 2010 FIFA World Cup in the US via the new ESPN 3D channel. DirecTV also will broadcast the first Major League Baseball games in 3-D in July, as well as its 2010 All-Star Game on July 13.

DirecTV announced it would launch three 3-D channels in June with partner Panasonic, including on-demand, pay-per-view and 3-D "sampler" channels.

But watching 3-D TV may be more complicated than some consumers realize.

"Because it's coming first in movies, [consumers] start with a completely immersive experience, which they won't begin with at home," said Rhoda Alexander, director of monitor research for market analyst iSuppli. "The glasses are a major hurdle. Ultimately, [the technology] needs to be glasses-free for 3-D to cross over into the mainstream."

"It's not plug-and-play by any means," agreed Chinnock, who added that consumer expectations and enthusiasm for the technology have been set too high by the ease of the cinematic 3-D experience.

"It will be the 'era of disillusionment' which we enter soon," he said.

The 42-in. autostereoscopic 3-D display by Philips uses the 2D-plus-Depth format, including Declipse, with gives additional occlusion information for a real 3-D "look around" effect. Courtesy of Philips.

Do you wanna touch?

There are more than a dozen touch screen technologies, including resistive, projected capacitive, surface capacitive, infrared and optical imaging.

The choice of technology used often is dependent on the application and the size of the screen, but "no touch screen technology is perfect," said Dr. Jennifer K. Colegrove, director of display technologies for DisplaySearch. Resistive and projective capacitive together own 81 percent of the touch-screen market.

Resistive screens contain parallel layers of conductive material. The bottom layer is usually printed on a stiff material, such as glass, while the top layer, the layer the user touches, is printed on a flexible material such as plastic film. The user touches the top layer with either a stylus or his finger, bending the flexible film until it touches the bottom layer and changes the resistance of the layers.

Projected capacitive screens also contain the two conductive layers, but they are sealed between two sheets of glass. The user interacts with an electric field, so the conductive layers don't need to touch. This makes the screen more durable than the resistive type, but, unlike resistive, it can't be used with a stylus or when the user is wearing thick gloves.

Resistive screens currently represent 50 percent of the market and are being manufactured by 90 of the more than 190 touch-screen suppliers worldwide, Colegrove said. However, DisplaySearch forecasts that projective capacitive, now at 31 percent, will become the leading touch technology this year, based on revenue. Projected capacitive technology is used in products such as Apple's iPhone, iPod Touch and iPad, and in the Motorola Droid and other smart phones.

Touch-screen shipments rose from 468 million units in 2008 to 600 million in 2009, a surge of 29 percent. Touch-screen module revenue was about $3.6 billion in 2008, and DisplaySearch forecasts it will hit $13 billion by 2016.

Emerging applications such as e-books, slate PCs and pocket projectors will boost the touch industry this year, Colegrove said, with projected capacitive touch, optical imaging and the high transmittance type of touch technologies benefiting most.

What the touch industry still needs are scratch-resistant, hard-coated plastic and wear-resistant, antismudge, antireflection coatings, according to Gary Barrett, chief technology officer of Touch International, which, with partner DMC, produces more than 500,000 touch screens a month at seven plants.

Trends in touch

New trends in the touch industry include gesture recognition, sunlight readability, pen and finger control, on-cell (built outside the display, typically on the surface of the color filter substrate, beneath the polarizer), in-cell (built inside the display, typically between the thin-film transistor and color filter) and multitouch options.

3M Touch Systems Inc. announced its 20-finger multitouch display during Display Week. The projected capacitive display is capable of a response time of less than 6 ms for 20 simultaneous touches. Applications for the technology include computer-aided design, digital signage, computer gaming and security monitoring systems.

Haptic (from the Greek "haptesthai," to touch) features, which allow the user to feel vibrations, clicks and other sensations, were available in more than 30 percent of touch-screen phones shipped in 2009, said Christophe Ramstein, CTO of Immersion Corp. of San Jose, Calif.

The latest trend in haptic performance is HD haptics, Ramstein said, which deliver increased fidelity via piezoactuators. The actuators provide powerful, crisp and instantaneous feedback effects via a wide bandwidth (50 to 350 Hz) and have superior effects isolation because the actuator can be mounted to the touch screen instead of the housing.

GestureTek of Sunnyvale, Calif., makes gesture-recognition technology that enables touchless display control such as that demonstrated by Tom Cruise in the movie *Minority Report*.

Corning unleashes the beast

"Glass breaks … why don't you fix that?" is what Corning Inc. technologist Bill Decker said to Research and Development Director Bill Armistead about 50 years ago, according to company lore. Armistead soon launched "Project Muscle," which led to the development of a glass made ultrastrong through a proprietary chemical process. The material, dubbed Chemcor, wouldn't crack or break, even when bombarded with frozen chickens propelled at high speeds.

Although the material was used in the 1960s for aircraft, train and car windows, and in Corelle tableware, it proved too strong for some applications and was shelved.

Four decades later, Corning began receiving calls from cell phone manufacturers looking for a more rugged replacement to the easily scratched plastic covers the industry had been using for ~10 years.

In 2005, Corning researchers began to explore whether Chemcor, now called Gorilla glass, could be made sufficiently thin (and therefore lighter weight) for cell phones and other displays while also retaining its strength.

In 2007, they developed a composite of the glass that could be produced with a flawless surface in high volume while still being very thin. After that demand was met, they began tweaking the formula to fulfill calls for glass that is environmentally friendly.

Gorilla glass is green because it contains no heavy metals, Corning said, yet it has at least twice the strength of chemically strengthened soda lime glass at half the thickness. It is amazingly scratch- and impact-resistant; Corning videos demonstrating the glass's durability (such as a remote control hitting it at 65 mph and leaving nary a mark) have gotten thousands of hits on YouTube. Also, because it is stable at half the thickness of regular display glass, it is surprisingly flexible.

Gorilla is the cover glass of choice in 85 high-end notebook computers, mobile phones and other portable electronic and touch-screen-enabled devices on the market currently, such as the Droid, the iPad and the Dell Streak. More than 50 other products are expected to be released over the next six months, Corning said.

Because it is thinner than LCD and touch sensor glasses, in the future it can enable smaller and lighter devices that are more durable, Corning said. For example, LCD panel weights can be reduced up to 60 percent by thinning the cover glass from 0.7 mm to 0.3 mm, or about the thickness of three sheets of copier paper. And because Corning's glass is so strong, it can cover the entire panel, eliminating the need for a frame.

The technology also is becoming a profit powerhouse. Gorilla glass could become a $1 billion business within a few years, Corning CEO and Chairman Wendell Weeks announced in the company's

3M showed its 22-in. projected capacitive 20-finger Multi-touch Display M2256PW (left), and energy-efficient films for TVs, monitors and notebooks (right), along with its glasses-free 3-D film for handhelds, during SID Display Week 2010. Courtesy of 3M.

2009 annual report. The company said it expects Gorilla glass to boost sales in its Specialty Materials segment by up to 25 percent for the second quarter of 2010.

LEDs hit the backlight

For the home flat panel market, LED backlights are turning out to be a "must have" feature for LCD displays in 2010, not only because they make the displays thinner and lighter, but also because they can improve picture quality.

LEDs have been replacing cold cathode fluorescent lamps (CCFLs) as backlights in LCD panels at an ever-increasing pace and are expected to surpass CCFLs in 2012, according to industry experts. In smaller displays, such as notebook computers, the shift to LEDs has been very quick, thanks to demands in that market for ever-lower power consumption and for thinner and lighter computers. Notebook PC market penetration for LED backlights is expected to be 100 percent by the end of 2010 or the first quarter of 2011, according to DisplaySearch.

As solid-state light sources, LEDs are brighter, thinner and more durable than fluorescent lamps and do not contain mercury. They also provide a wider color gamut, consume less power and last longer.

There are two types of LED backlight configurations in LCDs: edge and direct. Edge-lit backlights, placed around the perimeter of the display, are thinner and require fewer LEDs, making them more cost-effective and more efficient. But they require a lightguide panel and a prism and have a problem with brightness uniformity. Direct-lit backlights, placed across the back of the display, can be locally dimmed, meaning that, as the picture warrants, LEDs in different areas of the panel can be shut off to improve contrast. But direct-lit backlights are thicker, use more power, generate more heat and require more LEDs, so they cost more to produce. Direct-lit backlight panels produce a

Global Lighting Technologies' edge-lit LCD TV backlight uses only 96 LEDs. Courtesy of GLT.

picture that better competes with the rich colors and deep blacks of plasma screens while consuming much less power than plasma, but they can't yet come close to competing with plasma in price.

Reducing the cost per lumen is very important for LEDs to dominate the TV market.

"LEDs are good at delivering a lot of light. They are very bad at delivering cheap light," said Jonathan "Jed" Dorsheimer, principal of equity research for Canada's global investment firm Canaccord Genuity.

Because of LED supply constraints and costs, edge-lit models will dominate until sometime in 2014, when direct-lit will increase as LED supplies increase, according to IMS Research.

San Bruno, Calif.-based startup Pixel Qi's display technology allows the backlight to be turned off when not needed. The company won silver in the 2010 SID Display of the Year awards for its 3Qi multimode LCD, which can deliver all the advantages of a standard backlit LCD, such as full-color and full-motion video, but which also has a reflective mode that can turn the backlight down or off in high ambient light levels, for a power savings of about 80 percent. Pixel Qi recently began production on its first product, a 10.1-in. e-paper screen with color and video for netbooks, multitouch tablets and e-book readers.

Another trend in backlights is to not have one at all. Qualcomm's proprietary mirasol display is a MEMS (microelectromechanical system) that reflects light using an interferometric modulator, so that specific wavelengths interfere with each other to create color. The San Diego-based company's technology – which it says is based on the same principle that gives a butterfly's wings their shimmer – consumes little power and features screens with high reflectivity of ambient light, meaning that they are easily viewable in conditions such as bright sunlight. In fact, in the outdoors, where a backlight isn't needed, the company says its display could have 10 to 100 times the battery life of LCD displays.

The first smart phone to incorporate a mirasol display, the V112, was announced in February 2008 by Inventec Corp. and was featured at the GSMA Mobile World Congress 2008 in Barcelona, Spain. That same month, Qualcomm announced a deal to develop mirasol-enabled handsets for LG Electronics. The first mirasol-based e-reader display is expected to hit the market later this year.

Qingdao Hisense Communication of China and Qualcomm partnered on the Hisense C108, the first cell phone to feature a Qualcomm mirasol display that can be seen even in bright sunlight. Courtesy of Qualcomm.

Displays go organic

Other trends in display applications include using organic LEDs (OLEDs), which emit their own diffuse light without the need for an additional backlight and which can be viewed at angles up to nearly 180°. OLED revenues will grow to more than $5 billion in 2016, up from $600 million in 2008, according to DisplaySearch, with mobile phone displays continuing to lead the market with $2.5 billion in revenue in 2016. TV will be the second-largest application in 2016.

There are a number of small-size (11 and 15 in.) OLED displays available on the market, but the backplane used is costly and challenging to mass-produce.

Active-matrix OLEDS (AMOLEDS) have advantages over thin-film transistor (TFT) LCD panels for 3-D viewing because the left and right images can be separated completely, but breakthroughs in TFT backplanes and color patterning are needed to move AMOLEDs to large sizes, DisplaySearch said. The market for small sizes is gearing up, however. DisplaySearch estimates that about 20 new AMOLED production lines will be installed or upgraded in the next three years.

As with OLEDs, AMOLEDs are self-emissive (emitting their own light when electricity is applied) and very green (mercury-free). AMOLEDs have a fast response that is 1000 times better than plasma panels and TFT-LCDs. Their benefits for 3-D include the fact that the stereo images can be separated perfectly, frame by frame, sequentially. TFT-LCDs use a line-by-line progressive technique, which means there is some crosstalk, or ghost images, when there is a delay in switching the images between eyes. The less crosstalk, the better the 3-D effect.

AMOLED technology also is the next big thing in mobile displays, said Dr. Sang-Soo Kim, Samsung Mobile Displays executive vice president, in his Display Week keynote address.

The company, which started AMOLED production in 2007, announced in May that it will invest an additional 2.5 trillion won (approximately $2 billion) to develop the largest AMOLED display manufacturing plant in South Korea. The new Gen 5.5 (1300 × 1500 mm) AMOLED line will be established by 2012, with a capacity of 70,000 phone panels per month.

Kim said Samsung Mobile is forecasting the production of 600 million AM-OLED units in 2015, but added that "1 billion are possible."

One issue with AMOLEDs is their reflectivity in bright sunlight, making the screens harder to see.

Super AMOLED displays have integrated touch screens and are brighter, clearer and less reflective than normal AM-OLEDs, giving them greater visibility in sunlight. Super AMOLEDs are featured in three new Samsung smart phones hitting markets mostly outside the US this year: the Wave, the Galaxy S and the Galaxy Beam, which also includes a Texas Instruments picoprojector.

AMOLED TVs from a Gen 8 fab are on the horizon, Kim said, predicting that "AMOLEDs will be mainstream for premium TVs by 2015." One Gen 8 substrate can produce 18 32-in. panels.

In the future, AMOLEDs also could be used to create transparent displays. LG and Samsung demonstrated such prototypes during Display Week.

Into the future

So what innovations are on the horizon? Displays that can "see," said Microsoft's Bathiche. "Touch is just scratching the surface."

Two years ago, Microsoft introduced its Surface table, which resembles a coffee table-size horizontal iPad and can be found mostly in restaurants, hotels and other public venues. The technology is "a membrane that blends virtual and physical worlds," Bathiche said.

In his Display Week keynote address, Bathiche showed a video of Microsoft's vision of the future, which included wall-size transparent displays that "make you feel like you're reaching into the screen – that this person across the world is literally sitting beside you."

Osram Opto Semiconductor's Oslon LX LEDs, 1-W LEDs for backlighting LED displays, pack almost 80 percent of their light into the lightguide with the aid of an optimized lens, allowing the display to be made ultrathin and uniformly illuminated, even with single-side injection. Courtesy of Osram Opto Semiconductor.

The company is developing the technology to be bidirectional, which will allow it to recognize gestures up off the table, to re-create objects stacked up off the surface of the table and to reproduce gestures such as folding, tearing and stretching in a virtual image as though it were a real one.

"We will take virtual objects and make them feel real."

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Spectral reflectivity and interferometry for optical lens analysis

BY DAVID RIDEOUT
OLYMPUS AMERICA INC.

There are more than 500 companies in the US alone that make optical equipment. The number of products with built-in lenses is increasing. Few cell phones or personal computers are sold today without a still or video camera included. We see the predominance of microlenses in CCD arrays and the move toward the use of LED lighting as a green alternative. One day, every Christmas light might even include a lens.

Today's optical lenses are being manufactured according to ever-increasing requirements for precision, rendering easy, accurate and reportable inspection critical. In addition, industrial use of optical components is increasing exponentially, so efficiency and cost-effectiveness in manufacturing and quality control are more important than ever.

Although inspection of lenses and coatings is vital to the success of many products, quality and measurement issues must be balanced with the need to keep costs down and throughput up in a production environment. The cost/capability balance is a key driver for what instrument is used. In addition, experience shows that various technologies have particular strengths in handling specific types of lens inspections.

Today's spherical and aspherical optical lenses are inspected and analyzed for a number of features, including flatness, curvature, coating thickness, color measurement and reflectivity. Any deviation in curvature or flatness of a lens from its original design will change the focal point of the light passing through the lens and also may increase the level of spherical aberration within the optical system.

This will alter the specifications and effectiveness of the lens, changing the performance of the primary product as well, be it an LED or a camera. In addition, lens coatings continue to evolve, and the coatings themselves often require additional levels of inspection. Changes in the thickness, reflectivity or color level of a coating affect the way light is transmitted through the lens. For example, antireflective coatings absorb light – thus reducing reflection – and other coatings may change the level of static electricity being transmitted through the system. If a coating does not match design specifications regarding reflectivity, evenness or thickness, it can affect the usability of the final product.

Two technologies most often used in the inspection of optical lenses are interferometry and a type of spectroscopy called spectral reflectivity. Interferometers analyze the actual shape of the lens by examining how light entering it is refracted or reflected.

Spectral reflectivity systems allow measurement of the thickness, optical properties and reflectivity of coatings, defining the way the lens absorbs or reflects various wavelengths of light. As such, they allow manufacturers to ensure that the correct types of coating are used and that the proscribed thickness and evenness of the coating on each lens element is correct in a manufactured optical system. Both technologies address part of the overall application, but neither alone is sufficient to do a complete analysis.

Olympus has been building lenses for microscopy, endoscopy, photography and other advanced applications since 1919 and uses both technologies extensively to measure and analyze its optical products. The company builds its own spectral reflectivity and interferometry systems to meet its exacting standards for both optical performance and cost efficiency. These systems currently are not sold in the US, but there are numerous commercially manufactured inspection systems that are available to lens manufacturers.

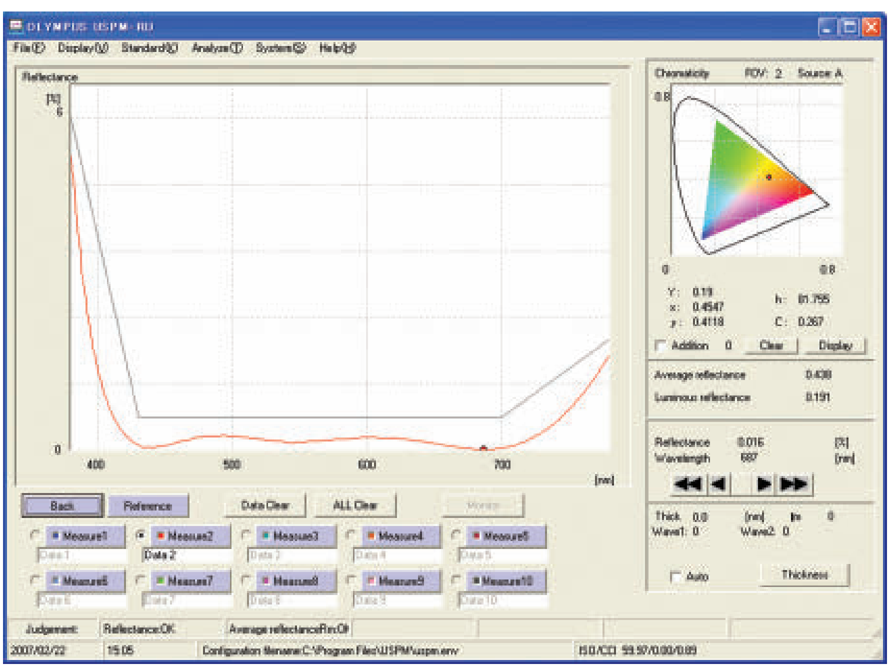

Figure 1. Spectral reflectivity is commonly used to analyze lens coatings. An Olympus USPM-RU captured this image.

Spectral reflectivity

Spectral reflectivity systems usually consist of a specialized type of microscope and custom software. The sample is struck with light at specific wavelengths, and all reflected light is analyzed. The returning light has been altered by the sample, and the alteration can be analyzed to determine the reflected or incident direction and wavelength. Analyzing the reflected spectral composition from a coated sample and comparing the data received to reference optical properties can help engineers determine the precise wavelength characteristics of a coating (Figure 1). Coating thicknesses also can be analyzed using a laser confocal microscope if the user knows the refractive index of the coating. Current software platforms can do this automatically for quick inspections.

Using the same spectral data, users can determine the thickness of the coating because spectral reflectance also is affected by the difference between the light reflected by the coating and the light reflected by the lens surfaces. Comparing thickness levels with corresponding spectral reflections provides direct correlation that can be used for measurement.

The greatest advantage of spectral reflectivity systems is that they offer nanometer- or even angstrom-level repeatability. In addition, analysis can be performed using either transmitted or reflected light, depending upon the system and the inspection requirements. One drawback in the past has been the need to avoid internal reflection from the rear surface of the lenses being examined. However, a key advantage of some more recent systems is that they allow rapid and highly accurate spectroscopic measurement of thin samples without interference from rear surface-reflected light, which was not possible with traditional spectroscopes. Thus, companies now can avoid back-side interference without incurring the additional time and cost of special sample preparation.

Interferometry

Interferometers typically are tabletop devices that use light to compare a fabricated product to a reference sample whose dimensions it is intended to match (Figure 2). Light is passed through a reference lens to the fixtured sample (lens) and then onto a reflecting mirror, where it is sent back to the receiver. When the sample image is combined with a reference image, the fringe pattern generated is used to analyze the shape of the product's optical surface.

Depending upon the specific technique

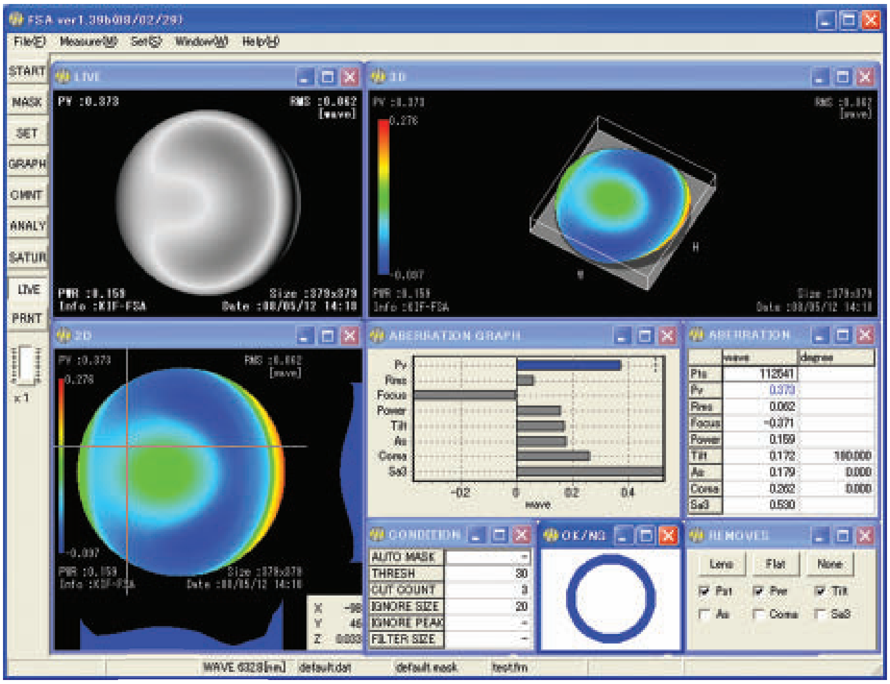

Figure 2. Lens curvature is typically inspected using interferometry. An Olympus KIF-20 captured this image.

Figure 3. As industrial use of optical components continues to expand, efficiency, cost-effectiveness and quality control in manufacturing become more important than ever. Most digital cameras today include still and video, and their lenses must be inspected carefully. The PEN E-P2 digital camera was inspected with the Olympus USPM-RU.

being used, an interferometry system may use white light or laser illumination. The instrument most commonly used for lens inspection is a laser-based technology called a Fizeau system, which typically uses a reference sample similar to the surface being inspected. Some higher-end models can accommodate both flat and spherical surfaces, but most systems do just one or the other.

The results reveal any variations in height from the theoretical smooth surface of the lens, with the user receiving both an image of the fringe pattern itself and data describing the deviation from the reference surface. Software then can analyze these differences to provide highly precise and repeatable measurement data on how much the manufactured product varies from the reference sample (Figure 2).

Importantly, because interferometers can be used to examine surfaces larger than 100 mm, entire lenses can be analyzed at one time. And interferometers can provide reproducible data below 100 nm at very low magnifications. Fizeau interferometers also have the advantage of flexibility, accommodating not only lenses but also almost any surface needing precision flatness inspection, including wafers, mirrors, solar collectors and magnetic heads.

Other surface analysis technologies are available to provide similar measurements such as profilometers and laser confocal microscopes, but each has trade-offs. Profilometers, although sometimes easy to use, can be slow and offer little beyond what the interferometer can achieve. In addition, they often feature touch probes, which can damage delicate lenses.

Laser scanning confocal microscopes provide enhanced lateral measurement and slope inspection. They are, however, usually not able to provide Z-axis measurements as precise as those offered by interferometers. And though they have enormous capabilities for a wide variety of purposes, confocal microscopes are neither the least expensive nor the easiest systems to use in a manufacturing environment. They are most often devoted to off-line engineering and research and development work, while interferometers are optimized for volume production.

Today's lens manufacturers most often use both spectral reflectivity systems and interferometers to analyze their products. For instance, a phone manufacturer might demand that the curvature of the tiny lenses in its mobile phone cameras be inspected via interferometry, while the evenness of the coatings on those lenses is verified via spectral reflectivity.

In the future, product advances may lead to further reduction of unwanted light reflecting from rear surfaces in lenses, better reflectivity for minute areas, quicker and more accurate results, enhanced measurement wavelengths and improvements in software that one day could allow a manufacturer to combine data from various lens and coating inspections for enhanced process control.

Meet the author

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Mounting Quality Counts:

Flat and Sturdy for Precision Positioning Apps

BY THOMAS BARTHOLOMÄUS AND BEDA ESPINOZA, NEWPORT CORP.

In our feature article in the March 2009 issue ("Heat & Motion Duke It Out," p. 60), we pointed out that the dominant cause of error in most motion applications is temperature, or, more precisely, temperature changes. Temperature changes hold the key to high-precision positioning applications. We discussed the fact that various materials (e.g., aluminum, granite or steel) used in a lab setup have different linear thermal expansion coefficients. For example, the changing temperatures during an experiment can create significant drift and affect repeatability or reproducibility in a motion control process due to the expansion of the optical table, the aluminum base of a linear stage or its steel lead screw, or even an overhead granite bridge.

Even though temperature change is the main source of error in motion systems, in this article we will direct our attention to other error sources that must be addressed in positioning applications. Consideration must be given to the effect of the flatness of mounting surfaces and overhanging loads on the performance of precision positioning systems.

Pitch error

Precision stages are typically machined to high tolerances. The smoothest surface profiles that maintain flatness and straightness lead to higher accuracy in motion or positioning tasks. The stages are generally tested under ideal conditions – in rooms that are temperature-controlled and on very flat mounting surfaces. Typical mounting surfaces used in metrology are granite flats with surface flatness ranging anywhere from 1 to 5 µm.

In reality, as opposed to the controlled testing environment, the most common mounting surface is a vibration isolation table with stainless steel skins. The table's surfaces are usually ground with a pattern of drilled and tapped holes spaced 25 mm along the length of the table. A honeycomb network of ribs separates the top and bottom steel skins, providing stability and rigidity to the table. The honeycomb is glued into place as the skins are squeezed between flat platens. The overall flatness of the table depends on the flatness of the platens, and the local flatness depends on the quality of the drilling and tapping operation. Typical flatness of honeycomb-structured tables is on the order of ±0.10160 mm over 0.60960 m, or about 16 µm per 100 mm.

Figure 1 illustrates a linear stage mounted directly onto a surface with a flatness of 5 µm over 100 mm of travel. The resulting deformation of the stage bearings introduces a pitch error on the stage as an object moves from left to right. Based on the geometry shown, the resulting pitch is 100 µrad over 100-mm travel.

Referring to Figure 1 again, the sample is either 100 mm above the theoretical plane of the drive screw that may have a motor-mounted rotary encoder or above the plane of the linear encoder. Because of the induced pitch error, the point of interest is now ahead by 10 µm (100 µrad × 100 mm). Of course, the closer the sample is to the measurement plane, the less pitch error effect there is.

In this case, 5-µm flatness introduces a pitch error of 100 µm. For a less flat table, the pitch error can only become worse.

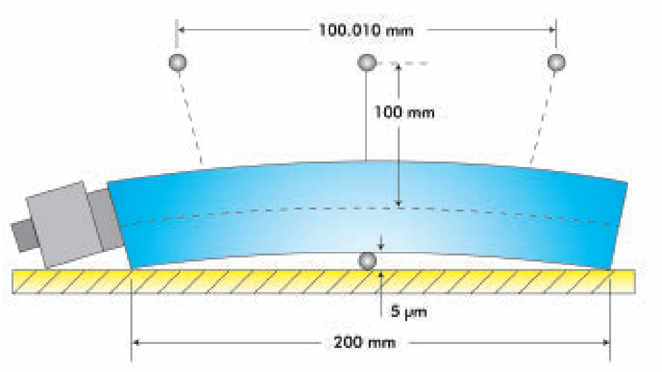

Figure 1. Depicted is a 200-mm stage on a nonflat surface. For sectors and chords, the angle (α) can be derived with the following formula: $\alpha = 8 \times h/L = 8 \times 0.000005/0.2 = 200$ µrad = >100 µrad for 100-mm travel.

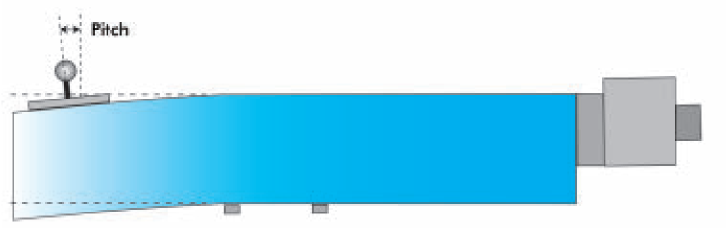

Figure 2. If a stage is not fully supported, pitch errors can occur when a load moves toward the unsupported side of the stage.

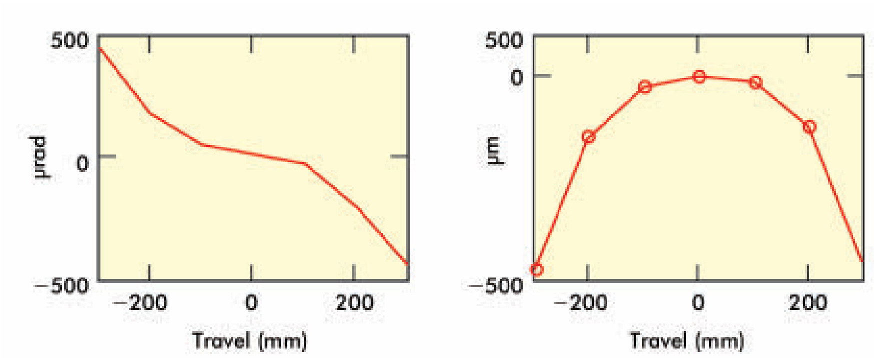

Figure 3. In this example, a 450-μrad pitch error equals a 45-μm linear error.

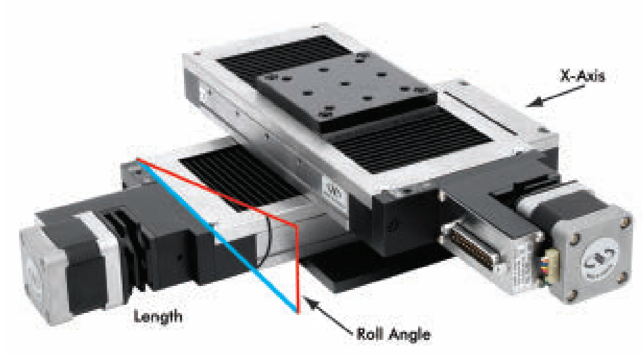

Figure 4. In this example, travel is ±250 mm, the load on the Y-stage is 5 kg, the stiffness constant (kαx) = 1 μrad/N-m, and the roll angular deviation due to load overhang is 12.5 μrad (1 μrad/N-m × 50 N × 0.25 m). At the extreme end of the Y-stage, the roll is ±12.5 μrad, and the flatness is 3.13 μm (12.5 μrad × 0.25).

To eliminate the effect of nonflat surfaces, a number of solutions are available, if one has a steel table. Mounting stages on granite bases with flatness of 5 μm or less (available from Newport Corp.) and placing the granite base on the table will reduce the effect of the lack of table flatness. Another method is to use three-point kinematic supports under the stage, which defines a perfect plane, thereby eliminating distortions. However, the precision stage in this condition must be very stiff, with enough rigidity to handle the unsupported sections of the stage.

Base support and load distribution

Another source of error is the amount of support underneath the precision stage. Ideally, the base of the stage is fully supported, so the load is distributed through the bearing elements into the base and evenly over the mounting surface. In Figure 2, a 600-mm stage is supported only at the middle of travel. As the 60-kg load is moved to the extreme ends, the load induces a pitch error.

The left graph in Figure 3 shows a pitch error of 450 μrad. Using simple geometry with a sample at 100 mm from the measurement plane, this equates to a 45-μm linear error at each end of travel, as shown in the right graph.

A specific case of load distribution is on X-Y stacks where the load can cause angular deviations as the center of gravity moves beyond the bearing support of the lower X-stage, in the overhang region (Figure 4). Usually for high-precision products, stiffness constants are provided by experienced suppliers of motion products. In this example, the angular deviation constant around the X-axis, kαx, equals 1 μrad/N-m.

When the 5-kg load is moved to the extreme position of the Y-axis, the resulting roll angle deviation to the X-axis is 12.5 μrad. Similar to the effect in Figure 1, this angular deviation acts as a pitch error effect on the Y-axis. Also, this roll angle equates to a flatness of 3.13 μm. With an X-stage that has a wider base, the angular deviation constant will be smaller, so the effect of overhanging loads is less.

It is clear from our discussion that attention must be paid to the quality of the surface to which a precision stage is mounted, preferably 5 μm or better. Consider also fully supporting the stage and the width of the bottom stage to reduce the angular deviation effect. All these considerations will ensure achievement of the performance specified by the precision stage manufacturer.

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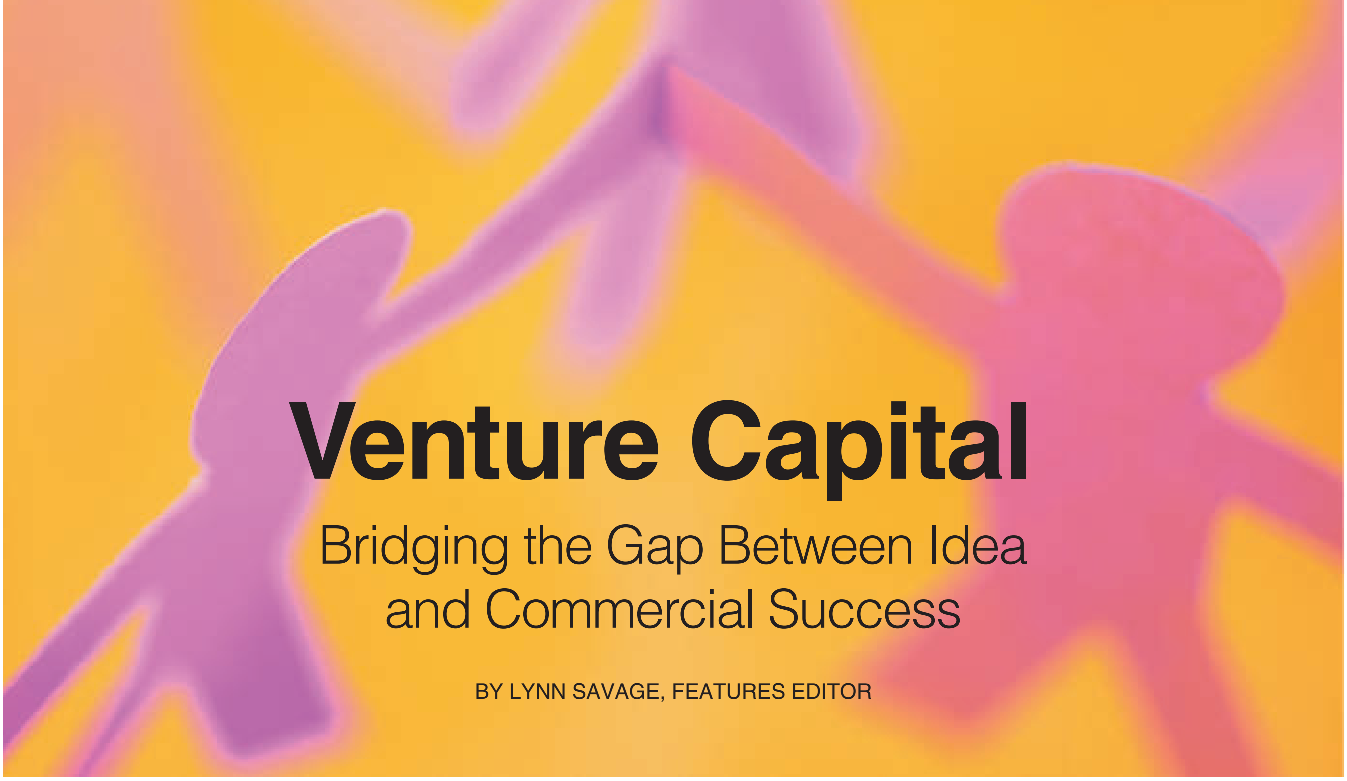


Venture Capital

Bridging the Gap Between Idea and Commercial Success

BY LYNN SAVAGE, FEATURES EDITOR

After years of sweat, toil and heavy thinking, you and your colleagues have done it – created the Next Big Thing. Now all you have to do is start a company and hold the door open for the line of customers who will march through. With any real luck, you can walk away from the tenure track and the grind of academe!

Not so fast, friend. How are you going to pay for those dreams?

If you want to open up a candy store or other small business, a traditional local bank is your first choice. If you have a dynamic new technology that will change the industry in a major way, however, you need more than what the local bank can offer. You have to pay for equipment, real estate, personnel and much more to transform your breakthrough into a workable commodity and then get it into the market. There are several ways to generate the funds to develop a technological breakthrough into a viable business, but none are as promising – or demanding – as venture capital (VC) organizations.

It takes more than promising candidates, however, to convince VC companies to hand out money. Instead, exhaustive vetting processes are used to put the applicants through their paces.

According to the National Venture Capital Association (NVCA), based in Arlington, Va., member companies may identify 10 potentially good fits for every 100 business plans submitted. Of these 10, though, only one will survive the due diligence process and get funded.

Neil Cameron, materials sector specialist at Emerald Technology Ventures in Toronto, said, “The cost of capital for VC equity is high, so it is important that every dollar invested creates significant value.”

Emerald Technology Ventures focuses on clean-tech companies that work in the energy, advanced materials and water-related market segments.

In addition to gaining the cash to start his business, the entrepreneur gets something more from the VC company: its full attention. To safeguard their investments, VC institutions take on an everyday role in a nascent company, typically assigning one of their own to the company’s board of directors, then helping to find savvy upper management people who can drive the new firm forward.

The NVCA notes that any technological concept that promises an incremental improvement on existing products is not likely to make VC companies open their hearts or their wallets. This can be detrimental to would-be entrepreneurs coming out of academia, who are accustomed to working in small steps, writing and publishing papers that herald incremental successes.

Who gets funded?

“We are looking for passionate, industry-savvy management and technical teams with disruptive technologies addressing clean-tech market,” Cameron said. No matter what the market, it seems, these are the general qualities being sought after by VC organizations.

At the Invest in Photonics event held in March in Bordeaux, France, some two dozen applicants sought a share of €30 million ($36 million) in available funds. The criteria that the applicants had to meet were as follows:

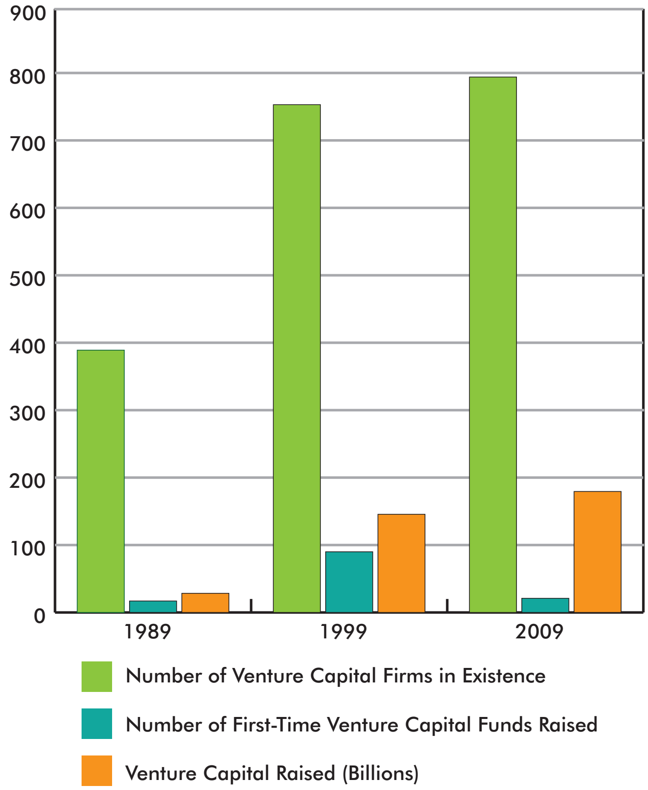
- Relevance to photonics industry
- Size and growth potential
- Novelty of their product or application
- Viability of business model
- Coherence between their 5-year business plan and the amount of funding sought
- Management strength

David Gold of Access Venture Partners (AVP) in Westminster, Colo., said that firms typically look for tech companies that already have some polish, but that his own company looks for entities that have the foundation of a great business but might yet have a few rough edges.

This philosophy led AVP to work with TerraLux, an LED innovator based in Boulder, Colo. Started by Anthony Catalano in 2003, TerraLux has developed an intellectual property portfolio centered around replacement modules for portable lighting devices, such as surgical lighting and flashlights. Writing in his blog, *Green Gold*, Gold stated that when Catalano was presented with the ability to move from strictly portable lighting improvement to general lighting OEM work, AVP saw past the uncertainties and provided TerraLux with a “modest” bridge investment.

AVP then helped refine TerraLux’s market strategy, enhanced the company’s operations, enabled a professional accounting system, implemented its first financial plan and recruited its CEO Jim Miller.

On March 22, TerraLux announced that it had closed on an additional $5.6 million round of financing – a round that included the



Venture capital experienced steady growth until the tech industry bubble burst in 2000, but the funds are still out there to be tapped by entrepreneurs. Data courtesy of Thomson Reuters.

participation of both AVP and Emerald Technology Ventures.

"[TerraLux's] team and products are addressing a small but very rapidly growing market – conditions that favor venture-grade return on investment," said Emerald's Cameron.

From the other side

OneChip Photonics Inc. of Ottawa also recently secured a new round of funding, bringing total investment in the company from VC sources to $19.5 million. The company works with BDC Venture Capital, GrowthWorks Canadian Fund, DCM and Morgenthaler Ventures. OneChip is developing what it terms the world's first passive optical network transceivers based on fully integrated photonic integrated circuits, or PICs.

According to Steve Bauer, OneChip's vice president of marketing and communications, the company has faced a lot of industry skepticism over its technology.

"Therefore, our biggest challenge has been convincing prospective investors and customers that OneChip has what it takes to build these extremely low-cost, high-performance photonic ICs," he said.

Bauer attributes some of the company's success at attracting four venture companies to the experience of OneChip's CEO, Jim Hjartarson, who previously co-founded the company Catena Networks. The achievements of that company, which also was backed by Morgenthaler Ventures, carried over into OneChip's foray into venture capitalism.

The prerequisites for funding remain unchanged, Bauer agreed. "You must have a breakthrough technology, a large market opportunity, a strong and sustainable proposition and business plan, and an experienced management team with a successful track record."

Getting out

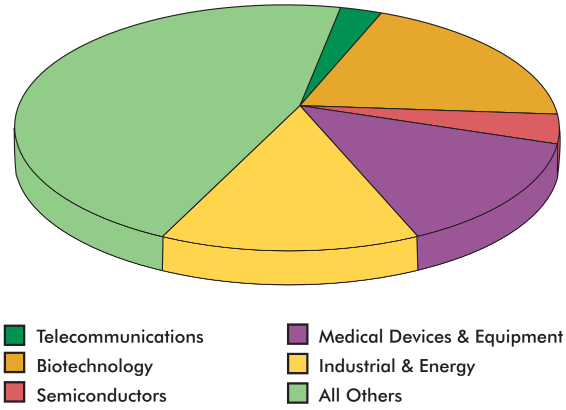
Venture capitalists are well agreed on one point: They don't want to work with your new company forever. After five to eight years or so, they want to collect on their investment.

In the past couple of years, the economic state hasn't been kind to VC companies and their charges. In an interview with *Mass High Tech*, Emily Mendell of the NVCA said that the "real challenge is the exit market – to either go public or get bought – and that part has stalled." Still, building an exit strategy is an important part of starting and running a new tech company. If nothing else, having one shows the VC that you are focused on the realistic prospects of your technology and your people.

Nonetheless, only one in six VC company clients eventually goes public, and one in three is acquired. More outright fail than go public. This is the high risk that gives investors indigestion.

Most indicators of VC success continued to drop from 2008 to 2009, following a trend begat by the tech bubble popping in 2000 and collapsing in 2001. This year has showed some promise for a return to better news, but worries over the euro and the financial status of Greece, Spain and other countries have retightened the flow of funds and choked off investments. The analytical organization Thomson Reuters reported recently that fund-raising as well as exits via initial public offerings or acquisition will stay challenging through the rest of 2010. The group maintains, however, that there are still eager venture capitalists prowling the markets for suitable investment opportunities.

The life sciences area, including medical devices, remains strong, but clean tech (LEDs, solar, etc.) is the "most visible emerging sector," according to Thomson Reuters. Nonetheless, even this promising area dropped from $4.116 billion across 290 deals in 2008 to $2.170 billion across 209 deals in 2009.



In 2009, most investments from venture capital firms went to industries with a strong photonics presence.

The drifting market for raising capital puts much of the onus of initiating and cementing deals onto the entrepreneur, even as he or she makes those first tentative steps toward growing an organization around a new technology.

"Building a company by bootstrapping may not be as sexy as raising a large venture round right out of the shoot," said Access Venture Partner's Gold, "but the discipline it instills to focus on customers and revenues can create some of the most exciting real businesses in the long run."

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ADDING FIBER PAYS OFF FOR INDUSTRY

BY HANK HOGAN
CONTRIBUTING EDITOR

For Electro Scientific Industries Inc. (ESI) of Portland, Ore., getting fiber into its diet has been one key to success.

Among other things, the company makes a line of micromachining systems for the semiconductor, flat panel display, photovoltaic and other industries. Some of these systems are powered by fiber lasers, a technology in which a fiber doped by rare earth elements, and typically pumped by a diode, acts as the lasing medium. The choice of when to go with this approach over an alternative depends in part on what is being machined and where the system will be used.

"We deploy fiber lasers in places where we require, predominantly, high average power, and we want industrial robustness that extends well beyond a year," said Jeffrey Albelo, ESI's general manager for interconnect and micromachining.

As the ESI example shows, fiber lasers are being used for cutting, marking and other materials processing. They also are showing up in lidar and other applications. Their efficiency, compactness, relatively high power and ruggedness often make them the laser technology of choice – provided the wavelengths offered match the wavelengths needed.

Recent advances promise new fiber laser capabilities, including the ability to engineer polarization modes not possible before. A look at these and other developments reveals some of what is in store for the technology, the industry and applications.

Going down … and up

With increasing peak power and repetition rates, fiber lasers are moving into applications that were handled in the past by other technologies at ESI. In part, according to Albelo, that is because fiber lasers are not only more robust but generally cheaper on a per-watt basis than YAG lasers, the other solid-state laser technology used by the company. The company does a lot of beam conditioning in its products, so another plus is that fiber lasers are very amenable to software manipulation.

One of ESI's products, for example, puts two fiber lasers to use, combining them with precise positioning to increase machining speed. The wavelength of the lasers is about 1 µm, which is appropriate for the metallic features the system is designed to handle.

But today, fiber lasers aren't the answer to all of the company's needs. When asked what he wants, Albelo replied, "The answer is very easy: ultraviolet."

In general, he said, shorter wavelengths allow more efficient coupling of laser energy into the material being processed. Thus, a fiber laser with power in the ultraviolet would be helpful, as would one with a polarized beam and a higher repetition rate. Of course, Albelo wants these advances without sacrificing any of the current advantages offered by the technology.

The request for lower wavelengths is one that the industry is aware of and is trying to meet, said William S. Shiner, vice president of industrial products at high-power fiber laser leader IPG Photonics Corp. in Oxford, Mass.

"We're already at 532, which is a visible green. We've already frequency-doubled that to the UV. We just haven't released product yet," he noted.

Although efforts aimed at creating an efficient UV fiber laser are under way, the technology has undergone growth in other areas. Steve Norman is chief technology officer at SPI Lasers in Southampton, UK, a wholly owned subsidiary of the Ditzingen, Germany-based Trumpf Group. He noted that his company's products have seen a steady increase in power over the past five years.

"We've power-scaled from 50 to 100 W to 200 to 400 W. We're now in volume production with 400-W products," he said.

The latter power can be ganged together to create multikilowatt systems, with that power being used to speed materials processing. The trade-off for achieving higher power in this way involves an increase in the number of modes. However, in many

A fiber laser cuts silicon. Courtesy of SPI Lasers.

high-power cutting and welding applications, a multimodal beam is preferred, in part because it produces a more uniform distribution of energy on the workpiece.

There's an app lab for that

Besides power or wavelength, other parameters that can be tailored to an application involve pulse characteristics. Marking plastic, for example, may work best by using relatively low pulse energies delivered at a higher repetition rate and by using a predetermined waveform. All of these settings can differ from those that are best when working metal.

Figuring out the right laser setup can be a challenge. That's one reason SPI runs application labs in both the UK and in Santa Clara, Calif. Equipped to do cutting, welding, scribing and analysis, these sites do research and development to prove new application feasibility and to optimize processing parameters.

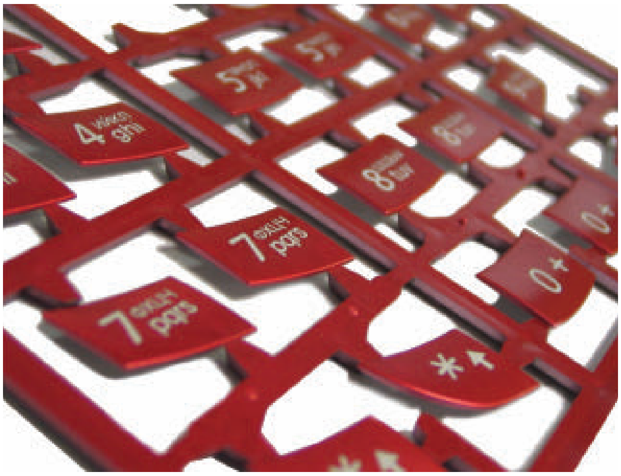
Meeting this type of need lies behind a Portland, Ore., micromaterials processing facility established by ultrafast fiber laser maker Fianium, which also is based in Southampton. The applications lab is located within and run by Summit Photonics, which offers third-party photonics engineering services.

The partnership between the two was announced last year, but the site was only fully equipped and operational in May of this year. Colin Seaton, global vice president of sales and marketing at Fianium, noted that much of the initial investigations into materials processing with picosecond lasers has been done with "scientific-type setups," systems that offer vendors such as Fianium an opening.

"We've got the benefit of cost, complexity and reliability that the fiber laser brings, compared to those other types of systems," he said.

As for the applications that might be done at the lab, Summit's managing director, Brian Baird, noted that there is a broad area of interest in picosecond processing of semiconductors and thin films. He gave a talk at Photonics West this year in which he pointed out that wafer scribing, silicon micromachining, laser marking and thin-film trimming are all possible areas where the technology could be used.

"Those areas requiring high repetition rates and good precision in the beam quality and pulse energy delivery are prime candidates for being in picosecond laser products," he said.



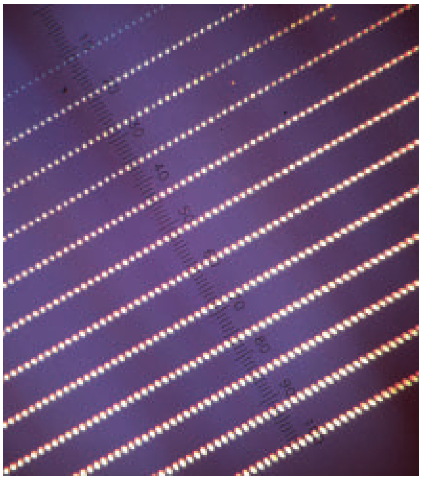
With the right settings for power, repetition rate and pulse waveform, fiber lasers can mark metals or plastics, as has been done with the parts shown here. Courtesy of SPI Lasers.

Remote sensing

There are, of course, industrial uses of fiber lasers that don't involve materials processing. One example can be found in lidar, an application being pursued by Keopsys SA of Lannion, France. The company's products are used for laser ranging systems that measure distance to a point and wind speeds of the air, or do 3-D scanning of an object. This is done using wavelengths that range from 532 nm to 2 µm.

Fiber lasers are well suited for lidar for a number of reasons, said Keopsys' vice president and founder Jean-Marc Delavaux. "The two most important are they're lightweight and [have] low energy consumption."

Keopsys touts its V-groove side-pumping approach, which leads to a one-step coupling process of the diode pump laser into the double-cladding gain fibers used in the company's lasers. Keopsys believes that this gives its products a 90 percent coupling efficiency, which it asserts is significantly higher than would be possible otherwise. That, in turn, helps lower power consumption and improves performance in lidar and other applications.



Processing silicon for solar cells could benefit from visible picosecond fiber lasers, as shown here with this run of the effects of 532-nm picosecond pulses on silicon-nitride-coated photovoltaic-grade c-silicon. Pulse energy increases from upper left to lower right. Courtesy of Brian Baird, Summit Photonics.

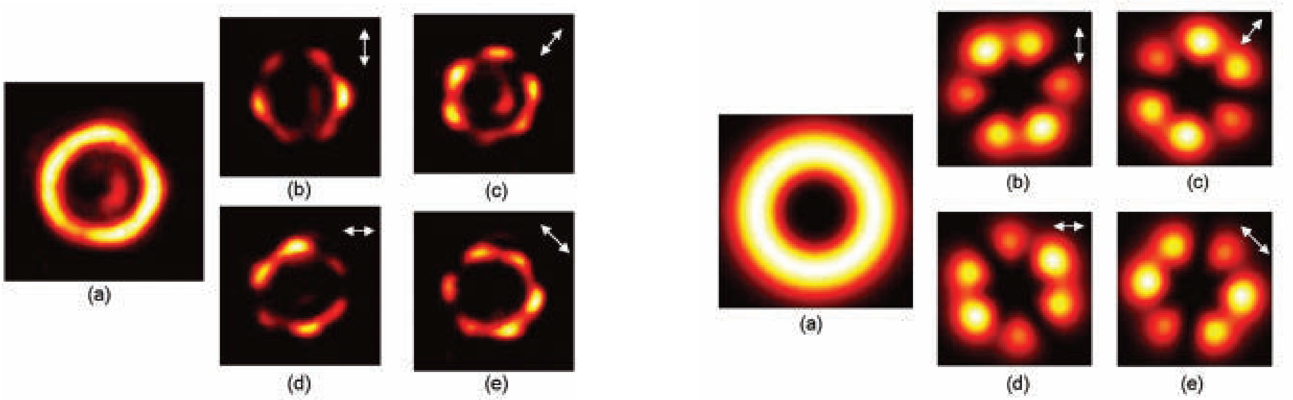
Putting polarization to work

Finally, recent research has shown that fiber lasers in the future may have another knob that can be adjusted. Researchers from the University of Dayton in Ohio recently reported on a fiber laser with an adjustable polarization output. In a May 10, 2010, *Optics Express* paper, Qiwen Zhan, associate professor of electro-optics, and his team described a specially designed laser cavity. By combining that with a uniaxial c-cut calcite crystal, they created a cylindrical vector beam with cylindrical polarization symmetry.

Such polarization is different from the traditional variety, which is typically either linear or circular. This nontypical polarization, and the ability to adjust it, could prove useful in optical tweezers and in micromachining, Zhan said.

In both cases, cylindrical vector polarization has been shown to yield better results than the traditional variety. Also, in both cases, the best polarization depends upon the task, so being able to adjust parameters as needed is important.

Zhan said the choice of fiber is critical in the group's research because the fiber determines how many polarized modes



Experimental results are shown of a complex vectorial mode created using a fiber laser (left), with numerical simulation results (right). (a) The intensity profile of the output mode; (b)-(e) the beam intensity profiles after a linear polarizer (transmission axis indicated by white arrow), show the different modes. Courtesy of Qiwen Zhan, University of Dayton.

can be supported in the laser cavity. The crystal is key to selecting and producing the reconfigurable vectorial output.

In their demonstration device, the researchers showed that modes with radial, azimuthal and generalized cylindrical vector polarizations could be generated by translating one lens within the laser cavity. They also showed that more complicated vectorial vortex output modes could be created by introducing some angular misalignments into the setup.

Transforming these lab results into products will require improving the output power to something over 1 W in continuous-wave operation, Zhan said. His research plans also call for exploring Q-switch, mode-locking, frequency conversion and other operation modes. He also intends to investigate more complicated vectorial modes.

Eventually this could lead to a new type of device, and it is one that Zhan believes he can build, given the right funding.

"The ultimate goal is to achieve a compact all-fiber high-power fiber laser producing reconfigurable vectorial mode outputs. I already have a strategy to achieve this," he said.

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THE

Ti:SAPPHIRE LASER:

FROM RESEARCH TO INDUSTRY AND BEYOND

BY JULIEN KLEIN
SPECTRA-PHYSICS

Since their invention in the early 1980s, titanium-doped sapphire ($Ti:Al_2O_3$ or Ti:sapphire) lasers and amplifiers have enabled countless applications in fundamental research in physics, biology and chemistry. Today, they play an important role across a wide range of photonics applications, including multicolor ultrafast spectroscopy, multiphoton deep-tissue imaging, terawatt and petawatt physics, and "cold" micromachining.

The first reported Ti:sapphire laser operation was performed in June 1982 by Peter Moulton at the 12th International Quantum Electronics Conference in Munich, Germany.[1] It was the first time Ti3+ was used as the active ion for laser gain. In 1998, Spectra-Physics offered the first commercial Ti:sapphire laser, a broadly tunable continuous-wave model and, in late 1990, the first ultrafast Ti:sapphire laser, a picosecond mode-locked oscillator. Soon thereafter, the ultrafast and tunable laser communities quickly replaced their cumbersome dye lasers with the popular argon-ion-pumped Ti:sapphire systems, resulting in a sudden paradigm shift rarely seen in research.

During their quick ascension in popularity, these laser systems continued evolving with the introduction in the mid-1990s of tabletop commercial amplified systems based on chirped pulse amplification techniques and, in 1996, with the Millennia, a high-power diode-pumped solid-state (DPSS) 532-nm laser. The use of DPSS lasers over argon-ion lasers as the pump significantly reduced the complexity of ultrafast setups and drastically reduced the amplitude noise, a key improvement for demanding femtosecond spectroscopy experiments (Figure 1).

Since then, a complete set of accessories has been developed to support and complement Ti:sapphire lasers. Optical parametric oscillators and amplifiers can extend wavelength tunability to access the deep-UV (<200 nm) and mid-IR regions (>20 µm). Such spectrally agile tools have proved invaluable for multiwavelength time-resolved spectroscopy.

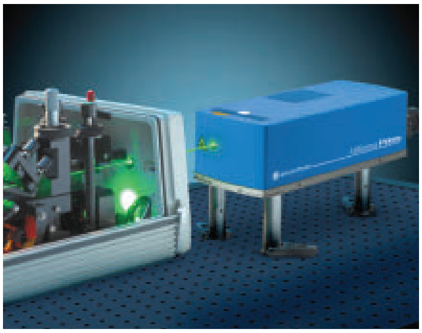
Figure 1. Shown is a diode-pumped solid-state laser pumping an ultrafast Ti:sapphire laser.

Compared with other competing media, the Ti:sapphire medium is extremely flexible and provides high performance and several advantages. It is unmatched in its characteristics for delivering a combination of broad spectral bandwidth, a range of repetition rates, wide tunability and high-average-power levels. Spectral outputs of Ti:sapphire lasers range from ultranarrow single frequency to several hundred nanometers of bandwidth, resulting in ultrafast pulses as short as a few oscillations of the electric field at 5.5 fs. At the same time, repetition rates can range from single-shot output for maximum energy up to multigigahertz quasi-CW output with tunability of 400 nm and average powers of many watts.

As the push for even shorter, almost single-cycle pulses and high-precision optical metrology gained momentum, an important development was the stabilization of the carrier envelope phase (CEP), which paved the way for the generation of attosecond (10^{-18} s) pulses in the x-ray spectrum through high-harmonic generation. Attosecond laser sources are extending the frontier in probing dynamic molecular processes with unprecedented time resolution.

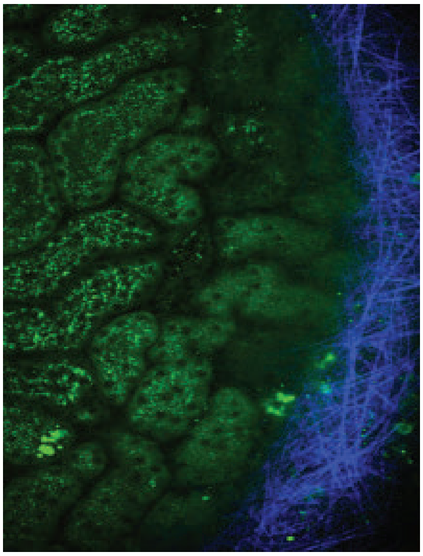
Figure 2. This image of a mouse kidney, in vivo, using second-harmonic generation (SHG) imaging for collagen (blue) and autofluorescence signal (green), was taken using a Spectra-Physics Mai Tai eHP DeepSee ultrafast laser. Courtesy of Dr. Claudio Vinegoni, Center for Molecular Imaging Research at Massachusetts General Hospital, Harvard University.

CEP stabilization also plays a critical role in optical frequency metrology, where an octave-spanning CEP-stabilized ultrafast oscillator can be used as a frequency comb. Frequency combs are accurate "optical clocks" and can measure optical frequencies with extraordinary precision. This work was honored with the 2005 Nobel Prize in physics, which was awarded to

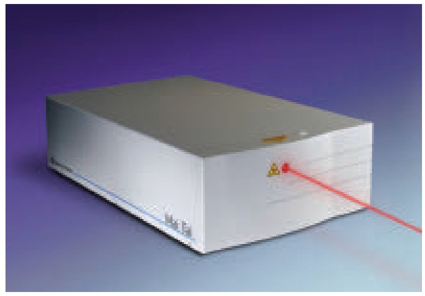

Figure 3. Pictured is the Mai Tai laser from Spectra-Physics.

Theodore W. Hänsch and John L. Hall.

In chemistry, Ti:sapphire laser systems are used to study chemical reactions on ultrafast time scales. Ahmed H. Zewail received the 1999 Nobel Prize in chemistry for his pioneering work in the transition states of chemical reactions using femtosecond spectroscopy. Recently, the field of coherent control has grown increasingly sophisticated, and devices to control and measure the spectral phase and amplitude of the ultrafast pulses have been developed.

In biology, Ti:sapphire lasers are instrumental in multiphoton microscopy (MPM), which has developed into the leading noninvasive laboratory tool for studying underlying biological phenomena. It offers high-resolution three-dimensional imaging in thick tissues, including in vivo specimens. Because MPM inherently relies upon a nonlinear process – two-photon absorption – it requires a high peak power, which at first limited the practicality of MPM in the absence of easy-to-use, tunable femtosecond lasers. The intensity of the laser required for an adequate signal would have damaged the sample.

However, a breakthrough occurred in 1990 when Winfried Denk, James H. Strickler and Watt W. Webb used a femtosecond dye laser in the first successful demonstration of MPM.[2] Because of the combination of ultrashort pulses and low duty cycle, these ultrafast lasers offered high peak powers with low average power – the ideal combination because lower average powers eliminated thermal damage issues. The lasers were cumbersome and difficult to maintain, and they required multiple mirror sets and adjustments.

It was not until the recent advent of turnkey, hands-free, commercially available, diode-pumped Ti:sapphire lasers such as the Spectra-Physics Mai Tai that MPM became more practical. The ex-

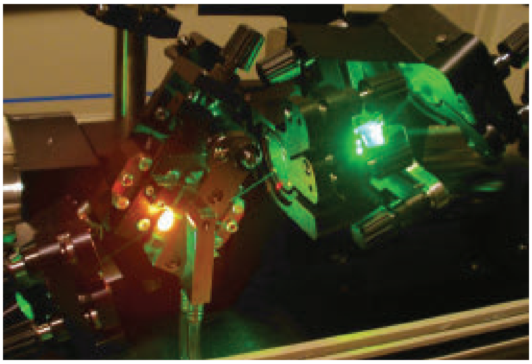

Figure 4. This Spectra-Physics Tsunami oscillator is being pumped by a Millennia laser at 532 nm. Courtesy of Lund University in Sweden.

tended tunability of these lasers has enabled the use of various dyes with distinct absorption spectra and chemical properties. Because in MPM the nonlinear signal is generated only in a small volume centered at the focal point of a tightly focused beam, the "out-of-focus" signal is greatly reduced compared with single-photon fluorescence microscopy – giving MPM automatic sectioning capability for deep imaging of live tissue (Figure 2).

Additionally, the Ti:sapphire laser has been instrumental in fields such as nonlinear physics and terahertz generation. It also is being used for cold micromachining, where the cutting, drilling and scribing are free of undesirable thermal effects.

Indeed, the Ti:sapphire is unsurpassed in its extraordinary breadth of performance and resulting diversity of applications. In particular, its ability to generate ultrafast pulses and wide wavelength tunability enable unprecedented advances across a range of disciplines in science, industry and beyond.

Meet the author

Julien Klein is senior manager of product marketing at Spectra-Physics, a Newport Corporation Brand in Santa Clara, Calif.; e-mail: julien.klein@newport.com.

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LIA
Becoming the Laser Institute of America

BY PETER BAKER
LASER INSTITUTE OF AMERICA

As just about everyone knows, American physicist Theodore Maiman fired the first laser in May 1960 in Malibu, Calif. What is less well-known is that, in February 1968, also in California, Maiman and other laser pioneers founded the Laser Industry Association to advocate for these endlessly fascinating tools. That group would become the Laser Institute of America (LIA) in 1972.

What began as a modest venture by the late publisher William Bushor has grown into the industry's leading voice for furthering the reach of lasers and their safe use. Bushor and LIA's first president, Arthur Lubin, recruited LIA's first board of directors, which included Maiman, Stanford University professor Arthur L. Schawlow and 10 other visionaries.

LIA's original directors were an august group, and their devotion to the power and potential of lasers set the tone that guides the organization to this day. Consider Schawlow, who went on to win the 1981 Nobel Prize in physics for laser spectroscopy. His playful demonstrations – putting a blue balloon inside a clear one and firing a laser to pop the balloon inside, or his efforts to create a laser out of Jell-O – led to our understanding of laser absorption and to innovations such as the distributed feedback laser.

Gordon Gould, LIA's third president, coined the term "laser" (light amplification by stimulated emission of radiation) and battled for decades to secure the patents for the inventions that led to his induction into the National Inventors Hall of Fame.

Springing from that lineage, LIA continues its mission "to foster lasers, laser applications and laser safety worldwide."

Early leaders of the Laser Institute of America gather in Orlando, Fla., in 1989. Top row, left to right: Bob Goldstein (1984 president), Warren Stevenson (1989), Milton M.T. Chang (1985), Fred Burns. Bottom row: Peter Baker (1987), Michael Bass (1988), Prem Batra and Sid Charschan (1980). All are LIA Fellows, and all except Fred Burns and Prem Batra are LIA past presidents.

LIA's purpose

As executive director of LIA since 1988, I have marveled at the organization's growth and expanding reach. I believe in offering our best contributions as good citizens of the world to further sustainable energy, manufacturing efficiency and user safety. Our purpose remains consistent across all the courses, workshops and conferences that we have created or co-sponsored, as well as the publications we offer. LIA's founders delineated its primary purposes as:

- To disseminate laser-related information and data in publications and symposia.
- To promote, conduct and sponsor/co-sponsor events related to laser subjects.
- To develop and present short courses, programs and curricula for training.
- To act as a focal point for collecting and disseminating data, inquiries and statistics regarding the laser community with regards to applications, safety, research and development.
- To act as a liaison with other organizations in the advancement of laser technology.
- To assist federal and state government agencies to enact legislation relating to the safety of laser products.

Meeting all those goals is a tall order. Sweating the details while simultaneously

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1 ☐ My principal job function is: (Please insert one letter only.)

Engineering- and Science-Related
- A research & development
- B design
- C application
- D manufacturing or production
- E measurement (testing, quality control or safety)
- F other engineering or science function (please specify) ____________

Management- or Business-Related
- G corporate
- 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)

7

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focusing on big-picture ideals and broad strokes is never easy, especially when trying to maintain the level of excellence LIA expects, and when faced with enormous obstacles such as the "great recession." But if our organization's pioneering founders taught us anything, it's that we continue our work because of our passion for progress in the face of the inevitable hurdles.

LIA prides itself on its reputation as a recognized and trusted global organization. It was former President David A. Belforte's initiative to establish a US-Japan conference on industrial laser applications that led LIA to create the International Congress on Applications of Lasers and Electro-Optics (ICALEO). This industry-leading show is nearly 30 years old and continues to bring the best and brightest minds together to create the future of laser applications.

We have since added the Pacific International Conference on Applications of Lasers and Optics, or PICALO, and the International Laser Safety Conference. Furthermore, we're holding our second annual Laser Additive Manufacturing Workshop, and we co-own the Automotive Laser Applications Workshop with the Fabricators and Manufacturers Association International. We also collaborate with Laser Zentrum Hannover and the Laser Processing Committee of the Chinese Optical Society on a China-specific laser-processes conference.

Among the many and varied societies and organizations with which we cooperate are the Association of Perioperative Registered Nurses, the American Welding Society and the Academy of Laser Dentistry.

One of LIA's proudest moments was signing up to work with the Occupational Safety and Health Administration (OSHA) as a partner in the OSHA Alliance to foster safer workplaces. We have trained many OSHA inspectors so that they know how to be effective when they visit establishments where lasers are being used.

On a smaller scale, we have shared information with the FDA regarding lasers and radiological health and have written a brief to help Texas lawmakers revamp their safety regulations. We offer a virtual avalanche of programs for safety officers in medicine, research and industry, ranging from a one-day safety overview to a five-day training course. Of course, LIA also makes its expertise available in online safety courses, and this year it has produced a laser-safety DVD called *Mastering Light*, which helps safety officers teach their own people.

Stanford University professor Arthur L. Schawlow, speaking to a group in Orlando, Fla., in 1989, was one of the first members of LIA's board of directors.

Meanwhile, our publications run the gamut from the *LIA Today* newsletter to a comprehensive series of American National Standards Institute (ANSI) Z136 laser-safety standards. LIA has been publishing the peer-reviewed *Journal of Laser Applications* for more than 20 years and also spreads its message via *Laser Systems Europe*, in partnership with the publishing company Europa Science Ltd.

Attendees of the 2008 International Congress on Applications of Lasers and Electro-Optics in Temecula, Calif., listen to a talk.

LIA's future

It has been my hard-won experience that advances in laser technology can take much longer than anticipated to achieve widespread acceptance. I have witnessed firsthand the lag time in adoption of innovations such as laser marking and resistor trimming. Applications I thought would be adopted within five years often took 15 or 20 to become widespread.

Milton M.T. Chang receives the Schawlow award from Michael Bass in Orlando, Fla., in 1989.

Treasurer Fred Burns receives a Fellow plaque from President Warren Stevenson in Orlando, Fla., in 1989.

Perseverance pays off, however. Look at where we are today: Lasers are everywhere, performing indispensable functions in shipbuilding, medical devices, photovoltaics, and the automotive and aerospace industries. A new generation of researchers doggedly pursues further innovations as we seek alternative energy sources and more efficient, cost-effective manufacturing processes.

Companies such as Trumpf Inc. and IPG Photonics Corp. are pushing the boundaries of what lasers can do. The excellent beam quality, reliability, versatility, power and efficiency of today's lasers have opened up new areas of application.

As we work to help our industry achieve its true potential in the 21st century, I am guided by a principle that former President Bill Clinton discussed in an interview with Newsweek. While maintaining the view that we are globally interdependent, he said that he frames his decisions and approaches on whether the issues confronting him create positive – or decrease negative – interdependence.

In 1960, the only laser was right here in Malibu. We had the whole market and all the knowledge. Now, lasers are made and applied worldwide. It is incumbent upon the LIA, our members and our partners to understand mutual needs and goals – to create positive or decrease negative interdependence – as we work to fulfill the promise that laser technology offers.

Meet the author

Peter Baker has been the executive director of the Laser Institute of America for 21 years. He has been involved with lasers and applications since 1967 and designed his first laser in 1970. He has served in various senior management roles in the laser industry, including as president and CEO; e-mail: pbaker@laserinstitute.org.

LASER TECHNOLOGY: THE NEXT 50 YEARS

BY JOCHEN DEILE
TRUMPF INC.

If one reviews what happened in the first 50 years of the laser's history, it becomes quite a challenge to predict what will happen in the next 50. Lasers went from being called "a solution in search of a problem" to becoming an integral part of many aspects of our daily lives. Today, lasers are used for diverse applications in fields such as materials processing, telecommunication, medicine, defense, science and astronomy, sensor technology, data storage and entertainment.

Within the first few years of the laser's invention five decades ago, many of the types of lasers that we use today had already been demonstrated.

The future starts yesterday

No matter how many new laser types are developed in the future or how many additional applications are found, a few advancements are inevitable because certain trends have been in the pipeline for quite a while.

Lasers will continue to become smaller and more compact, more efficient, and lower in cost in terms of investment and operation. They also will become even more reliable than they are today and will require less maintenance. These developments will pave the way for new applications and make it possible for applications already being discussed to become financially and/or technologically feasible.

The expansion of the range of all laser characteristics – such as power, pulse energy, wavelength and pulse length – and the ever-increasing level of integration of components within a laser and of lasers into other devices, will open the door for new applications.

Questions and more questions

More specific questions about the future of laser technology are, of course, difficult to answer definitively. Here are a few to think about:

Will we see completely new laser types, or primarily modifications and improvements of technology that already exists?

Will barriers to other technologies first have to be overcome for laser technology to take the next step? One possible challenge that comes to mind, for example, is battery technology that might be required for mobile laser applications.

Will safety issues have to be resolved before lasers can be deployed in unusual or less-controlled environments?

Will completely new laser applications evolve? Or will we simply see modifications and improvements to existing applications?

New new? New old? Or both?

Many researchers are working to replace the laser technology that already exists. One example is the use of lasers in picoprojectors, allowing devices such as smart phones not only to take pictures but also to project them and other documents onto a screen. Researchers also are developing the next generation of laser technology for existing applications. In industrial production, lasers are being used to produce extreme-ultraviolet (13.5 nm) wavelengths that are enabling the continuation of Moore's Law – the doubling every two years of the number of transistors on an integrated circuit. Industry is focused also on decreasing photolithographic feature size.

Yet another evolving sphere is optical computing. A significant amount of research is happening in this field, and the collaboration of scientists and engineers might one day lead to a completely new level of computing. Light, in contrast to electric current, does not produce heat, which is a limiting factor in increasing processing speed. Because light beams, unlike traces for electric current, can cross without interacting, optical computing could provide alternate options for the layout of circuit boards.

The future looks bright – and interesting

In addition to the applications that are almost certain to become a reality is the long list of possible applications that most people living in the year 2010 would classify simply as, shall we say, "over the top."

In this futuristic category, the most predominant ideas are probably best summarized by the term "laser weaponry." Although some applications, such as the neutralization of surface land mines, already exist, more are to come. Interestingly enough, in the early days, laser beams were labeled by some researchers as death beams and, starting in the 1960s, were used as such in science fiction movies.

Another application possibility is power beaming. The concept behind this is that laser beams transport energy to places that are not easily reached via conventional methods. Examples include supplying energy to remote military camps or to a zeppelin (airship) stationed above a specific area for observation tasks.

The space elevator is another project on the horizon. A laser is used to deliver energy to a climber that travels up into space along a tether suspended from a satellite. An international space station already exists; if a space elevator is developed, it will facilitate access to other planets. At that point, lasers might be used for interplanetary communication. And while we're on the topic of space-related applications, we should mention that lasers potentially could be used to beam power *down* from space to Earth, using energy generated by solar cells stationed in space.

Another activity related to energy generation is one of the largest laser projects currently in development. At the National Ignition Facility, the beams of 192 lasers are focused onto a target composed of hydrogen to fuse the hydrogen atoms' nuclei and to produce energy. If successful, this could be a major component of solving the energy problem.

If the trends mentioned above are far-reaching enough, it might be possible not only to have laser pointers in a Swiss army knife, as we do today, but also even to replace the stainless steel blade with a laser blade. Just imagine the possibilities for a moment: You could cut down that tree in your backyard with a laser.

Now that we've speculated about the potential for future laser applications, let's take a look at the lasers themselves. Laser diodes certainly will increase in power, and we'll see dramatic improvements in their beam quality. Lasers that are widely discussed today, such as fiber and disk types, will be replaced by direct diode systems for many applications. And new materials such as nanopowders might lead to the development of entirely new laser types altogether.

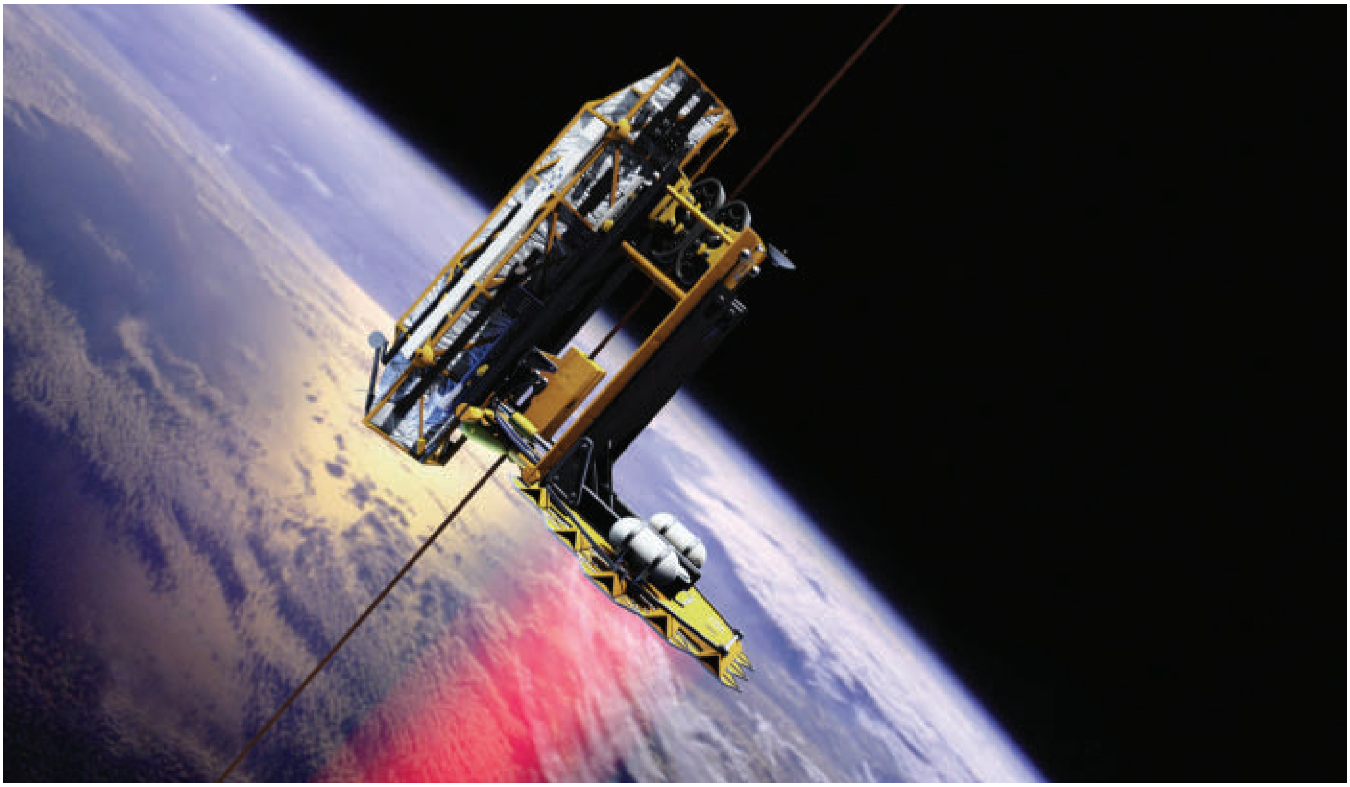
While there are many unknown aspects regarding the future of laser technology, one thing remains certain: The possibilities are endless.

As in the past, it is unlikely that we'll see the one single laser that can perform every application requiring one.

And as a laser guy, I really hope that no technology replaces the laser in the way that the laser has replaced other technologies. However, if I could gaze into a crystal ball for a moment and make a prediction, I'd have to say that it's a pretty safe bet that lasers will be around long after I'm gone.

Meet the author

Jochen Deile is the manager of new laser products for Trumpf Inc. in Farmington, Conn.; e-mail: jochen.deile@us.trumpf.com.



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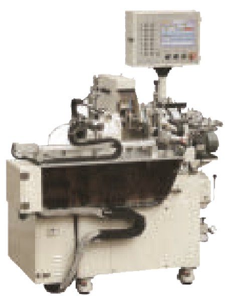

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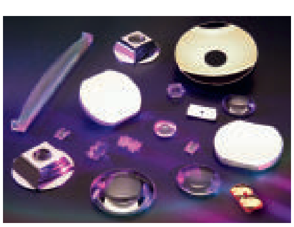

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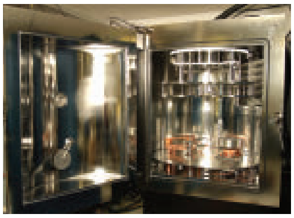

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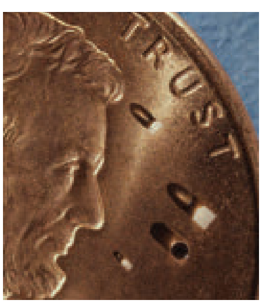

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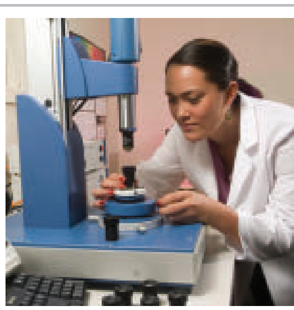

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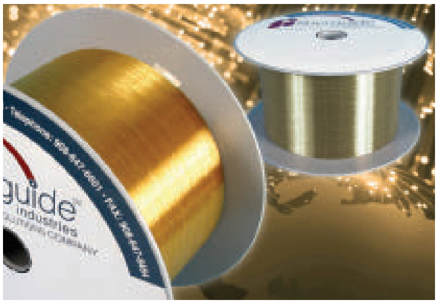

Coated Fibers

Delivering reliable operation in extreme conditions, the metal jacket series of gold- and aluminum-coated optical fibers from Fiberguide Industries Inc. has proved effective in a number of scientific applications, including Raman spectroscopy. They were originally developed for ultrahigh-reliability telecommunications. Their metal coating preserves their mechanical strength and provides resistance against the static fatigue caused by long-term tensile loading. The coated fibers can withstand a wide range of temperatures: aluminum from −269 to 400 °C, and gold from −269 to 700 °C. Gold or aluminum coating can be applied on continuous lengths to a wide variety of multimode, step index, graded index and single-mode fibers. Core to clad ratios of 1:1, 1:2 and 1:4 are available with numerical apertures of 0.12 and 0.26. Nonstandard sizes also can be manufactured upon request.

Fiberguide Industries
info@fiberguide.com

White OLEDs

Novaled GmbH has introduced white top-emitting organic light-emitting diodes (OLEDs) with a lifetime exceeding 50,000 h and a power efficiency of 30 lm/W at an initial luminance of 1000 cd/m^2. The white top-emitting OLED structure is made on metal substrates. Metal substrates bring advantages such as good heat dissipation, mechanical stability and bended designs, and they enable low-cost roll-to-roll production. The devices were developed using proprietary PIN OLED technology with the company's doping and host materials in association with a blue flourescent emitting material from SFC Korea. They have an indium tin oxide-free top contact and incorporate a proprietary light extraction material layer to enhance efficiency. This outcoupling material reduces the color shift over a wide viewing angle so that it can hardly be detected by the naked eye.

Novaled
info@novaled.com

Color Camera

Flir Systems Inc. has announced the launch of its ChromaNox line of electron multiplying CCD (EMCCD) ultralow-light security cameras. Incorporating advanced EMCCD technology, the cameras are available in VGA (640 × 480) and SXGA (1280 × 1024) resolution, and in color and monochrome models. They deliver high-quality images in light levels from bright sunlight to dark starlight. They feature proprietary image processing algorithms to bring out hidden image details in difficult scene conditions. Designed for use in demanding environments, the cameras meet Mil-Spec operating temperature requirements of −40 to 71 °C, ensuring long-term reliable operation. A wide range of ½-in.-format C-mount lenses enables both close situational awareness and long-range observation in light levels not considered possible with standard CCD and CMOS cameras.

Flir
sales@flir.com

3-D Camera

For improving uptime in packaging, automotive and electronics applications, Sick Inc. has launched a high-speed 3-D camera that measures color and the 3-D shape of objects, resulting in more reliable decision making and increased throughput and product quality. The ColorRanger E eliminates the need for several different cameras for the same task, which reduces solution cost and complexity. It solves various inspection tasks by measuring shape, contrast and surface defects to ensure product quality and production reliability. It provides high-resolution RGB color at up to 3072 pixels per channel, with on-chip white balancing and spatial correction. With simultaneous 3-D and color information at more than 11 kHz, multiple inspections can be performed in parallel at full production speed.

Sick
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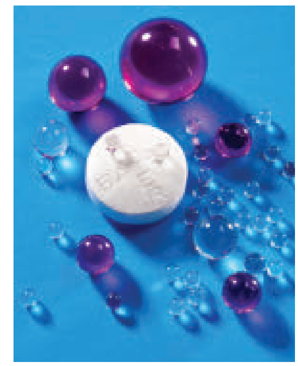

Miniature precision sapphire and ruby balls for use in medical and chemical pumps as check and metering valves, as ball and roller bearings, and as endoscope lenses and stylus tips are available from Meller Optics Inc. They are second only to diamond in hardness to provide good wear resistance, have a 2000 °C melting point, and are impervious to most chemicals, solvents and detergents. Suitable for applications in medical devices and instruments, these miniature precision balls are offered in 42-in. and metric sizes from 0.1 mm to 0.5 in. in diameter. They can be used as spacers in metrology applications, in flow meters, bar-code readers and fiber optics.

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sales@melleroptics.com

Laser Series

Designed for high-speed micromaterials processing, Rofin-Baasel Lasertech's PowerLine L laser series is targeted at photovoltaic manufacturing. The Q-switched solid-state lasers are designed for applications that require high average power and high pulse energy, such as thin-film removal on glass and flexible materials, ablation of dielectric layers, silicon processing, drilling and cutting. In the 1064-nm class, the PowerLine L 300 completes the company's laser range for edge deletion applications. It produces >200 W of laser power at 10 KHz and features an optimized square optical fiber with a 400-μm diameter. With selective opening of dielectric layers and direct laser doping, the device is suitable for use in mass production of enhanced solar cells. The frequency-doubled PowerLine L 100 SHG (second-harmonic generation) is suitable for use in various research projects. The laser source offers optimum beam characteristics and sufficient power for large production scale. The 532-nm green laser produces near-surface absorption in silicon and can be equipped with a wide range of long-living optical components and fibers.

Rofin
sales@rofin-baasel.co.uk

Thermoelectric Cooling Units

AMS Technologies' SD-330 and SD-250 compact thermoelectric cooling units are suitable for laser diode modules with footprints from 50 × 100 up to a maximum of 124 × 130 mm in medical and industrial applications. The solid-state devices omit the need for water cooling, reducing fan noise. Cooling capacity is up to 330 W when ambient temperature equals the temperature at the laser mounting plate. Using two 60-mm axial fans, a copper heat sink, six Peltier modules and a copper spreader and mounting plate, the units' maximum power consumption is 15 A at 24 VDC. They may be customized for various models and brands of laser diode modules, fans and power supply parameters. Suitable temperature controllers are available from the company.

AMS Technologies
salesinfo@ams.de

Immersion BARC

Brewer Science has launched the ARC29L coating, a state-of-the-art argon-fluoride immersion bottom antireflection coating (BARC) that provides broad photoresist compatibility and tuned optical properties for use as a top layer in a dual-layer BARC stack or as a single layer BARC on SiON. The coating is based on the proprietary ARC29SR coating platform and provides low substrate reflectivities of less than 0.1% for film thicknesses of less than 40 nm. It is suitable for extending leading-edge immersion processes in both single- and double-patterning lithography schemes. Its low thermal conductivity value delivers improved reflectivity control on absorbing substrates such as TiN and SiN.

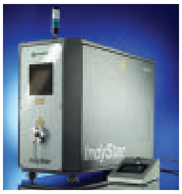
Brewer Science
rcox@brewerscience.com

3-D Imaging Camera

The Boeing Company is offering a compact, energy-efficient camera that provides 3-D images for military and commercial applications. Boeing Directed Energy Systems and wholly owned Boeing subsidiary Spectrolab have jointly developed the camera. It can be deployed on unmanned aerial and ground vehicles and can be customized to accommodate customer requirements. It can be used for mapping terrain, tracking targets and seeing through foliage. To create a 3-D image, it fires a short pulse of laser light, then measures the pulse's flight time to determine how far away each part of the camera's field of view is.

Boeing
marc.selinger@boeing.com

Excimer Laser



Coherent Inc. has added a new model to its IndyStar family of compact excimer lasers that offers a 2-kHz repetition rate for increased throughput. The fully Semi S2-certified laser incorporates several new output stabilization features for improved processing, making it suitable for use in semiconductor fabrication, testing, inspection and micromaterials processing facilities. It is offered with a choice of 193-nm (ArF) output, where it delivers 8 W of stabilized power, or with 248-nm (KrF) output with 12 W of stabilized power. Suitable for use in semiconductor applications such as photomask inspection and testing photolithography optics, it enables other high-speed processes also, including precision material ablation tasks and high-value marking applications.

Coherent
tech.sales@coherent.com

125-A Bipolar Amplifier

Kepco Inc. has added a high-current model to its four-quadrant 1-kW BOP bipolar operational amplifier series. The BOP 6-125MG enables the user to source or sink up to 125 A using a single 3U module with accuracy and readback in current mode of 200 ppm. The unit performs in current mode-voltage limit, as well in voltage mode-current limit. Up to five units can be operated in parallel for a source-sink capability of up to 625 A at 0 to 6 V, and up to three units can be connected for up to 125 A at 0 to 18 V. Switch mode technology provides low dissipation. Applications include battery test and characterization, corrector and injector magnets for medical imaging, and solar cell test and characterization.

Kepco
orozo@kepcopower.com

LED Driver

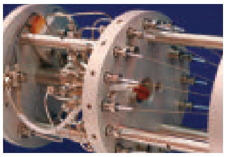
National Semiconductor Corp. has announced the LM3464 LED driver with dynamic headroom control and multiple outputs for high-power applications such as industrial, street and automotive lighting. It accurately and efficiently drives up to four strings of LEDs. The PowerWise controller maximizes system efficiency, simplifies design and reduces system cost. The driver includes four channels and drives up to 20 LEDs per channel, and its dynamic headroom control feature adjusts the supply voltages of the LED strings through the power supply feedback to the lowest level required to provide optimal system efficiency. By directly controlling the output of the offline regulator, the driver can eliminate the second stage switching regulator commonly required for offline LED power supplies.

National Semiconductor
new.feedback@nsc.com

Deformable Mirrors

Edmund Optics has released high-performance deformable mirrors that correct optical aberrations through wavefront manipulation and control, introducing differences in the optical path length across the entire wavefront. The mirrors can be integrated via a Gig-E connection and a dedicated Ethernet card into a polarization beamsplitter-based Twyman-Green interferometer. Suitable for use in adaptive optics applications, the mirrors are good tools for use in combination with wavefront sensors and real-time control systems. They have 32 radially packed actuators that control the shape of the silver-coated precision cellulose membrane. They have a 10-mm active area and offer 15 μm of actuator max stroke. They are suited for tabletop applications as well as OEM integration.
Edmund Optics
sales@edmundoptics.com

Transient Mass Spectrometer



Hiden Analytical Ltd.'s Transient mass spectrometer system is designed for the analysis of fast transient gas events at pressures near atmosphere. The compact benchtop system is based on the proprietary HPR-20 QIC series gas analyzers and features a fast response capillary inlet and the HAL/3F PIC mass spectrometer with a pulse ion-counting detector. The combination enables inlet system response times of <150 ms and measurement speeds of up to 500 data points per second over a seven-decade dynamic range. The system monitors species with molecular weights to 300 atomic mass units, with higher mass ranges available. The MASsoft control and data acquisition software provides integral calibration routines and user-programmable template files for automatic analysis. Applications include pulsed gas experiments for catalyst characterization, surface reaction and reduction studies, respiratory analysis and process control.
Hiden Analytical
info@hiden.co.uk

Ti:Sapphire Oscillator

Femtolasers Produktions GmbH has unveiled the FemtoSource Rainbow ultrafast Ti:sapphire oscillator with Carrier Envelope Phase (CEP) stabilized short optical pulses and multiple simultaneous outputs centered at 800 and 1030 nm, with 100% mutual synchronization guaranteed. Bandwidth at −10 dB is >260 nm, average mode-locked output power is >200 mW, and pulse energy and peak power at 78 MHz

are >2.2 nJ and >350 kW, respectively. Beam diameter ($1/e^2$) is <2.5 mm, beam divergence is <2 mrad, horizontal polarization is >100:1, and noise, measured from 10 Hz to 100 kHz, is <0.1% rms. Power stability is ±1%. Applications include amplifier/optical phase conjugation, power amplifier seeding, coherent terahertz generation, optical coherence tomography, multiphoton microscopy and time-resolved spectroscopy.
Femtolasers
info@femtolasers.com

SLD Source

Thorlabs Inc. has introduced the S5FC series benchtop superluminescent diode (SLD) light sources, which integrate proprietary indium phosphide SLDs manufactured by Covega (now known as Thorlabs Quantum Electronics, TQE) with Thorlabs' all-inclusive benchtop platform. The turnkey broadband SLDs are suitable for use in optical coherence tomography, imaging systems and fiber optic gyroscopes. Each benchtop is available in 1310- and 1550-nm wavelength versions with single-mode and polarization-maintaining fiber and is equipped with FC/APC bulkhead connectors for easy coupling. Typical power output ranges from 2.5 to 30 mW.
Thorlabs
techsupport@thorlabs.com

HAPPENINGS

PAPERS

Photonics 2010 (December 11-15) Guwahati, India
Deadline: abstracts, July 30, 17:00 IST (11:30 a.m. GMT)
Papers are sought for the International Conference on Fiber Optics and Photonics. The event will focus on the latest research in areas such as plasmonics, microfluidics, biophotonics, nonlinear and quantum optics, optical fiber and waveguide devices, nanophotonics engineering, and photonic crystal, polymer and subwavelength-diameter fibers. Contact Sunil Khijwania, Indian Institute of Technology Guwahati, +91 361 258 2716; photonics2010@iitg.ernet.in; www.iitg.ernet.in/photonics 2010.

ILSC 2011 (March 14-17) San Jose, California
Deadline: abstracts, August 15
Organizers of the International Laser Safety Conference encourage papers on a variety of topics related to laser safety practice and hazard control, including measurements, risk assessment, bioeffects, eye protection, medical lasers, high-power laser issues, nonbeam hazards and safety standards legislation. Contact Laser Institute of America Conference Department, +1 (407) 380-1553; ilsc@laserinstitute.org; www.laserinstitute.org/ilsc.

SPIE Smart Structures/NDE (March 6-10) San Diego
Deadline: abstracts, August 23
Researchers are invited to present their work at Smart Structures/NDE in areas such as nondestructive evaluation (NDE), smart sensors, aerospace systems, civil infrastructure and energy harvesting. Topics to be considered include nanotechnology, optical fiber sensors, structural health monitoring, and embedded and self-diagnostic sensors. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; spie.org.

AUGUST

SPIE Optics + Photonics: Optical Engineering + Applications (Aug. 1-5) San Diego. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; spie.org.

Laser Safety Officer Training Course (Aug. 3) Toronto. Contact Rockwell Laser Industries, +1 (800) 945-2737; training@rli.com; www.rli.com.

NIWeek 2010 (Aug. 3-5) Austin, Texas. Contact National Instruments Corp., +1 (800) 531-5066; www.ni.com/niweek.

Photon 10 (Aug. 23-27) Southampton, UK. Contact Jon Mackew, Institute of Physics, +44 20 7470 4800; conferences@iop.org; www.photon.org.uk.

International Conference on Coherent and Nonlinear Optics (ICONO)/Lasers, Applications and Technologies (LAT) (Aug. 23-27) Kazan, Russia. Contact ICONO/LAT Organizing Committee, +7 843 272 05 03; iconolat10@kfti.knc.ru; congress.phys.msu.ru/iconolat10.

SEPTEMBER

CIOE 2010: 11th China International Opto Electronic Expo (Sept. 6-9) Shenzhen, China. Contact Shenzhen BMC Herong Exhibition Co. Ltd., +86 755 8629 0901; fax: +86 755 8629 0951.

31st European Conference on Laser Interaction with Matter (ECLIM) (Sept. 6-10) Budapest, Hungary. Contact István B. Földes, Hungarian Academy of Sciences, fax: +36 1 395 9151; foldes@rmki.kfki.hu; www.top-congress.hu/2010/eclim.

EWOFS 2010: European Workshop on Optical Fibre Sensors (Sept. 8-10) Porto, Portugal. Contact INESC Porto, University of Porto, +351 220 402 301; ewofs@inescporto.pt; www.ewofs.org.

DISKCON USA 2010 (Sept. 9-10) Santa Clara, Calif. Contact Trudy Gressley, +1 (408) 294-0082; tgressley@idema.org; www.idema.org.

SPRC 2010 Annual Symposium (Sept. 13-15) Stanford, Calif. Contact Stanford Photonics Research Center, +1 (650) 723-5627; photonics@stanford.edu; photonics.stanford.edu.

IMTS 2010: International Manufacturing Technology Show (Sept. 13-18) Chicago. Contact The Association for Manufacturing Technology, +1 (800) 524-0475; amt@amtonline.org; www.amtonline.org.

Metamaterials 2010: Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (Sept. 13-18) Karlsruhe, Germany. Contact S. Linden, Congress Secretary, +49 7247 82 2861; congress2010.metamorphose-vi.org.

Principles of Lasers and Laser Safety (Sept. 14) Ann Arbor, Mich. Contact Rockwell Laser Industries, +1 (800) 945-2737; training@rli.com; www.rli.com.

Laser Safety Officer Training Course (Sept. 14) Ann Arbor, Mich. Contact Rockwell Laser Industries, +1 (800) 945-2737; training@rli.com; www.rli.com.

MNE 2010: 36th International Conference on Micro and Nano Engineering (Sept. 19-22) Genoa, Italy. Contact Corso F.M. Perrone, +39 010 659 8773; secretariat@mne2010.org; www.mne2010.org.

Remote Sensing (Sept. 20-23) Toulouse, France. Collocated with Security + Defence. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; spie.org/x6262.xml.

ICWMC 2010: Sixth International Conference on Wireless and Mobile Communications (Sept. 20-25) Valencia, Spain. Contact IARIA, www.iaria.org.

Laser Safety Masterclass (Sept. 21) Cambridge, UK. Contact Rockwell Laser Industries, +1 (800) 945-2737; training@rli.com; www.rli.com.

LANE 2010: Sixth International Conference and Exhibition on Laser-Assisted Net Shape Engineering (Sept. 21-24) Erlangen, Germany. Contact Bayerisches Laserzentrum GmbH, +49 9131 852 3239; info@lane-conference.org; www.lane-conference.org.

SPIE Laser Damage (Sept. 27-29) Boulder, Colo. Contact SPIE, +1 (360) 676-3290; spie@spie.org; spie.org.

OLEDs World Summit 2010 (Sept. 27-29) San Francisco. Contact Olga Adamovich, +1 (207) 781-9628; olga.adamovich@pira-international.com.

International Congress on Applications of Lasers & Electro-Optics (ICALEO) (Sept. 27-30) Anaheim, Calif. Contact Gail Lolacono, Laser Institute of America, +1 (800) 345-2737; icaleo@laserinstitute.org; www.icaleo.org.

Latin America Optics and Photonics Conference 2010 (Sept. 27-30) Recife, Brazil. Contact Optical Society of America, +1 (202) 223-8130; info@osa.org; www.osa.org.

ALAC 2010: Advanced Laser Applications Conference & Exposition (Sept. 28-29) San Jose, Calif. Contact International Laser Users' Council, +1 (734) 418-2365; www.alac-iluc.org.

OCTOBER

Comsol Conference 2010 (Oct. 7-9) Boston. Contact Yeswanth Rao, +1 (781) 273-3322; yeswanth@comsol.com; www.comsol.com/conference2010.

SPIE Asia-Pacific Remote Sensing (Oct. 10-15) Incheon, South Korea. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; spie.org.

International Wafer-Level Packaging Conference (Oct. 11-14) Santa Clara, Calif. Contact Melissa Serres, Surface Mount Technology Association, +1 (952) 920-7682; melissa@smta.org; www.iwlpc.com.

Semicon Europa 2010 (Oct. 19-21) Dresden, Germany. Contact Kelli Torres, SEMI Global Headquarters, +1 (408) 943-6979; ktorres@semi.org; www.semiconeuropa.org.

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Great balls of magnetism!

You've no doubt heard of ball lightning – perhaps even experienced it firsthand. But although the phenomenon has been known for millennia, it happens infrequently enough that there have always been doubts about its validity. Physicists at the University of Innsbruck in Austria think that ball lightning might just be a trick on the brain, having nothing to do with sight.

The mind can see many things without the need of photons zipping through the eyeball first. Just ask a colleague to whack you hard in the back of the head with his iPad, and you'll surely experience the sight of bright flashes – and maybe some cartoon stars or birdies, too. These phenomena are called phosphenes. Aside from violent strikes to the noggin, however, more gentle natural processes also may affect the mind's eye, including strong magnetism.

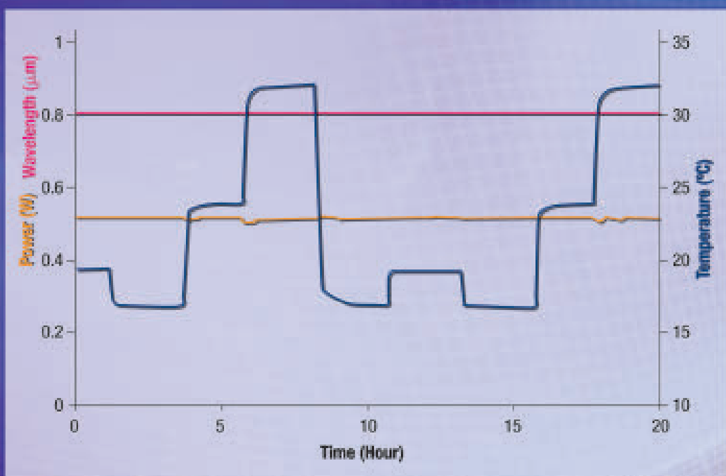
In Innsbruck, Alexander Kendl and doctoral student Josef Peer study the electromagnetic fields of lightning strokes, varying their strength and duration. They report in the June 28, 2010, issue of *Physics Letters A* that sufficiently strong magnetic fields induced by close-by lightning strikes can induce electrical fields in the brain, especially near the visual cortex. If there are several strong bolts in succession near an observer, the induced electrical field might produce phosphenes that register as rounded electrical effects, or ball lightning.

The results are inconclusive thus far, but they may go a long way toward explaining a quite rare experience. The research also may provide insight into the unintended consequences of placing the human brain too close to powerful magnetic forces – who knows what someone will think they see next?

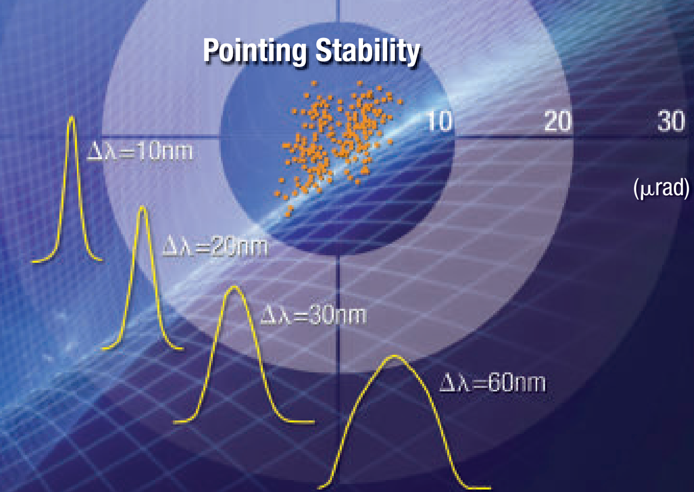
lynn.savage@photonics.com

Plasma physicists Alexander Kendl and Josef Peer use artificial lightning and luminous fireballs to study the effects of strong electromagnetism on vision. Courtesy of the University of Innsbruck.

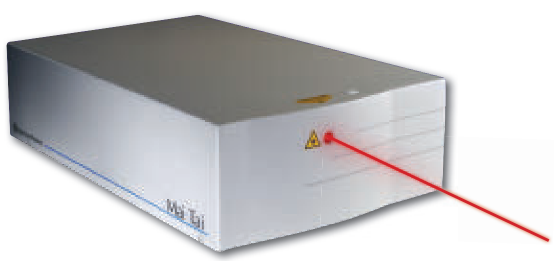
Unsurpassed Short Pulse Stability and Flexibility



Power and Wavelength Stability



Bandwidth Tunability



The Mai Tai® SP

Introducing the Mai Tai® SP, the most stable and first fully-automated, short-pulse oscillator for amplifier seeding. The Mai Tai SP laser delivers pulses in the <25fs to 100fs range, and features completely computer adjustable bandwidth. Our proprietary StabiLok® technology ensures that beam pointing and stability are always optimized – there is no need to realign the laser. Ever! That's stability and flexibility beyond compare. The Mai Tai SP is based on the proven Mai Tai laser platform, the one-box ultrafast oscillator with the largest installed base. The laser is powered with exclusive ProLite® laser diodes, the most reliable in the industry, with an average lifespan twice that of competitors. Unmatched stability and automated flexibility, plus the support of the Newport/Spectra-Physics' well regarded field service team make it time for a Mai Tai SP.

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