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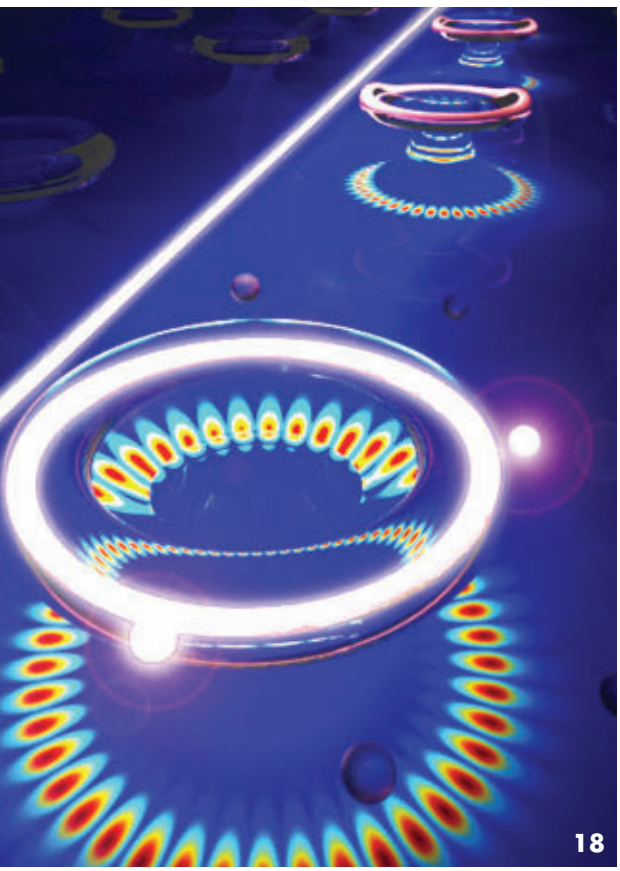

THE COVER
A typical task for an industrial laser: deep penetration welding of transmission components. Image courtesy of Trumpf.

DEPARTMENTS

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

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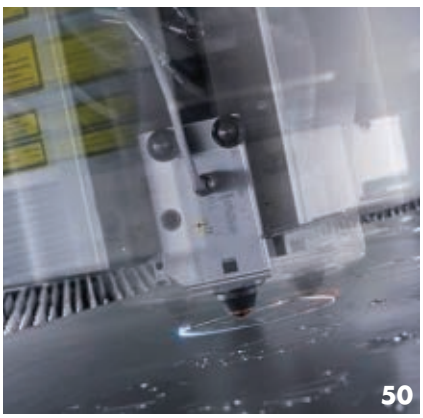
FEATURES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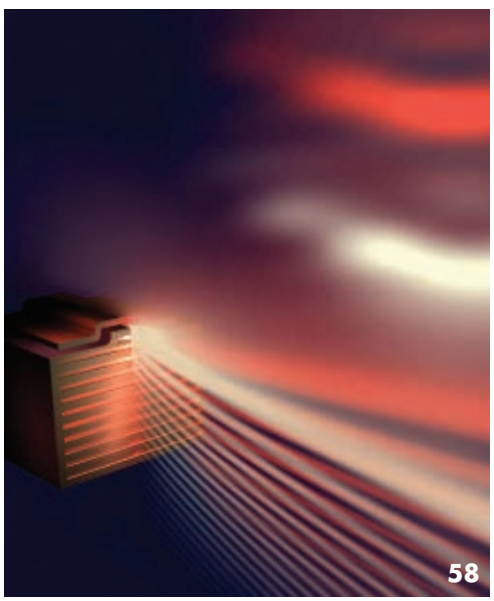
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Trends in 2009, predictions for 2010

January has become a time of special reflection. As New Year's Eve celebrations die down and New Year's resolutions rear their heads, it's common to look back at the previous year to glean lessons from both successes and mistakes and to make plans and predictions for the years to come. At *Photonics Spectra*, the January issue allows us to review technology and market trends and to look ahead at what to expect in the future.

The biggest trend that hit the industry in 2009 – and that will continue to have a profound impact in 2010 and beyond – wasn't exactly a technology trend, although it did affect development and sales of photonics technologies. The recession caused belt-tightening practically across the board, and in settings from industrial R&D to academe, everyone had to look closely at budgetary issues, even as stimulus funding eventually started to drift in.

But the recession hasn't killed off innovation. The feature articles in this issue will detail the biggest photonics developments of 2009 as well as predictions for the years to come in a range of technologies: optics, imaging, lasers and more.

The year 2010 marks the 50th anniversary of the invention of the laser, and the laser industry in general is seeing some signs of growth after a financially difficult year. Lasers in the life and health sciences, scientific research and solar sectors are doing better, thanks in part to stimulus funding, and the microelectronics industry is growing despite slower progress in other industrial sectors. At laser companies, the focus has been fixed steadily on innovation and collaboration, with a fair dose of consolidation as well. Experts predict that the global laser market will rebound after its drop in 2009, boosted by growth in semiconductors and communications equipment, and by continued development of new products.

From nonlinear optical effects for image contrast in biology and medicine to fiber lasers for clinical applications, from stimulated emission microscopy to one- and two-photon fluorescence microendoscopy, optics development in the biotech segment has been strong. Fiber optic cable at last has connected East Africa with international broadband networks, and service providers worldwide are working to get more bandwidth from their technologies. And high-brightness LEDs and adaptive optics are constantly finding new and exciting applications.

Imaging and vision are branching out, too, and even helping to expand the reach of solar technologies: Photonics-based imaging is being used to inspect solar cells in production and to position solar grids – and even to make solar systems cheaper. Apart from solar, new imaging and vision developments in both hardware and software are being applied to robotics, manufacturing, security and forensics, and more. CMOS sensors are growing, as are electron-multiplying CCD cameras, and vision interfaces are evolving too. Other photonics technologies, such as fluorescence microscopy, Raman spectroscopy, positioning systems, terahertz imaging, slow light and photonics integration, have received significant attention this year and are expected to grow in the future.

The future looks brighter for photonics as we move into 2010, and we're counting on innovation to continue this trend.

Tom Lawton

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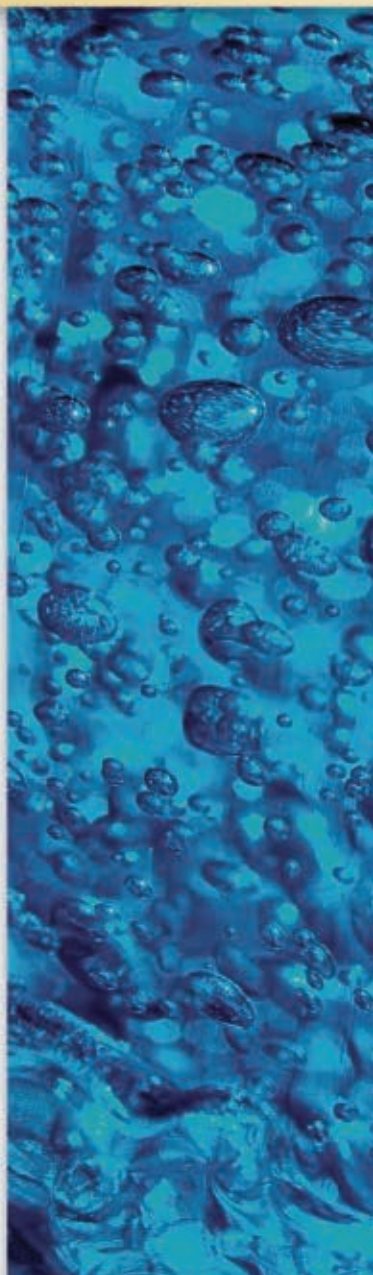

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A question on energy

I was pleased to see the GreenLight article "Making energy personal" (October, p. 35) on photocatalytic water conversion. In my opinion, this is the only long-term solution to our energy problems. Of course, this subject has been researched for years, primarily with TiO_2 and similar photocatalysts.

MIT professor Daniel G. Nocera is performing very valuable work in this field. However, one sentence in the article – "A catalyst for hydrogen gas existed previously" – made it sound as if he produced oxygen from water only.

If chemistry has not changed, water is composed of both hydrogen and oxygen. If you remove oxygen, what happens to the hydrogen? If the process is truly catalytic, the hydrogen must go somewhere. It is not used up in the reaction.

The ultimate goal is to split water with photons (sunlight), using a catalyst that is stable and robust. The products are hydrogen and oxygen, which, when separated, can be used in fuel cells.

Vernon Porter, PhD
Murphy, Texas

Photonics to the rescue

I received the October issue of *Photonics Spectra* and was immediately impressed with it and its contents. I was especially interested in the editorial, "Things are looking up." In it, Federal Reserve Chairman Ben Bernanke is reported to have said that we have turned a corner on the recession and that it is time to prepare for the recovery. Your comments reflect an attitude appropriate to this industry and are welcomed by all.

As you know, work continues in all areas of quantum physics as industry races to develop ultraefficient solar power, and next-generation nuclear power, waste harvesting and other technologies that will turn America once and for all into an energy-independent nation. We are currently in a paradigm shift in terms of our thinking about our future energy-needy economy and how best to satisfy its growing demands.

I'm aware of ambitious plans such as capturing the energy of lightning. Perhaps most esoteric of all is so-called "spherical pinch" geometry, which will allow high-energy lasers to fuse light hydrogen nuclei in the world's first cryogenic laser-pumped fusion experiment.

The discovery of light led humanity out

of darkness eons ago. Now, light will lead us to a new age.

Keep up the good work.

Joseph V. Marsh
Ararat, N.C.

Errata

A paragraph in the article by Boston Micromachines Corp., titled "Adaptive Optics in Biological Imaging with Two-Photon Microscopy" (December 2009, p. 42), was edited to imply that Dr. Michelle Day has employed adaptive optics (AO) in her work. The sentences should have read: "With the addition of AO, calibration issues would be significantly reduced, increasing the availability of the instrument. By implementing AO, the need for expertise in calibrating the instrument on a regular basis also would be reduced, leading to a lower cost of operation."

In "The Search for Other Earths" (October, p. 40), the Keck telescope image of the HR 8799 planetary system was attributed incorrectly. The image was provided courtesy of Christian Marois (Herzberg Institute of Astrophysics), Bruce Macintosh (Lawrence Livermore National Laboratory) and the W.M. Keck Observatory.

Clarification

An acknowledgment of assistance was missing from the article "The Search for Other Earths" in the October 2009 issue: Optical Research Associates (ORA) gratefully acknowledges the assistance of Dr. Wesley Traub and Michael Devirian of the Jet Propulsion Laboratory in Pasadena, Calif., whose expertise and insight were invaluable during research for this article. ORA also would like to acknowledge David W. Kuntz of Technical Marketing Services in Rancho Palos Verdes, Calif., for his contributions.

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The Best of 2009
In 2009, we saw the Large Hadron Collider (LHC) become the world's highest-energy particle accelerator, as well as limitations broken on how small lasers could be made, the arrival of the first Raman laser built using man-made diamonds, the development of an electronic metamaterial, and a breakthrough in CMOS image sensors. Visit Photonics.com for the year's top photonics-related breakthroughs in lasers, LEDs, imaging, optics, etc., as chosen by the editors of Photonics.com and *Photonics Spectra* magazine.

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In the February issue of Photonics Spectra …

Optoelectronic Materials
Indium tin oxide is one of several materials that are perfect, or nearly so, for a multitude of photonic applications, but are used at the cost of toxicity. Zinc oxide, however, is coming on strong as a less environmentally challenging material.

Holography Update
Holographic applications aren't limited to security and data storage. This feature article will examine some unique new applications of laser-driven holographic technology.

Fraud in the Lab
While the amount of lab fraud appears small, organizations like the National Institutes of Health take the problem seriously and give tutorials to teach researchers how to avoid scientific misconduct. There also are enforcement arms that actively investigate misconduct allegations.

EuroPhotonics
Features will include a look at IP/patent laws governing photonic technologies in synthetic biology as well as an imaging feature that will cover medical imaging as well as imaging for security and military applications, including research on IR and terahertz imaging, and digital imaging.

GreenLight
New inspection tools using electroluminescence and SWIR imaging systems are helping to meet the increasing demands for efficient and affordable multi-junction CPV cell inspection. Doug Malchow of Sensors Unlimited (part of Goodrich Corp.) discusses the use of SWIR imaging to detect cell uniformity and defects.

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Those who can do can also teach, and with improved results

BY GARY BOAS, CONTRIBUTING EDITOR

"Kids know what's up. Ninety percent of middle- and high-school science teachers have never had to solve an honest-to-god science problem using the tools of science," Dr. Samuel C. Silverstein told me. He is a professor of physiology and medicine at Columbia University in New York. "Without that sort of experience, most of them are simply repeating what the textbook says. Kids know immediately who's authentic and who's not."

Silverstein runs the Summer Research Program for Science Teachers at Columbia, which operates under the auspices of the National Science Foundation. He started it in 1990 with the idea that experience in the actual practice of science will improve the quality of science teaching and, in turn, lead to an increase in student interest and achievement. Then, as now, there was concern about US students performing less well in science, technology, engineering and math than students in other economically advanced countries.

A recent study showed that the participation of science teachers in a summer research program at Columbia University correlates with improved test performance for their students. The authors of the study suggest that this is due largely to the hands-on laboratory experience the teachers gained in the program. Shown here is Staceyann Hood-Collins, a science teacher at Teachers Preparatory High School in Brooklyn and a recent participant in the program.

Mentoring the teachers

Every year, the program accepts 10 to 13 middle- and high-school science teachers and matches them with Columbia University faculty members working in fields that interest the teachers. The university scientists agree to mentor the teachers, who become active members of the labs. For 16 weeks over two summers, the teachers read up on the latest research in their chosen fields and, importantly, participate in hands-on experiments. In addition, they assemble for a day out of every week for a variety of professional development exercises.

Immersing themselves in a research environment can provide teachers with a new perspective when they return to the classroom. Program participants have reported that the stress of adapting to the labs – of absorbing seemingly overwhelming amounts of information in short periods of time – helps them to better appreciate their students' difficulties. The experience also teaches them that they don't need to know everything, Silverstein explained. It gives them the confidence to say to a student, "That's a good question. I don't really know the answer, but let's see how we can find it."

In addition, the teachers have introduced to their classrooms a number of new constructivist educational practices. Ninety-six percent of those who participated in or completed the program in 2004 and 2005 upped the number of hands-on classroom activities and/or implemented new laboratory exercises, for example. Eighty-three percent introduced new technologies in their classes, such as chromatography and micropipettes.

And now there's quantitative evidence that training teachers in a laboratory environment contributes to improved academic performance for their students. To earn a high school diploma in New York state, students must pass five standardized Regents exams, one of which must be in science – in biology, for example (or "Living Environment," to use Regents terminology). In the Oct. 16, 2009, issue of *Science*, Silverstein and colleagues reported on the pass rates of program participants' students.

They found that, in the year before participants' entry into the program, 45.7 percent of their students passed a Regents science exam. This number was essentially the same as for students of nonparticipants. By the third and fourth years after the teachers' entry, though, their students' average science exam pass rates were 10.1 percent higher than those of the students of nonparticipating teachers.

The study's authors believe that the success of the program is due largely to the laboratory experience gained by the teachers. They are treated as colleagues in the research groups – tasked with addressing contemporary real-world scientific problems by working independently and thinking creatively to solve them. They grow both professionally and personally as a result, acquiring new skills and knowledge and achieving the confidence to impart these to their students, and helping them learn how to tackle problems similarly

Stretching the students' minds in these ways and challenging them to engage in solving problems independently and creatively are the real goals of the program. Indeed, Silverstein said, the most important take-home lesson from the *Science* study may be that low-performing schools don't have to be low performing. "Before, you could say, 'Well, this is the best these kids can be expected to do.' We now know, though, that is simply not true."

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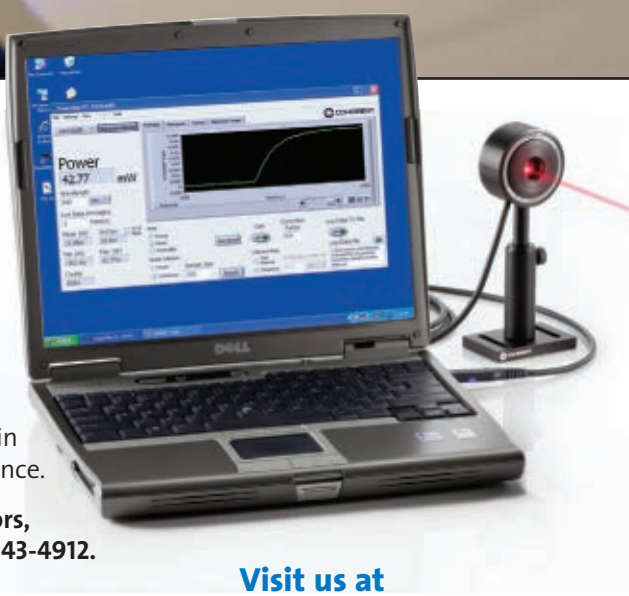

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Creating nanostructures with shadows

BERKELEY, Calif. – From out of the shadows, researchers at the University of California, Berkeley, have built nanostructures that might lead to more efficient solar power. Another potential application is improved nanoplasmonic-based and label-free chemical and biological sensors.

The idea for the technique came to research leader Luke P. Lee, a bioengineering professor, after he saw very narrow features arising from two shadows. That sparked a realization, he said. "If you combine two shadows, you can create a completely unexpected image."

The nanoscale implementation of this idea is dubbed "shadow overlap ion-beam lithography," and its description appeared in *Nano Letters* (2009, Vol. 9, No. 11, pp. 3726-3731). It involves the use of microscopic prepatterned structures, such as beads or pillars.

In a demonstration, the researchers used polystyrene beads measuring 477 nm across. They deposited these on a glass substrate and etched them back to 405 nm, opening space between them. To create the final nanostructure, they deposited a 20-nm layer of gold over the beads, using a directional method. The effect was that the beads created areas of varying thickness, or shadows, in the metal.

The investigators then used ion milling to remove the gold. Once again there was directionality, and once again the beads created shadows. The milling was at an angle, both to the beads and to the deposition. In the final step, they removed the beads. The result was an array of shapes, with the outcome depending on the angle of the deposition and milling. By adjusting either or both, the researchers could create a combination of nanoscale formations.

They characterized the structures using both near- and far-field optical techniques. They found that they could redshift the resonance peak from 580 to 680 nm by increasing the deposition angle, a result that agreed with calculations.

Lee noted several benefits of the new technique. The smallest features are in the nanometer range, far smaller and sharper than can be achieved with other methods. Using this approach, it also is possible to create shapes that cannot be fabricated with conventional mask-based lithography. Finally, unlike other high-resolution techniques such as electron beam lithography, shadow overlap ion-beam lithography offers high throughput and could be very cost effective.

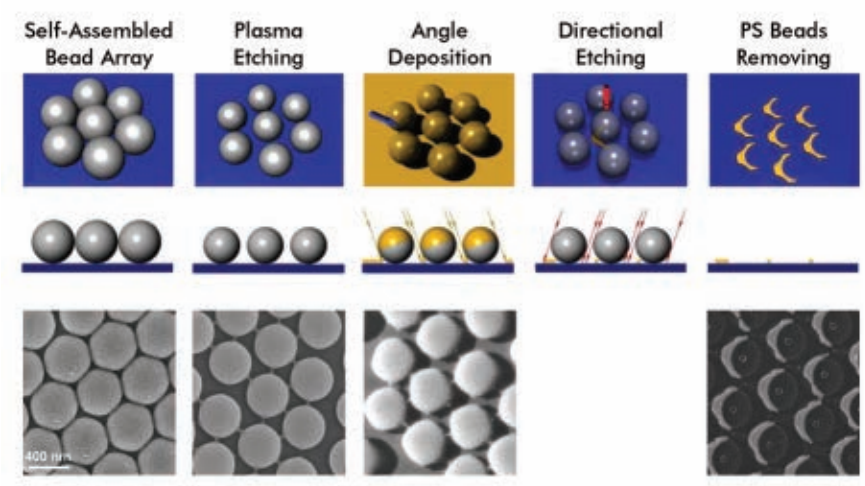
One drawback is the need for prepatterned structures. However, it may be possible to overcome this constraint by adjusting the deposition or milling angle.

Applications outside of a lab are still some time off, but the researchers intend to investigate two in the near term. One is label-free chemical or biological sensors, using nanostructures to create sites for surface-enhanced Raman spectroscopy or nanoscale plasmon resonance electron transfer absorption spectroscopy, a method developed in Lee's lab.

Another application of interest is the creation of nanoarrays tuned to specific wavelengths. These could be assembled into one device, opening up the possibility of harvesting light from the ultraviolet to the infrared. That would allow solar cells to work even when the sun isn't shining, Lee said.

"You can collect infrared energy at night. Even when you have cloudy conditions, you can still pick up some other wavelengths," he added.

Hank Hogan
hank@hankhogan.com



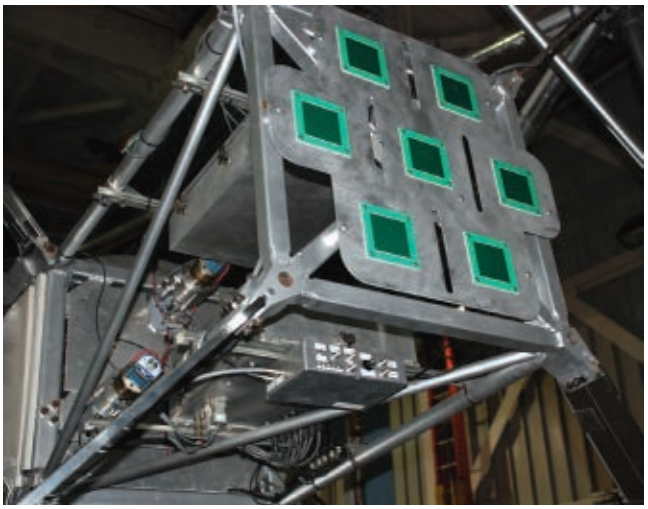
Inspired by the interaction of light and shadows in the ruins at Pompeii, researchers used directional deposition and milling to create unique shapes from nanoshadows. Courtesy of Luke P. Lee, University of California, Berkeley.

Protecting aircraft from lasers

LA JOLLA, Calif. – During the operation of astronomical telescopes, laser beams frequently are emitted into the atmosphere for satellite or lunar ranging. They also can be used to create artificial guide stars for correcting image aberrations.

The Federal Aviation Administration (FAA) requires that, when a laser beam is used, one or more individuals must be present outside the telescope to spot airplanes that might intersect the beam's path and to tell scientists to shutter the beam.

To make it easier to locate the aircraft, and to eliminate the need for human surveyors altogether, researchers from the University of California, San Diego (UCSD), created a detection system that can identify the presence of an airplane by its onboard



The antenna array is mounted on the sky-facing side of the secondary mirror support structure on the Apache Point Observatory 3.5-m telescope.

transponder and shutter the laser beam when the aircraft is within 15° of it.

The system is important for a pilot's protection from laser illumination that could interfere with his or her vision. Besides temporary loss of night vision, the pilot is subject to what Thomas W. Murphy Jr. calls the "startle factor" – the tendency to become distracted or alarmed when the cockpit lights up unexpectedly. Murphy, one of the device's inventors, is an associate professor of physics at the university.

Never the twain shall meet

Transponders are FAA-mandated traffic control instruments found on all commercial and on most private aircraft. They indicate the plane's location and flight direction.

To detect a transponder, the new system is equipped with two antennas – a broader one with an angle of 90° and a narrower one with a 30° angle – that are aligned with the optical axis of the initial laser beam. The narrow and broad beams receive a portion of the transponder's power – which ranges between 70 and 500 W – to measure the angular distance from the aircraft to the main laser beam. When the airplane is determined to be too close to the main beam, it is shuttered.

"This [mechanism] can simply be a wand that is lowered into the beam to prevent its exit from the laser enclosure," Murphy said. It takes less than 30 µs for the system to react to a signal.

If a plane comes within range of the detection system, and factors such as saturation of a signal or a fast-acting aircraft cause inactivity from the antennas, a backup responder, or signal processing unit, will shutter the laser beam, while also logging the aircraft's identity and altitude.

The researchers tested the method at the Apache Point Observatory in Sunspot, N.M., between December 2008 and August 2009. The device was coupled with a 3.5-m telescope used in a series of lunar ranging experiments named APOLLO (Apache Point Observatory Lunar Laser-ranging Operation).

There were glitches during testing. At the university, which is near two major airports, false triggers from beam reflections caused the system to shutter the laser beam 80 percent of the time during peak hours of the day. "The high density of traffic around UCSD, together with an expansive clutter of buildings on the ground, led to overlapping signals and multipath interference, respectively," Murphy said.

However, because observatories are situated in more remote locations, the system should not experience any problems under normal conditions, according to William A. Coles, co-developer of the system and professor of electrical and computer engineering at the university.

To ensure the effectiveness of the device and to alleviate some of the effects from obstructing signals, the researchers are refining their technique. "We are preparing a minor upgrade that will be insensitive to orientation and have somewhat improved rejection of multipath interference," Coles said.

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A backward shock wave comes forward

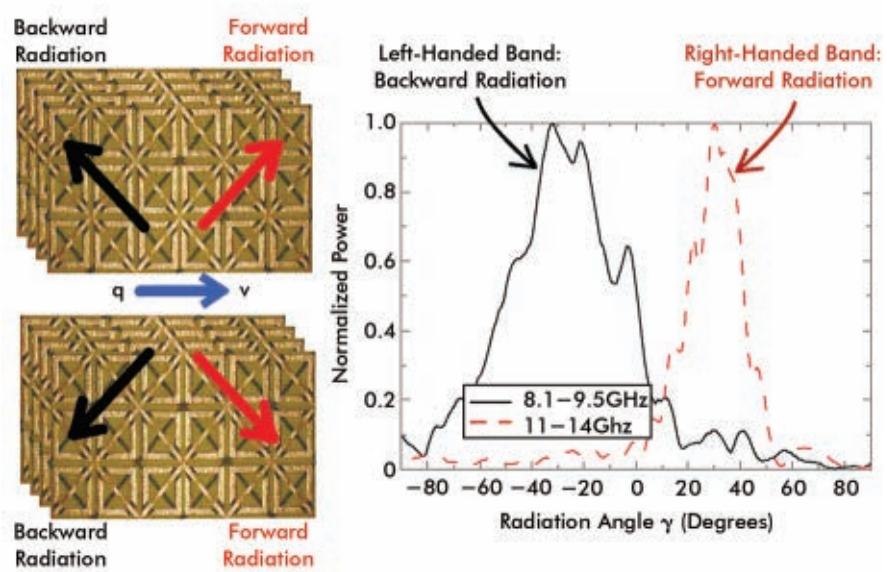
HANGZHOU, China – A group of researchers has demonstrated a reverse photonic shock wave. As a result, high-energy physics could have a new particle detector, and proposed invisibility cloaks already may have been pierced.

The speed of light is the ultimate in space but not in air, water or other materials. In such media, charged particles can move faster than light itself. When they do, they give rise to Cerenkov radiation, an example being the blue glow seen near an underwater nuclear reactor.

To date, all Cerenkov radiation has been in the forward direction because all known natural materials are right-handed and have a positive index of refraction. But the development of left-handed metamaterials – which are engineered to have a negative index at specific wavelength bands and for particular electromagnetic modes – gave professor Min Chen, a physics professor at MIT in Cambridge, an idea a few years ago.

"We should build a backward-emitting Cerenkov detector so that the radiation could be readily separated from the emitting particles," he said.

Following Chen's idea, graduate student Sheng Xi, associate professor Hongsheng



A backward photonic shock wave could lead to new particle detectors. Simulated charged particles traveling faster than the speed of light through a left-handed material (latticework on left) give rise to backward traveling microwave radiation (trace on right). Courtesy of Hongsheng Chen, Zhejiang University, and Min Chen, MIT.

Chen and professor Lixin Ran, all of Zhejiang University, implemented the concept, as outlined in the November 2009 issue of *Physical Review Letters*. In doing so, they overcame several problems.

The first is that optical frequency metamaterials not only are difficult to build but also suffer high losses. So the researchers chose to use microwaves, where a low-loss left-handed metamaterial is easier to design and build.

That decision led to another hurdle, however. Cerenkov radiation power is strongly dependent on frequency, so microwave emissions would be much weaker than optical ones.

The researchers solved this problem by not using particles. Instead, they showed mathematically that they could mimic moving particles, at least as far as Cerenkov radiation is concerned, by using a rectangular waveguide with an array of slots. In fabricating their demonstration device, they printed 17.5-µm-thick copper in a rod-and-split-ring structure with dimensions of a few tens of a millimeter. They repeated the structure every 3 mm over a polytetrafluoroethylene substrate 33 µm thick.

With this easily fabricated structure, they achieved negative refraction at a frequency from 8.1 to 9.5 GHz. They confirmed backward Cerenkov radiation at these frequencies.

Because the radiation and the particle travel in opposite directions, this could give rise to better detectors. Reversed Cerenkov emission also could be a new radiation source. The next step will be verification with actual charged particles moving through a metamaterial. One goal will be to do this at optical frequencies, which the recent development of bulk optical left-handed metamaterials may make possible.

As for invisibility cloaks, one proposed implementation uses left-handed metamaterials to guide light around an object and make it invisible. According to new research, that invisibility can be punctured, Chen said.

"Backward Cerenkov radiation is the only electromagnetic method known to us to detect the above cloak by shooting an electron beam through the left-handed shell."

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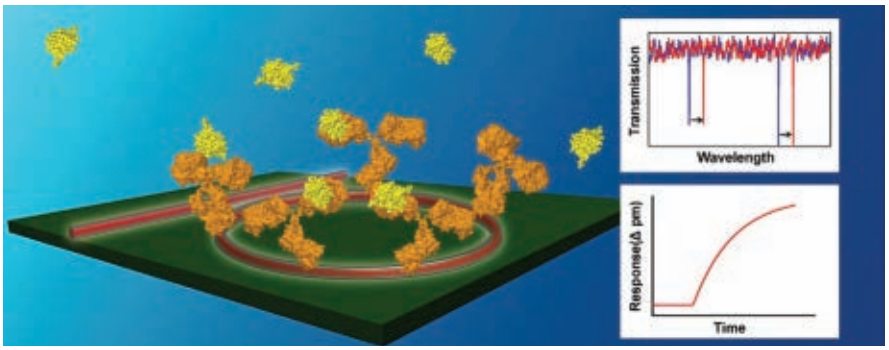
Optical microrings boost cancer detection

URBANA-CHAMPAIGN, Ill. – Sensitive detection of biomolecules is of great interest for applications such as drug development, virus detection, environmental monitoring and medical diagnostics. In contrast to optical biosensors based on surface plasmon resonance, interferometers or resonant cavities, integrated silicon-on-insulator microring sensors offer fast sample preparation and measurements, even on small sample quantities, and are exceptionally scalable, which will be key for multiplex analysis. Using this technique, researchers at the University of Illinois have demonstrated reliable, label-free detection of a clinically important cancer biomarker with a very low limit of detection.

Optical microring resonators have found many applications to date in integrated optics and telecommunications, where they are used as wavelength selection filters. They consist of very small ring-shaped waveguides – typically a few micrometers in radius – with input and output couplers. They can be made in different materials using lithography processes known from semiconductor manufacturing. Light injected into the microring via the input waveguide travels around the circumference; certain wavelengths interfere resonantly with others already in the cavity, forming so-called whispering gallery modes. This can be observed in a sharp dip in the transmission at the output.

What makes these structures so attractive for sensing purposes is the fact that this resonance wavelength is strongly dependent upon the refractive index of the material surrounding the waveguide substrate. What makes them handy for the sensing of biomolecules is the fact that a capture protein can be attached to the sensor surface, enabling linkage with its complementary protein, called the analyte, to be tested. For this "functionalization," the right chemical treatment of the waveguide surface is needed to prevent nonspecific protein adsorption.



Microring resonators can be used to detect specific molecules because their transmission spectra are very sensitive to refractive index changes in the surrounding material. The presence of other molecules has this effect and can be made selective for certain molecules if the surface is prepared in a specific way.

Although this may sound a bit cumbersome, the good news is that, unlike most commercial biosensors, this method does not require molecules to be "labeled," which can complicate detection and decrease reliability. Instead, reliability and accuracy are improved by the fact that a large number of individually addressable microrings can be made on a single substrate with little extra effort – which means that many tests can be run in parallel and compared. Due to the rings' small size, this is even possible for small sample sizes. Alternatively, groups of rings can be functionalized for different target molecules, and a variety of tests can be performed in parallel on the same small sample. Furthermore, nonfunctionalized microrings can be used as control sensors and to compensate for potential environmental effects.

The University of Illinois team, led by professor Ryan C. Bailey, whose work was published in *Analytical Chemistry* (2009, 81 [22], pp. 9499-9506), aims to make such new proteomic technologies available for clinical use. The researchers demonstrated detection of the clinically important protein biomarker carcinoembryonic antigen (CEA) in undiluted serum using an initial-slope-based quantitation method.

CEA was detected at clinically relevant levels, and concentration was determined. Comparison with commercial enzyme-linked immunosorbent assay equipment showed that the label-free microring sensor platform has a comparable limit of detection (2 ng/mL) and superior accuracy in the measurement of CEA concentration across a three-orders-of-magnitude dynamic range. Based on this, the researchers say that their future goal is to extend the platform for highly multiplexed label-free bioanalysis.

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Isolating hot spots enhances Raman results

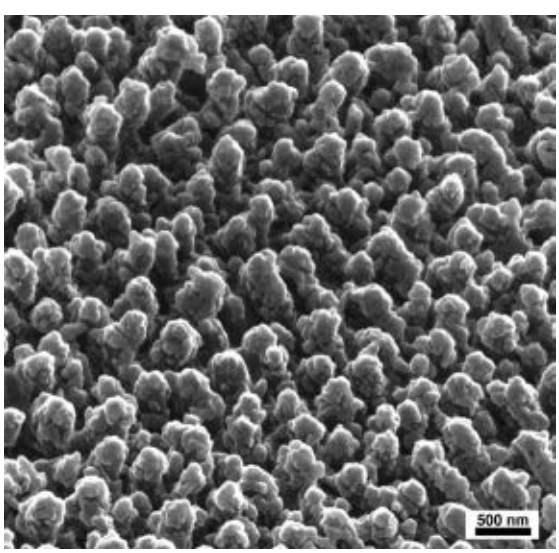
CAMBRIDGE, Mass. – A new technique demonstrated by a Harvard group may provide environmental researchers, chemists and forensic investigators with a new tool to detect and identify trace molecules.

The research combined the two separate concepts of surface-enhanced Raman scattering and multiphoton lithography, said Eric Mazur, physics professor and team leader. "A lot of innovation consists of putting two existing ideas together to enable something new. This is a prime example."

The result was a 27-fold improvement in Raman scattering and a molecule-identifying signal. This initial result can be improved through further optimization of the technique, Mazur said.

Because it is sensitive to molecular bonds, a Raman signal can serve as a molecular fingerprint and allow the identification of unknown substances. The problem is that Raman scattering is small and the signal, therefore, weak. That makes detection of trace molecules virtually impossible.

As the name implies, surface-enhanced Raman scattering boosts the Raman signal because of an interaction between molecules adsorbed to a surface and the surface itself. The enhancement can sometimes be quite large, increasing the signal by more than a billion times. It also can be much less than that.



This close-up shows what could be the basis for a new trace chemical detection tool. The helium-ion microscope image shows a silver-coated surface-enhanced Raman spectroscopy substrate. Multiphoton lithography, performed with femtosecond laser pulses, selectively exposes photoresist. Molecules can then adsorb only at electromagnetic spots, leading to stronger and more repeatable total signal enhancement. Courtesy of Eric Mazur, Harvard University.

This great variation means that the few sites with large enhancement contribute most of the signal. When there's less than a single layer of molecules, which would be the case during trace analysis, such variation makes detection unreliable. One time, more of the molecule of interest will produce most of the signal – the next time, it may not.

The Harvard group solved this problem through multiphoton lithography, a technique where the simultaneous absorption of two photons leads to a feature in a photoresist. The researchers first fabricated the surface-enhanced Raman substrate, using a femtosecond laser to create an array of microscopic cones spaced 500 nm center to center. They covered the cones with silver nanoparticles, leading to a substrate with an aver-

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To isolate the hot spots, they coated the substrate with a resist layer thick enough to stop any molecules from reaching the surface. They then scanned the surface with laser pulses at 795 nm, almost twice the optimum resist exposure wavelength of 436 nm.

Because of the silver, these pulses caused multiphoton exposure of the resist, but only at electromagnetic hot spots. The researchers then removed the resist from the hot spots and left it everywhere else, guaranteeing that only the spots with the highest surface enhancement were exposed for adsorption. When they tested the substrate, they found that it had 27 times the signal of an unprocessed one, as reported in the Nov. 18, 2009, *Journal of the American Chemical Society*.

The group is now optimizing the process, and it hopes to eventually produce substrates with sufficient enhancement at every available molecular adsorption site for single-molecule surface-enhanced Raman spectroscopy.

"The ultimate goal is to enable new ways to perform trace-level detection of molecules with great specificity," Mazur said.

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'GRIN on steroids': New lens uses opaque metamaterials

DURHAM, N.C. – It doesn't look like a lens; it looks more like a tiny set of Venetian blinds. It's not even made of traditional lens materials such as highly polished glass or plastic. But a new generation of lenses has the potential to make big changes in radar and telecom systems by offering greater detail and a wide field of view, according to engineers from Duke University.

Advances in metamaterials allow the new lens to focus the direction of electromagnetic rays passing through it in a way far superior to that of conventional lenses. More than 1000 pieces of the same fiberglass material used in circuit boards make up this prototype lens, which is etched with copper, measures 4 × 5 in., and is less than 1 in. high. Arranging the pieces in precise parallel rows enables the lens to direct rays as desired.

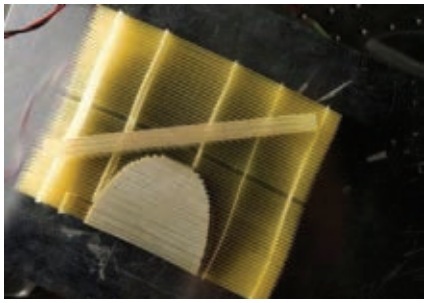
"For hundreds of years, lens makers have ground the surfaces of a uniform material in such a way as to sculpt the rays as they pass through the surfaces," said Nathan B. Kundtz, postdoctoral associate in electrical and computer engineering at

Duke's Pratt School of Engineering. "While these lenses can focus rays extremely efficiently, they have limitations based on what happens to the rays as they pass through the volume of the lens.

"Instead of using the surfaces of the lens to control rays, we studied altering the material between the surfaces. If you can control the volume, or bulk, of the lens, you gain much more freedom and control to design a lens to meet specific needs."

Clear spheres known as gradient index (GRIN) lenses have been investigated as an alternative to conventional lenses, but they are difficult to fabricate. Also, because they have spherical focus points, they have proved difficult to incorporate into most sensing systems, which are two-dimensional and have trouble processing the spherical images. The new lens has an angle of view of almost 180° and a flat focal point.

Kundtz conducted his experiments in the laboratory of senior researcher David R. Smith, the William Bevan professor of electrical and computer engineering, and



A new lens is a carefully constructed lattice of circuit board materials. Courtesy of David R. Smith Lab, Pratt Engineering. Credit: Duke University Photography.

provided the first demonstration of what previously had only been theorized. He used microwaves for his most recent experiments, noting that it is theoretically possible to design lenses for wider frequencies as well.

"We've come up with what is in essence GRIN on steroids," Smith said. "This first in a new class of lenses offers tantalizing possibilities and opens a whole new application for metamaterials.

"While these experiments were conducted in two dimensions, the design should provide a good initial step in developing a three-dimensional lens. The properties of the metamaterials we used should also make it possible to use infrared and optical frequencies."

With metamaterials similar to those used in the new lens, Smith's team created one of the first "cloaking" devices in 2006.

According to the researchers, a single metamaterial lens could be used to replace traditional optical systems that require vast arrays of lenses; the new lenses also could provide clearer images. Although size constraints keep traditional lenses from being practical for large-scale systems such as radar arrays, this new generation of lenses could be used to better direct beams in such systems, they say.

The research was supported by the US Army Research Office's Multiple University Research Initiative. The results appeared as an advance online publication of the journal *Nature Materials*.

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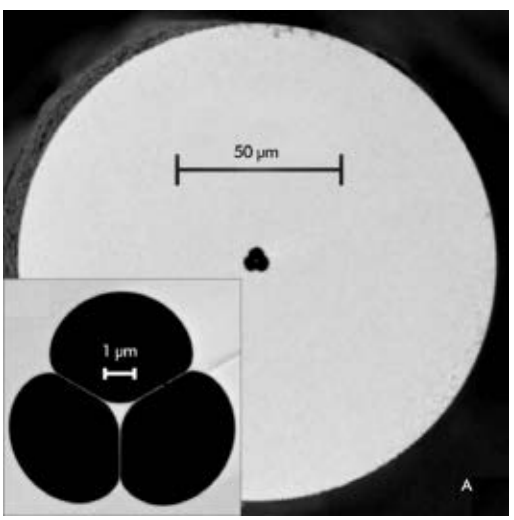
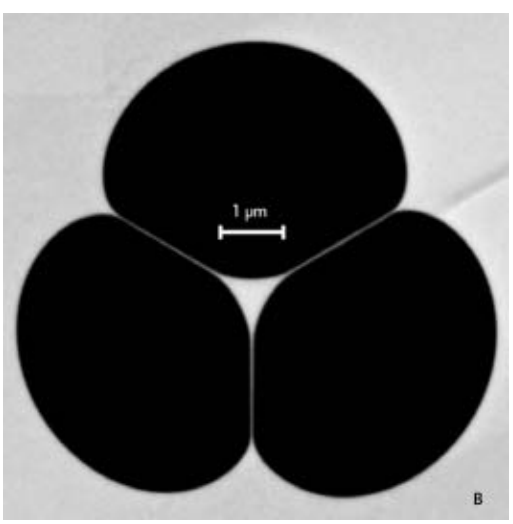
Pushing light to new limits

ADELAIDE, Australia – Australian researchers are rewriting the rules on how light behaves when confined in ever-smaller optical fibers. Everything has its limits, and light-carrying optical fibers are no exception. Until now, it was thought that, as the size of the optical fiber shrinks, light becomes more and more confined until it reaches a point beyond which it cannot be squeezed any smaller, and it rapidly begins to diverge. This ultimate point was thought to occur when the strand of fiber is just a few hundred nanometers in diameter.

Now, Shahraam Afshar and colleagues Wen Qi Zhang, Heike Ebendorff-Heidepriem and Tanya Monro at the University of Adelaide have discovered that they can push beyond that limit by almost a factor of two. They can do this thanks to a breakthrough in the theoretical understanding of how light behaves at the nanoscale, and thanks to the use of a new generation of nanoscale optical fibers being developed at the university.

"Rapid progress in fabrication of optical planar waveguides and microstructured fibers within cladding with high refractive indices has provided access to an emerging class of optical waveguides," Afshar explained. "Unlike standard waveguides, these have a high-index contrast between core and cladding, inhomogeneous cross sections and subwavelength dimensions."





At the University of Adelaide, next-generation nanoscale optical fibers are being developed with a high-index contrast between core and cladding, inhomogeneous cross sections and subwavelength dimensions. The triangular-shaped glass core region, which measures just 450 nm, is represented in both the larger panel (A) and the inset (B), surrounded by three large holes. In panel (A), the large gray area surrounding the core is glass; with a total diameter of 150 µm, it makes up the rest of the fiber. Images courtesy of Wen Qi Zhang, Heike Ebendorff-Heidepriem and Tanya Monro.

Conventional wisdom dictates that pulse propagation in optical waveguides is described by the nonlinear Schrödinger equation. However, when it comes to the novel waveguides developed by Afshar's team, all bets are off, and the equation no longer describes the behavior of light accurately.

"We have discovered that the ultimate limit of squeezing light into an area is smaller than what is expected according to standard theories," Afshar said. "This means that we can access much higher nonlinearity in optical waveguides, which is important both in terms of fundamental studies of guided nonlinear optics and their applications."

This discovery is expected to lead to more efficient tools for optical data processing in telecommunications networks and optical computing, as well as new light sources. But, according to Afshar, any application relying on guided nonlinear optics can benefit from the findings.

The next step for the Australian group is to explore induced nonlinear polarization and supercontinuum generation.

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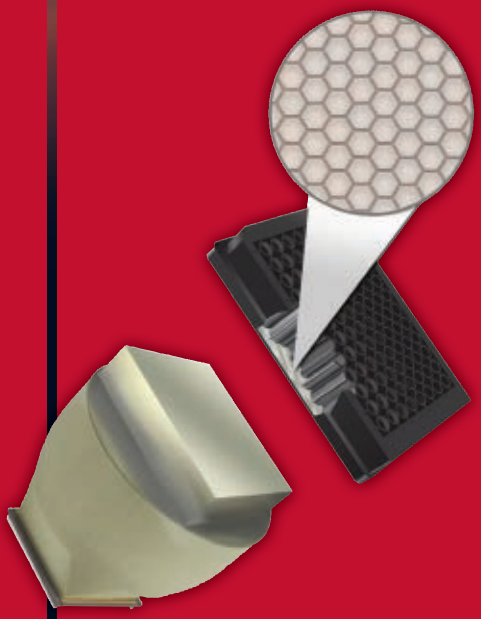

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THE PULSE OF THE INDUSTRY

Artificial vacuums unleash speed of quantum computing

TORONTO – Instilling photonic crystals with the occasional quantum dot triggers a vacuumlike effect that alters light in such a way that may make ultrafast optical computing possible.

Sajeev John of the University of Toronto and his student Xun Ma were investigating the mechanisms of optical switching using photonic crystals, part of an effort to develop an all-optical transistor that operates within a photonic chip as an electronic transistor acts in a computer chip.

According to Ma, he and John sculpted an artificial vacuum inside a three-dimensional photonic bandgap material, or photonic crystal, and embedded it with artificial atoms (quantum dots) inside the vacuum. Firing picosecond laser pulses on the quantum dots enabled them to control the electronic state of the artificial atoms. Each pulse raised the quantum dots out of their ground state, and a train of pulses kept them there as long as the pulses were tuned just below the atomic resonance. A stream of laser pulses just above the resonance dropped the quantum dots back to their ground state.

"We designed a vacuum in which light passes through circuit paths that are one one-hundredth of the thickness of a human hair, and whose character changes drastically and abruptly with the wavelength of the light," John said. "A vacuum experienced by light is not completely empty and can be made even emptier. It's not the traditional understanding of a vacuum."

Ma added that the color-coded laser pulses sequentially excite and de-excite the quantum dots in trillionths of a second. The particles, in turn, can control other streams of optical pulses, enabling optical information processing and computing.

The ultrafast laser pulses also carry and impart very little energy – on the order of femtojoules – meaning that any optical switches made with the technique would not be subject to the overheating experienced by common electronics.

"This new mechanism enables micrometer-scale integrated all-optical transistors to perform logic operations over multiple frequency channels in trillionths of a second at microwatt power levels, which are about one-millionth of the power required by a household lightbulb," John said. "That this mechanism allows for computing over many wavelengths, as opposed to electronic circuits which use only one channel, would significantly surpass the performance of current-day electronic transistors."

The research is reported in the Dec. 4, 2009, issue of *Physical Review Letters*.

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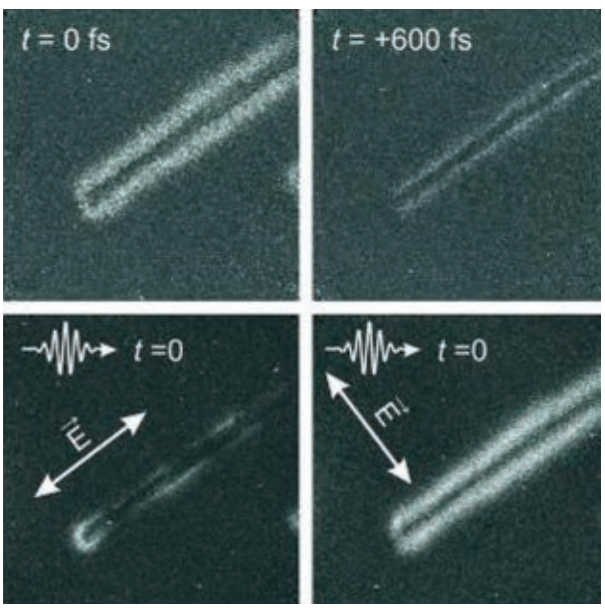
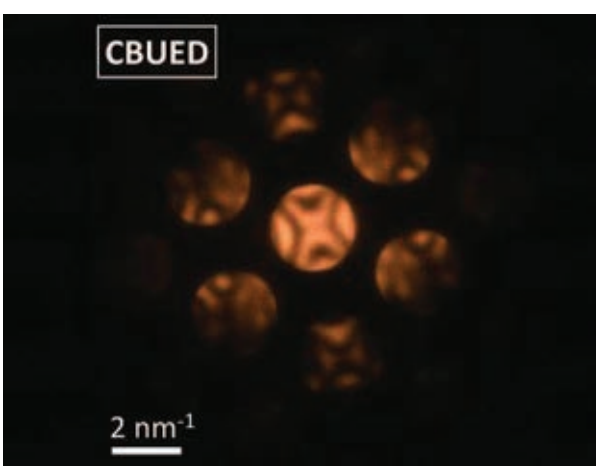
Filming photons using electrons

PASADENA, Calif. – A new technique that tracks and images nanoscale matter in real time also enables researchers to image electrical fields produced by the interaction of electrons and photons.

The method, which uses four-dimensional microscopy, was developed by researchers at the Physical Biology Center for Ultrafast Science and Technology at California Institute of Technology (Caltech). The center is directed by Ahmed H. Zewail, the Linus Pauling professor of chemistry and professor of physics at Caltech.



These photons were imaged in nanoscale structures (carbon nanotubes) using pulsed electrons at a very high speed. Shown are the evanescent fields for two time frames and for two polarizations. Images courtesy of Ahmed Zewail, California Institute of Technology.



This diffraction was obtained for silicon with 4-D electron microscopy. The nanoscale can be determined from the patterns in the structure.

Zewail was awarded the Nobel Prize in chemistry in 1999 for pioneering the science of femtochemistry, the use of ultrashort laser flashes to observe fundamental chemical reactions occurring at the timescale of the femtosecond. Although the work "captured atoms and molecules in motion," Zewail said, snapshots of such molecules provide the "time dimension" of chemical reactions but not the structure or architecture of those reactions.

With 4-D microscopy, Zewail and his colleagues could see the architecture, which employs single electrons to introduce the dimension of time into traditional high-resolution electron microscopy, providing a way to see the changing structure of complex systems at the atomic scale.

In electron diffraction, an object is illuminated with a beam of electrons. The electrons bounce off the atoms in the object, then scatter and strike a detector. The patterns produced on the detector provide information about the arrangement of the atoms in the material. However, if the atoms are in motion, the patterns will be blurred, obscuring details about small-scale variations in the material.

In research published in the Oct. 30, 2009, issue of *Science*, Zewail and postdoctoral scholar Aycan Yurtsever addressed the blurring problem by using electron pulses instead of a steady electron beam. They first heated the sample by striking it with a short pulse of laser light, then with a femtosecond pulse of electrons – which bounce off the atoms – producing a diffraction pattern on a detector.

The electron pulses are so brief that the heated atoms do not have time to move much, thus producing a sharper image. By adjusting the delay between when the sample is heated and when the image is taken, the scientists can gather a number of still images that can be strung together into a movie.

"Essentially all of the specimens we deal with are heterogeneous," Zewail said, with varying compositions over very small areas. "This technique provides the means for examining local sites in materials and biological structures, with a spatial resolution of a nanometer or less and time resolution of femtoseconds."

The new 4-D microscopy technique, reported by Zewail and postdoctoral scholars Brett Barwick and David J. Flannigan, was published in the Dec. 17, 2009, issue of *Nature*. The visualization process involves the interaction between electrons and photons. Photons generate an evanescent field in nanostructures, and electrons can gain energy from such fields, enabling them to be visible under the 4-D microscope.

In photon-induced near-field electron microscopy (PINEM), certain materials – after being hit with laser pulses – continue to "glow" for a short but measurable amount of time (on the order of tens to hundreds of femtoseconds). In their experiment, the latter researchers illuminated carbon nanotubes and silver nanowires with short pulses of laser light as electrons were being shot past.

The power of this technique lies in the ability to visualize the evanescent field when the electrons that have gained energy are selectively identified, and to image the nanostructures themselves when electrons that have not gained energy are selected.

"As noted by the reviewers of this paper, this technique of visualization opens new vistas of imaging, with the potential to impact fields such as plasmonics, photonics and related disciplines," Zewail said. "What is interesting from a fundamental physics point of view is that we are able to image photons using electrons. Traditionally, because of the mismatch between the energy and momentum of electrons and photons, we did not expect the strength of the PINEM effect or the ability to visualize it in space and time."

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Whispering-gallery sensor can measure a single nanoparticle

ST. LOUIS – Nanoparticles can be found nowadays in approximately 800 products, from sunscreen to anti-graffiti paint, plastic beer bottles and home pregnancy tests, and researchers are working on ways to assess how these particles affect human health and the environment.

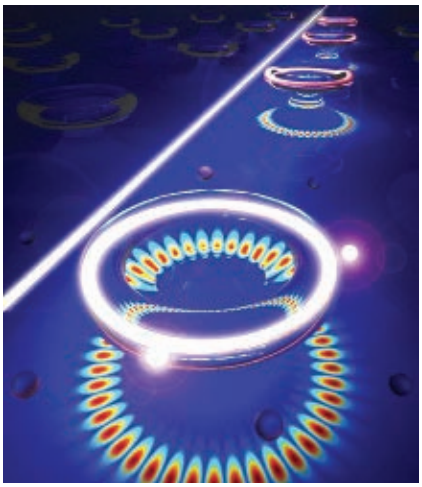
A new sensor on a chip could help in this effort. The sensor, devised by Dr. Lan Yang, assistant professor of electrical and systems engineering at Washington University, and her research team not only can detect single particles but also can measure them. Yang and her team predict that the sensor, an improved version of a whispering-gallery microresonator, will be able to measure particles smaller than 100 nm in diameter, about the size of a virus particle. Their work appeared in the advance online publication of *Nature Photonics* on Dec. 13, 2009.

In architecture, a whispering gallery is a space beneath a circular or elliptical area such as a dome in which, if a person stands at one focus and whispers, someone at the focus on the opposite end of the gallery can hear what is said because the line of sound emanates directly between the focal points. At normal speaking volume, the sound circulates around the dome more than once, and the signal is garbled.

On a much smaller scale, laser light can be coupled into a circular waveguide: a glass ring, for example. When the light strikes the boundary of the ring at a grazing angle, it is reflected back into the ring. The light wave can travel around the ring several times before it is absorbed, as long as the frequency of the light fits perfectly into the circumference of the ring. This perfect-match resonance is called a whispering-gallery mode.

The faint outer edge of the light wave penetrates the surface of the glass ring and allows the resonator to function as a particle detector: When a particle attaches to the ring, the light wave is disturbed and the resonant frequency is changed. The degree of change can be used to measure the size of the particle.

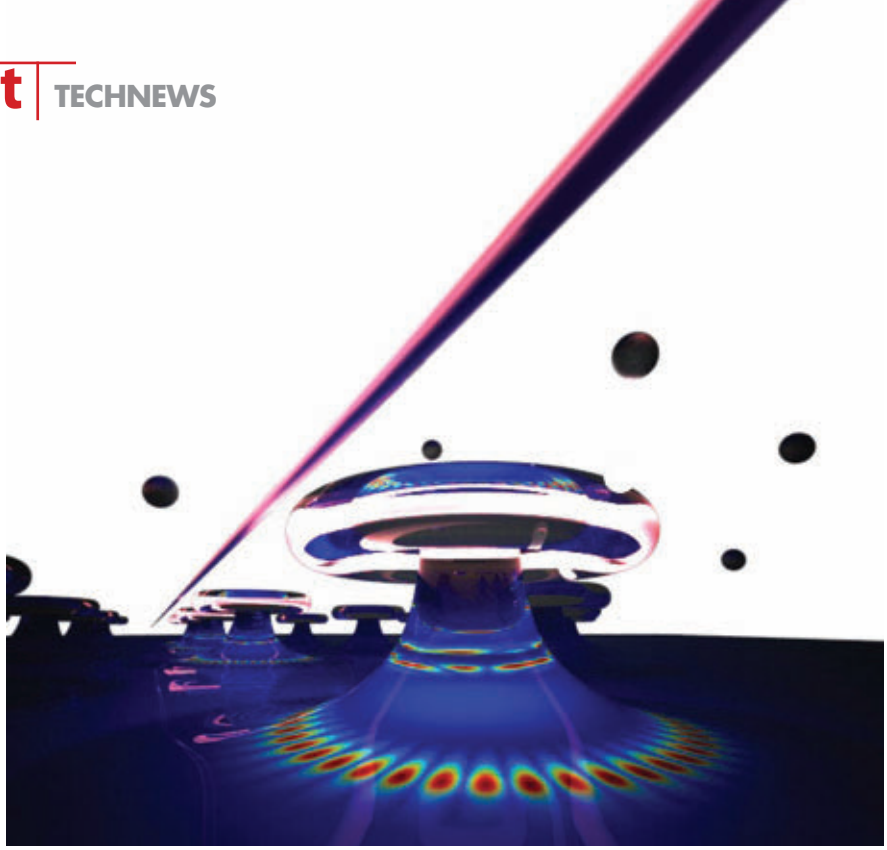
But microresonators have two major problems, Yang said. One is that the resonant frequency can be affected by vibration or temperature changes, not just the presence of particles. The other is that the frequency shift depends on the spot at which the particle attaches to the ring. If a particle lands on a node (the dark blue areas reflected on the base of the pedestal in Figures 1 and 2), it will cause less of a disturbance to the light wave, appearing smaller than it would if it landed on an anti-node (the red spots visible on the base).



New high-Q microresonators could be mass-produced on silicon wafers; each torus is 20 to 30 μm across. In this image, two particles (bright spots) have landed on the closest microresonator and are acting as scattering centers, disturbing the light waves in the torus. This allows the particles to be detected and measured. Images courtesy of Jiangang Zhu and Jingyang Gan, Washington University in St. Louis.

The solution: a self-referring sensing scheme possible only in an exceptionally good resonator with virtually no optical flaws. To achieve this, Yang and colleagues developed a microresonator with a quality factor, or Q value – a measure of microscopic imperfections that sap energy from the resonating mode – of about 100 million, which means that light circles the ring many, many times. Because recirculation increases the interaction of the light wave with particles on the ring's surface, mode splitting becomes a viable approach to particle detection.

Each whispering-gallery mode is actually two modes, as the light travels both clockwise and counterclockwise around the resonator, usually with the same frequency. A particle that attaches to a res-



Particles that land on the resonator disturb a light wave circulating in the torus (whose nodes and anti-nodes are visible on the torus's base). These disturbances provide information about the particles' sizes. The pink line receding into the distance is an optical fiber through which light is coupled into and out of the torus.

onator functions as a scattering center that couples energy between the two modes, which rearrange themselves so that the particle lies on a node of one and an anti-node of the other. This disturbs one wave much more than the other and splits the mode. The split mode is easily seen in the team's ultrahigh-Q resonator, but it can't be resolved in a low-Q resonator.

Vibration and temperature changes aren't an issue with mode-splitting sensors; neither is the particle-location problem. The clockwise and counterclockwise light waves share the same resonator and therefore the same noise; any jiggle that biases one will bias the other by the same amount. And the mode split will still vary with the location of the particle, but the ratio of the mode split and the difference between the breadth of the two modes will be dependent solely upon the size of the particle.

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Europe signs on to big x-ray facility

HAMBURG, Germany – Europe soon will boast a multimillion-dollar research facility that promises to open up completely new research opportunities for scientists and industrialists alike. The European X-ray Free Electron Laser (European XFEL), which will be located in Germany, will generate ultrashort x-ray flashes 30,000 times per second, with an intensity a billion times brighter than that of the best conventional x-ray radiation sources.

Using the x-ray flashes of the European XFEL, scientists will be able to map the atomic details of viruses, decipher the molecular composition of cells, take three-dimensional images of the nanoworld, film chemical reactions and study processes such as those occurring deep inside planets.

Construction and operation of the European XFEL is being realized as a joint effort of 12 countries: Denmark, France, Germany, Greece, Hungary, Italy, Poland, Russia, Slovakia, Spain, Sweden and Switzerland. Representatives from 10 member nations took an important step toward realization of the facility when they met Nov. 30, 2009, to sign the international European XFEL agreement. The pact lays the foundations for the facility

The international European XFEL convention was signed in November 2009 at the Town Hall in Hamburg, Germany. Images courtesy of European XFEL 2009.

Shown is the European XFEL construction site at DESY-Bahrenfeld in Hamburg in June 2009.

under international law and defines the financial contributions of the partner countries.

Totaling €1082 million – at 2005 price levels – the construction and commission of the new x-ray laser facility rely solely on the support of its partners. As the host country, Germany covers 54 percent of those costs. Russia bears 23 percent and the remaining nations, between 1 and 3.5 percent each. But with investment comes return, and this is expected to be big.

"The contributing countries participate not only in the construction, thereby obtaining a lot of knowledge in state-of-the-art accelerator and x-ray systems technology, but also participate in the definition of the scientific program and in its preparation," said Dr. Thomas Tschentscher, director of user operations at the European XFEL. "The partners, therefore, have the opportunity to be involved in leading-edge x-ray research, which will provide education for scientific and engineering staff as well as the development of a scientific life in the fields of interest."

The facility will be open for business in 2015 when proposals for scientific investigations will undergo a peer-review process, and approved experiments will be invited and supported by the facility staff. Connections with the photonics community are paramount because one of the key aims of the laser facility is to study matter at the time and length scale of atomic motion. This involves the challenging goal of obtaining time resolutions on the order of 10 fs, using optical lasers.

Tschentscher believes that the project is a chance for Europe and the contributing countries to demonstrate how scientists can benefit from joining forces. "The European XFEL shows how the collaboration of an international team of experts can result in a world-class facility, which will serve a large community and help to advance new scientific applications," he said.

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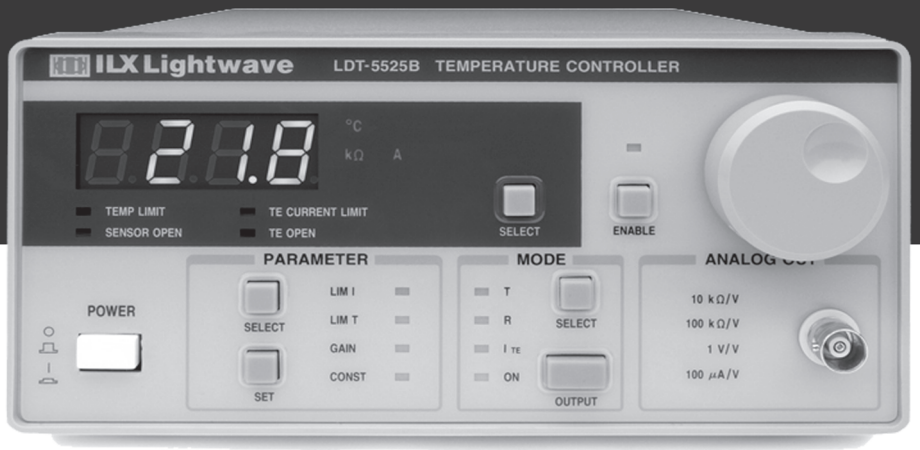
Precision Laser Diode Temperature Controller



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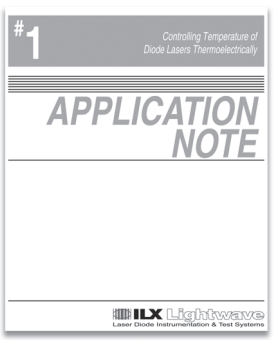

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Startups to watch in 2010

Even in a troubled economy, young optics and photonics companies continue to press forward. Here are 10 newly minted businesses to keep an eye on as we move into the new year.

• **Cyan Optics**, founded in 2006 and headquartered in Petaluma, Calif., offers highly integrated packet optical transport systems for the telecom industry. In September 2009, the company formally introduced its Z-series multilayer transport platforms with more than 20 carrier customers; it reported that it had raised at least $27 million in three rounds of funding from venture capital companies such as Azure, Grande Ventures, Kinetic Ventures and Norwest Venture Partners.

• Poway, Calif.-based **Daylight Solutions** has developed a broadly tunable or fixed-wavelength mid-infrared laser source combining quantum cascade gain media with its external cavity quantum cascade laser technology. Using this source, the company manufactures a range of components, subsystems, and systems for sensors and high-power illuminators.

"We recognized that, if you can generate sources and subsystems operating in the 3- to 12-µm range, you have a number of clear market opportunities," said CEO Tim Day. "But they also have to be very compact, fully integrated telecom-type packaging solutions."

The company serves three major sectors. The first is the scientific research market. The second is defense and security applications – for example, thermal imaging, laser aiming, countermeasures and free-space communications – that can benefit from low-weight, highly integrated systems. The final sector is sensors, for CO_2 or glucose detection, for instance.

"There's a whole range of molecules that you can address if you have control of the wavelength in the 3- to 12-µm regime," Day said. The sensors also can be used for environmental monitoring and medical diagnostics applications.

• **FASORtronics**, in Albuquerque, N.M., manufactures guidestar lasers for observatories to use with adaptive optics. These sodium laser sources are based on a single-frequency, continuous-wave architecture demonstrated at the US Air Force's Starfire Optical Range. The company's plan is to propose, engineer and build guidestar lasers for use with the larger telescopes, including the 8- to 10-m telescopes in operation and the 25- to 50-m telescopes on the drawing boards.

Los Angeles-based RealD has utilized polarization control solutions from ColorLink, which it acquired in 2007, to advance its 3-D technologies for the theater and home markets.

• Boulder, Colo.-based **mBio Diagnostics** reports that it is developing simple yet robust medical diagnostic solutions for doctors' offices and clinics as well as for less traditional point-of-care locations – kiosks in large discount stores, for example. The company's initial focus is on infectious disease testing, particularly multiplex assays for HIV- and AIDS-related co-infection screening and HIV patient management.

Besides domestic markets, the company is designing the screening systems for developing countries as well, thus helping to meet an important global health care need. It currently has an instrument in Mozambique (The word "mbio" is Swahili for "fast."), where it is running clinical trials. Chris Myatt, founder and CEO of mBio Diagnostics, a subsidiary of Precision Photonics, expects to have a product on the market in 2011.

• **Mobius Photonics**, which recently moved its headquarters to Mountain View, Calif., offers fast-pulse fiber-based laser sources. The current product family, dubbed the G1+ Laser System, features fundamental (infrared) as well as second- and third-harmonic (green and UV) outputs. The system generates pulse durations down to the hundreds of picoseconds and up to the tens of nanoseconds.

The sources are used in several application areas, said Kiyomi Monro, vice president of business management at Mobius. In microscopy, for example, they are used in stimulated emission depletion (STED) experiments at the Max Planck Institute in Munich, Germany, offering a novel laser source for STED microscopy that should facilitate development of more compact and versatile systems.

• **OneChip Photonics** of Ottawa develops and manufactures high-performance optical transceivers based on monolithic photonic integrated circuits in indium phosphide for a variety of telecom applications, including access networks and other mass-market broadband applications. The company believes that this technology will help to overcome the various cost and performance barriers that have hindered widespread deployment of fiber to the home.

OneChip announced last March that it had secured $19.5 million in venture capi-

In Boulder, Colo., mBio Diagnostics is developing medical diagnostic solutions focusing on infectious disease testing. The company is designing the systems for developing countries as well as for the domestic market and therefore is making them simple yet rugged.

tal financing from Canadian and US investors including BDC Venture Capital, DCM, GrowthWorks Canadian Fund and Morgenthaler Ventures. In addition, it was cited as being on Canada's "Companies to Watch" list at the 2009 Deloitte Technology Fast 50 Awards. Also in 2009, OneChip received the Outstanding Technology Company Award from the IEEE Ottawa Section.

• Sunnyvale, Calif.-based **Picarro** produces gas analyzers for monitoring carbon emissions. Conventional infrared spectrometers offer relatively limited sensitivity to trace gases in the atmosphere – typically the parts-per-million level. Using its WS-CRDS (wavelength-scanned cavity ring down spectroscopy) technology, Picarro has demonstrated gas analysis at the parts-per-billion level and, in some cases, the parts-per-trillion level.

The company, which received a Technology Innovation Award from the *Wall Street Journal*, has built the technology into a portable device that needs relatively little maintenance, so it is easily deployed in the field. Thus companies that are required to reduce emissions under cap and trade or other rules can measure the emissions remotely in the downwind plume, for example, at considerably reduced cost.

• **QD Vision** of Watertown, Mass., another *Wall Street Journal* Technology Innovation Award winner, has developed quantum dot lighting technology with which to improve the color quality of LED lamps, among other applications. Founded in 2004, the company has secured more than $20 million in private investments.

• Since its inception in 2003, Los Angeles-based **RealD** has become the leading provider of 3-D projection technology for movie theaters, with its products accounting for roughly 90 percent of the US 3-D market today. And much of this success, said Joshua Greer, president and co-founder of the company, is due to the acquisition in 2007 of Boulder, Colo.-based ColorLink, whose polarization control solutions – and in particular its retarder stack technology – have since served as cornerstones of the company's development efforts.

In addition to developing its cinema and pro lines – the latter serving several branches of the military, for example – RealD is eyeing the home 3-D market. "The movie industry is used to seeing revenue from home video and other markets," Greer said. "So we have been quietly working toward this through technology developed for the pro line. We have been preparing for 3-D in the home for a number of years."

• **Solyndra**, headquartered in Fremont, Calif., produces cylindrical solar modules designed specifically for the commercial rooftop market. The cylindrical design provides for more efficient collection of sunlight across a wider range of angles, even capturing light reflecting off the roof. At the same time, the thin-film technology used with the modules contributes to lower production costs.

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Position yourself in photonics

LEXINGTON, Mass. – For job hunters trained in the photonics/optics fields with an associate's degree to a PhD or beyond, experts in photonics job recruiting and hiring trends provide some insight into what they see on the employment radar, where one might look for jobs and how best to prepare for the 2010 job market.

"Oftentimes companies affected by an economic downturn tend to cut deeper into their human capital resources, so during a recovery they find themselves even more shorthanded, which can lead to a positive bubble in hiring. My expectation is that we will start to see this in the first and second quarter of 2010," said Howard

Rudzinsky. He is a representative of Louis Rudzinsky Associates, a photonics, electronics and software job recruitment and placement firm based in Lexington, Mass. Rudzinsky is a 25-year veteran in optics and photonics recruitment and placement.

"The demand for jobs in most aspects of the photonics industry will be on the rise. Those who will be most successful in the re-emerging photonics job market will be those who are most versatile. If you are a PhD or soon to be one, be more pragmatic; be more 'applied' in your research," he advised.

"People will need to be more interdisciplinary and multiskilled. For example, if you are an optics or lasers person, pick up some optomechanical skills, or a computer-aided design package, such as ProE or Solidworks, or Matlab or Labview software for test. Become a better communicator and a technical resource to sales and marketing and/or customers," he said.

There is likely to be a rising demand for photonics in defense/aerospace, industrial laser applications, photovoltaics and optoelectronics, optical test and measurement, and some aspects of telecommunications, Rudzinsky noted.

Designers and engineers of biomedical devices – "There is a great demand for biomedical devices that will drive down the cost of health care – and thus for the people that have the training and ability to design them. The intersection of optics and biology is an important field right now," according to Duncan Moore, who is a vice

provost for entrepreneurship and professor of optics, optical and biomedical engineering, and business administration at the University of Rochester in New York. Moore also serves as chairman of the International Commission for Optics Committee on Regional Development of Optics.

Small- to medium-size photonics companies – "There are jobs available in small- to medium-size companies for people trained in photonics-related fields, Moore said. "These jobs are harder to find, however, and more networking and research will be necessary on the part of the job hunter." Hit hard by the recession, the big corporations have downsized and aren't as likely to be found recruiting at college fairs or otherwise reaching out for candidates to the extent that they have in the past, according to Moore.

Engineering and manufacturing – "I would like to put a plug in here for good engineering and manufacturing talent. It makes the difference between winning share coming out of the recession or collapsing just when opportunity opens up. It's critical, and in the US, it's undervalued, especially in academia and in certain parts of the country. It's my view that the demand for those workers is always a little greater than for the other types," said Tom Hausken, director of components practice

at Strategies Unlimited, a market research firm for advanced technologies based in Mountain View, Calif.

Rudzinsky noted that engineering professionals with manufacturing design skills and the ability to implement cost-saving operational strategies, processes and techniques will be in greater demand as companies control costs, and margins become smaller.

Cyclic and growing industries – Cyclic industries, including the semiconductor tool business, contract manufacturing and anything related to commodities, are likely to be rehiring, Hausken said. He added that growing photonics industries are re-hiring, too, to meet the demand for products such as high-brightness LEDs, LED lighting, image sensors, biomedical equipment, various sensing subsystems, and components in the field of energy and energy conservation.

Marketing and salespeople – "Both large and small companies cut back on these positions until the market warms up, so there may be more openings when revenues are growing again," Hausken said. He emphasized that it is important to have cross-education in an aspect of the business that isn't your field.

Photonics technicians – Results from a photonics industry survey released in September 2009 by the National Center for Optics and Photonics Education (Op-Tec) in Waco, Texas, indicated that 2100 new photonics technicians will be needed over the next year in the US, particularly in the areas of research and development as well as production and manufacturing. The center says that the average starting salary for these positions exceeds $39,000 and is even higher for those who hold an associate's degree in applied science.

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Outlook positive for remote sensing

WELLESLEY, Mass. – The global value of remote sensing products is expected to reach $11 billion by 2014, up from an estimated $8.3 billion in 2009, with a compound annual growth rate of 6 percent, according to a report from BCC Research, a market analysis firm. The report, titled *Remote Sensing Technologies and Global Markets* (IAS022B), was published in October 2009.

"In the study, I looked at the remote sensing market from the perspective of four platforms for the instrumentation: spaceborne, airborne, terrestrial and aquatic," said analyst James Wilson, author of the report. "To a large extent, the platform determines the type of instrumentation. Photonic and optical instrumentation are compatible with all four platforms."

The product value of instruments for the largest segment – space-based satellite platforms, estimated to be worth $3.3 billion in 2009 – is expected to reach $4.4

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billion in 2014, with a compound annual growth rate of 5.7 percent. The value of instruments for the second largest, the airborne aircraft-based platform, is expected to rise from an estimated $2.3 billion in 2009 to $3.1 billion in 2014, with a growth rate of 6.4 percent.

Instrument values for terrestrial and aquatic platforms are projected to have growth rates of 5 and 8.7 percent, respectively, from 2009 to 2014.

Among the basic types of photonics-based remote sensing instruments are cameras (film and digital), and laser, lidar, hyperspectral and multispectral.

Wilson said that the spaceborne platform segment is large for obvious reasons: superior height and unobstructed views. Satellite-based remote sensing instruments are used to collect imagery and other data from the Earth's surface for various purposes.

"Also, from a business standpoint, the technology is mature, and the risks are insurable – you can plug a dollar value into a business plan. Satellite platforms can outperform expectations in terms of their ability to generate revenue by operating

longer than their nominal lifetimes. Once the satellite and ground network are in place, a business can scale up with minimal human intervention. You see operators of space-based platforms expanding their business by absorbing aerial photography companies, and not the other way around," he noted.

Land-use planning

Wilson divided the remote-sensing product market into 20 application areas, among which instruments used for land planning were projected to be the strongest performers, with a compound annual growth rate of 15.6 percent predicted from 2010 to 2014.

The land-planning application is expected to thrive, mostly because this area of remote sensing dovetails with geographic information services organizations, which are receiving funding through the US government's American Recovery and Investment Act, he said. The act contains numerous programs that will speed the adoption of geographic information systems by state and local governments.

"Photonics/optical-based remote sensing has contributed to the systems in that it has provided an intuitive interface; for example, one might click on an online image of a house obtained through satellite imagery to get its sales and tax history," he said.

"The funding will provide the needed financial impetus to put in place infrastructure that encourages further use of the systems as a revenue generator. Municipalities raise most of their revenue from taxes or

noncompliance fines. Linking aerial and space imagery to geographic information services enables communities to improve tax collections by identifying parcels that are underassessed, such as a home with a swimming pool that was constructed without building permits," he added.

This type of sensing also can improve the richness of information about locations. For example, Wilson said that there are companies that help identify the location of precious metal deposits on the basis of change in leaf color caused by the presence or absence of these metals.

"Challenges to the space-borne remote-sensing industry include surviving an era of reduced defense spending and dealing with the sorts of privacy issues that Google is now fighting," he said.

Agriculture, public health

The values of remote sensing products used in agriculture and public health applications are expected to have compound annual growth rates of 11.7 percent each from 2010 to 2014. Growth rates in the single digits are projected for products used in oceanography, cartography, urban and suburban planning, intelligence gathering, disaster management, climate change studies, atmospheric research, forestry, border protection, natural hazard monitoring, weather forecasting, law enforcement, right-of-way management, hydrology and fresh water resources, land mine detection, and oil, gas and mineral exploration.

No growth is predicted for the products in archaeological or culture site protection, according to the report.

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Licensing Agreement JDSU of Milpitas, Calif., has licensed patent rights for fundamental picosecond laser technology to Hamamatsu Corp. of Bridgewater, N.J., for the development of microelectronic products. The technology is suitable for micromachining and applications related to microsurgery, robotics, biological warfare detection and high-precision optical radar. JDSU specializes in telecommunications testing and measurement.

LIA Award Presentation Bill Shiner, vice president of industrial markets at IPG Photonics Corp. in Oxford, Mass., has received the 2009 President's Award from the Laser Institute of America. The prize, presented at the ICALEO conference, honors individuals who have made significant contributions to the society, enabling its growth and prosperity. This was the first time in more than five years that the award had been presented.

IEEE Award In Ottawa, OneChip Photonics has received the 2009 Outstanding Technology Company Award from the IEEE Ottawa Section. At the 65th Annual General Meeting and celebration of IEEE's 125th anniversary, the company was honored for its breakthrough approach and optical transceivers based on a photonic integrated circuit. Both will enable the deployment of fiber-to-the-home, and new business and consumer broadband applications.

Photonics Cluster Launched The Southern European Cluster in Photonics and Optics has been launched to improve the competitiveness of the optics and photonics sectors in Spain and southern Europe. Comprising nearly 40 research institutions and companies, it will focus

on industrial solutions. Its goals will be to promote research and development collaborations among industry and research organizations, to increase international business, and to improve, attract and maintain talent.

$4.5 Million Grant Momentive Performance Materials Inc. of Albany, N.Y., has received $4.5 million in funding from the US Department of Energy to continue to develop technology for low-cost production of LEDs used in solid-state lighting and for increased LED performance. The grant will help the company develop the commercial-scale technology, processes and equipment needed for mass-production of energy-efficient LEDs, which could reduce the national energy consumption for lighting by 29 percent.

Fiber Laser Project A collaborative, large-scale integrated project funded by the NMP (Nanosciences and Nanotechnologies, Materials and New Production Technologies) Directorate in the 7th Framework Programme of the European Commission has been established. LIFT, or Leadership in Fiber Laser Technology, is a €16 million endeavor to expand the limits of advanced materials processing applications through a new generation of fiber-based lasers. It will develop innovative laser sources, enable a greater market share for existing applications and create new application areas for manufacturing. The project also will build a network of European components suppliers and laser systems manufacturers.

Industry Standards Development Leaders from the Automated Imaging Association, the European Machine Vision Association and the Japan Industrial Imaging Association have signed a cooperative agreement to develop and promote global machine vision standards in Stuttgart, Germany, at the 2009 Vision trade show. Standardization issues now will be developed by one lead association and promoted mutually by the group as a global industry standard. If there is no consensus on the global need for a standard, each association retains the right to develop standards outside the cooperative group.

Growth Opportunities In Zurich, Switzerland, power and automation technology group ABB has reorganized its automation division to accommodate the needs of its customers. The effort will enable the company to tap growth opportunities in service, expand its presence in the manufacturing sector and better respond to the demand for energy-efficient solutions. Under the reorganization, the business units currently in the Automation Products and Robotics divisions will be regrouped into two new divisions: Discrete Automation and Motion, and Low-Voltage Products.

Funding Supports Competitiveness The research project PrOpSys (production technology of optical systems for high-power diode lasers) has demonstrated a fully automated assembly and adjustment of a high-power diode laser. Created to target the development of technical bases for mass-production-suited designs and the associated fully automatic manufacturing technology for micro-optical systems and high-power diode lasers, the project is funded by the BMBF (German federal ministry of education and research) and will continue to utilize the research of companies and institutes.

Infrared Camera Milestone Waltham, Mass.-based Flir Systems Inc., a thermal imaging and stabilized camera systems manufacturer, has announced the delivery of its 100,000th commercial-use infrared camera. The Flir BCAM SD infrared camera was sold by its distributor, Professional Equipment, to the owner of Bob the Inspector Inc. in Green Valley, Ariz. The owner and distributor were honored at an awards ceremony to commemorate the milestone, during which the owner received the imager, compliments of the Massachusetts company.

Framework Agreement Fremont, Calif.-based Solyndra Inc., a manufacturer of cylindrical photovoltaic (PV) systems for commercial rooftops, has signed a long-term framework agreement with alwitra GmbH & Co. of Trier, Germany, a

roofing systems supplier. Under the terms of the agreement, the solar panels will be manufactured at Solyndra's facilities in Fremont and in Milpitas, Calif. Its thin-film PV systems generate more electricity on an annual basis from typical low-slope commercial rooftops than do conventional flat panel types, according to the company.

Machine Vision Distributor Appointed Laser diode manufacturer Frankfurt Laser Co. of Friedrichsdorf, Germany, has appointed Microview & LingZhi Image Tec. Co. of China, Mitra AS of Turkey and Osyris Industriel of France as distribution partners for its operations in the machine vision, marking and target designation markets in their respective countries.

Authorized Integration Component-level solutions developer Matrox Imaging of Montreal has brought its Authorized Integrator Program to Europe to help manufacturers find qualified local machine vision consultants to integrate vision systems into their manufacturing processes. Systems integrators who join the program will receive benefits including preferential pricing on the company's hardware and software products, prequalified sales leads, personalized applications support, and frequent training sessions and marketing support.

OLED Research Funded Merck KGaA, Applied Materials Inc. and Braunschweig University of Technology (TU-BS) have announced that they have received a grant from the German Federal Ministry of Education and Research to develop processes to reduce the cost of manufacturing organic LED (OLED) lighting. The three-year project, called Light InLine (LILi), is being led by Applied Materials, which will join forces with Merck, a manufacturer of OLED materials, and TU-BS, a center for OLED research. The project is centered at the advanced development facility in Alzenau, Germany.

German Partnership Specim (Spectral Imaging Ltd.) of Oulu, Finland, a hyperspectral imaging components and systems manufacturer, has announced a distribution agreement with SoliTec GmbH in Germany. Through the partnership, the former company will strengthen its visibility and services in Middle Europe. The distributor will provide support in operating hyperspectral imaging systems in various airborne platforms and will represent the Finnish company's airborne imaging spectroscopy application hyperspectral systems in Germany, Austria and Switzerland.

CEI Opened In the UK, more than 80 representatives from the academic and business communities gathered at The Open University's Milton Keynes campus to celebrate the opening of the e2v center for electronic imaging (CEI). The CEI is a joint collaboration between the university and e2v of Chelmsford, UK, a specialized components and sub-systems manufacturer. Dedicated to the research and development of advanced technologies for electronic image sensing, the two organizations will invest £3 million into the UK economy over five years for new research activity through the CEI.

MRF Machine Optical components manufacturer Optimax Systems Inc. of Ontario, N.Y., has expanded its capability of manufacturing high-precision spheres and aspheres with the acquisition of QED's Q22-Y machine. With the magnetorheological finishing (MRF) system, the company has increased speed and accuracy, and has produced results better than $\lambda/20$ peak-to-valley on diameters up to 200 mm or greater. It will leverage the machine to extend its capabilities to include prisms, and free-form and cylindrical optics.

Optoelectronics Center Established In Clemson, S.C., the Optoelectronics Research Center of Economic Excellence has been established in the Holcombe Department of Electrical and Computer Engineering at Clemson University. Private gifts from telecommunications companies Comporium of Rock Hill and PalmettoNet of Columbia, both in S.C., along with a state match, raised $4 million for the center's establishment. It will strengthen the research program in the Center for Optical Materials Science and Engineering Technologies.

Changing for Performance

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Stimulating sustainability: Trends in government policy

BY ANNE L. FISCHER
SENIOR EDITOR

Germany previously was known for its automobile industry. Now it is solar. Not bad for a country with more clouds than sun.

The country achieved its title as the world leader in the solar industry largely through its ambitious feed-in tariffs. When the new government took over last fall, however, there were concerns that feed-in tariffs would be slashed by 30 percent. That did not happen. Tariffs already were set to drop between 9 and 11 percent this year, so the new government's reduction of 15 percent is not hard to swallow.

The results of Germany's gross feed-in tariffs are many: jobs, a strong solar industry and an increase in energy generated by the sun.

Not all feed-in tariff programs remain robust, however. Spain's solar industry suffered a crash last year, with many blaming it on an overambitious tariff program. There was so much interest in solar installations – 3 GW installed in 18 months – that the government committed payments of more than $26 billion, far more than it had bargained for. Unlike Germany, there was no planned reduction in tariffs if targets were met or exceeded.

In response to the crash, the Spanish government upped its target and reduced tariffs, but a backlash rippled throughout the industry with excess supply, price cuts, job losses and more. In the end, much was learned. Spain has a revised tariff program, and rooftop installations remain strong.

In the US, the long-term extension of the federal Investment Tax Credit (ITC), coupled with new rules that allow utilities to take advantage of the tax credits, has spurred growth. And individual states now have their own programs and incentives, most notably California, with its 10-year $3 billion Go Solar California Campaign.

As part of the ITC program, utilities offer rebates and performance incentives. According to the Interstate Renewable Energy Council, the capacity of photovoltaic installations completed in 2008 grew by 63 percent over 2007, with California leading the way with a 95 percent increase.

Although China was once the world's largest producer of photovoltaic modules, it exported more than it kept for its own energy needs (see "Forecast: partial sun in China," *Photonics Spectra*, June 2009, page 31). The country now has set an ambitious goal for installed solar capacity: 2 W by 2011 and 20 GW by 2020.

The Indian government also has made the move, announcing the National Action Plan on Climate Change, which calls for 20 GW of electrical power to be generated by solar by 2020 (see "Solar in India," *Photonics Spectra*, August 2009, page 31). Not surprisingly, India also recently announced a feed-in tariff program.

There is no denying that government incentives, done right, boost investment in green and clean technologies.

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Pushing the envelope: Trends in green research and technology

Raising efficiency while lowering costs is the trend in solar as well as solid-state lighting. Researchers have been working toward this end in both areas for decades, and there are many advances to report.

In the solar research arena, scientists are looking at new materials, such as cadmium telluride (CdTe) thin film, nanoparticles, optical fibers and more. First Solar of Tempe, Ariz., hit the milestone of $1 per watt in October 2009 with its CdTe technology, but, like others, the company continues pushing the envelope of research to try to meet grid parity without subsidies and has set 2012 as a target. And the quest goes on. A group in Jerusalem, for example, is working on glass plates coated with silver nanoparticles and dyes with just a thin strip of silicon along the edges. The method is expected to result in solar panels with 20 percent efficiency that can be manufactured at lower costs than traditional silicon-based panels. Developed by Renata Reisfeld's group at Hebrew University, the technology is being commercialized by GreenSun Energy, where Reisfeld was formerly chief technology officer.

In June of last year, *Photonics Spectra* reported the use of zinc by a team at Northwestern University in Chicago to develop low-cost photodetectors ("Not just for your nose," p. 35). Georgia Institute of Technology researchers are now using zinc oxide nanostructures on optical fibers in a 3-D photovoltaic system.

Old materials, new ways

Others in solar research are using established materials in a new way. Brian Korgel's group at the University of Texas

GreenLight

at Austin is using CIGS (copper indium gallium selenide), a material that he said is known to work well, to reinvent how the devices are made. Korgel noted, "In a sense, all of these research groups and companies are competing to find the solution. In terms of society, it's not a competition – it's people trying to solve the energy problem."

Another trend is the pairing of solid-state lighting with solar, whether in shared technologies or in the final application. For example, drawing on work with nitride materials used in solid-state lighting and blue lasers, Phoenix-based RoseStreet Labs Energy is developing a photovoltaic cell that combines traditional silicon with a nitride thin film. According to Bob Forcier, chairman and CEO, the company initially was developing a triple-junction cell but decided to focus its research first on a "simpler, more elegant first product." Forcier indicated that the company is currently testing a hybrid device that could achieve 25 to 30 percent efficiency.

Solar Roadways is a group that's testing LEDs embedded in a road paved with solar cells. The brainchild of Scott Brusaw, chief executive officer of the Sagle, Idaho-based company, the idea is to generate electricity on the road, with road lines and signage "painted" under the surface with LEDs. A prototype is currently under development for the US Department of Transportation.

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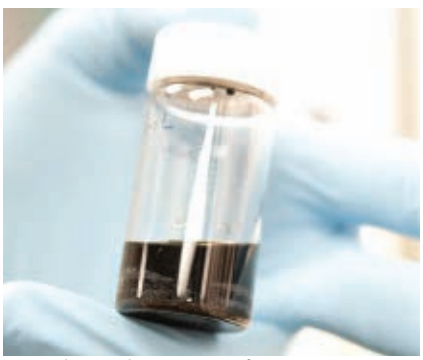
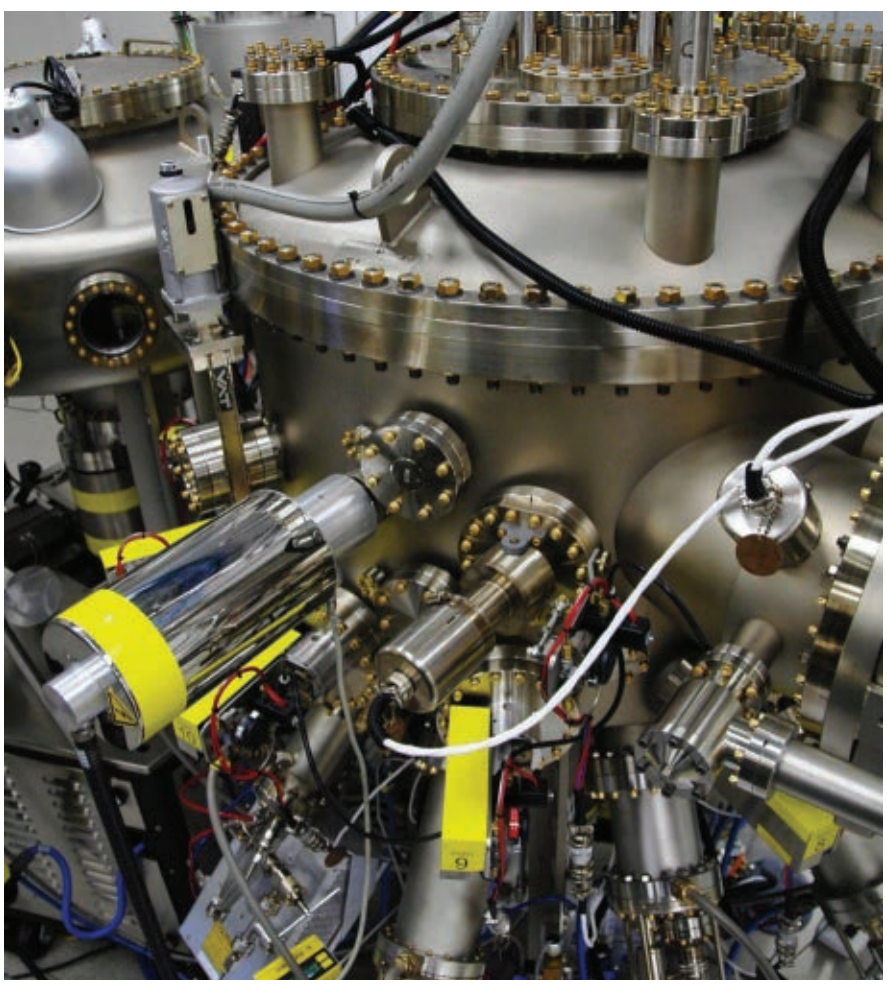


Researchers at the University of Texas at Austin are working on sunlight-absorbing nanoparticle inks.



RoseStreet Labs Energy tests hybrid photovoltaic cells on its pilot line.

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Flipping the switch: Trends in green applications

From stand-alone solar power stations to recycling systems that use machine vision, systems that were futuristic visions not so long ago are real-world applications today.

Personal power stations using alternate energy are emerging from the lab and landing on the farm. SunPods Solar Smart Technology Systems from San Jose, Calif.-based SunPods Inc. are examples of how solar energy can be put to use in a single application. These self-contained solar generators run on or off the grid to power wells, irrigation and water-distribution systems. They have polycrystalline or monocrystalline photovoltaic modules and are rated at 200 to 220 W. Their use is aimed at farms and ranches as well as at any off-grid project or area where power is unreliable.

LED lightbulbs

The Edison bulb, or the incandescent, is on its way out after a 130-year run. As countries impose restrictions on the sale of incandescents (some have banned them entirely) or impose efficiency regulations on lightbulb use, compact fluorescent lightbulbs and LEDs are stepping into the limelight.

And, just in time, LED bulbs that fit into standard sockets are appearing on the market. The usual name brands have come out with 60-W bulbs, and then there are startups such as Netherlands-based Lemnis Lighting and Florida-based EarthLED – and there are sure to be more. The price is around $40 to $50 for a 60-W equivalent, which is high until you weigh the advantages: They last 40,000 h compared with 15,000 for compact fluorescent lightbulbs; contain no mercury; are dimmable; and are twice as energy-efficient as compact fluorescent lightbulbs (85 percent more than incandescent). Expect prices to drop in the future, too, bringing cost of ownership down even more.

Roofing tiles with solar cells

Solar based on the semiconductor alternative, CIGS (copper indium gallium selenide) has much potential because of a lower cost of manufacturing and greater application potential. Take rooftops as an example. Instead of bolting large silicon-based photovoltaic panels on roofs, solar energy can be drawn from the roofing tiles themselves.

Solar energy is being generated from roofing materials that blend right in. Shown here are Powerhouse shingles from Dow Chemical Co.

Vision sensors won't take out the trash, but they are helping to sort it with recycling systems such as this short-wavelength infrared-based solution. Courtesy of Eagle Vizion.

Two US-based companies, Dow Chemical Co. of Midland, Mich., and SRS Energy of Philadelphia, recently announced solar roofing materials. Dow's Powerhouse tiles look like regular asphalt shingles, but they are small CIGS-based solar panels with an efficiency of what Dow claims to be above 10 percent. The US Department of Energy awarded Dow $20 million to help develop Powerhouse and other building-integrated products, which are manufactured in the company's Midland facility.

Solé Power Tiles from SRS Energy look like a traditional ceramic roofing tile but are embedded with thin-film amorphous silicon solar cells from United Solar Ovonic of Auburn Hills, Mich.

Machine vision sorts the trash

Recycling is a trend in itself, whether required of corporations through government directives or of individuals through municipalities. The trend is giving rise to myriad machine vision solutions, some of which have such sophisticated sensing ability that they can pick over various materials.

Sensors Unlimited Inc. of Princeton, N.J., part of Goodrich Corp., for example, has indium gallium arsenide short-wavelength infrared detectors and spectrometers at work in plastics and other recycling applications. Less expensive than their cooled detector counterparts, they operate at room temperature without fans or cryogenics, according to Douglas S. Malchow, business development manager for industrial products. He noted that they can capture absorption spectra without any sample preparation (beyond washing the plastics).

In some cases, particularly when only dealing with a couple of plastic types, two or three line-scan cameras are installed, each with bandpass filters that correspond to the key wavelengths that differentiate one plastic type from another. The images then are combined to identify and sort the plastics into the right bins.

These are just a few of the many applications that use state-of-the-art technologies to make a difference. Even more exciting than talking about the potential of green technologies is actually seeing them in use to help reinforce global sustainability efforts.

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Fad or future: Green market trends

Market research indicates that the trend toward sustainability will be growing even a brighter shade of green in the days ahead. One has only to look at the proliferation of LED backlighting in consumer goods, the falling cost and increased installation of photovoltaic systems, the adoption of LEDs in numerous lighting areas – and the optimism surrounding it all to understand that the green we're seeing today is not about to fade away.

Bright prospect in lights

Cost has always been an issue with LEDs. Now costs have dropped to the point where LEDs are the way to go in general lighting, backlighting and more. Christopher Blansett, an equity analyst at JP Morgan in Silicon Valley in the San Francisco Bay area, believes that we'll see a new generation of LED lighting products in the next 12 months that will lower the ownership cost of LED lighting below that of mainstream fluorescent products for the first time. He noted that municipal, commercial and industrial users who "made the transition to fluorescent lighting 20 years ago" are most likely to be early adopters of LED-based lighting to reduce their operating costs further.

On the chip side, demand for LEDs for large-size backlight operations, general lighting, smart phones and other applications has been so strong that, according to Taiwanese research firm LEDinside, it's caused a strain in the supply chain, but the market has also stabilized (and, in some cases, dropped) pricing for white LEDs. Naturally, with prices dropping, adoption is soaring. One LED manufacturer who is taking flight is Durham, N.C.-based Cree. The company announced that it will add 575 jobs in the next three years and will increase production in both its Durham and China plants.

The OLED niche

Organic LEDS (OLEDs) have been a technology waiting to take off. According to a market research report released by iSuppli in October 2009, OLEDs have found a home in high-end televisions – a niche market, but a strong one nonetheless. The report forecasts that OLED-TV revenue will increase by a factor of 200 through 2015, driven by consumers seeking incredible image quality as well as lower energy consumption compared with that of the television's LCD counterpart.

Steady advance in solar

The solar business has been a roller coaster ride for most. Numerous factors contribute to the unsteadiness: the downturn in the global economy, the price of silicon, the crash of the market in Spain and increasing market saturation. According to Photon Consulting's *Solar Annual 2009* report, the supply chain will be completely saturated by 2010. This will lead to cost reductions and lower profit margins for module makers. In November, Santa Clara, Calif.-based Applied Materials, a maker of semiconductor manufacturing equipment, announced cuts of 10 percent

or more of its workforce. CEO Mike Splinter indicated that the cuts are cost-saving measures in response to the consolidation they're seeing among customers, loss of orders and the simple fact that supply is exceeding demand.

The good news is that while costs come down, installations – and thus manufacturing – go up. The falling cost of solar photovoltaics was the focus of a report (*Tracking the Sun II*) recently released by the US Department of Energy's Lawrence Berkeley National Laboratory, which found that the average installed cost of a solar system declined by 30 percent from 1998 to 2008, with a 4 percent drop in 2009. In *PV Manufacturing in the United States*, by Greentech Media of Cambridge, Mass., analysts report that they expect the US will have 38 photovoltaic manufacturing plants by 2012, compared with 26 at the beginning of 2009. Consequently, solar component manufacturing will rise, creating as many as 20,000 new jobs over the next four years.

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2010
Trends
Lasers

Lasers set to blaze new trails

BY MELINDA ROSE
SENIOR EDITOR

As the 50th-anniversary celebration of the invention of the laser begins, the industry itself is making a cautious rebound after months of belt-tightening, consolidation and reassessment in the wake of a worldwide recession that put the brakes on laser growth. The microelectronics industry is on the rise, and some laser manufacturers are seeing an upswing in the life and health sciences. Solar and scientific research segments are being driven somewhat by funds finally flowing from economic stimulus packages, and industrial segments such as materials processing are continuing to recover more slowly.

Leaner and meaner

Perhaps driven by grim news in the microelectronics sector, which contributed 29 percent of its revenues in 2008, Newport Corp. made some aggressive moves in September of that year to streamline operations and reduce costs, such as outsourcing some manufacturing to its new facility in Wuxi, China, and reducing its head count and personnel costs, actions expected to save more than $15 million in 2009.

Also in 2008, bolstered by government investment support and strong industry and consumer demand, Newport invested significantly in developing products for applications in thin-film solar panel manufacturing, including automated scribing and edge deletion systems, lasers, solar simulators, advanced positioning systems, optical systems, and test and measurement systems.

By January 2009 at Photonics West, laser company CEOs were talking about the need to innovate, collaborate and consolidate. Those three things have been much in evidence throughout the year, with the introductions of many new and innovative products, the announcements of several key acquisitions, and the continuation of belt-tightening and consolidation plans.

In 2009, Coherent Inc. of Santa Clara, Calif., trimmed its work force by 24 percent, closed its St. Louis facility, vacated a building it leased in San Jose, Calif., and consolidated sales offices in Japan.

In October, it acquired StockerYale Inc.'s laser diode module and specialty optical fiber businesses, based in Montreal and Salem, N.H., respectively.

"These new products position us in the machine vision market and enable new applications in bioinstrumentation, especially in the area of structured life," Coherent President and CEO John Ambroseo said during a fourth-quarter earnings call in early November.

With semiconductor laser devices now being produced at its Sunnyvale, Calif., plant, Coherent also plans to exit its epitaxial growth facility in Finland by the end of fiscal 2010.

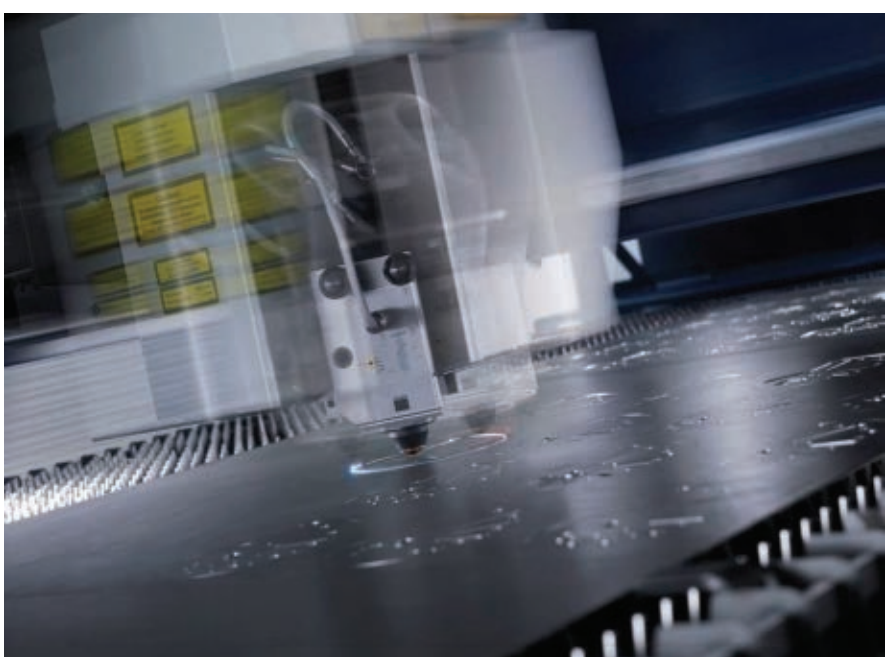
In early 2009, Oxford, Mass.-based IPG Photonics Corp. implemented a cost-cutting program that included decreasing the manufacturing costs of its major products by producing components such as couplers, processing cables, optical heads and chillers in-house, rather than buying from other suppliers; decreasing the cost of its low-power lasers, including pulsed ones, by 15 to 20 percent; and cutting its bonus program and moving about one-third of its employees to a shorter workweek.

The company also put the release of its CO_2 lasers, announced in May 2008, on hold.

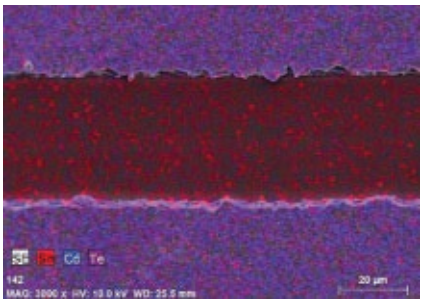
"It is not a good time to introduce it in this economic climate, where the sales of CO_2 flat bead cutting machines have plummeted and we are gaining traction very rapidly in the sales of fiber-based flat bead cutting machines," said Bill Shiner, vice president of industrial markets for IPG Photonics.

In June 2009, Newport announced that it was acquiring Oclaro's New Focus business, a portfolio that includes optoelectronics, high-resolution actuators, tunable lasers and optomechanics, in exchange for its high-power diode laser manufacturing operations in Tucson, Ariz.

"The New Focus acquisition has had a positive impact both from a product-market perspective and financial perspective for Newport," said Herman Chui, senior director of product marketing at Spectra-Physics. "The overlap with the Spectra-



With the TruLaser 1030, Trumpf said it offers something completely new: a machine with low investment and operating costs, as well as extremely simple operation. Courtesy of Trumpf.



Top, the new Quasi CW 532-nm Fiber Laser. Bottom, performed with just 0.1-W average power, clean scribing of the top layer is achieved without any damage to the underlying layer. The scribing speeds achieved were 2000 mm/s, and the frequency used was 150 kHz. Images courtesy of IPG Photonics.

Physics part of Newport is relatively small and is primarily on two fronts: The New Focus tunable lasers complement some of the Spectra-Physics tunable lasers from a product-offering perspective, and some of the New Focus operations now share the Santa Clara facility."

Newport relocated the Spectra-Physics Lasers Div. headquarters from its five-building campus in Mountain View, Calif., to a smaller, more modern manufacturing site in Santa Clara, Calif., to improve efficiencies, save money and facilitate the integration of New Focus. The move was expected to be finished by the end of 2009.

The new headquarters "is a state-of-the-art facility for lasers," Chui said. "The building was previously facilitated for medical device manufacturing, and many millions of dollars were invested in facilities infrastructure upgrades."

Industrial market

The recession hit the entire laser market hard, and the industrial market was no exception. In March, industry analyst Strategies Unlimited predicted that the industrial market would fall 32 percent in 2009, back to 2004 levels. Returning to 2008 levels would take about four years, the company said, with materials processing applications taking longer to recover and fiber lasers bouncing back faster than most.

After three grim quarters in 2009, however, some companies are now seeing some market bright spots.

"We have seen a modest upturn, particularly in the medical, photovoltaic and semiconductor industries, and are hopeful this will continue through 2010," said Trumpf Inc.'s Burke Doar, vice president of sales and marketing.

"Like just about all companies, Trumpf Inc. was affected by the economic downturn through reduced sales. However, we have not ceded any ground in our laser development efforts," Doar said. "If anything, those efforts have been strengthened, as evidenced by our continued ramp up of manufacturing lasers and components out of the LITE Building at Trumpf's Farmington, Connecticut, facilities."

Coherent reported that its $107.6 million revenue for fourth-quarter 2009 exceeded its expectations and grew 9.3 percent from the previous quarter.

The company reported new booking records for its Chameleon series of lasers, used predominantly for biological imaging, and for its amplifiers that support basic chemistry, physics and materials science research.

Coherent also emphasized its low price and economical operating cost when promoting its new Leap excimer laser, introduced last June. The laser is primarily intended for micromachining applications in microelectronics and medical device manufacturing.

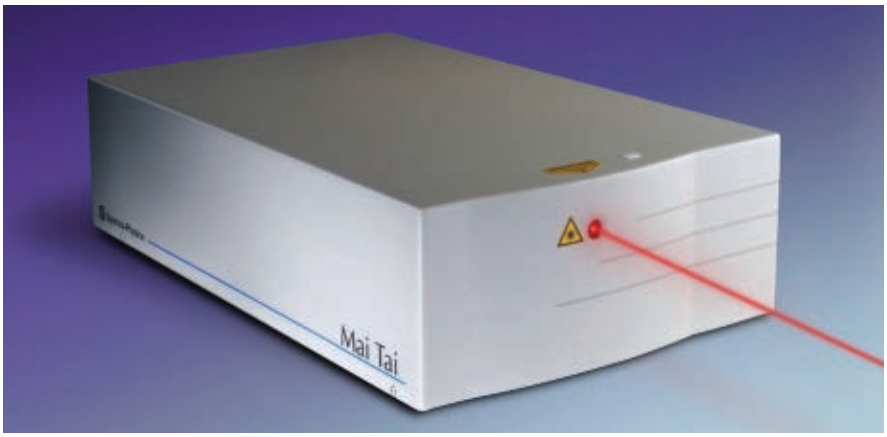
Spectra-Physics introduced its first industrial fiber laser, Alliant, in May 2009, and the market response has been moderate, Chui said, in keeping with the softness of the industrial laser segment.

"We continue to be investing significantly in fiber laser technology, and we believe it will play a significant role for us in some key areas, including industrial, microelectronics and other applications," he said.

The third quarter of 2009 was significant for Newport and Spectra-Physics because it marked the division's return to profitability for the first time since 2007.

The quarter "was a significant step in the continuing transformation of Spectra-Physics," Chui said. "We are seeing some level of growth into 2010 in most all of our end markets, and we are optimistic about the direction of our business."

He said the company "is seeing some recovery in the microelectronics and industrial markets, including semiconductor, photovoltaic, flat panel and other microprocessing applications; continued growth in the life and health sciences market,



Above, Spectra-Physics' Mai Tai SP (short pulse) laser is the first fully automated short-pulse ultrafast oscillator with computer-adjustable bandwidth and wavelength. At right, Spectra-Physics introduced its first industrial fiber laser, Alliant, in May 2009. Images courtesy of Newport Corp./Spectra-Physics Laser Div.

including bioinstrumentation and bioimaging applications; and strength in our research business.

"In short, yes, we are encouraged, although cautiously so, about the direction in both the laser market and our business," he said.

Semiconductors, stimulus and solar

Although the semiconductor market experienced a major slump in 2008 and most of 2009, some improvements have been seen in the past few months.

Coherent reported that its microelectronics industry bookings during the fourth quarter, although down 20 percent from the same quarter a year ago, had surged nearly 85 percent over the third quarter of 2009.

"It is our observation that Tier One tool vendors are recovering more rapidly than Tier Two or Three players," Ambroseo said during an earnings call. "While not a surprising development, it does beg the question of what the customer landscape will look like in 12 to 18 months."

An active application area in the semiconductor field is the generation of laser-produced plasma-emitting extreme-ultraviolet (13.5 nm) light for the next generation of photolithography tools, said Tim Morris, general manager of Trumpf's Laser Technology Center in Plymouth, Mich.

"There are a number of developers working on this, using high-power CO_2 and/or DPSSL [diode-pumped solid-state laser] sources," he said. "If the developers are successful in creating cost-effective tools with adequate throughput, a significant market for the chosen laser sources will develop over the next decade."

Some companies are betting on solar to help them through the microelectronics and industrial sector slump, with government subsidies in many countries helping fund the expansion.

"We expect that solar cell technology will continue to see significant growth, although the demands in this sector are ever-changing and vary dramatically from region to region," he said. "Recent reports indicate strong markets in China, Greece, Italy and the US into 2010 and beyond."

New manufacturing processes in the solar industry are increasingly requiring the use of lasers. Standard in the industry today is the use of lasers for edge isolation of crystalline solar cells and scribing processes for thin-film solar cells.

"In the future, new processes like laser doping, laser annealing, laser drilling and laser edge deletion will increase the demands for laser sources in the production of solar cells and modules dramatically," Morris said.

IPG's Shiner said his company has seen benefits from economic stimulus money in the US from manufacturers of electric car batteries, who require high-power fiber lasers, as well as from a government-funded geothermal project and several solar projects.

"We have been seeing a moderate positive impact in our scientific lasers business as a result of the economic stimulus, and we expect the benefit of the stimulus to increase into 2010," Chui said.

"The industry has slowed down, and financing is a question mark, but the stimulus money will help, and efficiencies will improve," Rofin-Sinar President and CEO Günther Braun said of the photovoltaics industry in a CEO discussion of the economic crisis during Laser World of Photonics in Munich in June. "It's a nice opportunity for us. It will pick up in 2010 – it's a little slow right now. It hasn't reached 10 percent of our company, but it is becoming important to us."

"Our internal estimate for stimulus-based orders in the US for the fourth quarter was approximately $4 million to $5 million, with nearly all of the money coming via the National Science Foundation," Ambroseo said during the earnings call.

Medical market

IPG sees medical and computer technology segments as receptive to replacing older technologies with fiber. "They are very rapid to embrace new cost-effective technology," Shiner said.

The company expects demand for fiber lasers for medical applications to increase in 2010, "as several new companies are now integrating IPG lasers into their systems in the dental and dermatology fields," Shiner said. "In addition, we have begun to ship in volume our high-power diodes that are being used for several medical procedures."

Coherent's products for the instrumentation market saw an increase in demand, especially in flow cytometry and confocal microscopy, in the fourth quarter, Ambroseo said. "There is growing expectation within this market that stimulus funds from NIH [National Institutes of Health] will drive a round of adoption, which could be behind some of the Q4 order growth," he said.

Seeing green

Some companies are seeing green – as in green lasers – as a way to make more green.

"Green-emitting lasers are enabling new applications – in particular, welding of high-reflective materials like copper, ablation of thin films, drilling of silicon and structuring layers with a thickness of a few hundreds of nanometers," said Jürgen Stollhof, product manager at Trumpf's Laser Technology Center. "Trumpf currently has products under development using rod, fiber and disk laser technology to produce green laser light. We will be

showing a green-emitting disk laser with up to 700 watts at Photonics West 2010."

Trumpf's TruMicro Series 5000 lasers are short-pulsed disk lasers that emit a green wavelength beam with little or no heat impact. "Primary applications include ablation of layers in the solar cell industry, cutting of nonmetals like plastics and ceramics, and drilling of holes mainly in the electronics and semiconductor industry," said Peter Grollmann, product manager of Trumpf's TruMark laser marking line.

IPG also introduced a green spectrum laser in 2009, and Shiner said it has so far supplied 20 or so units to companies working on photovoltaic cells, which are still in the evaluation phase.

Coherent introduced its new high-power Mamba Green DPSSL this past summer for industrial and scientific applications as well as the 532-nm Matrix, a Q-switched DPSSL for micromachining tasks in solar, semiconductor and medical device manufacturing. It also launched 532-nm, and 2- and 5-W optically pumped semiconductor laser versions of its Verdi line of compact all-solid-state continuous-wave lasers for scientific and commercial applications.

Coming attractions: Lasers in 2010

After falling in 2009 for the first time in almost 10 years, the global laser market is expected to grow about 11 percent in 2010, according to Strategies Unlimited, helped by rebounds in the semiconductor and communications equipment business.

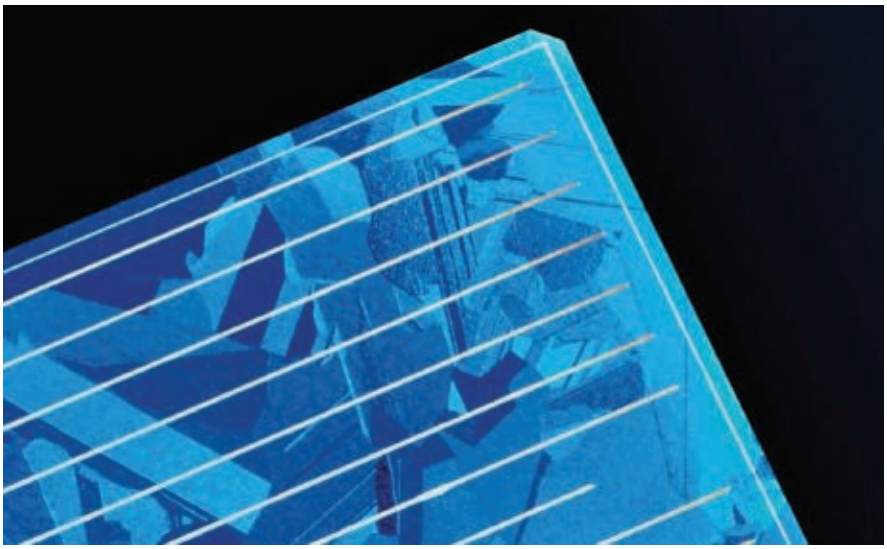
"Semiconductor and display manufacturing tools, biomedical systems and R&D are already on the rise," said Dr. Tom Hausken, the analyst who conducted the survey, in a press release. "But slower sectors, such as most of materials processing, will not see growth until late 2010 or even 2011."

For their part, laser companies in 2010 will continue to introduce products that have new capabilities and that make their customers' jobs easier, more efficient and less costly.

At Photonics West 2010, IPG Photonics will introduce a line of long-pulsed fiber lasers that have a high peak power and a low average power, to compete against pulsed YAG lasers, Shiner said. The new lasers will have peak powers of up to 5000 W, with average powers of 150 to 250 W.

In terms of IPG's plans for 2010, "You will see a substantial increase in the utilization of fiber lasers in the sheet metal markets, improvement in the beam quality of all of our high-power lasers, the introduction of higher-powered air-cooled units and a continued size reduction at all power levels," Shiner said.

Introduced in the summer of 2009, Coherent Inc.'s 532-nm Matrix, a Q-switched diode-pumped solid-state laser, has applications in solar, semiconductor and medical device manufacturing. Courtesy of Coherent Inc.



Above, the lines around the edge of the bright blue solar cell are made by a laser. At right, a laser drills a hole in a connecting rod. The hole allows lubricant to flow to the contact surface. Courtesy of Trumpf.

Trumpf showcased six new products at Fabtech 2009 in November and has at least four new lasers slated to be on display at Photonics West 2010.

"We are seeing a dramatic interest in improving the productivity and cost-effectiveness of existing welding applications, prompted by the cost, efficiency and capability improvements of DPSSL sources and optics," Morris said.

Disk lasers combined with scanner optics are highly efficient and cost-effective and provide unprecedented remote laser welding performance, Stollhof said.

"Virtually every automotive component manufacturer currently using significant resistance spot welding is evaluating the remote laser welding, which on some components can provide order of magnitude productivity increases," he added.

"We expect to see continued advances in output power, cost per watt and other parameters in lasers for industrial manufacturing and microelectronics," Chui said. "This trend should continue to result in the enablement of new applications for lasers in these markets, both in replacing less effective technologies and in creating completely new applications."

During the first three quarters of 2009, Spectra-Physics introduced 18 major new products. Although that number is impressive, "We primarily concern ourselves with the impact the products have in the market and how they enable our customers to address their applications," Chui said.

He cited the company's recently introduced Mai Tai SP laser, the first fully automated short-pulse ultrafast oscillator with computer-adjustable bandwidth and wavelength, as one such product that allows scientific customers to perform complex experiments in new ways.

"One revolutionary product can have a dramatic impact, sometimes more than many other products combined," he said.

The company also has a range of new high-performance lasers ready to hit the market in early 2010.

IPG says it continues to work aggressively to make fiber the choice over other types of lasers, such as CO_2 in the metal cutting market and pulsed YAG in the welding and drilling sectors.

Anthony DeMaria, a chief scientist at Coherent's CO_2 operation in Bloomfield, Conn., is not ready to cede the 46-year-old CO_2 laser's market share just yet.

"Despite its maturity, the CO_2 laser is still introducing new technologies and continuing to evolve," he said. "It has captured the largest portion of the laser revenues associated with the materials processing market. It has been reported that the percentage of laser sales to the materials processing market is divided 40 percent, 32 percent, 19 percent, 7 percent and 2 percent between CO_2, solid-state rod and disk, excimer, fiber and direct-diodes lasers."

Last June, Coherent debuted the smallest 1-kW CO_2 laser available, emphasizing the Diamond E-1000's size – 1500 × 500 × 400 mm – for space-sensitive applications, as well as the fact that the sealed laser requires no external gas supply, and its compact laser head can be brought close to the workpiece, eliminating the costs and complexities of long beam delivery systems.

DeMaria predicts that, in 2010, industrial-quality, 1000-W average output power, sealed off, RF-excited, diffusion-cooled CO_2 lasers with 20,000 hours' lifetime before the need to replenish the laser gas will be introduced into the laser materials processing marketplace and will sell for less than $100/W of average power.

"These new CO_2 lasers will be small and rugged enough to mount the laser head with its integrated RF power supply directly onto a robotic arm with only coolant lines and a DC power cord connected to the laser," he said. "The availability of such advanced, low-cost lasers to small manufacturers of laser materials processing systems will enable them to compete with the large manufacturers of such systems who are vertically integrated."

IPG has been developing relationships with OEMs in China, and China was a bright spot for the company's high-power lasers in its recent third-quarter report.

"We are experiencing growth in the high-power market in an economy where our competition is showing large decreases," Shiner said. "This indicates part of our growth is from an increase in market share rather than a market growth. China will continue to be a large growth opportunity for IPG, as there is very little history or established relationships for high-power technology in China. Decisions will be made on the most cost-effective technology, where fiber lasers usually win."

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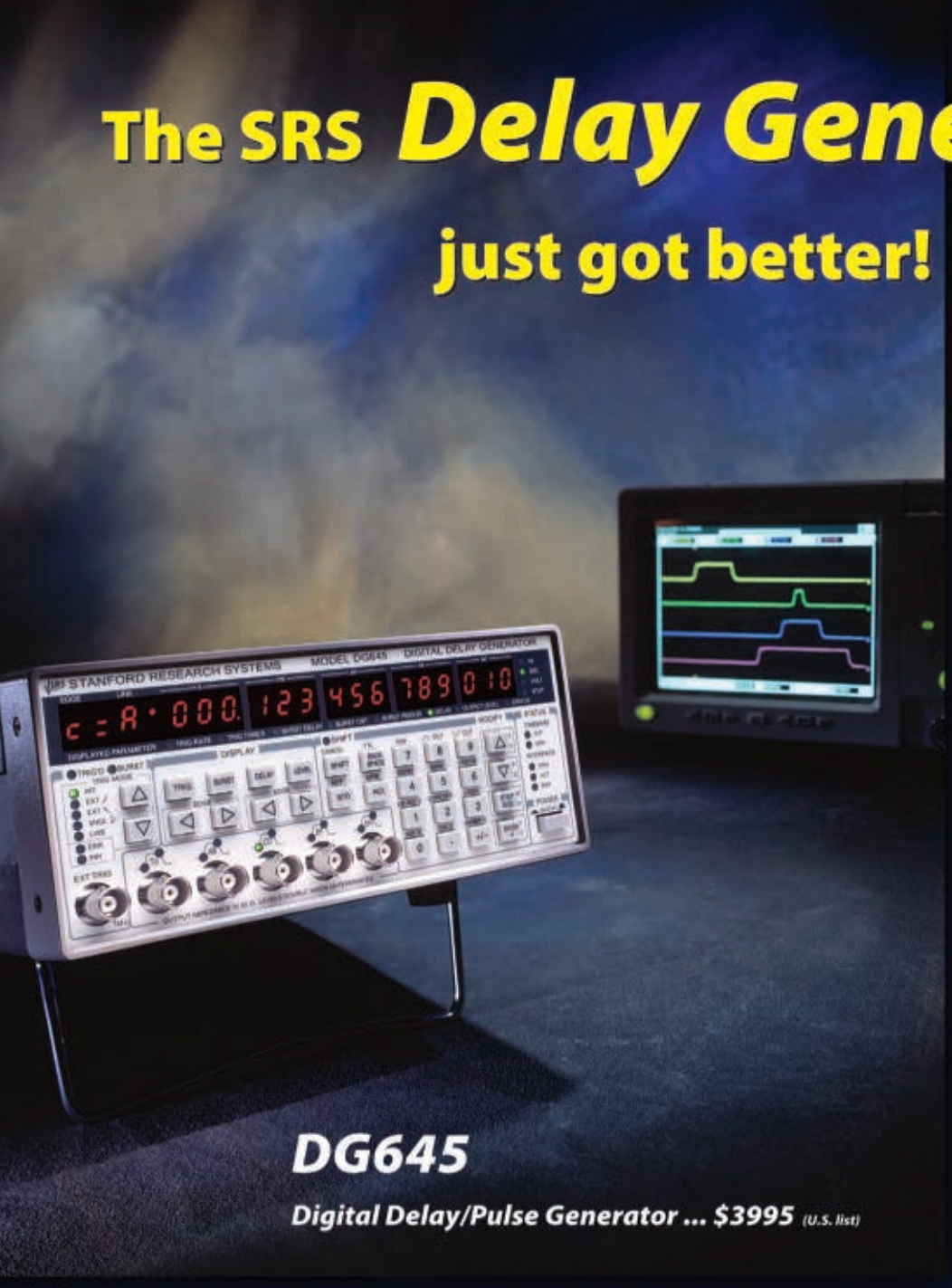

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Come up to the lab and see what's on the slab

BY MELINDA ROSE
SENIOR EDITOR

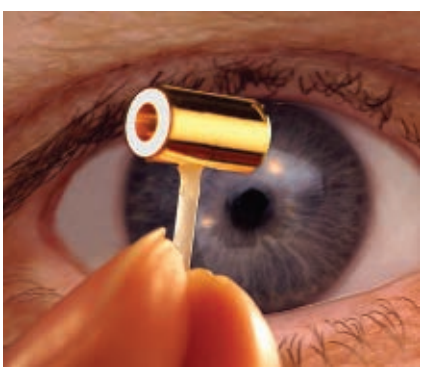
Laser achievements in the laboratory this past year ranged from some of the smallest ever made to some of the largest, from the debut of the world's first hard x-ray free-electron laser to creation of the most powerful light ray yet by a solid-state laser.

A major laser milestone for 2009 was the announcement that a facility that aims to harness the power of stars and giant planets was finally ready to be put into action.

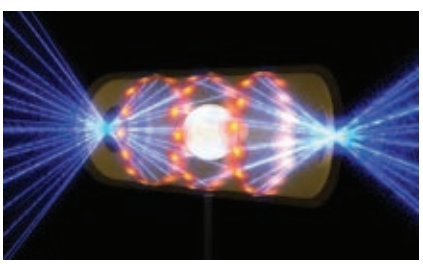
With its 192 giant laser beams, the National Ignition Facility (NIF), located at Lawrence Livermore National Laboratory outside of San Francisco, is the world's largest and highest-energy laser. It will deliver at least 60 times more energy than any previous laser system.

NIF was built as a part of the National Nuclear Security Administration's (NNSA) program to ensure the safety, security and effectiveness of the nuclear weapons stockpile without underground testing.

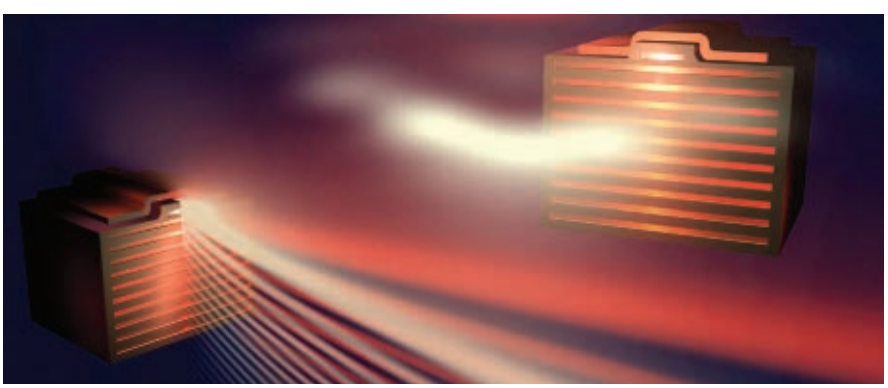
The facility, dedicated May 29, will begin experiments this year that focus the energy of all its ultraviolet laser beams – nearly 2 million joules – for a few billionths of a second onto a hydrogen fuel-filled gold target the size of a BB called a hohlraum. NIF's goal is essentially to cre-



A National Ignition Facility (NIF) hohlraum. The hohlraum cylinder, which contains the fusion fuel capsule, is just a few millimeters wide, about the size of a pencil eraser, with beam entrance holes at either end. The fuel capsule is the size of a small pea. Credit is given to Lawrence Livermore National Security LLC, Lawrence Livermore National Laboratory, and the US Department of Energy, under whose auspices this work was performed.



This artist's rendering shows a NIF target pellet inside a hohlraum capsule with laser beams entering through openings on either end. The beams compress and heat the target to the necessary conditions for nuclear fusion to occur. Ignition experiments on NIF will be the culmination of more than 30 years of inertial confinement fusion research and development, opening the door to exploration of previously inaccessible physical regimes. Credit is given to Lawrence Livermore National Security LLC, Lawrence Livermore National Laboratory, and the US Department of Energy, under whose auspices this work was performed.



An example of a compact, multibeam and multiwavelength laser. Unlike typical semiconductor lasers that emit single beams of light pointing in a single, well-defined direction, the multibeam laser can use versatile light sources. The innovation has potential use in applications related to remote chemical sensing, pollution monitoring, optical wireless and interferometry, and it was developed by a team of applied scientists from the Harvard School of Engineering and Applied Sciences, Hamamatsu Photonics and ETH Zürich. Courtesy of the lab of Federico Capasso, Harvard School of Engineering and Applied Sciences.

ate the power of a star in the lab to advance fusion energy technology.

"The tiny star created is about the diameter of one hair," said Dr. Peter J.K. "Jeff" Wisoff, associate director of NIF and Photon Science, during a session at the Frontiers in Optics Conference in San Jose, Calif., in October. The implosion of the fuel pellet is equivalent to the energy created by the explosion "of a hand grenade or two," he said. The goal is to release more energy than the laser energy expended to create it.

People joke that "fusion is 50 years away, no matter when you ask," NIF Director Edward Moses said during a plenary speech at the Conference on Lasers and Electro-Optics (CLEO), held in Baltimore last June. "But NIF could make it happen in two years."

Wisoff said NIF's two goals are to "start ignition experiments in 2010 and to demonstrate a reliable and repeatable ignition platform so we can become a national user facility."

In November, NNSA announced that recent NIF tests showed that its laser beams can be delivered effectively and are capable of creating sufficient x-ray energy to drive fuel implosion, an important step that shows NIF can fulfill a key requirement of the fusion process. The Laboratory for Laser Energetics also presented results showing the most compressed fusion capsules to date.

Northrop Grumman Corp. of Redondo Beach, Calif., announced in March that it had produced the most powerful light ray yet created by a solid-state laser, measured at more than 105 kW. The achievements included a turn-on time of <1 s and continuous operating time of 5 min with very good efficiency and beam quality, the company said. The weapon system was developed for Phase 3 of the US military's Joint High Power Solid State Laser program.

"This achievement is particularly important because the 100-kW threshold has been viewed traditionally as a proof of principle for 'weapons grade' power levels for high-energy lasers," said Dan Wildt, vice president of Directed Energy Systems for Northrop Grumman's Aerospace Systems sector. "In fact, many militarily useful effects can be achieved by laser weapons of 25 kW or 50 kW, provided this energy is transmitted with good beam quality, as our system does. With this milestone, we have far exceeded those needs."

The Linac Coherent Light Source (LCLS) at SLAC National Accelerator Lab in Menlo Park, Calif., the world's first hard x-ray free-electron laser, produced its first laser light last April.

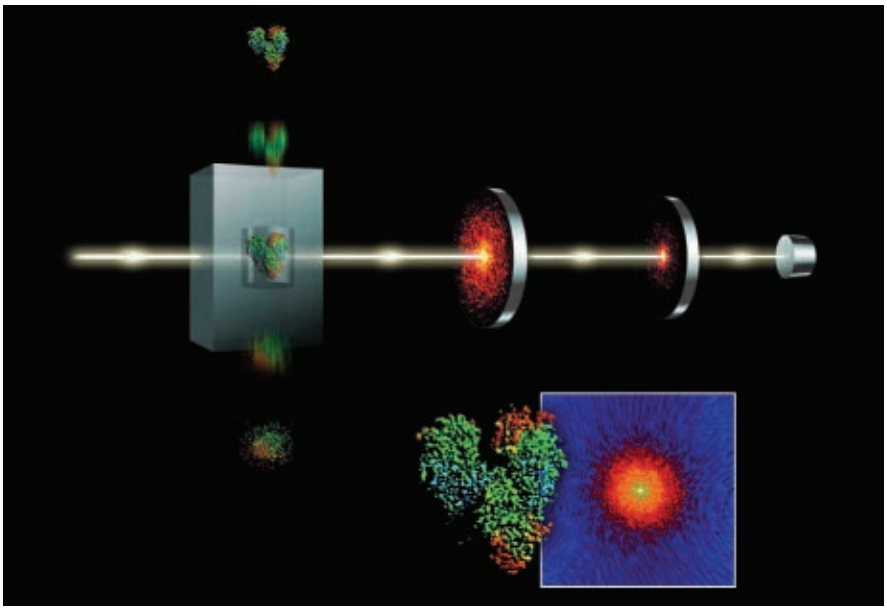
"This is the most difficult light source that has ever been turned on," said LCLS construction project director John N. Galayda.

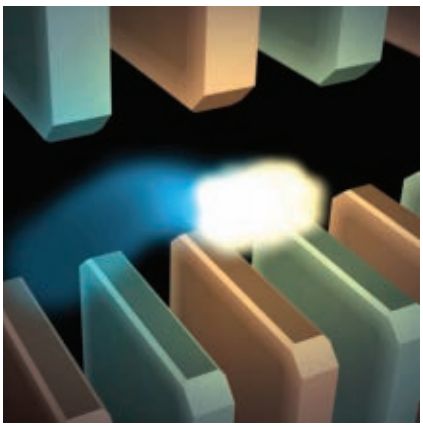
Instead of using mirrored cavities to amplify light, the LCLS creates light using free-flying electrons in a vacuum. It uses the final third of SLAC's two-mile linear accelerator to drive electrons to high energy and through an array of undulator magnets that steer the electrons rapidly back and forth, generating a brilliant beam of coordinated x-rays.

The LCLS can resolve detail the size of atoms at 10 billion times the brightness of any other man-made x-ray source.

"No one has ever had access to this kind of light before," said LCLS Director Jo Stöhr.

By 2013, the LCLS is expected to provide groundbreaking research in physics, structural biology, energy science and chemistry, among others, once all six of its scientific instruments are online. Early experiments already have provided new insights into the fundamentals of atomic physics and have successfully proved the machine's ability to control and manipulate the underlying properties of atoms and molecules.





Above, the Linac Coherent Light Source (LCLS) will create 3-D holographic images of single molecules using ultrafast pulses of very intense hard x-rays. At left, the LCLS creates intense pulses of hard x-rays using tightly packed bunches of electrons traveling through arrays of undulator magnets. Shown here is an artists's conception of an electron pulse between the alternating poles of the undulator. Images courtesy of LCLS.

Last fall, researchers used the LCLS' strobelike pulses to strip neon atoms of all their electrons. The extreme brightness of the laser beam also allowed them to study two-photon ionization, an event where two photons pool their energy to eject a single electron from an atom.

The Fraunhofer Institute for Laser Technology (ILT) unveiled the world's most powerful ultrashort-pulse laser during Laser World of Photonics 2009 in Munich in June. The femtosecond laser, which comprises a single-pass amplifier with four mirrors and one laser crystal, has an average output of more than 400 W and holds the record for average output among lasers with pulse durations of <1 ps.

The Fraunhofer researchers said they achieved the breakthrough by reinterpreting the InnoSlab technology that has been under development at the institute for more than 10 years. The technology already forms the basis for many nano- and picosecond laser systems currently in industrial use.

Many notable achievements in laser research also were accomplished in the past 12 months or so in university campus labs.

In late December 2008, researchers at Princeton University's Mid-Infrared Technologies for Health and the Environment (MIRTHE) center announced their discovery that a quantum cascade laser (QCL) can generate a second beam with very unusual properties, a feat that could lead to lasers that operate more efficiently and at higher temperatures than existing devices, for applications including environmental monitoring and medical diagnostics.

"This discovery provides a new insight into the physics of lasers," said Claire F. Gmachl, who led the study. Gmachl, an electrical engineer at Princeton University, is the director of MIRTHE.

In January 2009, Harvard University's Federico Capasso led a study that revealed for the first time a measurable, repulsive Casimir force that could be tailored for a wide range of new nanotechnology applications.

Attractive Casimir forces can limit the ultimate miniaturization of microelectromechanical systems because the attractive forces may push together moving parts and render them inoperable, an effect known as stiction, or static friction.

At the nanoscale, these quantum forces compel metallic surfaces placed very close to each other in a vacuum, in fluid or in air-filled space to attract. Capasso and his group discovered that replacing one of the two metallic surfaces immersed in a fluid with one made of silica switched the force between them from attractive to repulsive.

"Repulsive Casimir forces are of great interest since they can be used in new ultrasensitive force and torque sensors to levitate an object immersed in a fluid at nanometric distances above a surface. Further, these objects are free to rotate or translate relative to each other with minimal static friction because their surfaces never come into direct contact," Capasso said.

Last April, Capasso and applied scientists at the Harvard School of Engineering and Applied Sciences, working in collaboration with researchers from Hamamatsu Photonics KK in Japan, sculpted a metallic structure, dubbed a plasmonic polarizer, directly onto the facet of a QCL. They used the device to demonstrate that the direction of oscillation of the emitted radiation, or polarization, can be designed and controlled at will for new applications in photonics and communications.

"The novelty of our approach is that, instead of being conducted externally, which requires bulky and expensive optical components, manipulation of the beam polarization is achieved by directly integrating the polarizer on the laser facet. This compact solution is applicable to semiconductor lasers and other solid-state lasers, all the way from communication wavelengths to the mid-infrared and terahertz spectrum," Capasso said.

The team controlled the state of polarization by generating both linearly polarized light along an arbitrary direction and circularly polarized light.

Also in April, engineers at the Centre of Molecular Materials for Photonics and Electronics (CMMPE) at the University of Cambridge in the UK announced their development of self-organizing, tiny, highly tunable liquid crystal lasers that could soon be used in displays, in medical diagnostics and in sensors because they could be produced at a fraction of the cost of other display technologies.

The new technology uses liquid crystals in concert with a single, laser-based light source. Typically, lasers have two mirrors, and light bounces back and forth between them, but liquid crystal lasers do not use mirrors because the optical cavity is defined by the pitch (the length of one complete twist of a crystal). By controlling the degree of twist, the researchers discovered

how to tune the output wavelength of the liquid crystal lasers.

"These polychromatic lasers are capable of narrowband emission at any wavelength in the spectrum from near ultraviolet to near-infrared," said professor Harry J. Coles, director of the CMMPE. "When added to the ability to produce 100 × 100 arrays of such lasers, in tens of micron spots and, indeed, 10-micron cavity lengths, with very high conversion efficiencies of up to 60 to 70 percent, they open up a range of novel applications.

"Currently, the lasers use a single-pulsed solid-state miniature benchtop laser to pump the lenslet arrays, but we anticipate that this will be replaced by a miniature blue laser diode in the very near future," Coles said in April. "The [liquid crystal] lasers have already demonstrated quasi-CW working at a 10-kHz repetition rate and so, to the human eye, appear to be a continuous 'any wavelength' laser."

In July, a collaboration between researchers at Arizona State University and Technical University of Eindhoven in the Netherlands resulted in advances in overcoming previous limitations on how small lasers can be made.

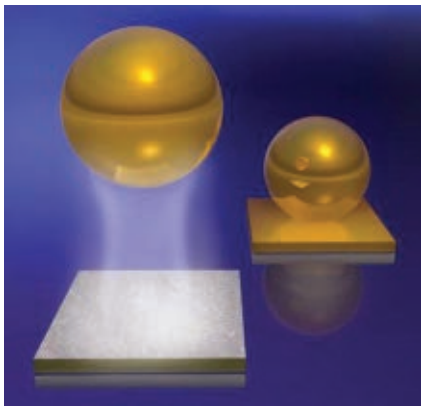
"This is the first time that anyone has shown that this limit to the size of nanolasers can be broken," said ASU team leader Cun-Zheng Ning. "Beating this limit is significant. It opens up diverse possibilities for improving integrated communications devices, single-molecule detection and medical imaging."

The theory of diffraction limit – a property associated with any wave, such as a beam of light – had said that the size of a laser in any one dimension (such as thickness) was thought to be limited to one-half of the wavelength involved.

But the ASU and Eindhoven research teams showed that there are ways around this supposed limit, including using a combination of semiconductors and metals such as gold and silver.

"It turns out that the electrons excited in metals can help you confine a light in a laser to sizes smaller than that required by the diffraction limit," Ning said. "Eventually, we were able to make a laser as thin as about one-quarter of the wavelength or smaller, as opposed to one-half."

In August, a team at the University of California, Berkeley, said that it had broken new ground in optics by not only successfully squeezing light into an incredibly tight space but by achieving laser action in finding a novel way to keep that light energy from dissipating as it moved. The researchers' new type of nanoscale laser concentrates light into an area one-hundredth the size of the smallest spot that can be produced by a conventional laser – a space smaller than a single protein molecule.



An artist's rendition of how the repulsive Casimir-Lifshitz force between suitable materials in a fluid can be used to quantum mechanically levitate a small object of density greater than the liquid (Figures are not drawn to scale). Foreground: a gold sphere, immersed in bromobenzene, levitates above a silica plate. Background: when the plate is replaced by one of gold, levitation is impossible because the Casimir-Lifshitz force is always attractive between identical materials. Image courtesy of the lab of Federico Capasso, Harvard School of Engineering and Applied Sciences.

"This work shatters traditional notions of laser limits and makes a major advance toward applications in the biomedical, communications and computing fields," said Xiang Zhang, professor of mechanical engineering, director of UC Berkeley's Nanoscale Science and Engineering Center, and head of the research team behind the work.

A technology that uses man-made diamonds to enhance the power and capabilities of lasers was announced in September by a research group in Australia.

The team's Raman laser has applications that range from defense technologies and trace gas detectors to medical devices and satellite mapping of greenhouse gases.

Existing Raman lasers typically use crystals of silicon, barium nitrate or metal tungstate to amplify light created by a pump laser. Compared with these materials, diamond has a higher optical gain as well as a greater thermal conductivity, making it ideal for high-power applications such as in defense, gas detection, medical devices and environmental monitoring. Diamond crystals also can be made to generate a wider variety of wavelengths of light, each of which has its own applications – from ultraviolet to far-infrared.

Also in August, researchers at Purdue University in West Lafayette, Ind., at Nor-

folk State University in Virginia and at Cornell University in Ithaca, N.Y., announced that they had created the world's tiniest laser, dubbed the "spaser." Because traditional lasers cannot be made small enough to integrate onto electronic chips, the scientists created the tiny spasers by harnessing surface plasmons instead of photons.

The nanolasers were spheres 44 nm in diameter – more than 1 million could fit inside a red blood cell. The spheres were fabricated at Cornell, with Norfolk State and Purdue performing the optical characterization needed to determine whether the devices behave as lasers.

The device – the first of its kind to emit visible light – represents a critical component for possible future technologies, including superfast computers that use light instead of electrons to process information, and advanced sensors and imaging, the researchers said.

In late November, Capasso was back in the news as part of an international team of applied scientists who had demonstrated compact multibeam and multiwavelength lasers emitting in the infrared.

In one of the prototypes demonstrated by the team, the new laser emits several highly directional beams with the same wavelength near 8 µm, a function very useful for interferometry, which requires two coherent beams: a probe and a reference. The probe beam interacts with a sample and recombines with the reference beam to reveal optical properties of the sample. A second type of laser emits multiple small divergence beams with different wavelengths – 9.3 and 10.5 µm – into different directions.

Although the researchers demonstrated the idea using mid-infrared semiconductor lasers emitting wavelengths in the 8- to 10-µm range, the concept can be generalized to lasers emitting other wavelengths in the near-infrared and terahertz spectrum, or to passive optical components such as optical fibers. For example, nanostructures can be patterned on the facet of optical fibers to help build microendoscopes for in vivo diagnostics, they said.

In early December, scientists led by Qing Hu, professor of electrical engineering at MIT's Research Laboratory of Electronics in Cambridge, described the first practical method for tuning terahertz QCLs, stating that their method is a fundamentally new approach to laser tuning that could have implications for other emerging technologies.

His new tuning technique requires a type of QCL called a wire laser, in which the wavelength of the transverse mode – the width of the one big undulation – is actually greater than the width of the laser itself.

Bringing a block of another material close enough to the laser deforms the transverse mode, which, in turn, changes the wavelength of the emitted light. In experiments, Hu and his colleagues found that a metal block shortened the wavelength of the light, while a silicon block lengthened it. Varying the proximity of the blocks also varies the extent of the shift.

Hu's group used a mechanical lever to bring a block of either silicon or metal close to a QCL from a single direction. But it has designed and is now building chips that would use electronically controlled microelectromechanical devices to bring the silicon and metal blocks in from different directions, giving the laser a precise and continuous tuning range from short to long wavelengths.

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2010
Trends
Optics

Optical tech sparkled in 2009

BY MARIE FREEBODY
CONTRIBUTING EDITOR

In a year that has seen the biggest recession in decades hit most market segments, you might expect a look back at the optics industry in 2009 to be all gloom and doom. But there are some bright spots in the darkness, where cutting-edge research and emerging applications are forging a promising future in many optics sectors.

For instance, research into novel nonlinear optical effects for image contrast in biology and medicine is one of today's hottest topics in optics. As professor Chris B. Schaffer of Cornell University in Ithaca, N.Y., explains, "Nonlinear optical imaging has become the technique of choice for in vivo microscopy studies in biomedical research. The combination of high-contrast, molecularly specific [with appropriate labels] and high-resolution imaging deep into tissue is unmatched by other microscopy methods."

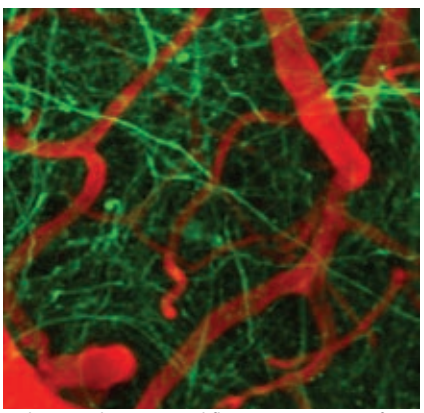
One of the most successful imaging methods is two-photon-excited fluorescence microscopy, a technique first demonstrated in professor Watt W. Webb's laboratory at Cornell in 1990 that allows micron-resolution imaging of living tissue up to a depth of 1 mm.

In the approach, a structure of interest is labeled within a tissue using a fluorescent dye. Next, high-intensity pulses from an infrared femtosecond laser are tightly focused into the sample, causing localized excitation of the fluorescent molecule. Two photons from the laser pulse can interact with a single fluorescent molecule simultaneously, leading to the excitation of light emission and of an electron, but only in the focal volume where the intensity is sufficiently high. The emitted fluorescence can be detected and an image formed by scanning the position of the laser focus through the sample in three dimensions, a technique often called laser-scanning microscopy.

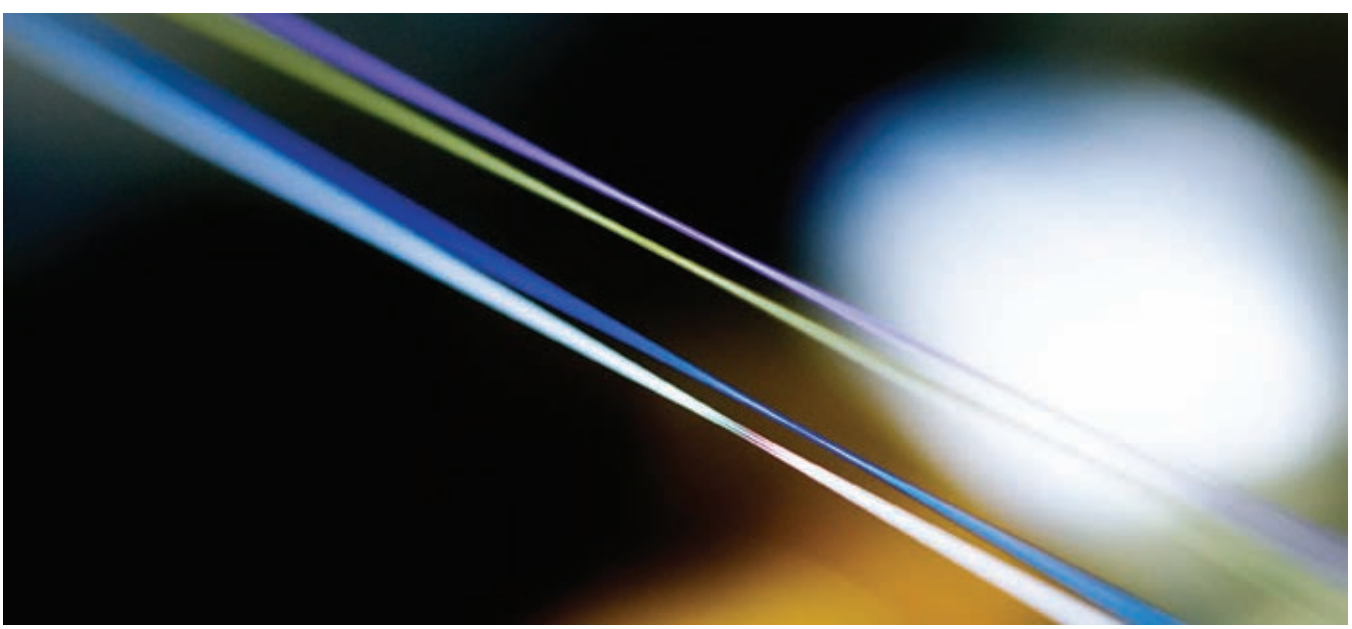
The crucial element that sets it apart from other fluorescence-based imaging techniques is the highly localized excitation. "Fluorescence is excited only in the [micron-size] focal volume and nowhere else in the sample," Schaffer explained. "Because of this, you can be sure that any fluorescence light you detect must have come from the focal volume, no matter how much that fluorescence scatters in the tissue on its way to the detector."

Looking beyond imaging

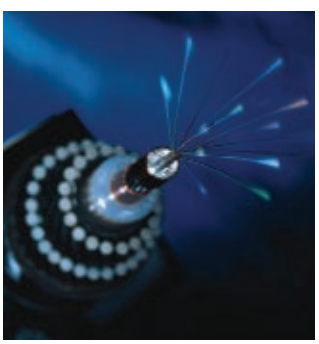
Most exciting about nonlinear optics are the many avenues of research being explored in laboratories worldwide. Thanks to this research, there were several notable advances in the field in 2009.



In this two-photon-excited fluorescence image of neurons (green) and blood vessels (red) in the brain of an anesthetized mouse, the blood vessels are labeled with an intravenous injection of fluorescent dye. The images were acquired on a custom-built two-photon microscope in Chris B. Schaffer's laboratory, using a fiber laser constructed in Frank W. Wise's laboratory that produces 100-fs pulses at 1030 nm. Courtesy of Matt Farrar and Chris B. Schaffer, Cornell University.



Shown is an example of Alcatel's optical fiber after the coloring process. Courtesy of Alcatel-Lucent.



Images at top and far left show Seacom's burial plow being hoisted and then lowered into the sea. The huge machinery prepares the way for the company's optical fiber cables. Left center, Seacom's project involved the installation of 17,000 km of undersea fiber optic cable, providing countries in East Africa with access to international broadband networks for the first time. Brian Herlihy, at left, has extensive experience in mega-infrastructure projects in Africa spanning disciplines including project development, financing and governmental liaison. Images courtesy of Seacom.

One of the most important takes advantage of new laser sources such as fiber, opening the field to clinical applications. Fiber lasers offer crucial advantages over their solid-state counterparts, including compact size and robust performance, which are useful for biological imaging and ocular surgery. Recently, researchers such as professor Frank W. Wise at Cornell have achieved a level of performance from fiber-based femtosecond lasers that meets or exceeds that of their much more cumbersome and expensive counterparts.

A significant advance in nonlinear microscopy took place in October 2009. Professor X. Sunney Xie at Harvard University in Cambridge, Mass., published work detailing the development of stimulated emission microscopy, opening the door to nonlinear spectroscopy applications in biology. The technique allows label-free imaging of molecules that absorb but do not fluoresce. The sensitivity of the technique is orders of magnitude higher than that for spontaneous emission or absorption contrast and could lead to possibilities for biomedical imaging, including label-free mapping of drug distribution and blood vessels in tissue.

At another US research camp last year, professor Mark J. Schnitzer and colleagues at Stanford University in California invented two forms of fiber optic fluorescence imaging, dubbed one- and two-photon fluorescence microendoscopy. By creating portable, miniaturized microendoscopy devices based on flexible fiber optics, the team can carry out minimally invasive in vivo imaging of cells in deep brain areas of freely moving mice. This remarkable feat could shed light on how cellular properties are affected by environment, training or life experience.

With so much varied research, the possibilities seem endless. According to Schaffer, there will be an increasing trend toward longer-wavelength nonlinear microscopy, which enables deeper imaging. He also predicts an explosion of new nonlinear contrast mechanisms that will allow important quantitative information to be gathered.

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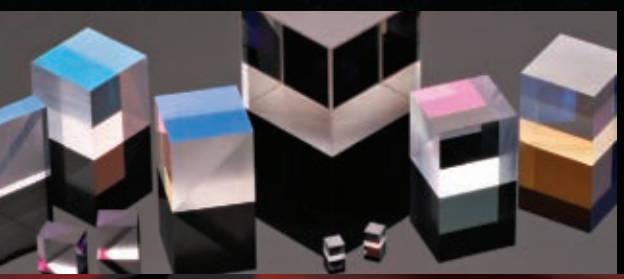

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mation, images, videos and much more directly into our homes. As consumer demand moves from simply surfing Web pages and downloading a few songs, to watching high-definition television (HDTV) and uploading home movies into e-mails or Web pages, the need for greater bandwidth bears down on service providers.

Fiber optics: The race is on

Sam Bucci, vice president of optical networks at Alcatel-Lucent in Ottawa, said that these companies are struggling to squeeze ever-higher bandwidth out of their technologies. "In 2009, bandwidth demand continued to grow at a significant rate, but service providers' profitability has not grown at the same rate. Network upgrades must be met with transport solutions that significantly lower total cost of ownership. This includes capital and ongoing operational expenses such as power, which must be achieved without sacrificing quality of service or reliability."

For an idea of today's network demands, a standard-definition television signal requires a bandwidth of about 2 Mb per second. HDTV requires as little as 4 Mb per second if the image is rather static; for example, as a person is being interviewed. But fast action, such as sporting events, requires more – as much as 8 Mb per second, even with new compression technology such as MPEG4.

Already being used in some academic and industrial settings is 3-D immersive HDTV, which is expected to hit the consumer market next year with the launch of Panasonic Corp.'s Full HD 3D Home Theater system. Such high-demand technology will require between 100 and 300 Mb per second. Current fiber optics technology can provide two-way transmission speeds of up to 100 Mb per second.

Easing traffic congestion

Just how will service providers cope with increasing demand on their networks? An emerging trend in the industry is the concept of Internet Protocol (IP) offloading. Just as vehicles can travel long distances more quickly via an interstate highway system, so, too, can light be transmitted more directly using the idea of offloading. "Traffic in the core of the network is mostly transitory and, as such, could be more economically handled at lower layers instead of bogging down valuable router resources," Bucci said. "The concept involves processing transitory traffic at the Optical Transport Network or [at the] DWDM [dense wavelength division multiplexing] layers, which can provide significant power savings."

In and out of Africa

In July 2009, a $600 million project involving 17,000 km of undersea fiber optic cable was completed, providing countries in East Africa with access to international broadband networks for the first time.

Brian Herlihy, CEO of Seacom, the company responsible for the project, said that Africa now can launch itself as a major competitor for call center/business process outsourcing. "Furthermore, clinical research that must share real-time data with hospitals around the world will now be possible, allowing science, education and other research to be carried out from anywhere in eastern or southern Africa as easily as it could be conducted in Cambridge, Massachusetts."

Bringing high-demand services in and out of Africa is Seacom's cable, which is composed of two fiber pairs with a total capacity of 1.28 Tb per second. For the first time, consumers in East and South Africa can enjoy high-speed Internet, peer-to-peer networks such as Skype, HDTV and IP television.

"We have given African communica-

Seacom's pull-through bore pipe helps engineers bury the cable underground. Courtesy of Seacom.

tions carriers equal and open access to inexpensive bandwidth, removing the international infrastructure bottleneck and supporting east and southern African economic growth," Herlihy said. "In Kenya, we have already witnessed the birth of three … national networks, South Africa is developing four national networks, and Rwanda is rolling out huge fiber networks throughout the country."

High-brightness LEDs display their true colors

High-brightness LEDs have been one of the most dynamic sectors of optoelectronics over the past 10 years. Dr. Robert V. Steele, director of optoelectronics at Strategies Unlimited in Mountain View, Calif., said the market grew from $800 million to $5.1 billion between 1999 and 2008, driven primarily by adoption in automotive, mobile electronics, outdoor signage and, more recently, lighting applications.

Applications for high-brightness LEDs are many and varied. Because they are as much as 100 times brighter than conventional LEDs, they are most suited for outdoor use. They can be found in traffic signals, pedestrian signals/controls, vehicle headlights and advertising billboards.

Although conventional LEDs can be used for indoor displays, their color range is very limited. "There are no blue conventional LEDs, and there is no true green – the green ones are actually greenish-yellow," Steele said. "So if full color displays or video screens are needed, requiring red, green and blue LEDs, then high-brightness LEDs must be used."

According to a study carried out by ElectroniCast Consultants, a market forecasting firm in Upper Lake, Calif., high-brightness and ultrahigh-brightness LEDs held 69 percent of the worldwide market share in terms of US dollar value in 2008 versus 31 percent attributed to conventional LEDs, which are used in solid-state general lighting applications. The report predicts that, by 2015, high-brightness and ultrahigh-brightness LEDs will hold a 97 percent global market share in solid-state general lighting applications.

Stephen Montgomery, president of international business expansion at ElectroniCast, said the main drivers of this remarkable growth will come from maintenance/labor, safety/security and "green tech" issues.

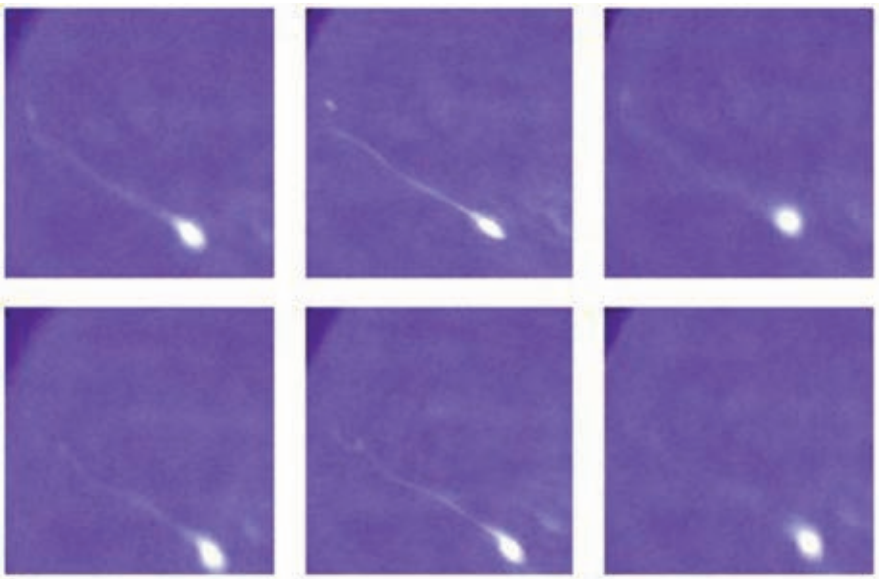
This year has seen a major uptake of high-brightness LEDs in backlights for LCD displays in notebook computers, televisions, monitors and in general lighting. In fact, the entire high-brightness LED market is growing so fast that Steele

predicts it will reach $14.9 billion in 2013.

For LED manufacturers and lighting specialists such as Osram Opto Semiconductors GmbH of Regensburg, Germany, the decline in the automotive and consumer electronics sectors has had a direct effect on business. But it is not all bad news, thanks to new markets opening in which high-brightness LEDs are prized for their size, lifetime performance, full-color quality and high-quality white light.

"[High-brightness] LEDs are already well established in some market segments such as architectural lighting, decoration/beautification and signage," said Dr. Michael Fiebig, Osram's marketing and business development manager for LEDs and organic LEDs. "In other segments, the breakthrough is about to take place step-by-step, notably in outdoor lighting, professional shop lighting and residential lighting."

The first projects are already under way in street and tunnel lighting and in lighting for city squares. Although the cost of high-brightness LEDs compared with conventional lamp technologies remains elusively high, Fiebig expects LED solutions to conquer mass markets within the next three years.



Shown are two consecutive sets of in-focus images of sperm swimming. Preliminary data was taken under negative phase-contrast illumination in collaboration with Dr. Jackson Kirkman-Brown and Dr. Dave Smith, both of the University of Birmingham in the UK, and Jez Graham of Cairn Research Ltd. Depth separation between in-focus planes – i.e., between images along rows – is 910 nm. Note the propagation of a knotlike structure along the tail and toward the head. Courtesy of Heriot-Watt University in collaboration with the University of Birmingham.

A clear picture of adaptive optics

Adaptive optics can be traced back to 1953, when the idea of improving the performance of optical systems by reducing

the effects of optical distortion was first proposed by US astronomer Horace W. Babcock. But it was not until four decades later, in the 1990s, that adaptive optics became widely used when advances in computer technology made the technique practical.

Today, adaptive optics can be seen at work both on the largest and smallest scales, including astronomy, medicine (such as retinal imaging) and for military purposes (such as rangefinding). More recently, adaptive optics has been used to enhance the performance of free-space optical communications systems, including the project under way at the US Air Force Research Laboratory in Rome, N.Y.

Dr. Michael Fiebig heads up marketing and business development of LEDs and organic LEDs in the solid-state lighting segment at Osram Opto Semiconductors GmbH. Courtesy of Osram Opto Semiconductors GmbH.

The challenge with free-space optical links between humans on and near the surface of Earth is the turbulence-induced distortions on information-bearing electromagnetic waves. Temperature gradients cause wind, and this wind is not always smoothly varying. In a sense, it boils. This effect can be seen in the form of mirages when we view distant objects across a hot plain, or ahead of us on a scorching highway. Using adaptive optics to eliminate distortion will provide the military with ultrahigh-bandwidth intelligence, surveillance and reconnaissance information in real time.

So far, Air Force researchers have established an optical link at distances exceeding 9 km in both stationary and flight situations. The next step is to test the system at higher altitudes to demonstrate greater air-to-ground distances.

At the opposite end of the spectrum, adaptive optics is making waves in microscopy. For example, remarkable work on male fertility as well as work producing 3-D snapshot images to track particles in live-cell biology are under way at Heriot-Watt University in Edinburgh, UK. Professor Alan H. Greenaway's team exploits two adaptive optic wavefront sensing technologies – phase diversity and image sharpness – in the same measurement to deliver depth measurements approaching λ/100-in. wide-field microscopy. The researchers currently obtain a depth resolution better than 10 nm, but with further improvements in photon-counting detector technology, they believe that angstrom-level resolution – required in molecular studies – is possible.

The group's 4-D sperm imaging project, which started in November 2009, examines the complex tail movement of sperm cells. Funded by the UK's Science and Technology Facilities Council, the project aims to contribute to important studies on human fertility.

For a clear idea on where adaptive optics technology is headed, it seems we will have to be patient. Until more efficient modulators and wavefront sensors are developed, Greenaway expects a pause in the evolution of adaptive optics systems.

"I believe that a point will come where a combination of these technologies in a complete adaptive optics system will suddenly open new possibilities and challenges, but the impetus to improve these components is first needed," he said.

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2010
Trends
Imaging
& Vision

Imaging steps up and out

BY HANK HOGAN
CONTRIBUTING EDITOR

For Kamalina Srikant, a product marketing engineer with vision software and hardware manufacturer National Instruments of Austin, Texas, improving imaging technology isn't just a good idea, it may be a necessity – in part, because it could help reduce the worldwide carbon footprint.

Vision systems can inspect solar cells, properly site and position a solar grid, and direct cells or mirrors to track the sun. Such techniques can lower the cost per watt of solar power by varying amounts and make it more attractive, thereby reducing carbon emissions.

Making solar energy economical is one of the grand challenges from the US National Academy of Engineering. The appearance of photonics-based imaging as part of a solution to one of the organization's objectives is no surprise to Srikant. "There's actually quite a few of them where vision could play a role to help solve some of these."

She cited, for example, reverse engineering of the brain and engineering of better medicines. Although not as big as these problems, several trends not only point to how improved imaging and vision systems are tackling smaller ones but also reveal some of what still must be done.

Gaining perspective and controlling robots

Despite what cameras depict, the world is not flat. For some applications, such as reading a label on a bottle, two-dimensional imaging is fine. However, that is not the case for what promises to be the growing use of vision in robotics.

Ignazio Piacentini, CEO of ImagingLab Srl in Lodi, Italy, a robotics and vision technology developer, noted that today's robots often perform fairly simple jobs blindly. By 2012, he said, up to 40 percent of new robots will make use of vision to automatically identify parts, to see if it is safe to take a particular path from point A to point B, to gain better positioning accuracy and to perform other tasks.

Such applications highlight a challenge. "Robots are inherently three-dimensional," Piacentini said. "Hence, moving from 2-D to 3-D vision is of tremendous importance."

There are a number of ways vision systems can accomplish this. They can do it stereoscopically, as people do, through the use of two cameras. Because of cost and complexity, however, most systems take another approach.

Vision systems cannot make the sun shine brighter, but they can improve the manufacturing of solar cells, thereby lowering the cost per watt of solar power. Courtesy of National Instruments.

Some use structured light, projecting a grid onto an object and deducing deviations from a plane by distortions in the grid, for example. Others employ laser scanners to extract distances point by point. Still others use time-of-flight measurements to gauge distance across an array. Currently, Piacentini said, although laser scanning and structured light are more robust for industrial applications, suitable time-of-flight cameras are starting to appear.

Besides hardware becoming available, software is beginning to show up. Wolfgang Eckstein, managing director of vision software supplier MVTec Software GmbH of Munich, Germany, said that his company is developing new 3-D imaging methods. One, for instance, offers perspective deformable matching, the better to identify objects whose appearance is distorted.

Three-dimensional vision, he said, "will revolutionize machine vision and will pro-

To avoid collisions while operating in tight confines, robots increasingly will use vision guidance, as are the ones shown here, which are involved in fully automated memory chip testing. Courtesy of ImagingLabs.

vide advantages to many applications in well-established industries such as semiconductors and robotics."

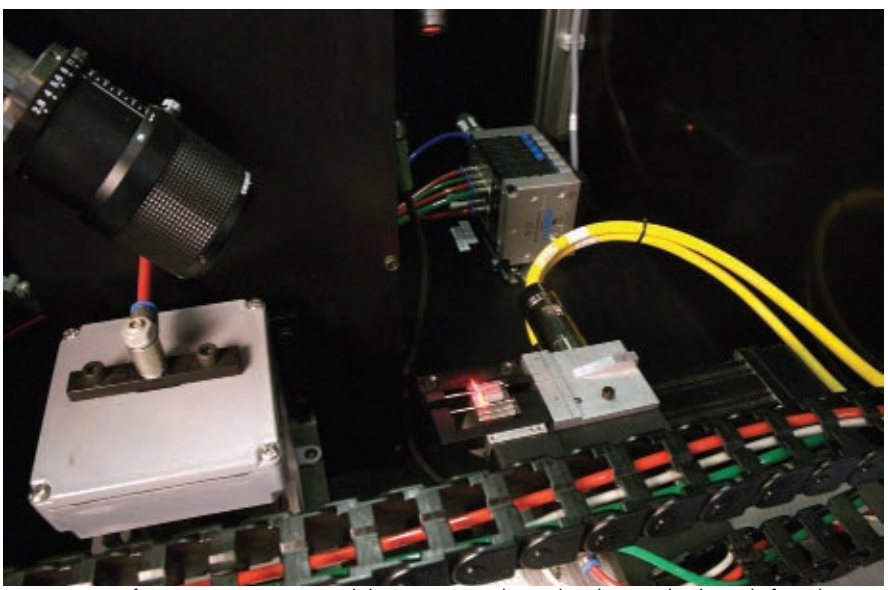
Adding the third dimension alone may not be enough, at least when it comes to some common robotic tasks, said Michael Muldoon, business solutions engineer for AV&R Vision & Robotics Inc. The Montreal-based systems integrator has been involved in hundreds of industrial automation projects.

The problem that Muldoon pointed to involves the field of view, resolution and speed. Often, a vision system will take measurements of a part to verify dimensional tolerances. Capturing images in 3-D could make that task faster and more accurate because fewer views will be needed and perspective-related distortions will be better accounted for.

But vision systems also are used for defect inspection. The challenge is that scratches, tool marks and other defects typically are much smaller than the dimensions of a part. Systems designed for measurement and those intended for defect inspection often differ markedly in resolution and in the speed with which they can scan an entire part, Muldoon said.

"There's a big gap between the two. So having a system that's somewhere in the middle – we would find that very useful."

Surveillance cameras are going digital, with increasing resolution. These cameras stream data using Internet Protocol. Courtesy of JAI.



Vision systems often measure a part's critical dimensions, as is being done here on the dovetail of a turbine airfoil. Vision systems also can inspect for defects. Performing both measurement and inspection may require two systems for efficiency. Courtesy of AV&R Vision & Robotics.

People watching

For other vision and imaging trends, consider the security arena. There, improved technology promises better performance and perhaps an end to one set of headaches, that of false alarms. However, bandwidth is a looming issue that may require smarter security cameras.

With regard to technological changes, one is that digital cameras are replacing analog ones. The new cameras use IP, or Internet Protocol, technology. They are addressable as nodes on the network, easily added or removed, and can be remotely configured from a central location. Moreover, the traffic to and from them can travel over any IP-capable network.

This change from analog to digital also will likely be accompanied by an increase in the resolution, said Tue Mørck, vice president of marketing at JAI in Copenhagen, Denmark. "We think the HDTV [high-definition television] format will be very popular. It will perhaps be the new standard in a few years."

That is good news for anyone or anything looking at an image, but potentially bad news for the network. The switch to a higher-resolution digital signal will roughly double the number of scan lines and increase bandwidth demand fourfold.

But network problems already are showing up. In moving to digital output, the feed from cameras also is moving onto a network where it must contend with other traffic. That load could include the streaming video from every other camera in an installation.

Eric Eaton, chief technology officer for BRS Labs of Houston, noted that cameras that offer megapixel resolution at 30 fps or more are available and seemingly affordable. However, their price is not the complete cost that must be paid. "When you plug them in and try to stream high-quality video on your network, you realize your bandwidth requirements and costs are so high that it really multiplies the effective cost of those beautiful cameras," he said.

BRS makes video surveillance behavioral analysis software. As such, its product must deal with network congestion and camera features, such as auto color and auto balance, that activate from time to time. These features can create artifacts in the data.

Smarter surveillance cameras could solve that problem and could help with bandwidth. The camera could analyze a scene and report back only the relevant elements, greatly reducing the amount of data traffic. Such benefits must be weighed against the extra cost and other factors, however.

That cost might be dropping in the near future because of another trend. Video analytics and security technology have been hobbled by a lack of interoperability between various cameras and incompatible data formats. That is changing, however, through such efforts as the Physical Security Interoperability Alliance, or PSIA.

With improved surveillance cameras, real-time-analytics can automatically spot someone crossing a fence (red rectangle in picture above) or a car stopped in the wrong spot (red square in picture at right). Courtesy of Agent Video Intelligence.

A final trend for video analytics involves determining how to better highlight significant events without flagging too many that are not important. This requires a balancing act, one that is getting easier and better as algorithms improve, imaging gets sharper, bandwidth increases, and more processing power becomes available.

However, an application related to video analytics may take off first, said Zvika Ashani, chief technology officer of Agent Video Intelligence Ltd. of Rosh Ha'ayin, Israel. The company provides video analytics solutions.

Ashani noted that software today can quickly categorize the shape, color, velocity and other parameters for every object in a scene. This capability readily lends itself to offline forensic analysis. For example, if someone wants to highlight, after the fact, all yellow vehicles traveling faster than a given speed, the software can quickly produce the data.

The situation is analogous to an Internet search engine. Most of what is presented is, in essence, a false alarm and irrelevant to finding what is being sought. But that does not mean the search results aren't useful, Ashani said. "Because of the way that they're being presented to you, you can very quickly zoom in on the relevant information. You're not very concerned about the false alarms."

The old standbys

There are, of course, vision and imaging trends other than the movement toward 3-D or the implementation of IP-based

streaming video for surveillance. These result from ongoing improvements, particularly among sensors and semiconductors.

Endre J. Tóth, director of business development for smart camera maker Vision Components GmbH of Ettlingen, Germany, said that these hardware improvements are making devices smaller, cutting their power consumption and reducing their weight. He also noted a change in sensors, representative of a long-term trend.

"A wider range of CMOS sensors is available for the gradually growing machine vision applications using CMOS sensors," Tóth said.

The continuing evolution of electronics and software also is leading to vision systems that combine the sensor, the image processor and the optics in one device. Philip Colet, vice president of sales and marketing at camera maker Dalsa Inc. of Waterloo, Ontario, Canada, characterized such integrated solutions as the ultimate in vision systems and indicated that they already are appearing.

"I've seen applications in automotive, for example, where you have devices that are mounted in the side mirror that will tell you if the passing lane is clear," he said.

Other automotive-related applications detect pedestrians crossing in front of a car and automatically put on the brakes. Such applications need an integrated solution because of space and cost constraints. They do not need the most advanced sensors.

One area that does need such devices is the life sciences, where researchers cannot afford to waste a photon. Here, technology promises better imaging, although the improvement does not always come from the sensor.

A case in point is a new camera from Photometrics of Tucson, Ariz. The company recently introduced a device that solves a bioscience imaging problem. Deepak Sharma, a senior product manager, explained that bioscience researchers typically must specify results in arbitrary units because, besides the experiment itself, a camera's output depends on the chips within it, the gain used and other parameters.

It is possible to calibrate for such variables, but the process can be involved. This year, Photometrics announced a scientific-grade camera that calibrates itself. It works by having the camera cut off outside light and then use internal light sources to derive the calibration curve. The process takes a few minutes.

The company chose to do this with an electron-multiplying CCD, or EMCCD, for a few reasons. One is the challenge of implementing the technology in an EMCCD, Sharma said. "We figured if we can do it with this type of sensor, we can do it for almost anything out there."

The other factor, he noted, is that, because it has been difficult to absolutely quantify results with a scientific-grade EMCCD camera, the new device solves a need. It also helps that such cameras come with a higher price tag than other imaging systems and are thus better able to support the additional cost of precision autocalibration technology. The cost-to-benefit calculations may be different for other cases.

General cost and market constraints may slow the ongoing development and deployment of vision systems with higher resolution, faster frame rates, lower cost and newer interfaces. However, Friedrich Dierks, chief engineer and head of software development for components at Basler AG of Ahrensburg, Germany, does not think the current economic slowdown will have a significant effect on the general trajectory of these trends.

"These developments are long term. They may speed up or slow down due to the crisis, but I don't think they will become different," he said.

Making connections

A final trend involves camera interfaces. No man is an island and neither is any camera. They all connect to the wider world, and several innovations promise to enable new capabilities, cut costs and, perhaps, enable applications that today cannot be done or are not feasible.

One of these interface developments is an upgrade to one of the most common camera connections. The new USB 3.0 standard, also known as SuperSpeed USB, should appear in commercial products in 2010. Besides eventually being inexpensive and widely available, USB 3.0 offers vision users a number of advantages.

"First and foremost, it's the bandwidth. You can go out to 400 MB/s, roughly, transfer rate. That is five times faster than FireWire, 10 times faster than USB 2.0 and four times faster than GigE," said Vlad Tucakov, director of sales and marketing at Point Grey Research Inc. The company, based in Richmond, British Columbia, Canada, has demonstrated a USB 3.0 prototype camera and plans to officially offer USB 3.0 cameras in the third quarter of 2010.

Some of the other benefits of the new interface include true isochronous data transfers that guarantee bandwidth on the bus and allow low-latency operation. Systems will know when the data from a camera will appear, a critical requirement in automation and other real-time applications. Also, users will be able to put multiple devices on a single connection. Finally, cable runs of 10 m will be no problem, and there will be enough power to run higher-performance CCD sensors.

The new interface's system architecture, wiring and connectors are different from the old. However, the new connectors are compatible with USB 2.0 when inserted partially. Complete insertion leads to a USB 3.0 connection. The new standard should be of interest to anyone who has considered a high-speed interface but has decided against it for cost reasons, Tucakov said.

Other vision interfaces also will see changes in the coming years, said Jeff Fryman, director of standards development at the US-based Automated Imaging Association (AIA). Higher bandwidth and longer cable runs in Camera Link, for example, are being considered.

Although it's compatible with USB 2.0 plugs, the USB 3.0, or SuperSpeed USB, standard offers much higher speeds and could be useful in many vision applications. Courtesy of Point Grey Research Inc.

For GigE Vision, plans call for an extension to handle more than a camera. "This would allow control of peripherals, like a light," Fryman said.

Other nonstreaming devices also could be managed, he added. To do so, these devices must have the needed hardware and software. However, because Gigabit Ethernet is a widely used interface, many devices might require only a change in their already resident code. Fryman expects a flood of new products that offer plug and play with GigE Vision to enter the market quickly after the standard is changed.

In another development, three key vision associations – AIA, the European Machine Vision Association and the Japan Industrial Imaging Association – recently announced plans to cooperate in future standards development and marketing. This approach could lead to a standard that is applicable to vision and imaging systems anywhere in the world. One result could be reduced costs for suppliers and lower prices for users.

Working cooperatively also will ensure other advantages to the process, and these are significant, Fryman said. "It's important that standards follow the proper procedures during development in a fair and transparent manner so that all stakeholders in the industry benefit."

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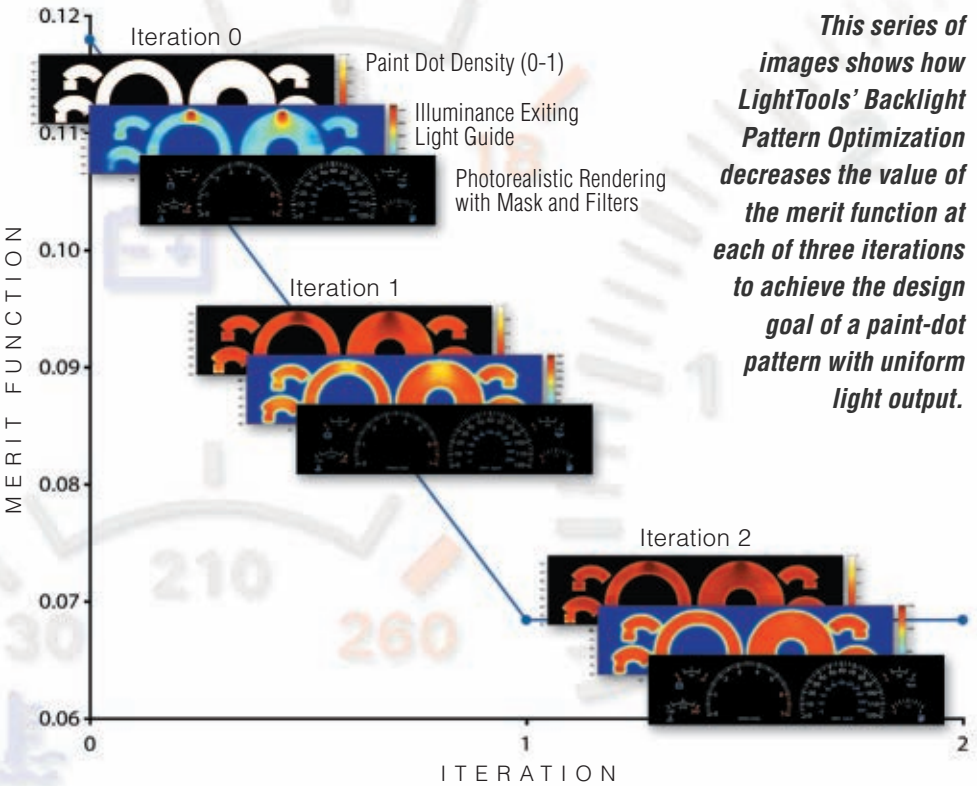

This series of images shows how LightTools' Backlight Pattern Optimization decreases the value of the merit function at each of three iterations to achieve the design goal of a paint-dot pattern with uniform light output.

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2010 Trends

Fluorescence
Spectrometry
Positioning
Terahertz
Slow Light
Photonics Integration

But wait – there's more … !

BY LYNN SAVAGE
FEATURES EDITOR

Well, now. You've read the previous articles covering the ongoing and upcoming trends in lasers, optics and imaging, but you're probably thinking that there's more to photonics than those technologies. You are correct; there is much more to the world of photonics. Here's what is happening in the rest of the industry.

A sense of fluorescence

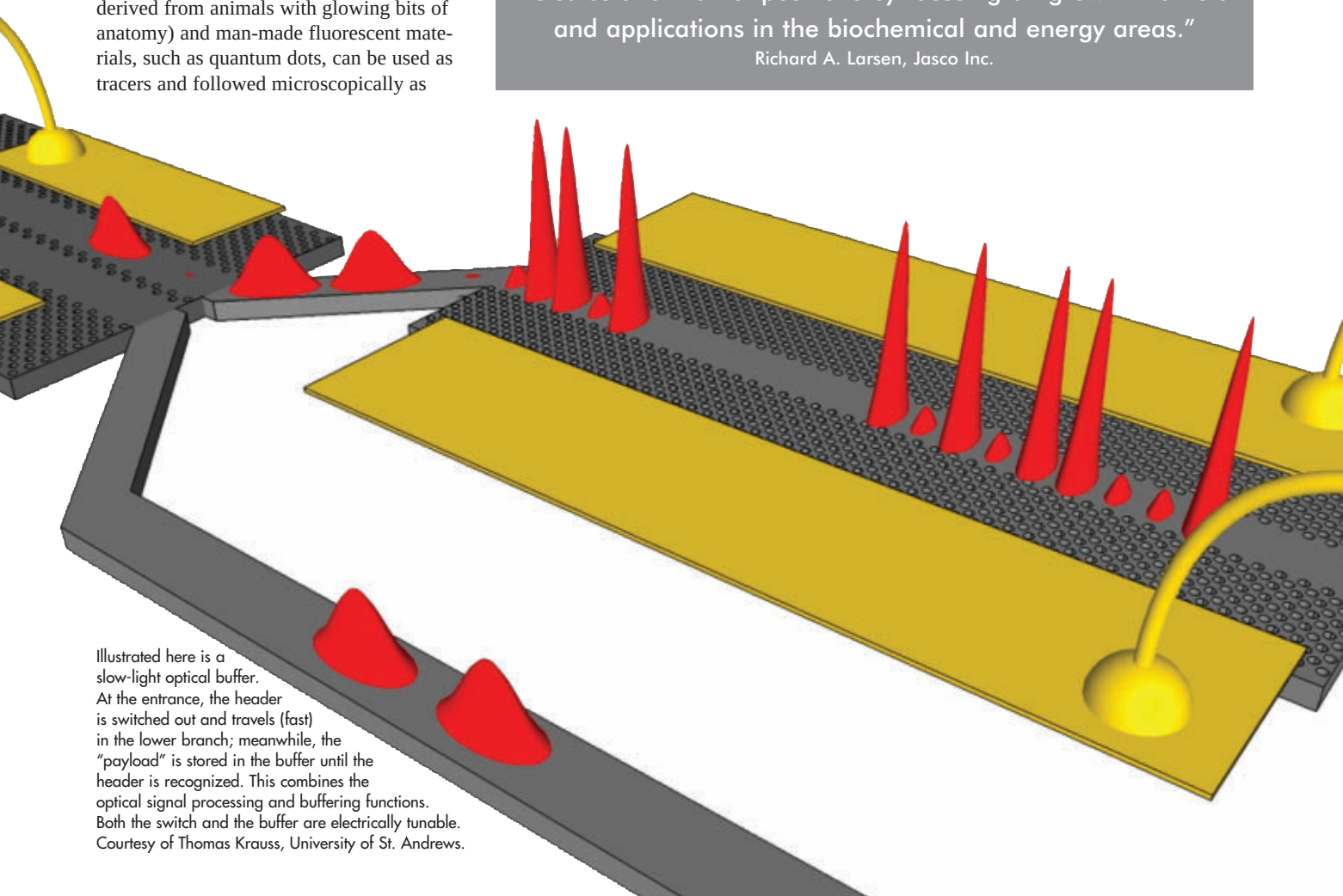
Whether artificial or from an organic source, fluorescing particles help researchers track biological processes down to the molecular level, for example, or help metallurgists characterize potentially useful new materials. Naturally fluorescent proteins (such as luciferase, typically derived from animals with glowing bits of anatomy) and man-made fluorescent materials, such as quantum dots, can be used as tracers and followed microscopically as they move across a surface. At other times, both kinds can be used as an ersatz flashlight, brought into proximity with nonglowing molecules of interest.

According to Jennifer L. Stow of the University of Queensland in Brisbane, Australia, there are three fluorescence imaging techniques most in demand currently:

1. Real-time imaging in cells and whole animals to visualize fluorescent molecules and cells under physiological and pathological conditions, along with their responses to gene mutations, drugs and others.
2. High-resolution techniques such as stimulated emission depletion microscopy, which permit molecular-level analysis.
3. Multiphoton confocal imaging and total internal reflection fluorescence microscopy, which offers the ability to track multiple fluorophores when analyzing protein localization, interaction and function.

Stow, who is deputy director of research at the Institute for Molecular Bioscience (IMB), located at the university, also notes that fluorescent proteins have an edge for

> "While some markets have decreased, Jasco has increased its sales and market positions by focusing on growth markets and applications in the biochemical and energy areas."
> Richard A. Larsen, Jasco Inc.



Illustrated here is a slow-light optical buffer. At the entrance, the header is switched out and travels (fast) in the lower branch; meanwhile, the "payload" is stored in the buffer until the header is recognized. This combines the optical signal processing and buffering functions. Both the switch and the buffer are electrically tunable. Courtesy of Thomas Krauss, University of St. Andrews.

Above, while other companies were laying off people during the downturn, PI invested in onshore design and manufacturing capabilities at its Auburn, Mass., headquarters. At left, the PI nanoXYZ microscope nanopositioning stage is designed and manufactured by PI (Physik Instrumente) LP. According to the company, the stage's cost, performance and flexibility have made it an invaluable tool for researchers in the bionanotechnology fields. Images courtesy of PI (Physik Instrumente) LP.

intracellular analysis, but that quantum dots have ever-expanding applications as surface or extracellular probes. The IMB is home to the brand-new Australian Cancer Research Foundation Cancer Biology Imaging Centre.

"The future will be use of proteins and dots in mixtures to provide complex labeling and analysis of cells and membranes," she said. "Fluorescence imaging is heading toward more colors, higher resolution, faster imaging – all geared toward molecular-level mapping and analysis."

Spectrometry breakdown

Breaking open a beam of light and reading the resulting spectral highlights as if they were high-precision tea leaves is an age-old technology. Nonetheless, it often is the best way to study subjects from atoms to stars.

Richard A. Larsen of Jasco Inc. says that the greatest interest in the field is centered on Raman spectroscopy.

"The technique is attractive for many reasons," he said, "and, as the pricing of Raman instruments continues to decrease as a result of technological developments, we expect this interest to continue to increase over the next few years."

Larsen also sees the use of spectrometry growing in several fields.

"Certainly, the energy sector will have increased demands, particularly for solar energy. As well, the biochemical industries continue to perform research in a number of areas, and spectroscopic imaging instruments are of increasing interest in this area," he said. "[Jasco is] expecting continued growth in our spectroscopy sales for 2010, with a focus in the research-grade Raman market."

Taking a position

Any system that incorporates lasers, optics and other precision tools often must include mechanisms for finely controlling the alignment and position of such instruments. Positioning systems, whether mechanical or piezoelectric in nature, get the job done. But are there changes in store in this niche?

According to a pair of leading companies, yes indeed.

Mad City Labs Inc. reports that it is seeing a surge in demand across the board in its positioning products.

"We are seeing active interest in the microscopy/biotechnology markets as well as increased demand in the inspection market," said the company's marketing director, Jenice Con Foo, who also noted that the Madison, Wis., company has seen little effect on sales during the recession. "We anticipate increased growth during 2010, not simply based on the economic

"An awakening in telecom capital investment is renewing interest in fabrication and packaging automation. Here, the challenge is to provide the multiaxis, submicron precision alignment automation economically in terms of both price and throughput."
Stefan Vorndran, PI (Physik Instrumente) LP.

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SOLUTIONS IN LIGHT

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recovery act, but also as a result of our increased product development, which we have continued during the recession."

The outlook appears just as sunny at PI (Physik Instrumente) LP of Auburn, Mass.

"Mechanisms, specialized controllers and software targeted toward life sciences are driving significant new applications and demand," said Stefan Vorndran, the company's director of corporate product marketing and communications. "Increasingly, the new generation of piezomotor coarse-positioning mechanisms is necessitated by increasingly stringent stability requirements [for] which this motion technology is uniquely well-suited."

According to Vorndran and his colleague Scott Jordan, PI has been able to keep investing in the next upswing even during the downturn, instead of laying off highly trained people.

"Tough economic times mean people and processes must work smarter. That means automation. Yields must continually improve. That means precision," Vorndran said. "And every industry we play in, from microlithography to data storage to photonics to medical design and life sciences, is driven by a continually compressing scale metric and the need for higher speed and throughput. That challenges us to provide better and better nanopositioning equipment at greater and greater values for the next boom."

Love terahertz

According to X.-C. Zhang, professor at Rensselaer Polytechnic Institute in Troy, N.Y., the most demand for terahertz (THz) imaging is for nondestructive evaluation systems. Suppliers for defense and homeland security are seeking ways to better sense chemical and biological weapons and explosives. Biomedical imaging with THz technology also may provide better diagnoses in a few years.

"In the past, [the] majority of THz research was in the linear spectroscopic measurements which use the relative low THz field strength (<1 kV/cm) as the source," Zhang said. "With new, intense THz sources recently developed, more nonlinear THz spectroscopic research (such as on dielectric materials measurement with greater than 100 kV/cm or even 1 MV/cm) is expected."

Zhang predicts that ultrafast THz-based technologies will grow quickly in the next few years, especially emitters with amplified lasers as sources in academic and national labs.

"Coupling high-THz field from free space into local devices, and performing dynamic study of materials could be hot topics," he said. "Ultrafast technology is the only realistic method to produce high-THz field (>100 kV/cm) with a tabletop system, and there are numerous commercial companies which are providing affordable amplified lasers with mJ pulse energy to generate intense THz waves."

Slow light speeds up

"I see two exciting developments on the horizon for 2010," said Thomas F. Krauss, who heads the microphotonics and photonics crystal group at the University of St. Andrews in the UK. "Optical signal processing at ultrahigh bandwidths [is coming], and the ability to tune the delay in slow light structures is improving dramatically. There may well be structures available that offer a tunable delay of up to 100 bits of information."

Slow light is just what it sounds like, even if it seems a bit counterintuitive at first. Changing the material through which

light passes – using a photonic crystal, for example – is one way of slowing it. Bringing light to a more reasonable velocity ultimately will make photonic, rather than electronic, computers possible.

According to Krauss, the strong point about slow light is that it enhances linear and nonlinear photonic functionality with terahertz bandwidth, which likely will lead to applications such as monitoring or regenerating optical signals.

Toshi Baba of Yokohama National University in Japan, who also is working on slow light research, notes that obstacles still remain to making the technology practical. Optical buffers and memory, for example, are still far from practical because they require long delays and high bandwidth with very low loss.

Integrating photonics

In addition to slow light studies, the prospects for optically driven communications and computing will depend on integration technologies – the hardware that will enable photons to work hand in hand with electronic circuits.

"In recent years, photonic integrated circuits (PICs) have transformed long-haul optical networks, and we believe PICs also have a tremendous role to play in the future of fiber access networks," said Steve Bauer of OneChip Photonics Inc. of Ottawa.

> "The future market for 10G Optical Ethernet Transceivers in the Data Center could be in the hundreds of millions of ports per year."
> – Steve Bauer, OneChip Photonics Inc.

According to Bauer, the company sees photonics integration technologies as becoming economically and technologically mandatory in high-volume business and consumer markets, outside of traditional telecommunications.

"We believe that the worldwide economy is starting to stabilize and that system providers and carriers, in 2010 and beyond, will embrace new technologies, such as photonics integration, that will help them deploy FTTx more cost-effectively than ever before," he said.

Alex Behfar of BinOptics Corp., however, sees it differently.

"For high-volume/low-cost applications, integrated InP photonic chips have not taken any significant market share as of now," he said. "For example, the vast majority of PON [passive optical network] diplexers and triplexers are still built using discrete InP components."

Behfar noted that BinOptics, which is based in Ithaca, N.Y., recently introduced a monolithically integrated edge-emitting laser (EEL) and monitoring photodetector (MPD).

"Initially, the EEL+MPD is expected to be used by customers that require the differentiated performance features offered by this product – for example, very tight distribution of MPD current," he said. "BinOptics sees this as its first high-volume monolithically integrated product, but the level of integration is just two active components – several decades behind silicon electronics."

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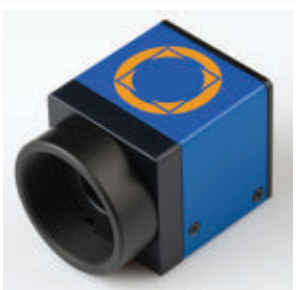

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The WIPO report

Patent filings are decreasing each year, but experts say not to worry

Francis Gurry, director general, states in the foreword of a 2009 report by the World Intellectual Property Organization (WIPO), "History has shown … that companies and countries which continue to invest in new products and innovation during times of economic recession will be those that will be best positioned to take advantage of the recovery, when it arrives."

At a time when the intellectual property market is declining worldwide, ultimately affecting innovation and financial growth, he believes it is essential to persevere in human creativity and inventiveness. However, statistics from the report show that the global economy has slowed down patent filings, and although the numbers are still positive, the percentages continue to decline each year. Nevertheless, Gurry and fellow experts from the organization assert that the future looks bright.

WIPO, headquartered in Geneva, is a specialized United Nations agency that promotes intellectual property protection internationally. The organization issued the *World Intellectual Property Indicators 2009*, including annual trends, based on utilization of patents and other forms of intellectual property in 2007.

Innovation interrupted

Research and development are supported by cash flow, so if funds aren't available, innovation may come to a standstill.

An estimated 6.3 million patents were in force globally in 2007 with two of the five largest patent offices – the US and Japan – filing 47 percent of the total, according to the report. Yet international patent filings are likely to fall this year by 5 percent, Gurry states.

In 2007, the US Patent and Trademark Office had the largest number of patents in force with more than 1.8 million. Along with Japan and China, the US was also leading in gross domestic product as well as research and development, and the three countries accounted for 59.2 percent of filings in 2007. Thereafter, the US Patent and Trademark Office lost its standing to Japan as 2008 brought zero growth; this year international applications are down by 14 percent. A report by the Organisation for Economic Co-operation and Development claims that total investments in the US for the first quarter of 2009 were down 60 percent from the year before.

Certainly, the US is not the only country affected by the crisis, as figures show a deceleration in patent filings worldwide. In 2006, filings increased by 5.2 percent, while in 2007 they increased by only 3.7 percent. Preliminary figures indicate a further reduction in 2008.

Although the patent filing rate is losing speed, patents are still a primary channel for novel discoveries. "If you look at the number of patent filings around the world in 2008, [they] still show positive growth over 2007," said Carsten Fink, WIPO's chief economist.

"Having looked at 2009 data, there has been a decline in research and development investments and a sharp fall in venture capital financing," Fink said. However, he believes the outlook is promising. "One can be more optimistic – most major economies have emerged from recession," he said, emphasizing that the economic crisis hit fully in the third quarter of 2008.

Staying positive

In contrast to the US, emerging nations in regions such as East Asia have had strong intellectual property growth. In particular, patent filings in China and South Korea grew exponentially in the past decade. As recently as the first quarter of this year, China's international filings increased 19 percent. Fink stated that, as companies in China are experiencing rapid growth, their business leaders are becoming increasingly familiar with intellectual property and the patent system.

Another perspective is that some countries are thriving in certain technological areas, Fink said. As stated in the WIPO report, between 2002 and 2006, as the rate for the filing of optical patents grew by 4.2 percent globally, Japan ranked first in number filed. The US, Australia, Israel and the UK prospered mostly from patents in the medical technology industry.

Until data for 2009 has been collected, it remains undetermined as to what direction patent filings have headed this year or where they will go in the future. But according to Fink, the worst of the recession is over; according to Gurry, finding solutions for the recession through investment in innovation should result in a sustainable future.

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Dazer Laser trademark withstands challenge

Laser Energetics Inc. of Mercerville, N.J., has announced that the trademark application for its Dazer Laser handheld, nonlethal light-fighting technologies has withstood a challenge from Taser International Inc. of Scottsdale, Ariz. The latter had contended that the trademark was too similar to its own Taser trademark and should be rejected by the US Patent and Trademark Office. Taser International, a provider of electronic control devices, terminated its opposition with prejudice. Dazer Laser is a developer of products for applications in industry, science, medicine, homeland security and the military.

Microarray products distributed in Europe

Oxford Gene Technology of Oxford, UK, providing high-throughput microarray services and biomarker discoveries, has announced its agreement with SciGene Corp. of Sunnyvale, Calif., a developer of instruments for the preparation and processing of DNA microarrays. The arrangement will allow the British company to distribute the American company's line of microarray sample processing equipment for DNA labeling, purification, hybridization, and array washing and drying to research facilities throughout Europe, excluding Germany.

LCD array substrate patented

LG Philips LCD Co. Ltd. of Seoul, South Korea, has received a patent for an LCD array substrate and its fabrication method. The invention provides a method of making an LCD device having an integrated driving circuit that decreases fabrication processes and lowers costs. The company

is a developer and manufacturer of thin-film transistor LCD panels for televisions, monitors and other mobile technologies.

Partnership to advance genetic sequencing

Biotechnology company Life Technologies Corp. of Carlsbad, Calif., and febit holding GmbH of Heidelberg, Germany, a genomic research provider, have announced their intention to collaborate. They will combine the former company's Applied Biosystems SOLiD high-throughput sequencing system with the latter's HybSelect Sequence Capture solution. According to the companies, blending their technologies will reduce time, expenditure and effort when performing genetic testing, helping researchers to understand complex diseases such as cancer, Alzheimer's and multiple sclerosis.

Optical transmitting apparatus patented

Fujitsu Ltd. of Kawasaki, Japan, a provider of information technology-based business solutions, has received a patent for an optical transmitting apparatus. The device consists of a unit that branches an input light and performs independent phase modulation. It also has a phase-adjusting unit that changes a phase difference between optical signals of respective arms according to a control signal.

Industrial Color Cameras

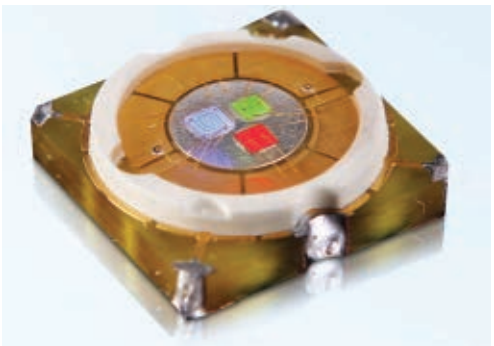
The Lw110 (board-level) and Lw115 (enclosed) industrial color cameras unveiled by Lumenera Corp. feature 1280 × 1024-pixel resolution and onboard processing to deliver good image detail, automatic white balance and exposure, and low fixed-pattern noise. The 1.3-megapixel progressive-scan ⅓-in. image sensor runs at up to 60 fps. Uncompressed images in live streaming video and still image capture are provided via a USB 2.0 digital interface. The software developer's kit includes sample code to integrate camera functions into OEM applications. Dynamic range is 60 dB, power consumption is ~2.5 W, and operating temperature is from 0 to 50 °C. The user can select 8- or 12-bit pixel data. An adjustable C-mount is provided, with a CS-mount available as an option.

Lumenera
info@lumenera.com

Vision Software

Cognex Corp.'s VisionPro 6.0 hardware-independent vision software now expands image acquisition options, with support for images up to 16 bits in depth and for nontraditional sources such as 3-D, thermal and x-ray imagers. The system offers high-accuracy calibration and image correction for line-scan cameras and expanded ID reading capability of 2-D codes. It also supports Microsoft 64-bit operating systems and enables users to switch between 32- and 64-bit systems. A calibration tool provides accuracy when using line-scan cameras. One calibration board image is enough to correct camera distortion and camera displacements such as rotation and tilt.

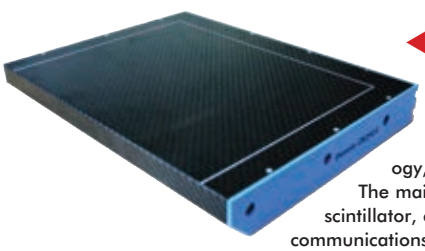
Cognex
john.lewis@cognex.com



Square-Shaped LED

Lumex has expanded its line of high-brightness LEDs with the introduction of the 3-W TitanBrite RGB, a square-shaped surface-mount technology LED. Measuring 10 × 10 mm, it has applications in electronic signage, industrial controls, safety/security lighting, general illumination, graphics backlighting and accent lighting. The RoHS-compliant device combines three 1-W dies in red (636 nm), green (525 nm) and blue (470 nm) in the same package with a flat epoxy lens. The square shape enables increased design efficiency with easier assembly and more array formation opportunities.

Lumex
lmxsales@lumex.com



Flat Panel X-ray Detectors

Dexela Ltd. has introduced a family of flat panel CMOS x-ray detectors for medical applications including mammography, tomosynthesis, breast and dental cone-beam CT, fluoroscopy, cardiology, angiographic imaging and bone densitometry. The main components are a CMOS image sensor, a scintillator, control electronics, and readout electronics and communications with the workstation. The image sensor has a photodiode array with 75-µm pixels. It produces low dark current and read noise and delivers high linearity and consistent response. It performs multiresolution readout with dynamically adjustable binning at 1 × 2, 2 × 2, 1 × 4, 2 × 4 and 4 × 4. Frame rates range from 26 to 86 fps. Features include 75- to 300-µm pixel pitch, high detective quantum efficiency and contrast, reduced image lag, and ready-to-run software and drivers.

Dexela
sales@dexela.com

Excimer Laser

LEAP, a high-duty-cycle excimer laser manufactured by Coherent Inc., is suitable for use in microelectronics and medical device manufacturing applications. It is intended for cost-sensitive, throughput-critical micromanufacturing tasks, such as for small functional devices with smart functions and microfluidic parts. The Novatube construction and discharge design provides low operation costs per watt. The direct UV laser emission delivers a per-pulse energy of 650 mJ at repetition rates of up to 200 Hz, for an average power of 130 W. The laser operates at 248 or 308 nm. Stabilized energy range is from 550 to 650 mJ, and typical pulse duration is 22 ±5 ns FWHM.

Coherent
tech.sales@coherent.com

Variable Luminance Source

Optikos Corp. has released the VLS-100, a variable, controllable source of uniform, visible illumination for testing cameras, image intensifiers, and visible to near-infrared night vision devices. It is used with I-Site software or as a stand-alone computer-controlled device. It features a 50-mm-diameter aperture with <2% luminance nonuniformity. Brightness is continuously adjustable over a dynamic range of 10^6 that is computer-controlled to within 3% of its set value. The source includes an automated variable attenuator and aperture wheel with high-resolution stepper motors. An integrated photometer provides real-time monitoring of exit port luminance and enables closed-loop control. The digitally controlled power supply ensures constant lamp output and stable color temperature that is NIST-traceable. The filter drawer allows for multiple filters to adjust color temperature and spectral output.

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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

Signature _____ Date _____

IMPORTANT: Unsigned or Incomplete Cards Are Disqualified.

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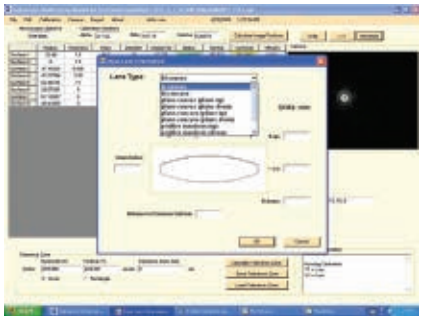
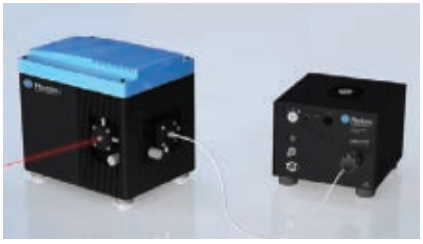
Measurement Software



For multielement optical lens assembly, Opto-Alignment Technology has introduced CalcuLens 2.1.0, optical centration measurement software that calculates real-time total indicated runout, with high-speed automatic centroid capture, eliminating user error and improving uniformity and repeatability. It performs noncontact and instant submicron measurements for any lens surface, including cylindrical and parabolic, and coated or uncoated optics. It accommodates radius of curvature from ±2 mm to infinity. The user can perform inspection and quality control of centrations and wedges, import Zemax files, generate and save quality assurance reports for traceability, share files over the local network and receive live technical support via the Virtual Network. Features include tolerance zone recognition for repeatable productivity and unit conversion between English, metric and ISO/DIN.
Opto-Alignment Technology
steve.bohuczky@optoalignment.com

Tunable Laser

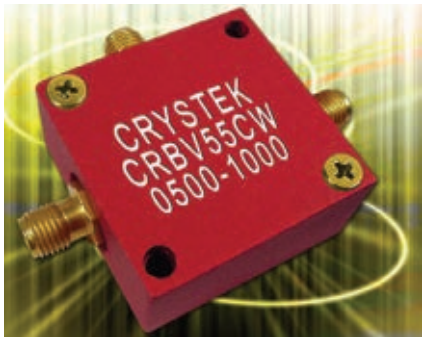


Photon etc. Inc. offers a tunable broadband laser source covering the ultraviolet, visible and near-infrared ranges from 370 to 2300 nm with a linewidth from 0.3 to 3 nm. It has an operating temperature from 10 to 40 °C and provides output power of up to 100 µW/nm. Equipped with the company's PhySpec software, it offers USB connection and a graphical user interface, and it is Windows-compatible. It is suitable for wavelength calibration of photometric and radiometric instruments in fluorescence, Raman and photoluminescence applications.
Photon etc.
info@photonetc.com

White LED Driver

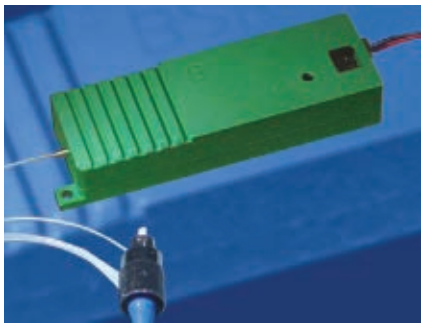
Advanced Analogic Technologies Inc. has launched the AHK2418E, a 16-channel white LED driver with full LED current and timing control for edge-backlit large-size LCD panels used in LCD TVs. Using external high-voltage metal-oxide semiconductor field-effect transistors (MOSFETs), it can drive many serial-connected LEDs with up to 100 mA per channel. Sixteen current sink devices allow the current in each MOSFET to be regulated to within ±2.5% accuracy and ±2% matching. A high-speed interface enables fast independent digital control of each current sink programmed to a maximum value using an external resistor. An 8-bit dot correction register compensates for variations in LED brightness during LCD setup, and two 12-bit registers control the gray-scale current and delay time.
Advanced Analogic Technologies
jcoughlan@analogictech.com

Voltage-Controlled Oscillators



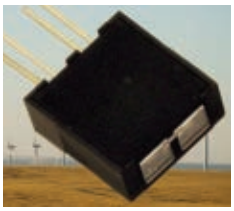
Suitable for telecommunications applications, the Crystek RedBox series voltage-controlled oscillators operate from 500 to 1000 MHz with an input voltage of 12 V, a control voltage range from 0.5 to 18.0 V and a maximum current consumption of 20 mA. Featuring a typical phase noise of −104 dBc/Hz at 10-KHz offset and second-harmonic suppression of −5 dBc, it offers a typical output power of 7 dBm. The oscillators are packaged in a robust aluminum enclosure with SMA connectors.
Crystek
sales@crystek.com

Fiber-Coupled Diodes



The FiberTECII series second-generation fiber-coupled laser diodes from Blue Sky Research are being distributed by AMS Technologies AG. The high-output-power modules, now offered in 488- and 532-nm wavelengths, operate from 405 to 1064 nm and integrate micro-optic beam shaping for high efficiency and stability. The devices offer 100 kHz of sharp edge modulation for most wavelengths. Applications include defense and homeland security, inspection and metrology, automated instrumentation, medicine, particle analysis and flow cytometry.
Blue Sky Research
salesinfo@ams.de

IR Reflective Switches



Providing alternative energy design engineers with a means of reliably and accurately detecting the speed of wind turbines, TT electronics Optek Technology Inc.'s OPB732 series long-distance infrared reflective switches have been employed in a 6-kW wind turbine for revolutions-per-minute (RPM) sensing. Placed at the turbine rotor, the switches are used internally to sense RPMs, and that data is then transmitted to a customer-accessible Web site via General Packet Radio Service. With its noncontact design, which features an emitter and a sensor protected from contaminants by a clear window, the reflective switch provides the reliability and accuracy necessary for monitoring turbine RPMs. It also is suitable for use in assembly line and machine automation, equipment security, door sensors, machine safety, end of travel sensors and noncontact reflective object sensor applications.
Optek
sensors@optekinc.com

Machine Vision Cameras

The Falcon line of machine vision cameras has been expanded by Dalsa Corp. with the addition of three models. The VGA300 HG, 1M120 HG and 1.4M100 HG feature proprietary CMOS image sensors and are suitable for use in electronics and semiconductor inspection and industrial metrology. The 1M120 HG delivers 1-megapixel resolution at 120 fps, and the 1.4M100 HG offers 1.4-megapixel resolution at 100 fps. All support Power over Camera Link, eliminating the need for a separate power cable. The fully programmable cameras feature exposure control, gain and offset adjustment, and flat-field correction. They are supplied in a compact 44 × 44 × 44-mm housing.
Dalsa
sales.americas@dalsa.com

Cooling Solution

Nuventix Inc. has announced the SynJet Universal DLM cooler for the Philips Fortimo LED Downlight Module. The thermal management solution is a 120-mm compact device suitable for recessed downlight applications where clearance is tight. Its luminaire design offers flexibility in installations where height is limited, or where spots require small rough-in holes. Measuring less than 60 mm in total height, it features silent operation and enables 2000 lm in a small profile.
Nuventix
info@nuventix.com

External Output Amplifier

A two-channel external output amplifier that provides up to 50-V peak-to-peak amplification of function/arbitrary waveforms has been introduced by Agilent Technologies Inc. It works with existing function generators to extend the voltage range and to offer low-distortion outputs. The 33502A amplifier is suitable for use in research and development and by test engineers who need signal sources greater than 20 V peak-to-peak, without sacrificing accuracy. The programmable pass-through mode enables use

in high-voltage applications including aerospace, defense, automotive and industrial. The fully isolated front end offers 5× voltage amplification. It can be independently configured with input coupling and input impedance to match specific circuits. The input path can be switched from amplified to unamplified without removing or reconnecting cables.
Agilent Technologies
janet_smith@agilent.com

8-Megapixel Camera

An 8-megapixel camera with GigE technology has been unveiled by SVS-Vistek GmbH. The svs8050 has a four-tap CCD sensor, and the output offers two RJ45 connectors and transmits at 2 Gb/s via two cables. The progressive-scan camera works with a Kodak interline transfer CCD with a diagonal of 22.66 mm. Maximum rate is 20 fps with full 332 × 2496-pixel resolution. In partial-scan mode or while using areas of interest, images with fewer lines can be read out at a higher speed. Binning with 2 × 2 pixels is possible, and the camera can be used in one- or two-tap mode. It is available in monochrome and color versions and is supplied with SVCapture configuration software and a software development kit. Input/outputs are provided and can be controlled via Gigabit Ethernet.
SVS-Vistek
info@svs-vistek.com

DPSS Laser

Cobolt AB has released a higher-power model of its Cobolt Mambo orange laser for use in fluorescence analysis applications, including confocal microscopy and flow cytometry. The continuous-wave diode-pumped solid-state (DPSS) laser operates at 594 nm with output power of 25, 50 and now 100 mW. It is built into a hermetically sealed compact package using proprietary HTCure technology for robustness. The single-longitudinal-mode laser produces low noise of <0.3% rms, a narrow spectral linewidth of <30 MHz, typical, and beam quality of M^2 <1.1. Based on proprietary periodically poled potassium titanyl phosphate frequency conversion technology, the laser is insensitive to pressure and humidity.
Cobolt
info@cobolt.se

Fiber Optic Cables

Berk-Tek has announced that its family of fiber optic cables includes fiber grades that exceed the recently ratified TIA-492AAAD for OM4 specifications. OM4 is a 50-≤m laser-optimized fiber with extended bandwidth over the previous OM3. It enhances the system cost benefits enabled by 850-nm vertical-cavity surface-emitting lasers for existing 1- and 10-Gb/s applications and future 40- and 100-Gb/s systems. It has an effective modal bandwidth of 4700 MHz*km and can reach a distance of 550 m for 10 Gb/s. The cables are available with two types of fibers that meet or exceed the OM4 standards. GIGAlite-10FB glass meets the standards, and GIGAlite-10XB surpasses them.
Berk-Tek
mike.connaughton@nexans.com

X-Y/X-Y-Z Nanopositioning Stages

PI (Physik Instrumente) LP has introduced two multiaxis stages for superresolution microscopy. They provide accurate motion with subnanometer resolution in two and three axes over travel

ranges of 200 µm in X-Y and X-Y-Z. The nano1×3 stages are designed for inverted microscopes from Leica, Nikon, Olympus and Zeiss. The large aperture accommodates microscopy accessories such as slide holders and Petri dish holders. Features include a 24-bit controller with USB, Ethernet and RS-232 interfaces and analog control, closed-loop control for subnanometer precision, and a longer lifetime because of ceramic encapsulated piezo drives. All parts are black anodized for minimum reflection. Options include a manual X-Y stage with a motor upgrade. There also is software support for leading image acquisition packages.
PI (Physik Instrumente)
photonics@pi-usa.us

Extended Power

Dilas Industrial Laser Systems has unveiled power extensions for its compact diode laser system series: 300 W out of a 200-µm fiber and 400 W out of a 300-µm fiber at 9xx nm. The fiber-coupled turnkey diode laser systems are based on conduction-cooled diode laser

bars. The systems are available with an industrial water-to-air chiller, a power supply and an integrated control unit. The 19-in. rack mount makes the laser and the cooling unit easy to integrate for OEM purposes. The systems can be combined with a variety of accessories for process control, including laser processing heads, cameras, pyrometers, galvo scanners and galvo scanners with integrated pyrometers. In combination with a galvo scanner, they can be used for quasi-simultaneous plastics welding.
Dilas Industrial Laser Systems
sales@dilas.com

DPSS Green Pump Laser

Sprout, a compact diode-pumped solid-state (DPSS) laser launched by Lighthouse Photonics, features noise elimination technology and is available in four versions, ranging from 5 to 10 W. Suited for Ti:sapphire laser pumping, the sealed, patent-pending 532-nm CW device offers a Seal enclosure that keeps dirt, dust and moisture out of the laser head for long lifetime and LockT optical mounting for permanent laser alignment. The power supply contains the fiber-coupled diode pump laser and an integrated closed-loop thermoelectric cooler. Noise is <0.03% rms. Features include automatic laser power control and USB/RS-232 interfaces for external monitoring and control. Applications include spectroscopy, flow cytometry, solar cell processing, ophthalmology, medical diagnostics, film subtitling and pumping dye lasers.
Lighthouse Photonics
info@lighthousephotonics.com

Volumetric Velocimetry System

A volumetric velocimetry system has been introduced by Dantec Dynamics Inc. When used with high-frame-rate cameras, it is suitable for experimental fluid dynamics research and theoretical model validation. It delivers kilohertz temporal resolution and obtains true volumetric velocity data by combining high-performance cameras with telecentric lenses and advanced volumetric illumination. The company offers solutions for experimental requirements in configurations using two, three or four cameras. For flows with a low particle number density, a volumetric particle tracking velocimetry algorithm is used. Flows with medium seeding density require a tomographic particle tracking velocimetry algorithm, and highly seeded ones use the least-squares matching algorithm.
Dantec Dynamics
usa@dantecdynamics.com

Laser Shutters

The FlexSorb line of laser shutters from nmLaser Products Inc. features a high damage threshold, quick switching speed, a small size, quiet operation and good thermal dissipation. The only moving part is a low-mass flexible ferromagnetic cantilever membrane that is moved in and out of the beam by noncontact electromagnetic techniques, reducing opening and closing shock, vibration and wear. The flexures are unaffected by foreign particles clinging to the magnetic pole, and they offer long lifetimes. All units are immersion cleaning-compatible and can be provided for cleanroom applications. Slightly overdamped controllers eliminate system ring, ensuring efficient energy transfer to the magnet. That heat is merged with the laser optical absorption heat and is dissipated using thermal conduction to a common mounting surface.
nmLaser Products
sales@nmlaser.com

b BRIGHT IDEAS

Optical-to-Electrical Converter

TIA-2000, a high-speed photodetector module manufactured by Terahertz Technologies Inc., is designed for direct optical-to-electrical conversion of radio-frequency modulated optical signals. It offers a typical bandwidth of DC to 20 GHz, with 18 GHz minimum. The optical input is supplied through a single-mode 9/125 fiber connector with an ultrapolish FC-PC connector or, optionally, with an angle-polished low-reflection FC/APC connector. The radio-frequency output is provided through an SMA connector. Typical optical responsivity is 22 V/W at 1550 nm when the unit is terminated with a 50-Ω load. Electrical return loss is 10 dB, operating temperature ranges from 0 to 40 °C, and the input numerical aperture is 0.11.

Terahertz Technologies
sales@terahertztechnologies.com

Imaging, Machine Vision Lenses

Edmund Optics has expanded its line of TechSpec imaging and machine vision lenses with the addition of more than 30 lenses, including TechSpec compact fixed focal length, compact telecentrics, high-resolution telecentrics and large-format telecentrics. The fixed focal length lenses support ⅔-in. imaging sensors and are available in focal lengths of 8.5, 12, 16, 25 and 35 mm. A broadband antireflection coating improves light transmission. The telecentric lenses offer low distortion and distance-independent magnification. They have 65- and 110-mm working distances at magnifications from 0.5× to 4×. The large-format telecentrics support sensors up to 28.7 mm diagonal with 4-megapixel resolution. The high-resolution telecentrics support ⅔-in. sensors with 5-megapixel resolution. They are available in magnifications of 0.28×, 0.5×, 0.9× and 1.7×.

Edmund Optics
medmund@edmundoptics.com

Photoelectron Spectrometer

Thermo Fisher Scientific Inc. has announced the Escalab 250Xi x-ray photoelectron spectrometer (XPS), a surface characterization tool for use by engineers working in R&D of new surface chemistries or performing routine characterization of surfaces, thin films and coatings. The system combines the high-performance spectrometer with proprietary Avantage XPS acquisition and processing software and an integrated parallel image detection system that enables quantitative spectroscopic analysis of small features within the image field of view. The Avantage data system guides analysts through data acquisition, interpretation, processing and report generation. Ion-scattering spectroscopy and reflection electron energy loss spectroscopy are provided with the instrument, and ultraviolet photoelectron spectroscopy and Auger electron spectroscopy are available as options.

Thermo Fisher Scientific
analyze@thermofisher.com

Progressive-Scan Cameras

JAI Inc. has introduced the AT-140CL and the AT-200CL progressive-scan color cameras. The former features three ½-in. Sony CCDs with 1392 × 1040-pixel resolution and a pixel size of 4.65 × 4.65 µm. The latter has three ⅓.8-in. Sony CCDs with 1628 × 1236 pixels and a pixel size of 4.4 × 4.4 µm. The CCDs are attached to a prism block that splits the incoming light into red, green and blue color channels. The AT-140CL operates at 25 fps with full 3 × 1.4-megapixel output via a Camera Link digital interface. The AT-200CL operates at 20 fps with full resolution. Faster frame rates can be achieved in partial scan and vertical binning modes.

JAI
camerasales.emea@jai.com

Laser Micrometer

The TLAser130s laser scan micrometer has been released by LaserLinc Inc. The compact single-axis device is for wire, centerless ground parts and multistrand measurement such as monofilaments. Its noncontact and high-speed scanning is suitable for flaw detection in small extruded products. With accuracy of ±0.00004 in., it measures diameter, detects short defects and profiles parts. It takes 1600 measurements per second standard, with an option of 4000. It has a separate transmitter and receiver and a 30-mm measurement window. It links to a PC running the proprietary Total Vu software that provides in-process tolerance checking, trending, statistical process control, feedback control, data logging and recipes.

LaserLinc
info@laserlinc.com

Vibration Isolator

Newport Corp. has announced the S-2000AC Stabilizer cleanroom isolator. It features automatic re-leveling and a 2000-lb load capacity and can be used for isolating optical tables, large inspection equipment and heavy machinery, and it can support large-area subfloors in cleanrooms. The hybrid chamber design maximizes isolation bandwidth and stability, and the precision leveling function improves repositioning after disturbance. The laminar flow damping minimizes amplification at resonance. It is available in heights ranging from 16 to 28 in. and is equipped with pneumatic re-leveling valves and float-height indicators. It features SafeLock mounting clips to secure the isolator to the bottom of any of the company's optical tables. It provides 1-Hz vertical resonant frequency and 98% vertical isolation efficiency at 10 Hz. Horizontal isolation begins at 2.5 Hz and reaches 95% efficiency at 10 Hz.

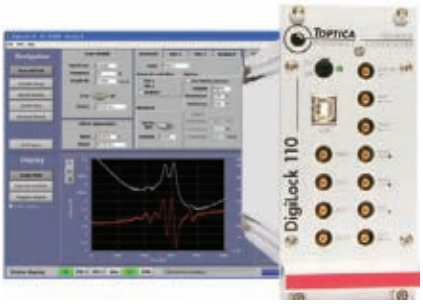
Newport
warren.booth@newport.com

GigE Vision Camera

Matrox Imaging has unveiled the Matrox GatorEye, an industrial IP67-rated Gigabit Ethernet camera for use in machine vision applications. It is available in six sensor configurations: 640 × 480 at 110 fps with a ⅓-in. monochrome or color CCD; 1280 × 960 at 22 fps with a ⅓-in. monochrome or color CCD; and 1600 × 1200 at 15 fps with a ⅓.8-in. monochrome or color CCD. To connect to external devices, the camera has an optocoupled trigger input, strobe output, eight general-purpose input/outputs and a controlled current source for driving LED illuminators directly. It can be powered by 12- to 24-VDC or by Power over Ethernet.

Matrox Imaging
imaging.info@matrox.com

Laser Controller



Toptica Photonics' DigiLock 110 is a digital module for laser control and frequency stabilization. It also can be used to control and analyze the laser digitally. Functions include side- and top-of-fringe locking, and signal visualization and analysis. In auto lock mode, the user can modify the scan parameters of the laser by dragging the mouse and zooming into a feature of a spectrum on the software oscilloscope screen. With the feature displayed, the user can "click & lock" to any peak or slope. The field-programmable gate array-based hardware makes the system flexible and fast. The unit has numerous inputs and outputs, up to a 100-MHz sampling rate and up to 21-bit precision. Total delay time is <200 ns, and the digital locking bandwidth is several megahertz.
Toptica Photonics
info@toptica.com

LED Measurement Systems

The ETΦ line of LED characterization systems from Orb Optronix Inc. measures the electrical, thermal and optical characteristics of LEDs and the quantity and color of light from LEDs over a range of temperatures and electrical input power variables. Automated data acquisition and comprehensive data analysis features allow users to view various groupings of data in more than 300 graphs. Light output, wavelength, chromaticity, correlated color temperature, forward voltage and efficacy can be measured. Models are offered in 1024- and 2048-pixel resolution, in spectral ranges of 380 to 780 nm, 250 to 500 nm and 360 to 1000 nm, and with optical bandwidths of 4.1 and 1.5 nm.
Orb Optronix
sales@orboptronix.com

Polarizing Patch Cable

Available from Chiral Photonics Inc. is a flexible in-fiber polarizing patch cable with a polarization extinction ratio better than 25 dB to launch or clean up a signal. Polarization is scattered out and not absorbed, suitable for addressing high-power needs. Standard wavelengths are 980, 1060, 1310 and 1550 nm, with a bandwidth >50 nm. Custom spectral windows are available upon request. The cable is supplied in

a standard 2-m length or can be tailored to length and connector requirements. The cable's standard jacket is a 3-mm-diameter furcation tube.

Chiral Photonics
lookdifferent@chiralphotonics.com

Current Amplifier

Femto Messtechnik GmbH has introduced an ultralow-noise variable gain current transimpedance amplifier for sensitive current and charge measurements. The DDPCA-300 has a switchable gain from 10^4 to 10^{13} V/A and a dynamic range of 240 dB. Peak-to-peak noise is 0.4 fA, enabling measurement of currents in the femto to pico ampere range. Features include adjustable voltage directly on the amplifier input for device-under-test biasing, a DC optimized design with high stability and low drift, manual control and a remote interface. Packaged in a miniature and rugged aluminum housing designed to optimize electromagnetic interference shielding, the device has applications including spectroscopy, photodiode and charge detector amplification, sensitive ionization, conductive

atomic force microscopy, quantum and biotechnology experiments, and preamplification for oscilloscopes, analog-to-digital converters and digital voltmeters.
Femto Messtechnik
info@femto.de

MEMS Inclinometers

The T700 series compact DC-operated solid-state microelectromechanical systems (MEMS) inclinometers has been launched by Sherborne Sensors to measure inclination proportional to sine of angle in one axis (model T710) or dual axes at right angles (model T720). Available in ranges from ±30° to ±90°, the devices feature a micromachined MEMS sensor with air damping. The units are packaged in a lightweight aluminum housing with an integral shielded cable connection, and they include positive mechanical stops for good shock resistance and reliable overranging protection. The characteristic error correction equation helps minimize uncertainties caused by zero offset, sensitivity error and linearity, and thermal zero and sensitivity shift. Measurement accuracy is better than ±1 mrad.
Sherborne Sensors
sales@sherbornesensors.com

Polymer Optical Components

Jenoptik's Optoelectronics Systems Business Unit has introduced polymer-based optical components manufactured for the closing velocity sensory system called City Safety. The laser-based optical sensor is used in cars to mitigate or stop accidents. The transmitter/receiver unit calculates the distance to objects and its approach speed from signals up to 10 m away. The design of the transmitter and receiver lenses is aimed at shaping the light of the laser diode. The tool inserts for the lenses consist of a number of different-size facets that are tilted in two axes and integrated into the tool.
Jenoptik
sales@jenoptik-ps.de

Laser Safety Glasses

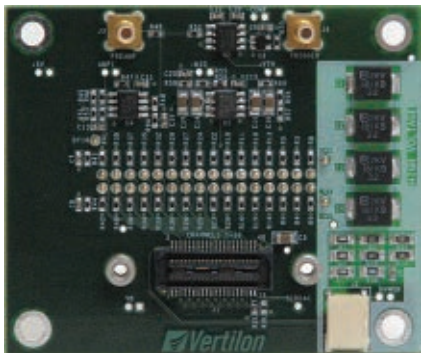
The F09, a lightweight, durable rubberized frame with side shields manufactured by Laservision USA, has adjustable earpieces that can be worn over most prescription frames. The lens is 62 mm wide and 50 mm high and can accommodate glass, polycarbonate or nanospec filters. The larger size provides increased viewing. The distance between the lenses is 17 mm, and temple length is 125 mm. The black frame is 54 mm high, 157 mm long and 147 mm wide, making it suitable for use with heavier filters. Accessories include a cleaning cloth, 1 oz of cleaning solution, a head strap and a soft case.
Laservision USA
info@lasersafety.com

Converter Transformers

The 782482 series RoHS-compliant converter transformers released by Murata Power Solutions Inc. are designed for use with Analog Devices Inc.'s ADM2482/7 transceiver chip sets employed to provide isolated RS-485 and RS-422 interfaces. Carefully controlled turns ratios ensure consistent performance, and the toroidal construction helps minimize electromagnetic interference. Housed in an industry-standard dual-in-line package using UL94 V-0 materials, the transformers measure 9.77 × 9.14 × 6.35 mm. Nominal input voltages are either 3.3 V or 5 V, depending upon the model. Both models have nominal output voltage of 3.3 V. Operating temperature ranges from −40 to 85 °C. Both models are backward-compatible with SnPb soldering systems.

Murata Power Solutions
sales@murata-ps.com

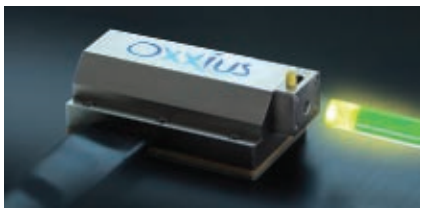
Sensor Interface Board



Vertilon Corp. has introduced the SIB232 sensor interface board for fluorescence detection applications using the Hamamatsu H7260 32-channel multianode photomultiplier tube (PMT). Used with a proprietary PhotoniQ data acquisition system, the board can simultaneously capture 32 channels of high-speed, low-level fluorescence events detected by the PMT. The company's latest circuitry for preamplification and discrimination of the H7260's last dynode signal enables the fluorescence event itself to generate the trigger for data collection from the PMT, without requiring an external signal. Applications include flow cytometry, confocal microscopy and bioaerosol detection.

Vertilon
info@vertilon.com

Yellow Laser



Oxxius SA has released the SLIM-550, a yellow diode-pumped solid-state laser that emits up to 200 mW at 550 nm. The instrument features a monolithic resonator, optical noise of <0.2% rms and pointing stability of <5 µrad. It consumes as little as 10 W. The device is suitable for fluorescence applications, enabling efficient light collection from phycoerythrin (PE) without unwanted excitation of allophycocyanin (APC). It also enables optical excitation of fluorescent proteins, including DsRed and dTomato.
Oxxius
sales.us@oxxius.com

UV-LED Spot Light-Curing System

China Good ST Group has introduced the GST-101D, a UV-LED spot light-curing system for applications in paper, wood, glass and plastic finishing, metal decorating, fiber optics, CD/DVD manufacturing and electronics. It employs heat dissipation technology that eliminates the need for a cooling fan. Each illumination head can be controlled separately. The system includes an RS-232C communications interface, and the start/stop illumination can be controlled by a foot switch or by an external input/output interface. Operating temperature ranges from 5 to 40 °C.
China Good ST Group
allen@st2109.com

Narrow-Linewidth Laser

Redfern Integrated Optics Inc. has added features to its Orion laser module. The new tunable narrow-linewidth laser provides end users with a fast-frequency tuning function or with a direct amplitude modulation function in a single compact package. SPI, RS-232 or RS-485 interfaces provide communication with the module and reduce development cycle time. The proprietary graphical user interface facilitates integration into fiber optic sensing systems. Users can directly modulate frequency with a bandwidth of 0 to 10 kHz via the nine-pin D-sub connector over a case temperature from 0 to 70 °C. This feature is part of the design of the Planex semiconductor laser platform and does not need the high-voltage drive electronics required by piezoelectric tuning technologies. The module also can be used in direct power modulation mode. Higher bandwidths are available upon request.
Redfern Integrated Optics
sales@rio-inc.com

Vision Applications

For industrial vision applications requiring 1- to 2-megapixel resolutions at frame rates of up to 120 fps, Baumer Ltd. has released the SX cameras. Featuring Kodak's progressive-scan interline CCD image sensors with Quad-Tap technology, they offer resolution of 1024 × 1024

pixels. The 1-megapixel cameras achieve speeds of 120 fps, depending upon the number of output taps used, and the 2-megapixel cameras offer horizontal and vertical resolutions of 1600 × 1200 pixels and operate at speeds of up to 68 fps. All models measure 52 × 52 × 54 mm, have a 5.5 × 5.5-µm pixel size and offer rugged housing and robust electronics that withstand a variety of application environments. The digital interface is Camera Link Base. Applications for the monochrome and color cameras include measuring and medical technologies, and semiconductor inspection.

Baumer
sales.us@baumergroup.com

CRI LED

To complete the Primax product portfolio and fulfill the lighting market demand, Dominant Semiconductors is extending this series with a high color rendering index (CRI) LED in a 0.5-W white version. The NAW-BSC is compliant with the US Energy Star guidelines, fulfilling the required minimum CRI of 75. With an operating current of 150 mA, this new-generation white LED produces 20 lm at a low thermal resistance. The CRI of minimum 75 and typical 80 makes it suitable for use in all lighting applications. The Primax LED series products, featuring a small package, high intensity and efficiency, are suitable for backlighting of displays and decorative lighting. They also enhance and support creative illumination in sophisticated automotive applications and in general and channel lighting.

Dominant Semiconductors
sales@dominant-semi.com

X-Ray Source

The L10711 microfocus x-ray source manufactured by Hamamatsu Corp. delivers the resolution (0.25 µm minimum) and stability required for x-ray nondestructive inspection, 3-D imaging and computed tomography (CT). The stable operation benefits customers performing x-ray CT scans. The built-in power supply and the improved cathode materials and design produce a stable x-ray focus spot size and stable, continuous output. The cathode design also makes it easy to replace. Two types of cathodes, one for high resolution (S mode) and the other for high intensity (W mode) are available. With the high-resolution cathode, the source produces a minimum resolution of 0.25 µm and a tube voltage range of 20 to 100 kV. With the high-intensity cathode, it produces 8 W of intensity, a minimum resolution of 0.8 µm and a tube voltage range of 20 to 160 kV.
Hamamatsu
usa@hamamatsu.com

Beam Shaping

Fisba Optik AG has developed a fast-axis collimation lens with total internal reflection that can collimate laser diodes and deflect beams at an angle of 90°. The TIR-FAC's integrated intelligent micro-optic components allow design freedom, and its focal length can be customized to system specifications. Focal lengths can be up to 1.5 mm. The lens has an integrated beam-shaping optic and features almost diffraction-limited collimation and good surface quality to avoid scattering losses. The high-performance coating ensures best possible transmission optimized to the laser diode wavelength.
Fisba Optik
aol@fisba.ch

Dome Lights

LDD Trading Associates LLC has released the IDD-KH series high-power dome lights now available in six standard sizes from 80 to 350 mm in diameter. The diffuse models are available with red, white, blue or green power LEDs. The largest model, the IDD-KH350's illumination intensity is greatest at up to 10-mm working distances, from which it uniformly lights a 300-mm field of view. The high-brightness power LEDs used in each model provide machine vision systems with light output for measuring, inspecting and reading applications where intense illumination is required. The lights feature a hemispherical dome to deliver a broad angle of illumination onto a part's surface to reduce shadows that can make imaging shiny spherical and irregular surfaces problematic. Models larger than 350 mm in diameter may be custom ordered.
LDD
sales@lddlight.com

Optical Fibers

Fiberguide Industries Inc. offers a full line of standard optical fibers with polyimide coating. Providing optimal performance of fiber optics in extreme thermal conditions, the coating accommodates oil and gas, aerospace, sensors, defense, and medical and security applications requiring high temperature resistance. It withstands operating temperatures of up to 400 °C (300 °C continuous), while conventional coatings such as acrylate, nylon and Tefzel begin to deteriorate between 100 and 250 °C. Polyimide-coated fiber is available in step-index,

multimode fibers with cores from 50 to 600 µm, 6.25-/125-µm and 50-/125-µm graded index, and in 4.8-/125-µm and 9.2-/125-µm graded index single-mode fibers. According to the company, it offers high-performance optical and mechanical specifications with tight dimension tolerances to produce good uniformity.
Fiberguide
info@fiberguide.com

Focus Drive

The NIKRFK focus drive with an integral electronic clutch is now available from Prior Scientific Inc. Designed for the Nikon Ti, 80i and FN1 microscopes, the focus drive offers resolution and repeatability under software control. The electronic clutch can be disengaged with the push of a button to offer users smooth operation when using the microscope's manual focus knob. An optional focus encoder kit provides accuracy with a 50-nm-resolution probe style encoder. The kit includes a controller, a focus drive mechanism, cables and a power supply. Available push-button functions on the device include engage and disengage clutches, go to zero, set zero, change speed, and buttons to move up or down. The drive delivers repeatability of 100 nm with an encoder, features a resolution programmable to 10 nm and operates at a speed of 320 µm/s.
Prior Scientific
ddoherty@prior.com

Blue LEDs

Opto Diode Corp. has unveiled its OD-469L high-output blue LEDs. Featuring a narrow beam angle, they are suitable for fluorescence applications in medicine, scientific testing instruments and forensics. The new lighting devices are available in a hermetically sealed TO-5 can with three leads. The electro-optical characteristics at 25 °C deliver total power output ranging from a minimum of 80 to a typical 170 mW. The dominant emission wavelength is from 465 to 475 nm with typical operation at 470 nm. Absolute maximum ratings at 25 °C include 1000-mW power dissipation (infinite heatsink), 350-mA continuous forward current, peak forward current (1/10 duty cycle at 1 kHz) at 2 A and reverse voltage at 5 V.
Opto Diode
sales@optodiode.com

Microplate Reader

BioTek Instruments Inc. has expanded its Synergy multimode microplate reader family with the release of the patent-pending Synergy H4 with hybrid technology. The newest model combines the sensitivity of filter-based optics with the flexibility of monochromator-based optics in a compact instrument for fluorescence-based applications. Its filter and dichroic-based fluorescence optics feature performs light filtering and purification with fast wavelength switching and readout speeds suitable for time-resolved Förster resonance energy transfer, fluorescence polarization and AlphaScreen and AlphaLISA applications. The modular device is compatible with the company's Take3 multivolume plate for low-volume measurements down to 2 µL.
BioTek
customercare@biotek.com

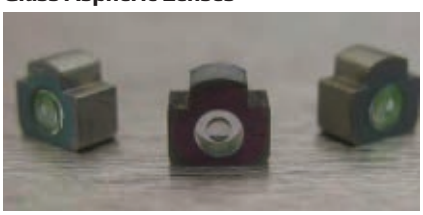
Metal Material

EOS GmbH has introduced the NickelAlloy IN718, a metal material for its EOSINT M 270 laser sintering systems. A heat-resistant superalloy, it corresponds to the Inconel 718 alloy. It is

a precipitation-hardening nickel-chromium alloy characterized with good tensile, fatigue, creep and rupture strength at temperatures of up to 700 °C. It is corrosion-resistant, has suitable cryogenic properties and can be used in many high- temperature applications. The main target for this material is the aerospace industry. The company has developed process parameters that enable part building and ensure that the relevant industrial standards for this material type are met. These include heat treatment in accordance with AMS 5662 and 5664 standards as well as tensile and stress-rupture properties at elevated temperatures.

EOS
info@eos-optronics.com

Glass Aspheric Lenses



LightPath Technologies Inc. has unveiled RoHS-compliant molded glass aspheric lenses with a high index of refraction for use in telecommunications systems. The company has developed a set of lenses that replaces its current lead glass-based products. Some of them are molded into holders for easy assembly. The demand for these lenses is being driven by the infrastructure upgrade for 3G wireless networks and new networks in developing countries, such as China, which has more than 700 million subscribers and continues to grow. Five models are available, with numerical apertures of 0.20, 0.60 (two models), 0.17 and 0.10. Focal lengths are 2.51, 0.60. 0.70, 4.0 and 2.51 mm. Outer diameters are 1.805, 2.0 × 2.2 (T-shape) and 3.00 (three models). Clear apertures are 1.01, 0.72, 0.84, 1.37 and 0.51 mm, and working distances are 1.84, 0.22, 0.29, 3.36 and 1.755 mm. One model has no holder, another has a T-holder, and three have cylindrical ones.

LightPath Technologies
info@lightpath.com

VCSEL

Oclaro Inc. has announced an RoHS-compliant vertical-cavity surface-emitting laser (VCSEL) for Intel's Light Peak optical technology market, designed for high-speed fiber optic communications links and for leveraging optical technology to connect electronic devices such as peripherals, workstations, displays, disk drives and docking stations. Delivering bandwidth starting at 10 Gb/s, the optical technology will enable Oclaro to expand into the computing and consumer electronic services markets. A full-length Blu-ray movie can be transmitted in <30 s. Features of the VCSEL include 850-nm multimode emission, low threshold and operating

current, low electrical parasitics, and a bottom-side cathode and top-side anode configuration. It operates in multiple transverse and single-longitudinal modes and emits a circular symmetrical beam with low divergence that can be coupled into 50/125- and 62.5/125-µm multimode fibers.
Oclaro
highpower@oclaro.com

Laser Diode Module

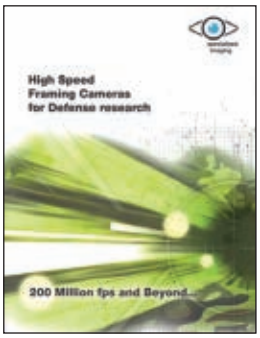
Vortran Laser Technology Inc. has introduced the Stradus 488-nm blue laser diode module that outputs 50 mW. The newest product in the company's Stradus line has been designed as an affordable alternative to the standard high-power-output diode-pumped solid-state lasers that are commonly used in flow cytometry and microscopy applications. It features digital modulation up to 200 MHz, with analog modulation at ≥500 kHz. Features include typical beam quality of M^2 1.25 and >90% circularity. Beam diameter is 1.3 mm for all wavelengths, pointing stability is <5 µrad/°C, and the module produces low noise of <0.1% rms from 10 Hz to10 MHz. It is suitable for OEM tasks in medical diagnostics, defect analysis, confocal microscopy, research and development, and laboratory applications.
Vortran
sales@vortranlaser.com

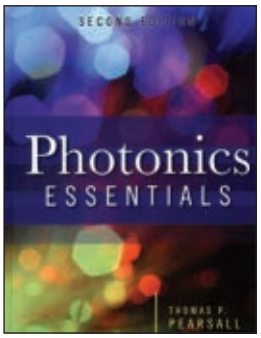
FireWire Camera Software

Toshiba Teli America Inc. has announced an upgrade of its TeliDCAM software and software developer's kit for its FireWire digital cameras, including support for Microsoft Windows 7. It has an automatic driver installer and supports 32- and 64-bit operating systems. Features include real-time frame averaging and integration, separation of the display and acquisition threads, a monitor synchronization mode and improved anti-tearing for zoomed video. The DcamViewer allows users to operate multiple cameras and save images in many formats, and the TWAIN driver enables interfacing to third-party imaging software. Users can acquire and display live video from one or several cameras, set a video format and triggering mode, grab 8- and 16-bit monochrome images or 24- and 48-bit color ones, choose a frame rate, and select the size and position of the scan area.
Toshiba Teli America
doug.freck@ttai.toshiba.com

Wedge LEDs

JKL Components Corp. has launched the LE-0903 series flattop wedge-base LED lights for panel illumination, display lighting, gaming machines, and landscape and architectural lighting applications. Also suitable for switches and low-profile applications, the series maintains a low 20-mm profile and is available in neutral white with either 12- or 24-VAC/DC voltage for design versatility. It offers durable, long-life LED technology in a T-3¼ wedge. The RoHS-compliant lights feature a 120° viewing angle with high brightness and output comparable to 3-W wedge-base lamps. Three cylindrical LEDs embedded in the wedge base deliver even light distribution.
JKL Components
sales@jkllamps.com





Fiber Optic Networks

Covering short-reach and long-haul networks, the volume *Planning Fiber Optic Networks* provides detailed information on major fiber optic parameters and includes background theory and design calculations. The 400-page document discusses topics such as signal propagation in a single-mode fiber, planning an optical loss budget, maintaining an acceptable optical signal-to-noise ratio, the effects of chromatic and polarization mode dispersion, and testing Ethernet and Sonet/SDH networks. Real-world examples are included. Bob Chomycz; McGraw-Hill Professional, New York, 2009; $79.95.
McGraw Hill Professional
customer.service@mcgraw-hill.com

Online Lens Selection

Navitar Inc. has introduced Optical Wizard 2.0, an updated online lens calculator. Aimed at engineers, end users and OEMs, the tool aids lens choice when a component is required for a machine vision system or other electronic imaging application. The resource features a user-friendly interface and provides step-by-step guidance. Users sort through the company's products by indicating camera sensor format, object size, working distance and other parameters. The newest version offers enhanced interactivity and earlier previews of lens selection and price.
Navitar
www.opticalwizard.com

Principles of Photonic Devices

Photonics Essentials, 2nd Edition, published by McGraw-Hill Professional, offers to introduce the tenets of photonic devices to a younger generation of students and engineers. The 320-page text targets second- and third-year university students and engineers looking for practical points rather than abstract theory. It stresses hands-on measurement techniques and supplies real-world examples featuring commercially available products. Topics such as photodiodes, LEDs, organic LEDS, lasers and optical fibers are discussed. Thomas P. Pearsall; McGraw-Hill Professional; New York, NY; 2009; $89.95.
McGraw-Hill Professional
customer.service@mcgraw-hill.com

LED Lighting Web Site

A new Web site has been launched by Lunera Lighting to help visitors learn about LED lighting and to introduce them to the company's products. It is organized in three sections. LED Resources provides information about the lighting industry, Lunera's Approach explains how the company creates lasting facility value, and Lunera's Product Information section includes cut sheets, Illuminating Engineering Society files, and UL certifications for the proprietary Series 2200 Grid Lay-In and Series 6400 Suspended Linear LED fixtures. Features include a region-of-interest calculator, a tools and downloads center, a listing of company representatives, a subscription function and a press room.
Lunera Lighting
www.lunera.com

Web Site

Wavelength Electronics' new Web site, designed for increased ease of use, was developed by engineers for engineers. Only two clicks are required to reach product datasheets for the company's precision laser diode drivers and temperature controllers, online design tools, references and industry links. A selection guide compares the core specifications of laser diode drivers and temperature controllers, accessed by clicking on the "products" button, and free technical support is available by clicking on the "contact" button. The "safe operating area" calculator function simulates the thermal requirements of a customer's design, and circuit calculators for the WLD laser diode driver and WTC temperature controller chips determine values for all external components, based on specific application input values. New features include tutorials, application notes, frequently asked questions and 3-D models.
Wavelength Electronics
www.teamwavelength.com

Laser Safety Eyewear Catalog

A 62-page color catalog detailing the new line of laser safety eyewear and filtered windows manufactured by Univet srl is available from ES Technology Ltd. Included is an introduction to current laser safety classifications and protection regulations for operators (EN207) and alignment (EN208). The catalog will be of interest to those involved in the use of lasers or intense pulsed light systems, those seeking to replace worn or damaged items, and those who want to learn about the latest safety guidelines.
ES Technology
r.church@estechnology.co.uk

Dedicated OEM Web Site

Ocean Optics has launched a Web site to augment its dedicated OEM engineering resources. Aimed at the needs of OEM customers, it offers product, application and engineering information geared to manufacturers of analytical equipment that requires optical and oxygen-sensing components. Visitors can browse only the products and content relevant to their mechanical, software, optical and electronic integration needs. The resource section includes manuals, datasheets, engineering drawings and educational articles.
Ocean Optics
www.oceanoem.com

Linear Actuators

The updated *Short Travel Rolling Element Linear Actuators* catalog from Specialty Motions Inc. includes new information on the SMI Easy Slide cross roller tables and on the ball and cross roller slides, which feature the True Travel anti-cage creep technology. The downloadable document also includes updated details on the Easy Slide ball slide and cross roller positioning stages and X-Treme motorized cross roller tables.
Specialty Motion
www.smi4motion.com

Synchronous Digital Hierarchy

The ComSoc Guide to Next Generation Optical Transport: SDH/SONET/OTN provides an overview of synchronous digital hierarchy (SDH), synchronous optical networking (SONET) and optical transport networks (OTNs) for engineers new to the field. The 211-page resource is also appropriate for manufacturers, network opera-

tors and graduate students who need a basic understanding of the topics covered. Described are network architectures, frames and structures, packet transport, mapping methodologies and concatenation, among other subjects. Huub van Helvoort; Wiley-IEEE Press; Hoboken, NJ; 2009; $63.50.
Wiley-IEEE Press
www.wiley.com

Adhesives, Sealants

A six-page brochure from Henkel Corp. titled *Solutions for the Solar Power Industry: Adhesives & Sealants*, details the company's Loctite adhesives and sealants for manufacturing photovoltaic and concentrating solar modules. The seven elastic bonding products highlighted provide adhesion for module-to-frame, module-to-bracket, mirror reflector and concentrator lens bonding, and for junction box mounting and steel bracket-to-mirror panel bonding.
Henkel
adhesives.inquiries@us.henkel.com

Polarization Holography

The 254-page book *Polarization Holography* reviews research carried out in the field over the past 15 years. The authors cover basic concepts in polarization and the propagation of light through anisotropic materials and present a theoretical basis for polarization holography. Materials used in the process are described. Various applications, including display holography and optical storage, are discussed in depth. L. Nikolova and P.S. Ramanujam; Cambridge University Press, Cambridge, UK, 2009; $110.
Cambridge University Press
publicity@cambridge.org

Research Articles

The Optical Society of America (OSA) has launched the interactive Web page Spotlight on Optics, which will provide summaries of select research articles from all 13 of its journals on a regular basis. Accessible through the society's database of journal articles, Optics InfoBase, the resource highlights articles that have been identified by the journal editors as demonstrations of critical new developments in optics and photonics research. Each article in Spotlight has open access. Readers can post comments to a Spotlight page.
OSA
www.osa.org

Fiber Fusion

Vytran LLC, a supplier of semi- and fully automated fiber fusion splicing, assembly and glass processing solutions, has launched an enhanced Web site that facilitates access to information about its products, services, markets and applications. Visitors to the portal can find details about the company's technologies for optical fiber stripping, cleaning, cleaving, recoating and testing. A video shows Vytran processes such as filament fusion and fire polishing.
Vytran
www.vytran.com

SEM Basics

JEOL Ltd. has released a 31-page publication titled *SEM: Scanning Electron Microscope A to Z: Basic Knowledge for Using the SEM*. Available for download on the JEOL USA Web site, the booklet covers the basic operating principle of the microscope as well as image display, the role of secondary and backscattered electron detectors, and the vacuum system. Other topics, such as the edge effect and the influence of accelerating voltage, also are considered.
JEOL USA
www.jeolusa.com

Lasers, Components

A 16-page expanded brochure from Elliot Scientific Ltd. summarizes the products and capabilities of the company's business areas: lasers; telecommunications; components and instrumentation; and cyrogenics and magnetics. Available in print and pdf, the document covers brand products for the Elliot Scientific and Elliot Martok lines, and offerings from the 36 companies that Elliot Scientific represents in the UK and Ireland.
Elliot Scientific
www.elliotscientific.com

HAPPENINGS

PAPERS

AIVELA 2010 (June 23-25) Ancona, Italy
Deadline: abstracts, February 6 (5:00 GMT)
The Italian Association of Laser Velocimetry and Noninvasive Diagnostics (AIVELA) invites papers for the Ninth International Conference on Vibration Measurements by Laser and Noncontact Techniques. Laser vibrometer systems, noncontact instrumentation and systems for vibro-acoustic testing will be exhibited. Contact E.P. Tomasini, Universita degli Studi di Ancona, +39 071 220 4489; aivela@univpm.it; www.aivela.org.

Ultrafast Phenomena (July 18-23) Snowmass, Colorado
Deadline: abstracts, February 17 (17:00 GMT); postdeadline: July 6 (16:00 GMT)
The Optical Society of America encourages submissions for its 17th International Conference on Ultrafast Phenomena. The generation of ultrashort pulses in the pico-, femto- and attosecond regimes and their applications to studies of ultrafast phenomena in various technical fields will be addressed. Contact OSA, +1 (202) 416-1907; custserv@osa.org; www.osa.org/up.

COSPAR 2010 (July 18-25) Bremen, Germany
Deadline: abstracts, February 19 (23:59 UTC+14)
Authors are invited to submit papers for the 38th Scientific Assembly of the Committee on Space Research and Associated Events. Topics to be considered include research in astrophysics from space, and the Earth-moon system, planets and small bodies of the solar system. Contact COSPAR Secretariat, c/o CNES, +33 1 44 76 75 10 (outside France); cospar@cosparhq.cnes.fr; www.cospar-assembly.org.

FEBRUARY

OPTRO 2010: Optronics in Defense and Security (Feb. 3-5) Paris.
Contact Tom Pearsall, +331 45 05 72 63; pearsall@epic-assoc.com; www.epic-assoc.com.

Winter College on Optics and Energy (Feb. 8-19) Trieste, Italy.
Contact V. Lakshminarayanan, +1 (202) 223-8130; custserv@osa.org; www.osa.org.

The Waterborne Symposium: Advances in Sustainable Coating Technologies (Feb. 10-12) New Orleans.
Contact Laura M. Fosselman, +1 (601) 266-4475; www.psrc.usm.edu/waterborne.

SPIE Medical Imaging (Feb. 13-18) San Diego.
Contact SPIE, +1 (360) 676-3290; www.spie.org.

SPIE Advanced Lithography (Feb. 21-26) San Jose, Calif.
Contact SPIE, +1 (360) 676-3290; www.spie.org.

META'10: Second International Conference on Metamaterials, Photonic Crystals and Plasmonics (Feb. 22-25) Cairo, Egypt.
Contact Said Zouhdi, +33 1 698 51660; said.zouhdi@supelec.fr.

PITTCON 2010 (Feb. 28-March 5) Orlando, Fla.
Contact The Pittsburgh Conference, +1 (800) 825-3221; info@pittcon.org; www.pittcon.org.

MARCH

SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring (March 7-11) San Diego.
Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; www.spie.org.

Lighting Quality & Energy Efficiency (March 14-17) Vienna, Austria.
Contact CIE-International Commission on Illumination, +43 1 409 56 31 0; cie2010@dm-and-c.at; vienna2010.cie.co.at.

Laser World of Photonics China 2010 (March 16-18) Shanghai, China.
Contact Messe München, +49 89 9 49 2 07 20; www.messe-muenchen.de.

Conference on Optical Fiber Communication/National Fiber Optic Engineers Conference (OFC/NFOEC) (March 21-25) San Diego.
Contact Optical Society of America, +1 (202) 223-8130; info@osa.org; www.osa.org.

Laser Optics Berlin 2010 (March 22-24) Berlin.
Contact Dorothea Baxter at Messe Berlin GmbH, +49 30 3038 2159; US: +1 (540) 372-3777; dbaxter@exhibitpro.com; www.messeberlin.de.

Picalo: Pacific International Conference on Applications of Lasers & Optics (March 23-25) Wuhan, China.
Contact Laser Institute of America, +1 (407) 380-1553; conferences@laserinstitute.org; www.laserinstitute.org.

MEDTEC Europe (March 23-25) Stuttgart, Germany. Contact Canon Communications, +1 (310) 445-4200; info@cancom.com; Mr. Alison Trebble, +44 1458 835 955.

Intertech Image Sensors Europe 2010 (March 23-25) London. Contact Stacey Ludlow at IntertechPira, +44 1372 802 052; stacey.ludlow@pira-international.com.

23rd International Conference on 3-D Image Processing in Microscopy/22nd International Conference on Confocal Microscopy (March 28-31) Shanghai, China.
Contact Qiushi Ren, +86 21 3420 4080; fax: +86 21 3420 4078; www.focusonmicroscopy.org.

Machine Vision China 2010 (March 31-April 2) Shanghai, China.
Contact Guo Qinrui, +86 21 6875 8536; guo.qinrui@sh.china.ahk.de; US: Dana Whalls, +1 (734) 994-6088; dwhalls@robotics.org.

APRIL

SPIE Defense, Security + Sensing 2010 (April 5-9) Orlando, Fla. Contact SPIE, +1 (360) 676-3290; www.spie.org.

CISILE 2010: International Exhibition for Analytical and Testing Instrumentation, Optical/Electronic Optical Instrumentation, Laboratory Furniture and Equipment, and Biotechnology and Instrumentation (April 8-10) Beijing. Contact Ivy Lee, +86 10 883 951 25; ivylee@cisile.com.cn; www.cisile.com.cn.

OSA Optics & Photonics Congress: Biomedical Optics and 3-D Imaging (April 12-14) Miami. Contact the Optical Society of America, +1 (202) 223-8130; www.osa.org.

Illumination and Stray Light Analysis Using Zemax (April 12-16) Celebration, Fla. Contact Zemax Development Corp., +1 (425) 822-3406; sales@zemax.com; www.zemax.com.

SPIE Photonics Europe 2010 (April 12-16) Brussels, Belgium. Contact Amy Nelson, +44 29 2089 4747; amy@spieeurope.org; spieeurope.org.

Lighting Japan 2010: LED/OLED Lighting Technology Expo (April 14-16) Tokyo.
Contact Reed Exhibitions Japan Ltd., +81 3 3349 8568; www.lightingjapan.jp.

2010 IEEE International Symposium on Biomedical Imaging (April 14-17) Rotterdam, the Netherlands.
Contact Laura J. Wolf, +1 (732) 981-3433; emb-exec@ieee.org; www.embs.org.

Laser 2010: American Society for Laser Medicine and Surgery's 30th Annual Conference (April 14-18) Phoenix.
Contact Nadine Tosk, +1 (847) 920-9858; www.aslms.org.

Smart Fabrics 2010 (April 15-17) Miami.
Contact IntertechPira, +1 (207) 781-9618; www.smartfabricsconference.com.

Society of Vacuum Coaters 2010: 53rd Annual Technical Conference (April 17-22) Orlando, Fla. Contact SVC, +1 (505) 856-7188; svcinfo@svc.org.

IEEE Wireless Communications & Networking Conference (April 18-21)

HAPPENINGS

Sydney, Australia. Contact Heather Ann Sweeney, +1 (212) 705-8938; h.sweeney@comsoc.org; www.ieee-wcnc.org/2010.

Photonics 2010: World of Lasers and Optics (April 19-22) Moscow. Contact Expocentre, +7 499 795 3799; www.photonics-expo.ru.

Interactive Displays 2010 (April 20-22) San Jose, Calif. Contact IntertechPira, +1 (207) 781-9800; www.intertechpira.com.

Organic Photovoltaics 2010 (April 28-30) Philadelphia. Contact IntertechPira, +1 (207) 781-9800; www.intertechpira.com.

MAY

iMAPS New England: 37th Annual Symposium & Expo (May 4) Boxborough, Mass. Contact Harvey Smith, +1 (508) 699-4767; harveys@imapsne.org.

CLEO/QELS 2010: Laser Science to Photonic Applications (May 16-21) San Jose, Calif. Contact Optical Society of America, +1 (202) 416-1907; custserv@osa.org; www.cleoconference.org.

2010 IEEE International Communications Conference (May 23-27) Cape Town, South Africa. Contact Heather Ann Sweeney, +1 (212) 705-8938; h.sweeney@comsoc.org.

Staying on the edge in a soft market

The economic downturn that has plagued the globe since 2007 has not affected all photonics companies badly, but those that are treading water best – or even thriving – are doing so by persistently developing new technologies, finding new applications for old tech and working with photonics-related associations to identify and take advantage of new ways of doing business.

One organization attempting to keep up a steady flow of new ideas and opportunities is Laser Zentrum Hanover eV (LZH). The Germany-based association recently made a pair of announcements that speak directly to its drive to sustain innovation, even in lean times.

LZH first announced that, with its partner neoLase GmbH, it has developed an application for the iPhone that can remotely operate a stand-alone laser system. Using the software, all of the functions of a laser in a specific location are always at hand, according to LZH, no matter where the phone is at the time – same room or different continent. The remote user can monitor and control the laser system's operating parameters, such as intensity and repetition rate. In addition, the application facilitates remote service calls via built-in diagnostic tools. No word yet on how use of the iPhone affects laser safety issues.

In its second announcement, LZH reported that the world's ecological consciousness has caught up enough to make practical a novel spectroscopy-based technique that had been in development since 1999. Dubbed Identitex, the long-boiling project aims to automate the practice of recycling some of the millions of pounds of used clothing that otherwise are discarded every year in Europe. For Identitex, LZH collaborated with several Dutch and German technology and textile companies.

Based chiefly on a visible/near-IR spectrometer devised by LZH, Identitex distinguishes both the color and material of old clothing that passes beneath it. According to LZH, the system can separate the blue from the black, the cottons from the nylon, at a rate of 10 kg/min with up to 99 percent accuracy. After sorting, recycled fibers of matching color and substance can be deconstructed and rewoven into new goods and put back on the market.

From old clothes to new phones, photonics can interweave itself into many lucrative endeavors.

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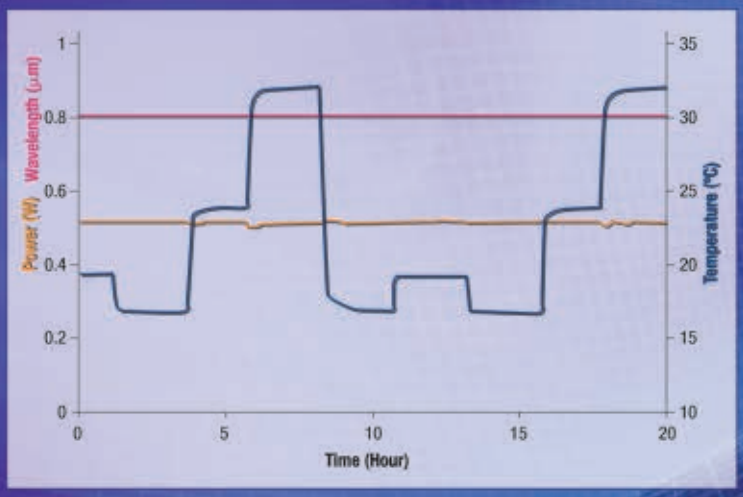
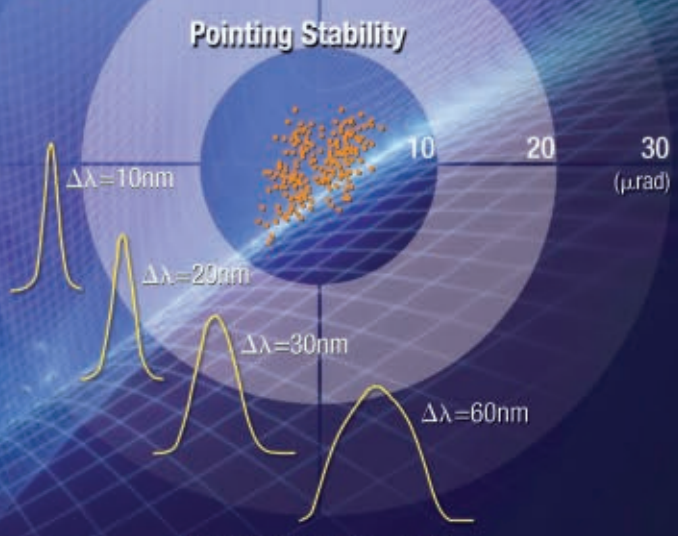
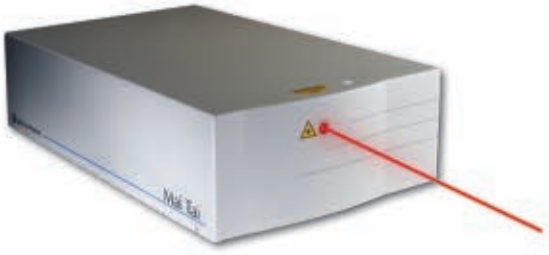


Power and Wavelength Stability



Bandwidth Tunability



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