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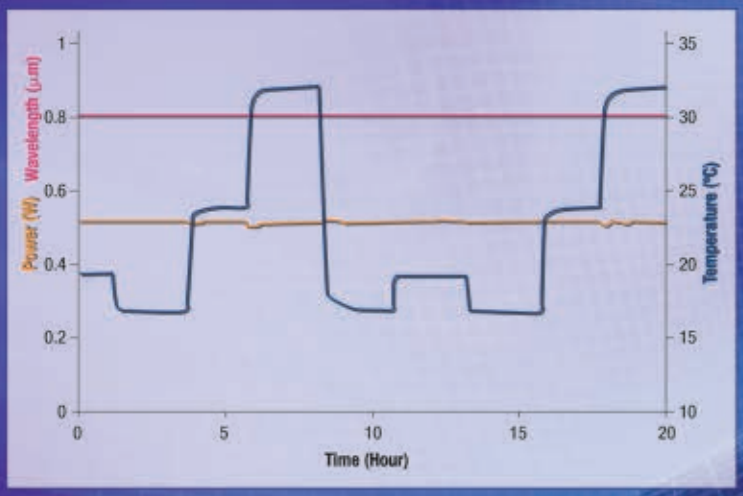

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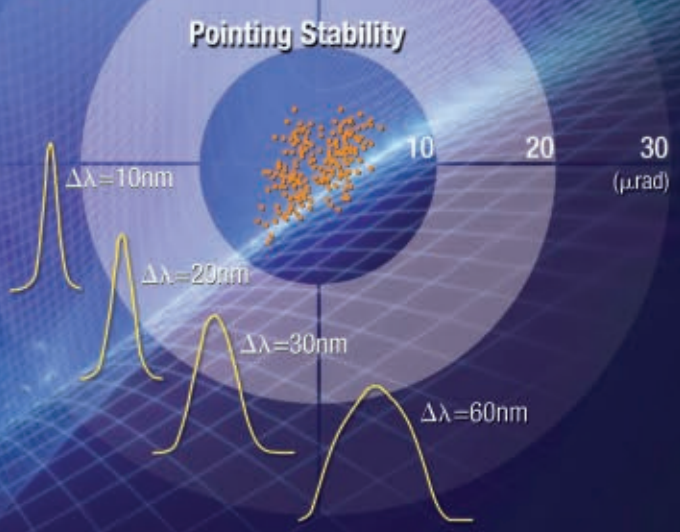

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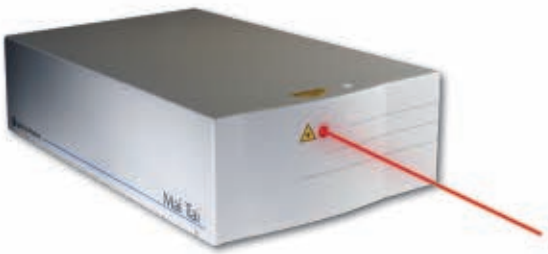

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THE COVER
This month's cover was inspired by the software feature on page 40; designed by Art Director Lisa N. Comstock.

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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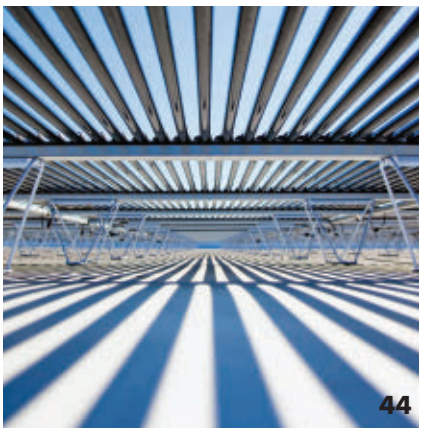
FEATURES



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Special EuroPhotonics Supplement

THE EUROPHOTONICS COVER
This month's cover photo reflects how consumers are driving the image sensor market. See the feature starting on page E 14.

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Things are looking up

The word from Washington and Wall Street these days is that better days are ahead. From President Obama to Federal Reserve Chairman Ben S. Bernanke to Treasury Secretary Timothy F. Geithner, the message is that we have hit the bottom of the recession and are headed up.

All this is good news for the photonics industry. Stimulus funds are pouring into green technologies such as solar power, which affects photonics companies from laser manufacturers to coaters. And the move to energy efficiency is providing an impetus for the LED industry, as these versatile devices find roles in applications ranging from street lighting to hospital operating rooms.

And here at Laurin Publishing, we are moving full steam ahead to report on these exciting developments, providing our loyal readers with the latest news, feature articles and insightful analyses.

For more than half a century, our goal has been to promote the industry through thick and thin, and this time is no different. Our staff has a combined total of 500 years of experience in monitoring the industry and providing it with the resources it needs to keep moving forward.

Just last year, we relaunched *Photonics Spectra* with a new look and new features to better serve our readers and advertisers. And, to keep up with the latest trends, we are expanding the focus of *BioPhotonics*, formerly *Biophotonics International*, to include an emphasis on product development and government and regulatory issues. Also, you will soon see a fresh new look for our photonics.com Web page. It will be loaded with enhanced features, expanded content and informative videos, all in an interactive, user-friendly format.

We have always had faith in the industry and have worked to drive it forward. We will continue to do so with a new sense of purpose and vigor.

So, with the economy on the mend, let's look to a brighter tomorrow.

Tom Laurin

Light Sensing Ideas

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Benefits, not danger

I read with interest the article by Gary Boas titled, "Just how dangerous are foreign researchers?" (June 2009, p. 62). I came to the US many years ago as a postdoctoral fellow from Germany and experienced firsthand the many benefits of an international exchange program.

I am afraid that if we limit or even lose the opportunity to attract young, highly qualified scientists from around the world, the US will fall further behind in global competition. Perhaps even more critical is that science will suffer because many good ideas, which could be developed by a team of US and foreign researchers, will not be developed to benefit mankind.

I therefore strongly suggest that we "rediscover" the value of foreign researchers and make sure that international exchange programs will not be reduced to a mere skeletal existence.

Christian T.K.-H. Stadtländer
PhD, MS, MPH, MBA, MIM
St. Paul, Minn.

Misleading photos?

The example of before and after photos of Chapel Hill, N.C. (August, p. 58), lit with incandescents and then Cree LEDs is misleading. Although the LEDs may have allowed for a more daylight-looking color temperature than the (presumably) high-pressure sodium and tungsten lights, there is no way they lit up the town the way it is shown. The before photo was obviously a much shorter exposure than the after photo, or the ISO setting on the camera was much lower. If the change shown had taken place, then Cree is responsible for one heck of an increase in light pollution and wasted illumination. Just look at the sky brightness in the after image.

Richard Anderson
Toronto

Cree Inc.'s response:

The photographer of these images said that the photos were taken at slightly different times of the day. The exposures used to take the pictures, however, were very similar and adjusted only to ensure the most detailed photos. Also, sometimes in the conversion from digital photo to a printed magazine, there can be some color variation, and these photos were not processed to make them look unreal, but each image was enhanced to provide the best-quality photo.

Gender battle

I read Gary Boas' article (August, p. 24) "The good – and bad – news on gender differences among science faculty." It is interesting that universities are promoting women in the sciences but are still not getting the number of applicants needed to justify their discrimination against men. It is obvious that women do not see themselves in those positions. Women discover early on that those jobs require a lifetime of dedication to the science or some novel concept that requires the individual be dedicated to the career.

Women have more important jobs to do, such as establishing a relationship, getting married and having children. As a result, looking at a tenure-track position is not that important in their grand scheme of life. Men have always put career above family, which is why many (not all) have suffered the personal tragedy of divorce. Women see a tenure-track position as destroying their dream of having a happily married life with children.

It also should be pointed out that all this attention on women in the sciences is having the effect of discouraging boys from pursuing a science career. Boys discover early in schools and universities that girls are getting all the attention, which discourages boys from engaging in the career field. Statistics have shown that boys are falling behind girls in all aspects of technical training. This is obvious from all the programs promoting women but not men.

In the old days, the characteristics required for a tenure-track position were not sex but intellectual scholarship, hard work and academic performance. Because we are now in the "enlightened progressive era," we do not use those characteristics for job requirements. Only those who look pretty are considered instead of actual intellectual competence.

I do not see women making any breakthrough contributions in science because it requires a lifetime of dedication and hard work. Women still have their passion toward their family and children, not their careers. This is good.

Maybe President Obama can help by mandating that all graduating women in the sciences must apply to tenure-track positions. That way, the universities will have more applications, which seems to be what is really important here.

Kevin Bolam
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WEB EXCLUSIVES:

Donors and Acceptors: New Developments in FRET

Förster resonance energy transfer, or FRET, has contributed to advances in a host of applications, and the development of the technique is ongoing. In recent years, FRET has benefited from a variety of new components and methodologies. In this Web Exclusive, Contributing Editor Gary Boas, takes a look at a new FRET technique that uses multilayer core-shell nanoparticles to exploit the phenomenon known as metal-enhanced fluorescence.

What's New with PCR

Polymerase chain reaction (PCR), the workhorse of biological analysis, is used in areas ranging from criminal investigations and disease diagnosis to biological research. For example, it is the test that determines whether a strand of hair found at a crime scene matches that of a certain suspect. News editor Caren Les explores what researchers in Japan are saying is a faster, more cost-effective and more flexible quantitative PCR test to analyze DNA for medical diagnostics and other applications.

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

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

In the November issue of Photonics Spectra …

High-Intensity Photonic Lattice Emitters

Many of these devices, which are replacing incandescent bulbs in projectors and other light sources, come in module form already with a temperature sensor to prevent overheating – something you must take into account when building a driver.

Lidar Scanners Slim Down

Thanks to advances in technology, lidar scanners are smaller and weigh less than ever before – but resolution has improved, and scanners have increased their ability to capture more returns per pulse.

Education Wavefront – Virtual Gaming

In the virtual world of "Universe Quest," Girl Scouts in California are creating characters and operating a virtual telescope, processing images of the cosmos that they obtain remotely from a telescope in Arizona.

Getting Venture Capital

How and when should startups approach venture capitalists? What are the steps involved in the process? What do VCs look for, and what makes them say, "Yeah, I want to invest in this idea"? Industry expert Milton Chang offers advice for up-and-coming companies.

Solar Inkblots

Nanoparticle "ink" in development will have solar cells within it, and will generate electricity when applied to rooftops and other structures.

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

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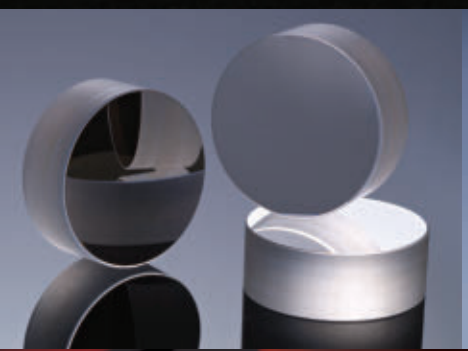

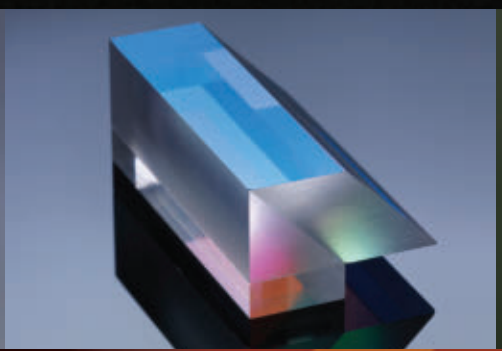

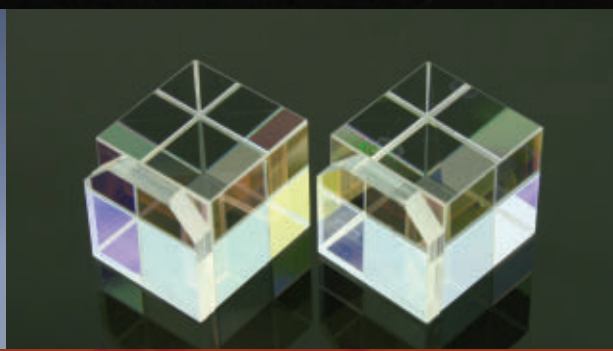

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The Teacher

AN INTERVIEW WITH NADER ENGHETA

BY DAVID L. SHENKENBERG, FEATURES EDITOR

After earning a PhD at Caltech, Nader Engheta spent four years at Kaman Sciences Corp. before joining the faculty at the University of Pennsylvania in Philadelphia, where he is now the H. Nedwill Ramsey Professor of Electrical and Systems Engineering. He has won many awards for both research and teaching and is known for his concept of optical lumped nanocircuits.

You spent some time in industry before becoming a professor. What was your industry experience like?
It was a very valuable experience. I learned a great deal from how the industry works, yet I always knew that the academic research university environment is where I wanted to be.

Your work has covered many areas. Why?
They have a common thread. I am very curious about different aspects of fields and waves. I am fascinated by the beauty of electromagnetic theory.

You are not only an electrical engineer, but also a member of the Mahoney Institute of Neurological Sciences. How does an electrical engineer move into neuroscience?
One of my areas of research is toward biological polarization imaging – how we can learn from nature and have better sensors, for example. The human eye has an amazing ability to detect optical signals, but the human eye is essentially polarization-blind. If someone sends a yellow light to our eyes, we can detect if it is yellow, bright or dim, but we cannot detect if it is horizontally or vertically polarized, but some animals can detect polarization. From the engineering and applied science point of view, I wonder how we can exploit these systems. For example, in camera systems, we are exploring algorithms that will enable the combination of polarization with other visual information from the scene.

How can this polarization information be used?
You can see farther away underwater or in any other optically scattering media. We have developed a technique using polarization and lighting that enables detection of the indentations in a flat surface.

Your research has covered nano-antennas. What applications are there for them?
If you look at a circuit inside your cell phone, the circuit could be in the micro regime. Could we have a similar concept in the nano regime? Could we detect an optical signal from the circuit? If you look at a regular antenna and you load a regular antenna with a circuit zone, could we do something analogous to that on the nanoscale? If I have a silver nanowire, imagine you have another nanomaterial, a nanoparticle. That particle would behave as a load on the nanowire " antenna," changing its resonance. That can open interesting possibilities. Could we have wireless communication using light? If 40 years ago someone had told me that we will have telephone communication without using any landline, I wouldn't have believed it. What I'm envisioning is wireless photonic communication in different nanocircuitries. We are doing proof-of-concept experiments.

Courtesy of Mike Ellis and *The Daily Pennsylvanian*.

Nader Engheta.

> "I think one of the most important aspects of the research or the scientist is to be in love with the subject. When you are excited, you can excite other people."

I thought you are a theorist?
By training, I have been a theorist, but more and more I am moving my group toward experiments. That work in my group is experimental work. Most of my work has been theoretical. We have done microwave work, epsilon-near-zero microwave experiments and so on. We are moving to optical microscopy. I just won a proposal to get an NSOM [near-field scanning optical microscope]. It will be here in three months.

Why do experiments?
I see the need to expand my work into some aspect of experimentation to show the proof of concept. That is exciting because I am learning every day.

One of your most recent papers is about transporting an image through a subwavelength hole.
It is a theoretical work to see how the concept of epsilon near zero would work. We show how the subwavelength image can be squeezed through tiny wires through a hole. You are familiar with Thomas Edison's wonderful work on plasmons through subwavelength holes? In this theoretical work, we have shown a completely different mechanism of energy transport through the hole. We started with an object and found out what would happen if we have a bunch of tiny objects through the wire of this epsilon-near-zero material.

Epsilon is permittivity, correct?
The relative value of permittivity would be near zero. What we have shown is that this material has interesting properties. We call it "super coupling." If you have waveguide one and want to connect to waveguide two, you get very good coupling with almost no reflection. This is useful if I want to bend the waveguide to fit it within a very small area and get very good transmission.

Have you done anything on quantum computing?
No, I have not done anything on that yet. I have in mind to look into that in the near future, particularly from the point of view of my optical nanocircuits. If you look at this optical nanocircuit concept that I'm developing, an interesting thing is how to connect ideas from one to another. This epsilon-near-zero material could be connected to this concept of optical nanocircuits. One concept that I have been

working on in relation to this concept is of moving particles. If you look at optics, that is a displacement current. What I'm quite interested in is how we can control the displacement current. Could we tailor my concept of optical nanocircuits to displacement? We have a paper under review on a nanocircuit board with material of epsilon near zero. If you have something like this, then imagine you cut a groove into this substrate. If there is an optical field in this substrate, then you have a vector in this current. Inside the groove, the epsilon is not zero, so your displacement would not be zero.

Your work has covered metamaterials and cloaking.

There's a lot of groups working on cloaking. One group is the transformation cloaking. There is another way to achieve cloaking. That is plasmonic. Ours is based on cancellation of the dipole moment. Imagine you have an object and a wave and get some scattering. You induce a dipole moment. Imagine you design a metamaterial layer around the object and induce opposite phase with the original dipole moment of the object. You almost cancel the induced dipole moment. Scattering would be reduced, leading to the invisibility of small particles. We have done an experiment using our own technique in the microwave. It hasn't been published yet.

Several awards that you have won have been for teaching. Were any of these awards based on student evaluations?

The S. Reid Warren Award for distinguished undergraduate teaching, I won that two times. The Christian F. and Mary R. Lindback Foundation Award, that one is based on letters from both colleagues and students.

What are the characteristics of a good teacher?

I love my job. I don't see any boundary by the way in departments. If I am interested in a topic, I try to learn about it and see how I can contribute to it. I think one of the most important aspects of the research or the scientist is to be in love with the subject. When you are excited, you can excite other people. In my opinion, teaching and research are intertwined. You cannot separate the two; all are pursuit of knowledge.

What are the biggest challenges in higher education today?

One of the challenges is to educate graduate students such that they can get into any field quickly. Electrical engineering, that field has changed significantly in five years, let alone 10 years. When you get your PhD and get your first job as a scientist or young faculty, it's very different. Any field you choose is evolving. What's more important is to teach how to approach any new topic because you have to find ways to solve problems no one has solved before.

What got you interested in math in the first place?

I became very fascinated with how a transistor radio works. Where does this sound come from in the air? I didn't know anything about this. I was talking to my older brother, and he said if you are interested in this, you should go into electrical engineering. Back in those days, people had in mind civil engineering. Electrical engineering was more of a novelty. One thing led to another. I have a picture of Richard Feynman from my PhD commencement at Caltech. I listened to his lectures. He was an amazing guy at explaining physics. Many students would go to his class.

david.shenkenberg@laurin.com

The value of discovery

Informal learning offers important counterpoint to formal education.

BY GARY BOAS, CONTRIBUTING EDITOR

More than 40 years ago, Frank Oppenheimer, a physics professor at the University of Colorado and the younger brother of American physicist J. Robert Oppenheimer, proposed a science museum to be housed in the vacant Palace of Fine Arts in the Marina district of San Francisco. The museum – which, as the Exploratorium, opened its doors in 1969 – would be a sort of "Library of Experiments," a teaching laboratory where visitors could discover the principles of mechanics, heat and electricity, for example, by directly engaging the myriad interactive exhibits in the museum in an informal, even playful way.

The mission of the Exploratorium was, in short, to democratize science learning. "All of those scientists came out of the Manhattan Project," said Dennis Bartels, the current executive director of the museum, referring to Oppenheimer and his contemporaries, "and many had fled fascist Europe. They believed that science and technology were far too important to leave only to politicians and scientists, that their future direction belonged to all of us." And they felt that a certain literacy in the sciences was essential to making informed choices in society.

This latter view is still relevant today, perhaps even more so. In the 1950s and '60s, scientific concerns were, for many people, limited to the threat of the atomic bomb. Now, as just one example, we are faced with almost daily discoveries in the world of genetics, which raise "fundamental questions about morality and ethics, about who we are as human beings," Bartels said. Science is also tied up in important quality-of-life decisions – involving health care, for instance – and in broader societal issues such as food production and the environment. At the very least, we need tools to disentangle the many, often contradictory claims made in these arenas.

Science museums and other "informal learning" institutions provide these tools, not just by educating people – young and old alike – about the many fields of study that fall under the rubric of "science," but by encouraging them to ask questions and inspiring them to learn more. Today there are more than 15,000 such institutions in the US, encompassing everything from science museums and aquariums to local astronomy clubs. By fueling people's sense of wonder – and helping them comprehend the world around them – they have become an important part of the social fabric.

The Exploratorium in San Francisco is an informal learning institution that seeks to educate people about science through interactive exhibits. The museum employs a team of scientists to develop the imaging exhibit and to offer demonstrations of what the microscopes can do. Photo credit: Lily Rodriguez, ©Exploratorium, www.exploratorium.edu.

Taking it to school

Informal learning differs significantly from the formal education provided in public and private schools. It offers a unique type of learning environment – open-ended as opposed to goal-oriented/assessment-based – and engages and motivates children in different ways. Thus, it can be viewed, indeed it usually is, as complementary to the education children receive in schools.

Still, schools could benefit by heeding the underlying ethos of informal learning institutions: that the process of discovery can be an end in itself. Few people are likely to excel in the workplace because they remember the general equation for photosynthesis. But if they exhibit a keen sense of curiosity, which once led them to ask, for example, how photosynthesis might have contributed to the evolution of complex life on the planet, they become more valuable employees – and better informed citizens. It is this spirit of inquiry, this type of creative thinking, that should be cultivated in students.

Science museums such as the Exploratorium and the California Science Center in Los Angeles seek to do just this (to read about my visit to the California Science Center, see my blog on photonics.com). By directly engaging children with open-ended investigations, they encourage them to ask questions, to want to

know why. At the same time, they hope to expand their reach by helping teachers implement these strategies in the classroom.

The Exploratorium has been educating teachers since its inception – through a teachers' institute as well as a successful mentoring program. Instructors use the museum's exhibits to demonstrate how complex scientific principles can be illustrated simply and creatively. In this way, they are changing the teachers' relationship to the subject matter. "We're moving the teacher from a third-person relationship, where they're passing on someone else's knowledge, to a first-person relationship, where they're figuring things out for themselves," Bartels said.

How does this play out in the classroom? When faced with a question they don't know the answer to, instead of bluffing their way through it, or dismissing the question, teachers trained at the Exploratorium will respond with, "That's a fantastic question. How would we figure out the answer?" They might even go off script for two or three days to explore ways in which they might do so.

"That's a remarkable teaching moment," he added. "It's those kinds of rich educational experiences that students never really forget."

Aiding standardized learning

Of course, public education is assessment-based. Stringent standards have been established as to what is to be taught and when; whether or not teachers and schools are adhering to these standards is determined by how well students perform on tests. Teachers, therefore, cannot give themselves over entirely to a discovery-based approach. The museums and their outreach coordinators recognize this and have accounted for it in their various programs.

The Amgen Center for Science Learning at the California Science Center also serves as the Los Angeles County GEMS (Great Exploration in Math and Science) Center, offering workshops and activity-based learning materials to schools and other educators throughout the community. The materials are designed to motivate and engage children through experimentation and direct experience, but always with an eye toward the standards associated with the particular grade.

For example, in the primary grades, the physical science standards are related to states of matter: solids, liquids and gases. The center offers two GEMS guides that help support those concepts. The first of these, "Liquid Explorations," looks at the properties of liquids (plain water, bubbly water and saltwater). Here, children observe what happens when a drop of food coloring is placed in each of these, and, later, are asked to classify and sort liquid samples according to their characteristics.

All of these activities support the California State Science Standards, said Anna Gaiter, director of professional development at the California Science Center. At the same time, they are designed to educate children by involving them in the discovery process. Thus, they encourage them to ask questions, to want to know more – a trait that, hopefully, will stay with them always.

gboas@eggship-media.com

Lasers light a better way to build a sub

ARLINGTON, Va. – By using laser projection instead of paper and string, an estimated half a million dollars could be saved on every Virginia-class submarine hull built by the General Dynamics Electric Boat Div. in Quonset Point, R.I. That adds up to tens of millions of dollars in construction cost savings for the planned fleet of attack submarines.

Development of the technique was funded by the Office of Naval Research (ONR), based in Arlington, which has been looking to develop and deploy advanced manufacturing techniques in shipyards. The new laser projection technology automates what had been a manual task of transferring drawings onto a hull, said Quentin Saulter, manager of the ONR Directed Energy Program.

"The projection system moves the lasers in a seamless fashion to project templates or lines on walls," he explained.

He added that the technique could have applications in the construction of airplanes, buildings and silos. Other large construction projects also could potentially benefit from the technology.

Virginia-class attack submarines run 115 m long and are 10 m at their widest point. During hull construction, thousands of electrical and ventilation hangers must be located and attached to the proper point. There also are thousands of studs that must be installed.

Conventionally, this has been done through the use of paper templates and string; for example, construction workers use string to measure where various attachments should be made, then the templates to determine the precise location and orientation of each attachment. This manual approach consumes significant time, with the burden made greater by the need to build in checks to eliminate human error.

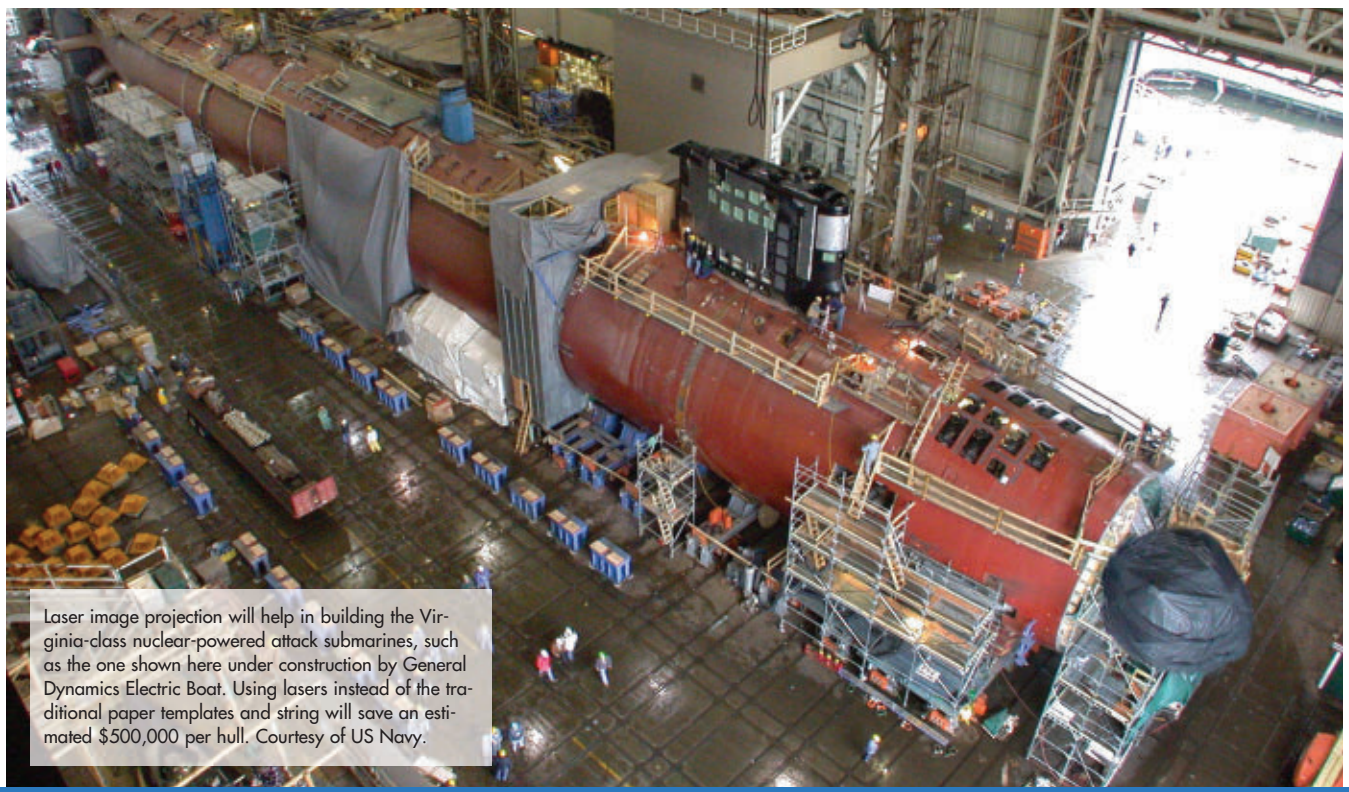
Looking to automate the process, the ONR funded the development of a laser projection system that can replace the paper and string. Saulter noted that the curved shape of a submarine makes this task easier because a laser beam can actually wrap around the entire cylinder.

The projection system that was developed has been tested and is now being deployed in manufacturing. The enabling technology is not the lasers, which can be the standard solid-state variety, but instead, computer control of the lasers, which must be fast enough to move the images seamlessly around on command. That requirement for a quick response also means that the controlling computers must have enough capacity to hold all of the construction plans in memory. Recent advances in technology have made it possible for systems to meet both criteria.

The laser projection approach should have some 7700 man-hours of work, and the automation could result in an 85 percent reduction in labor, as compared with the traditional method. Ultimately, production workers will have direct access to the ship's computerized construction model, Saulter said.

"The CAD [computer-aided design] models would actually drive the laser images, saving steps by making templates and diagrams of where fasteners need to go on walls," he explained.

Hank Hogan
hank@hankhogan.com



Laser image projection will help in building the Virginia-class nuclear-powered attack submarines, such as the one shown here under construction by General Dynamics Electric Boat. Using lasers instead of the traditional paper templates and string will save an estimated $500,000 per hull. Courtesy of US Navy.

Guiding light is not just a soap opera

BOSTON – Computers of the future may use light rather than electricity for logic functions. “There is this dream of the all-photonic circuit to guide light and perform functions,” commented Willie Padilla, a professor at Boston College. Such light-based computers could run much faster than ordinary ones.

An all-photonic network also could make the Internet speedier. “It is estimated that an all-photonic Internet could transmit data at a couple hundred gigabits per second,” Padilla added. “This is ten thousand times faster than current high-speed connections.”

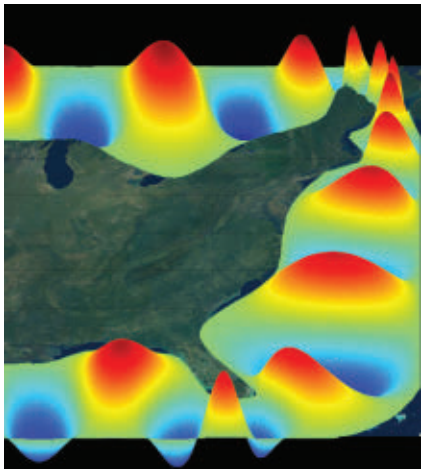
One of the challenges in developing all-photonic computers and an all-photonic Internet is navigating light around curves and crossing points. Waveguides for this purpose could be made out of metamaterials – man-made materials with unusual physical properties.

In the Aug. 17, 2009, issue of *Optics Express*, Padilla and Nathan Landy, now at Duke University in Durham N.C., laid out the theoretical framework for a metamaterial waveguide that travels around a region with many irregular curves. To demonstrate the flexibility of their method, the researchers used a map of the Eastern seaboard of the US as an example of a pathway with irregular curves for light to travel around.

To bend the light around the numerous twists and turns of the coastline, they imagined a grid of squares within a large rectangle. The researchers used this rectangle to represent a waveguide for light to travel through. Then they used mathematics to transform this rectangular “waveguide” and its internal grid lines to conform to the map of the coastline.

The grid lines represent a physical property called the permittivity. When the rectangle and its internal grid lines are conformed to the map of the coastline, the permittivity varies spatially with regard to the coastline. Because the permittivity is related to the refractive index, the refractive index varies with respect to the coastline.

The light generally travels straight ahead even though it is distorted. “The light … doesn’t know that it is traveling on this complicated path,” Padilla said. “The light sees normal waveguide straight space.”



In a theoretical analysis using a map of the Eastern coastline of the US as an example, researchers describe a method for navigating light around complex curves. Courtesy of Nathan Landy.

The fact that the light moves on an overall linear path, the researchers noted, will enable the creation of waveguides without resonant losses even for a three-dimensional waveguide. They added that the conformal mapping technique could be used to make a concentrator. “This demonstrates how complex or versatile this method is for demonstrating devices that we cannot comprehend yet,” Padilla said.

They referenced epsilon-near-zero tunneling, an idea advanced by Nader Engheta, who is the subject of this month’s profile on page 16. They wrote that their method is broadband and avoids complex impedance-matching techniques, both advantages over epsilon-near-zero tunneling. However, they conceded that their method requires calculating the refractive index for each curve.

Since this theoretical demonstration, the researchers in the Padilla lab have constructed a metamaterial device that functions at microwave frequencies. They have not formally published this work in a peer-reviewed journal.

David L. Shenkenberg
david.shenkenberg@laurin.com

Satellite proves its worth

This summer, the GOES-14 satellite took its first full-disk visible image of the Earth. Courtesy of the NASA GOES Project.

GREENBELT, Md. – The Geostationary Operational Environmental Satellite (GOES) system has been expanded by a new satellite, GOES-14. Designed and run by NASA and the National Oceanic and Atmospheric Administration (NOAA), the GOES system provides forecasters with up-to-date information on weather patterns.

Tested by NASA this past summer, GOES-14 is stationed 22,300 miles above the Earth's surface, at 89.5 west longitude, where it will remain for five months. In late July, it provided its first visible full-disk image of Earth, taken by Imager, a system built by ITT Industries Inc. of Fort Wayne, Ind., that provides 1-km resolution from an altitude of 36,000 km.

Although similar in many ways to the GOES-8 through -13 satellites – several of which are still in use – GOES-14 has several upgraded sensors to improve weather detection. By adding an optical bench for its Imager and Sounder, another instrument from ITT Industries, scientists improved image navigation and registration. Previous versions could track 1-km pixels with an accuracy of about 4 km, but GOES-14 can track to 2 km, enabling meteorologists to more accurately track the progress of severe storms and wildfires.

The satellite also carries an improved Imager 13.3-µm channel with 4-km nadir resolution for better monitoring of cloud top products and volcano activity and improved telescope entrance filters on its Solar X-ray Imager (developed by the Lockheed Martin Solar and Astrophysics Laboratory), with automatic flare detection software to prevent the device from staring at damaging solar flares. GOES-14 also restores the solar x-ray sensor capability of the NOAA National Weather Service Space Weather Prediction Center because GOES-10 through -13 satellites have nonfunctional or very degraded x-ray sensors.

Thomas M. Wrublewski, a physical scientist at the NOAA Liaison Office, said that one of the most difficult parts of developing the technology for the satellite was that "there were very tight thermal and mechanical requirements. If you can imagine the error that a slight wiggle in a handheld telescope would make when looking at a far-away planet like Jupiter, you would appreciate the challenges here."

NASA expects the testing to be completed this winter, at which point control of the satellite will be handed over to NOAA. The latter plans to hold the satellite in orbit on standby until needed.

Rebecca C. Jernigan
rebecca.jernigan@laurin.com

Small device prevents diode death

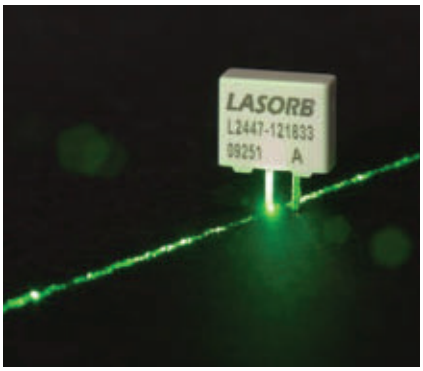
ORLANDO, Fla. – Electrostatic discharge (ESD), reverse bias and power surges are common causes for the malfunction or premature failure of laser diodes, LEDs and photodiodes.

As a solution, William Benner, president of Pangolin Laser Systems, has devised a component called Lasorb, described as an "ESD absorber," which protects diodes and other optoelectronic equipment. The device could benefit applications in electronics, medicine, and solid-state laser pumping and instrumentation.

Triggers

According to Benner, some companies have experienced laser diode performance anomalies without knowing the actual cause. Pangolin, which within the company refers to the Lasorb as a "ghost buster," believes the product solves these mysteries once it's applied. "There can be phantom phenomenon going on inside the laser diode driver that people really don't understand," Benner said, "but when you attach the Lasorb, it tends to moderate most strange behavior."

ESD can be generated in many ways, but it is usually related to human activity, such as touching a device after walking across a carpet or vinyl surface, or repositioning a machine. Depending on how an individual works with the product or where the diode is placed within the device, the voltage produced can reach the diode directly or indirectly.



Lasorb helps to protect diode function and life expectancy by preventing the electrostatic disruptions and power surges typically caused by touching a device or turning it on or off. During testing, the component was found to be 100 percent effective in defending red and infrared as well as Blu-ray diodes from negative and positive ESD events up to 15 kV.

Electrostatic activity can range from 4000 to 32,000 VDC, but if a laser diode with a terminal voltage of 2.2 V is hit with only 1000 V of ESD, the diode is likely either to expire or have permanent latency, while its lifetime becomes radically reduced.

When a laser diode is powered up, it is vulnerable to overvoltage and overcurrent if the power supply exceeds the voltage parameters of the diode, while powering down has a reverse effect. If the device is continually turned on and off, the effect of power surges accumulates over time and eventually leads to laser diode fatigue and premature failure.

Typically, a normal working laser diode operates effectively under strong forward-bias conditions – that is, the voltage runs through the diode in the typical direction. Yet a reverse-bias condition, which Benner describes as voltage going through a diode the "wrong" way, can significantly harm its performance. "Laser diodes don't like this very much at all and will be damaged by even slight amounts of reverse bias," he said.

According to Benner, Pangolin decided to design the Lasorb after testing many existing laser diode protection devices but finding none that had sufficient defense capabilities against ESD, reverse bias and power surges.

Defense mechanism

Lasorb is intended to prevent the negative polarity of a laser diode while also prohibiting discharge from exceeding the maximum forward-bias conditions. The Lasorb attaches by connecting the LDA and LDK terminals, respectively, to the anode and cathode of the laser diode. Placing the component as close as possible to the diode – no more than a gap of 1 cm – will help to inhibit stray surges from getting past the ESD absorber.

Integrated into the circuit is a "fast acting" diode that is able to protect the laser diode from reverse bias and negative ESD. Unlike Schottky diodes – a common mechanism for electrostatic protection – these fast-acting diodes, Benner discovered, survive ESD events. "The fast-acting diode is formed by a *p-n* junction, so it might be called a 'normal' diode," Benner said. "However, the properties and specifications of this particular diode are beyond the norm."

Also included in the device is a slew-rate detector, which monitors the voltage between the LDA and LDK terminals and can distinguish between normal diode function and ESD or power surges. As voltage strikes, the Lasorb conducts current between the terminals and away from the laser diode, therefore protecting it. Lasorb's reaction time is believed to be below 800 ps, fast enough to catch nanosecond-level ESD events. "This part does something that we haven't seen any other part do," Benner said. Other solutions fail to fully protect laser diodes because their response time is too slow, or their voltage detection range is insufficient for the wide scale of energy derived from electrostatic activity and power surges.

Additional advantages include Lasorb's ability to safeguard a diode whether the entire system is on or off, and whether or not the laser is emitting. "This is one of the most unique benefits of Lasorb," Benner said. "Our tests and demonstration videos show that we can protect a laser diode even while it's lasing."

Amanda D. Francoeur
amanda.francoeur@laurin.com

For lasers, small and thin are in

NORFOLK, Va. – Lasers just keep getting smaller and smaller: Recently, only a couple of months after the report of the world's thinnest laser, the world's smallest laser was announced. Both developments barely precede the 50th anniversary of the laser, which will be celebrated worldwide next year.

Both the ultrathin and ultrasmall laser purport to enable all-photonics computers and Internet capability, which theoretically will be much faster than current computing and Internet speeds. A light-based system must have a source of light, and a very small laser can be integrated much more practically, with tiny computer chips, than a gigantic laser ever could.

The smallest laser, which was made by a team of researchers from three US universities, consists of a spherical particle only 44 nm in diameter. It also is the first of its kind to emit visible light.

The team consisted of Mikhail A. Noginov of Norfolk State University, Vladimir M. Shalaev and Evgenii E. Narimanov of Purdue University in West Lafayette, Ind., and Ulrich B. Wiesner of Cornell University in Ithaca, N.Y., and their associates. The three groups contributed equally to the work.

"This nanolaser may find a number of applications – maybe biomedical diagnostics or some sort of therapy," Noginov said. "Maybe some sort of sensors. On the other hand, there is some ongoing new effort to develop a new generation of electronics that will operate at light frequencies; potentially the speed of computers can be increased tens of thousands of times."

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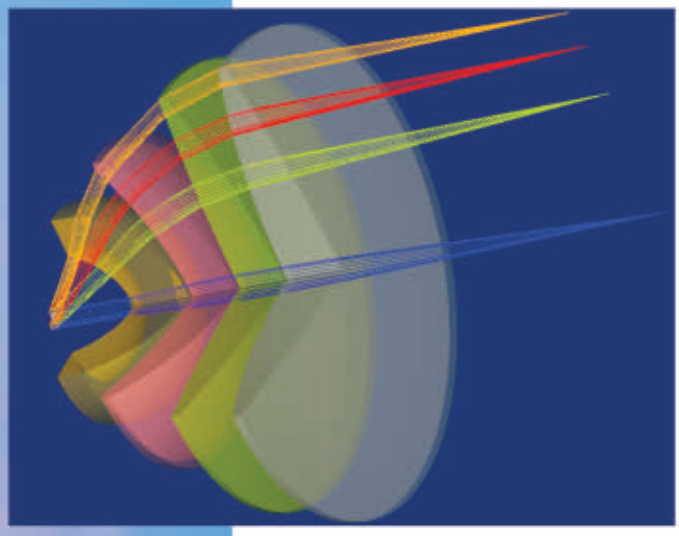

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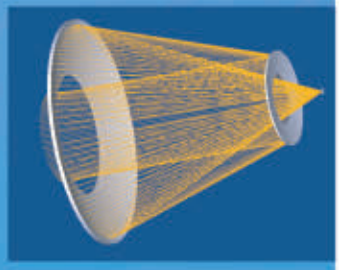

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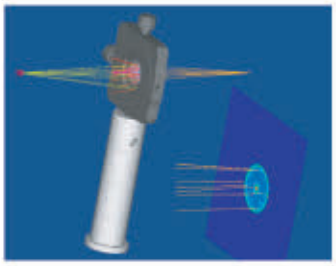

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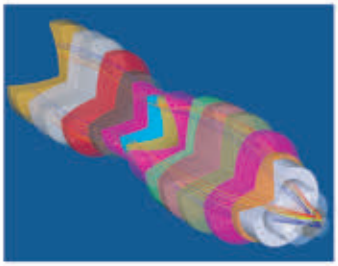

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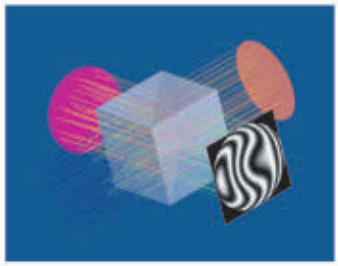

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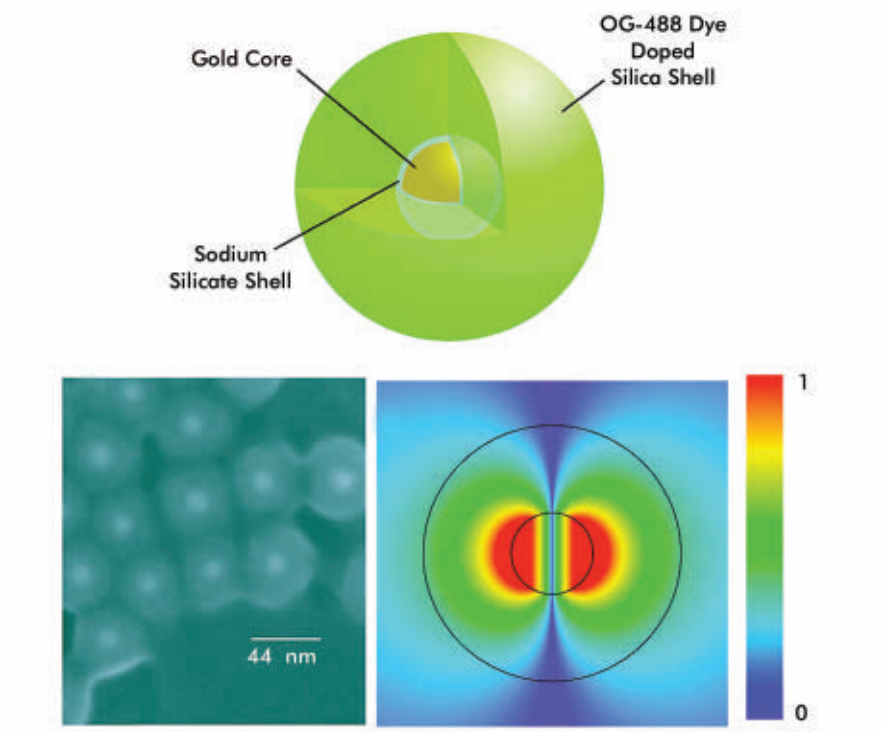


Shown is the conceptual illustration of the particle on which the new laser is based (top), an SEM image of the particles (bottom, left) and a conceptual image of the emission of the particle (bottom, right). Courtesy of Noginov et al.

Photons from electrons

Noginov and company call this little laser the spaser, for "surface plasmon amplification by stimulated emission of radiation." The size of a conventional laser in any one dimension is believed to be limited by one-half the wavelength of light, but the spaser operates in an unconventional way. Instead of amplifying photons, it amplifies surface plasmons, which are oscillating clouds of electrons on the surface of a metal that can emit photons of light when stimulated. For this reason, the researchers chose to give the particle a metal core; in this case, gold.

However, these surface plasmon oscillations usually dissipate too quickly to produce amplified light like a laser. The researchers discovered that they could make the plasma oscillations last long enough to do so when they encapsulated the gold core in a silica shell filled with a dye called Oregon Green 488 (OG-488).

Once the dye was excited with a laser, it transferred its energy to the gold core, generating surface plasmon oscillations sufficient to produce greenish laserlike

light at 531 nm in all directions rather than a focused beam. “Our laser does not produce a beam, and this does not mean that the laser does not have a coherence,” Noginov explained.

The investigators generated the spaser beam with a 466-nm laser with <90-ps pulses at a 40-MHz repetition rate, as described in the Aug. 16, 2009, online publication of *Nature*. “Our laser is laser-pumped,” Noginov said. “The size of the pumping system is typically not accounted toward the size of the laser-pumped laser.”

However, to be practically incorporated into computers, the plasmons must be stimulated electrically in a semiconductor. “What we did – we demonstrated the proof of principle of the spaser,” Noginov explained. “The use in practical electronics schemes will, most likely, require an electrically pumped device. The groups of [Martin T.] Hill of [Technical University of Eindhoven in] the Netherlands and [Cun-Zheng] Ning of Arizona State University [in Tempe] successfully work in this direction.”

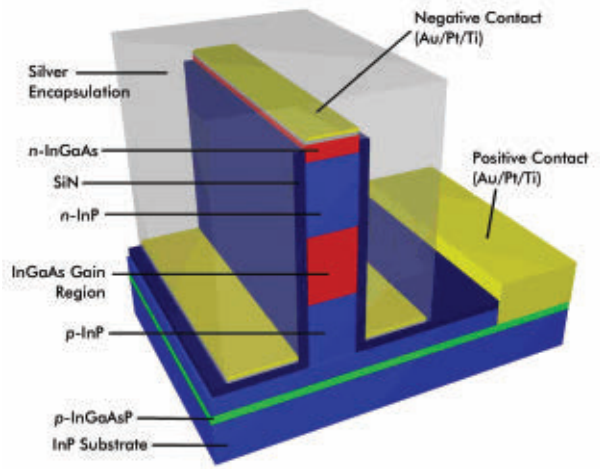
In the June 22, 2009, issue of *Optics Express*, just before the details on the world’s smallest laser were released, Hill, Ning and their associates reported developing the world’s thinnest laser. This laser runs on electricity instead of on an external laser source.

“We think that [the spaser project] is very interesting work,” Hill said. “For some applications, electrically pumping of the laser will be preferred. The structure we use is quite well suited for this electrical pumping.

“We think that these lasers could be used where a very fast modulation speed, very small, low-power laser is required; for example, short-distance ultrafast communications or ultrafast signal processing of optical signals. There may be new niche applications due to the high fields and high pumping densities available in these lasers and also the ability to locate many subwavelength-size devices close together.”

Likes it cold – for now

Their laser is an upright rectangular structure 3 or 6 µm in length with a semiconductor core width that varies from 90 (±20) to 350 nm. The rectangle is made of five layers: metal, insulator, semiconductor,



Conceptual drawing of the ultrathin laser. Courtesy of Hill et al.

insulator and metal. The semiconductor is InP with an InGaAs core, SiN is the insulator, and a thin layer of silver is the metal.

There are two contact points that the researchers connected to positive and negative electrodes. These contacts are made of a mixture of gold, platinum and titanium. The flow of the electricity from the negative to positive electrode excited the semiconductor core gain medium of InGaAs, which emitted infrared light at 1500 nm.

At extremely cold temperatures down to 10 K, the laser operated in plasmon mode, whereas it operated in transverse electron mode at room temperature.

"In the paper, we gave results for the smallest waveguides at lower temperatures in order to show the behavior clearly," Hill said. "However, in the experiments, there were indications that these thinnest devices could still work up to, say, 100 to 200 K.

"Some of the wider devices, which don't propagate a plasmonic mode, operated at room temperature. We expect in the future that we will succeed in having the smaller plasmonic mode device also operating at room temperature."

David L. Shenkenberg
david.shenkenberg@laurin.com

Single-photon converter expands IR spectrometry

GAITHERSBURG, Md. – A cleverly designed single-photon detector has enabled scientists at the National Institute of Standards and Technology (NIST) to develop a highly sensitive and low-cost spectrometer that operates in the infrared.

The technique could be used in many areas that require ultrasensitive spectrum measurement in the region, such as biomedical research, nanotechnology and quantum information. What's more, the detector can measure – at the single-photon level – weak infrared light given off by fragile bio- and nanomaterials.

Until now, steady progress had been made to increase the efficiency and sensitivity of detectors operating in the visible and ultraviolet regimes. However, such detectors have proved too inefficient and slow to detect single photons in the near-infrared. The performance of today's infrared detectors also has limited the sensitivity of the spectrometers in which they are used.

In a study published in the August issue of *Optics Express*, professor Xiao Tang and colleagues at NIST have found a way to use existing detectors to measure infrared photons that have been converted up to the visible.

"Silicon avalanche photodiodes [Si-APDs] work very well, but only for wavelengths shorter than 1000 nanometers," Tang explained. "So we converted photons at 1310 nm to 710 nm, where Si-APDs have highest detection efficiency."

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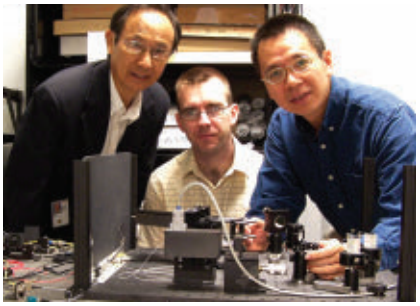
In the NIST approach, a 1550-nm narrowband pump laser scans the infrared signal photons and converts to visible light only those that have the desired polarization and wavelength.

Conventional spectrometers use a dispersion element such as a prism, a grating or a tunable narrow bandpass filter to separate light into its component wavelengths. The NIST team, however, uses the law of energy conservation in the wavelength conversion process. In this way, the spectrum of signal light can be obtained by sweeping the pump laser wavelength without the need for dispersive optical elements.

"When we tune the pump wavelength, a spectrum of the signal photons is obtained," Tang said. "Since our up-conversion detector has such a low noise level, the sensitivity of the spectrometer is as high as −126 decibels above 1 mW at 1310 nanometers, with a signal-to-noise ratio of 10. The sensitivity is three orders of magnitude higher than any commercial optical spectral analyzer."

This result opens up the possibility that scientists in fields ranging from forensics to quantum communications can deal with infrared photons almost as easily as with visible photons.



Xiao Tang, Oliver Slattery and Lijun Ma, left to right, make up the NIST research team that developed a highly sensitive and low-cost spectrometer that operates in the IR region. Courtesy of Xiao Tang.

As government employees responsible for helping US industries with new technologies, Tang and colleagues are prepared to cooperate with any company that wishes to commercialize this technology.

The next step for the NIST team is to use the newly developed spectrometer to obtain more advanced results in its quantum communications research.

Marie Freebody
mariefreebody@physics.org

Tunable light source reaches nanoscale milestone

SOUTHAMPTON, UK – In the race to develop ever-smaller and -faster optical devices, researchers have built the first tunable nanoscale light source driven by free electrons. Dubbed the "light-well" by its creators, the novel emitter could one day be used as an on-chip light source for nanophotonic circuits or in large assemblies for optical memory or display applications.

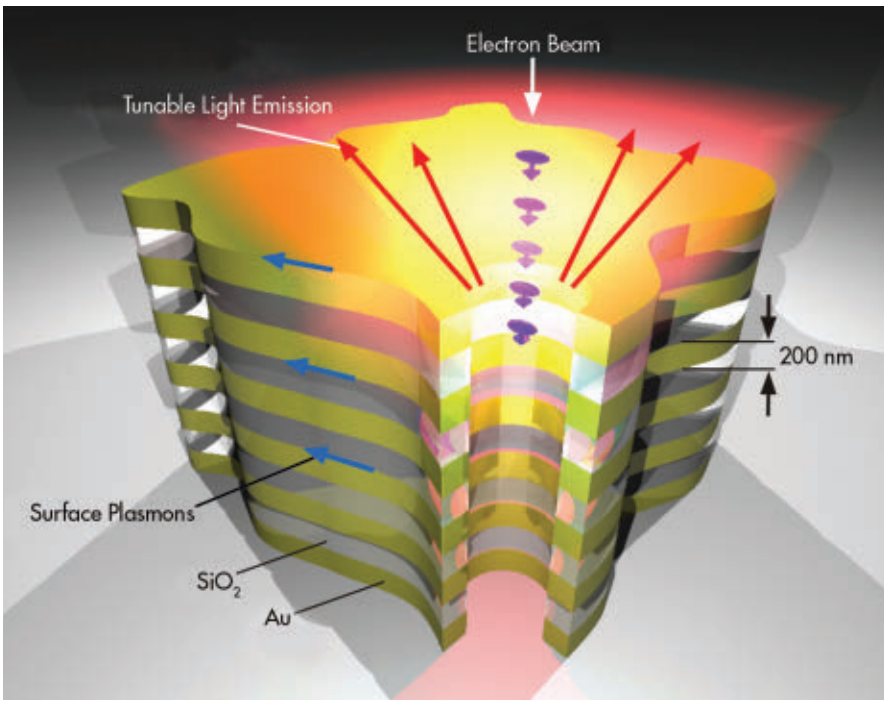
Dr. Kevin MacDonald, senior research fellow at the University of Southampton and co-inventor of the light-well, said that tunable chip-scale light sources could open up a range of possibilities in nanophotonics, including spectroscopic lab-on-a-chip devices for medical diagnostics. In other sectors, such devices could, for example, eliminate the need for individually colored pixels in next-generation displays. Instead, a single light-well at each pixel could emit the full range of colors required.

The most significant aspect of the light-well is that it combines nanoscale size with tunability. Many of today's electron-beam-driven radiation sources, such as synchrotrons and free-electron lasers, are inherently tunable but are generally macroscopic – often facility-scale systems. On the other hand, many of the nanoscale light and surface plasmon sources that have been proposed in recent years are fixed-wavelength.

The Southampton group, with partners in Taiwan and Spain, describes its work in a paper on the arXiv server; the paper is currently under review for journal publication. Although the study is at the proof-of-principle stage, the team sees a path toward chip-scale integration.

Anatomy of a light-well

"In our experiments, we used a scanning electron microscope to drive light-well emission," MacDonald said. "However, chip-scale electron sources are already well developed for vacuum-micro-



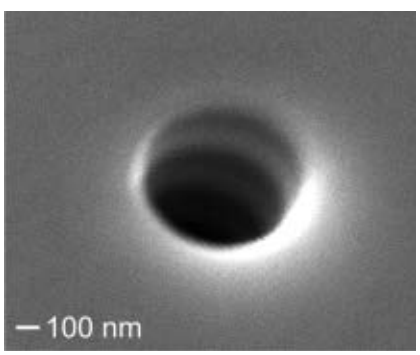
The light-well, seen here in an artist's impression, is a tunable chip-scale light source that could open up a range of possibilities in nanophotonics. Images courtesy of the Optoelectronics Research Centre, University of Southampton.

electronic and flat panel display applications. The task of integrating such sources with light-well structures is not trivial but should certainly be possible."

The light-well comprises a 700-nm hole drilled through a stack of alternating layers of gold and silica, each with a thickness of 200 nm. Although structurally simple, the light-well's emission is not yet fully understood and remains a key challenge for the team.

In a broad approximation, light is generated by a beam of electrons directed through the tiny aperture in the metal-dielectric stack via the formation of dipoles between electrons and their "mirror images" in the wall of the well. As the electrons travel down the well, the alternating dielectric environment causes the dipole to oscillate and emit light. In the experimentally demonstrated structure, adjusting the energy of the electron beam from 20 to 40 keV enables the team to tune the wavelength of the emitted light from red to the near-infrared. Varying structural periodicities will provide access to different spectral ranges.

The light-well provides an output intensity of 250 W/cm² at the peak emission wavelengths, which corresponds to an efficiency of around 3×10^{-5} photons per electron. MacDonald admits that there is considerable work to be done before commercialization can be considered. The light-well structure must be optimized to maximize output intensity and achieve narrower emission linewidths, and it must be engineered for integration with chip-scale electron sources.



The internal periodic structure is visible in this electron microscope image of an experimental light-well.

"We are currently working on numerical and analytical studies in preparation for the fabrication of new sample structures and further experimental investigations," MacDonald concluded. "For example, we expect to achieve narrower linewidths in longer wells."

Marie Freebody
mariefreebody@physics.org

Nanophotonics market: Upward bound

WILMINGTON, Del. - The value of the global nanophotonics component market is expected to reach $3.6 billion by 2014, experiencing a compound annual growth rate of 100.7 percent from 2009, according to a report published by MarketsandMarkets, a research and consulting firm in Wilmington, Del. A similar pattern can be expected for the nanophotonic devices market, which is expected to grow from a current market size of $1.8 billion to $58 billion in 2014.

Published in June 2009, the report, titled *Nanophotonics – Advanced Technologies and Global Market (2009-2014)*, aims to identify and analyze products, applications and materials for the nanophotonics market.

Among the components and products addressed in the report are nanophotonic LEDs, organic LEDs (OLEDs), near-field optics, photovoltaic cells, optical amplifiers and switches, and holographic data storage systems. Nanophotonic applications include lighting, indicators and signs, nonvisual technology, telecommunications, entertainment and consumer electronics. And materials include photonic crystals, plasmonics, nanotubes, nanoribbons and quantum dots.

Nanophotonics technology is expected to enter the mainstream market because of attributes such as low weight, high thermal stability, power efficiency and long working life, according to the company, which predicts a significant increase in the number of applications in near-field optics, holographic memory and optical amplifiers.

The company projects that the Asian market will hold almost the lion's share – nearly 74 percent – of the total global nanophotonics revenues in 2014. The region dominates in the nanophotonics LED and OLED markets, which are expected to hold a nearly 80 percent share of the market by 2014. Asia, particularly the Asia-Pacific region, is already the hub for the manufacture of electronic and semiconductor devices, the company says. In upcoming years, it expects, Asia to dominate in the market areas of optical amplifiers, near-field optics and holographic memory as well.

The US and European market shares will likely see compound annual growth rates of 161.1 and 160 percent, respectively, from 2009 to 2014, according to the company. The latter two regions offer large consumer bases for nanophotonic devices.

Nanophotonic LEDs

The value of the nanophotonics LED market, the largest segment, is expected to reach $2.7 billion by 2014, up from $106 million in 2009, at a compound annual growth rate (CAGR) of 91.3 percent. The optical amplifier and holographic memory device segments are estimated to have a CAGR of 239 percent and 234.6 percent, respectively, from 2009 to 2014, according to the company.

In the nanophotonics LED market, the high-beam LED has the highest market share, followed by the UV LED. The major application areas for these components include lighting and traffic signaling, backlighting in electronic displays, artificial photosynthesis, medical technology, UV curing and counterfeit detection, the company says.

It also predicts that the optical fiber amplifier segment will achieve the highest CAGR in the period 2009 to 2014, followed by that of semiconductor amplifiers. It projects that the holographic data storage systems segment will have a CAGR comparable to that of optical amplifiers, and that OLEDs will be the slowest growing segment of the market.

Challenges

Among the major challenges facing nanophotonics technology manufacturers are the high cost of integrating nanotechnology with photonic equipment and components, difficulty in justifying price increases for performance, the need for an experienced and knowledgeable labor force, and the extensive R&D costs for bringing in new products.

In the field, researchers are working on increasing product performance by using nanophotonics, cost-effective industrial integration of nanotechnology and photonics, and increasing the application bandwidth for nanophotonics.

The major issues facing the overall nanophotonics industry include upcoming technologies such as silicon and nanosilicon photonics, improvement in volume production techniques for nanomaterials, and cheaper and improved techniques for integration.

As for nanophotonic materials, the demand for their large-scale production is a challenge, as are health concerns associated with their use. Their high cost also is an issue, as is the increase in related R&D costs as the market for the materials becomes competitive.

The global downturn did not significantly affect the nanophotonics market because it already is a niche industry and has major applications in LED, OLED and photovoltaic cells – markets that have grown even in the downturn, the company says.

Caren B. Les
caren.les@laurin.com

SBIR Funding SCI Engineered Materials Inc. of Columbus, Ohio, has been awarded a two-year Phase II Small Business Innovation Research (SBIR) grant. The company, which manufactures ceramics and metals for applications in photonics and thin-film solar, will use the funding to develop round wires for use in high-magnetic fields developed for high-energy physics experiments.

Phosphorescence Licensing Performance Indicator LLC of Lowell, Mass., has acquired an international nonexclusive license for a portfolio of glow-in-the-dark pigments. Developed by the University of Georgia Research Foundation Inc. in Athens and the University of Puerto Rico in Rio Piedras, the pigments can be designed to emit light in any color of the visible spectrum for nearly a day. The seven phosphors included in the agreement are environmentally safe.

European Agent In Cambridge, UK, TeraView Ltd. has appointed a distributor for its range of terahertz solutions and technology. LOT-Oriel of Darmstadt, Germany, will be the exclusive agent for TeraView's products in Germany, France, Switzerland, Austria and Italy.

Distribution Agreement Allied Vision Technologies GmbH of Ahrensburg, Germany, has added another distributor to its international network. A machine vision company in Istanbul, Turkey, E3TAM, will sell Allied Vision's product range in Turkey. The agreement includes the

sales of the FireWire and Prosilica GigE Vision digital camera program.

UK Relocation Agar Scientific of Stansted, UK, has moved to M11 Business Link, a custom-designed business park on the outskirts of Stansted. The company, which supplies microscopy accessories and consumables, chose the location because of its access to transportation options and to its offices and laboratories.

Laser Lab Opens Miyachi Unitek of Monrovia, Calif., has opened the Midwest Laser Applications Laboratory in Wixom, Mich., where the company will work with customers to conduct sample evaluations and create applications reports using its range of Nd:YAG and fiber laser welders and markers. Sharing a building with AET Integration Inc. will give Miyachi access to AET's cross sectioning and inspection laboratories and will enable more detailed inspections.

Shanghai Subsidiary Launched Optis France SAS of Toulon, France, has opened a wholly owned subsidiary in Shanghai, China, to serve the nearby automotive, aerospace, defense and electronic industries. The facility will provide technical and sales support as well as a variety of training courses for the company's light simulation and visualization software.

UAV Imaging Developed Sensors Unlimited Inc. and Cloud Cap Technology, both part of Goodrich Corp. of Princeton, N.J., will collaborate to provide specialized imaging solutions for the military, security and surveillance markets. The companies are combining their technologies to develop imaging devices for small unmanned aerial vehicles (UAVs) as well as for manned safety and surveillance tasks.

X-ray Center Established Tokyo-based Rigaku Corp. has created Applied Rigaku Technologies Inc., a subsidiary focusing on energy-dispersive x-ray fluorescence (EDXRF) and related elemental analysis technologies. Located in Austin, Texas, the new company will help develop x-ray-based analytical instruments and technologies for metrology use. The EDXRF Center of Excellence occupies a newly built 20,000-sq-ft facility.

Restructuring in Singapore Suss MicroTec of Garching, Germany, has announced the restructuring of its Asian sales offices. The company has consolidated its Bangkok, Thailand and Singapore offices at a single Singapore location that will service its lithography, wafer bonder and test systems lines. The company has named ZMC Technologies of Singapore as its general sales representative for Malaysia, Singapore and the Philippines.

Exclusive Distributor BFi Optilas International SAS of Evry, France, has signed an exclusive distribution agreement with Labsphere Inc. of North Sutton, N.H. The European company will sell and support its partner's products, which include instruments for spectroscopy and LED characterization, throughout Austria, France, Germany and Switzerland.

CAD Award Newark, N.J.-based Simphotek Inc. has been awarded a two-year $750,000 Small Business Technology Transfer Phase II contract by the US Air Force Office of Scientific Research. The grant will enable the company to continue developing optical computer-aided design (CAD) software to simulate the interactions of light with linear and nonlinear optical materials. The software could have applications in analyzing photoactivated phenomena in materials used for optical devices, medical diagnostics and renewable energy.

Slow Start The Large Hadron Collider, run by CERN of Geneva, is planning a slow start this fall. Scientists in charge of the project have decided to run the machine at 3.5 TeV per beam initially, as they hope to prevent a repeat of last year's incident. They hope that the device eventually will run at the 7 TeV it was designed for.

Energy Grant In Berkeley, Calif., the Lawrence Berkeley National Laboratory has been granted $40.3 million in funding from the American Recovery and Reinvestment Act. This grant is in addition to the $115.8 million the laboratory received in March from the US Department of Energy Office of Science. The new funds will go to five projects at the laboratory, including equipment improvements to the Advanced Light Source, which will total $11.3 million.

$14 Million Financing Plextronics Inc. of Pittsburgh, a company specializing in printed solar, lighting and other organic electronics, has completed its Series B-1 financing round, receiving $14 million to develop its research, development and pilot manufacturing programs. The majority of the funding came from Solvay North American Investments LLC, a member of the Solvay Group, which is headquartered in Brussels, Belgium. Solvay's $12 million investment makes it the largest minority shareholder of Plextronics.

Nanotube Funding In Newhaven, UK, Surrey Nanosystems has received £2.5 million in second-round financing. Granted by a variety of investors, the capital will help the company commercialize its low-temperature growth process for carbon nanotubes, which could be used in silicon integrated circuit manufacturing.

Divisions Added Supplier of LED products CoolLED, headquartered in Andover, UK, has added two new divisions. Its design division will address the requirements of OEMs that want to incorporate LED technology into their products, while its industrial division will focus on products for markets where LED lighting is currently in use, such as medical, UV curing and printing.

Global Agreement Mouser Electronics Inc. of Mansfield, Texas, has signed a global distribution agreement with DBM Reflex Lighting Solutions of West Laval, Quebec, Canada. The contract provides the Canadian company with its first distributor. Mouser will stock its partner's high-brightness LED lenses.

There's a lot of nanoscience at Pittcon.

"This is my seventh Pittcon. It's a unique opportunity to hear quality papers and interact with researchers presenting ideas relevant to my work. There are always excellent exhibits and training classes—and I'm delighted with the increased emphasis on nanoscience. This year the most exciting presentation was the Nanotechnology and Electron Microscopy Symposium from Japan. It was wonderful to experience the fruits of Pittcon's international sponsorship of high quality presentations."

WARREN LAYNE | *Chemist, U.S. Environmental Protection Agency*

I appreciated the ability to investigate new methods and compare similar products.

"The exhibition was very beneficial. I was looking for new and improved methods for 5-day BOD analysis—and I found some! It was also good to meet the representatives of the companies we work with. I think that building and maintaining these relationships is important for both the companies and their clients."

NATALIE NICHOLS | *Laboratory Associate, Illinois EPA*

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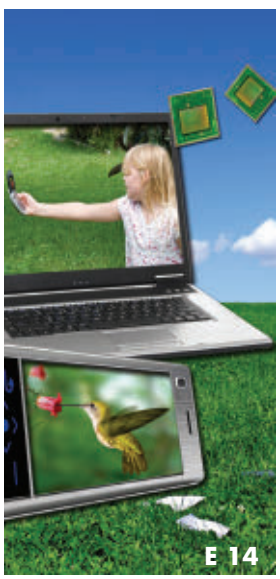
NEWS



FEATURES

DEPARTMENTS

THE COVER
This month's cover photo reflects how consumers are driving the image sensor market.
See the feature starting on page E14.

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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Alice and Bob talk quantum encryptedly across Vienna

VIENNA, Austria – Researchers from all across Europe have set up a quantum key distribution (QKD) system that demonstrates the growing capabilities of this technology at the network level. Forty-one research and industrial organizations from the European Union, Switzerland and Russia recently demonstrated quantum encrypted information transfer over an eight-node meshed optical network. The demonstration was an outcome of the SECOQC QKD conference held October 2008 in the Austrian capital, the results of which were recently published. SECOQC is the acronym for Development of a Global Network for SEcure COmmunication based on Quantum Cryptography, a project funded by the European Union within the Sixth Framework program.

Cryptography, i.e., protecting data, is an important issue when it comes to today's computer and communications networks, not only for bank transactions and Internet payments, but also for keeping e-mail and other information private. In contrast to traditional public key cryptography, which relies on the computational difficulty of certain mathematical functions for its security, quantum cryptography relies on the foundations of quantum mechanics, which comes with a fundamental benefit: The process of measuring a quantum system generally disturbs it, so a third party trying to eavesdrop will perform measurements that will inevitably introduce detectable anomalies. The two communicating users can discover the presence of any third party trying to gain knowledge of the secret key.

Alice and Bob are the commonly used names for the transmitter and receiver, respectively, of information in quantum cryptography. Devices such as those shown have been used to perform a network-level demonstration of the technology. Photo courtesy of id Quantique SA.

The photon's role

In today's quantum cryptography approaches, not only are photons used to transport information but also their quantum nature is used to facilitate the encryption. The sender – commonly labeled "Alice" by the cryptography community – transmits a string of polarized single photons to the receiver "Bob." By carrying out a series of quantum measurements and public communications, they establish a shared key while testing whether an eavesdropper ("Eve") has intercepted any bits of this key en route. This key is then used to encrypt and decrypt the message data, which can be transmitted (at higher speeds) over a standard communications channel.

In practice, however, generating the single-photon pulses required for BB84, the original quantum cryptography protocol, is a big challenge. Single-photon technology is progressing, and ways have been found to overcome the difficulties. However, QKD is still limited by a number of constraints, in particular the limited distance over which key distribution is possible, as well as its comparably low rate, which decreases exponentially in relation to distance. Last but not least, QKD communication is inherently point-to-point, which could be a significant obstacle in the majority of relevant application scenarios.

The SECOQC approach to QKD networks – and core of the network demonstration in Vienna – has therefore focused on the so-called trusted repeater paradigm. Unlike the alternative, the quantum channel-switching paradigm, which creates an end-to-end quantum channel between Alice and Bob, the trusted repeater paradigm transports the keys over many intermediate reliable locations (nodes).

During the demonstration, different types of QKD technology and protocols were used between the nodes – with certain interoperability requirements, however. Beyond those essentials and performance requirements, including a 25-km minimum distance (over standard telecom fiber) and 1-kb/s key generation at that range, a variety of tactics were taken for the eight QKD links. The approaches belonged to six types of systems and give a good overview of the various avenues being pursued in QKD today.

• The Swiss company id Quantique SA, which produces commercially available quantum cryptography devices, used a technique closely related to the BB84 protocol. However, it shifted the phase rather than the polarization of the photons, and it used a clever self-compensation method to stabilize the phase between both ends.

• Toshiba Research Europe Ltd. of the UK contributed a so-called one-way weak coherent pulse system with decoy states. This is also a phase-encoding QKD system with two interferometers that are stabilized by pulses that are time-multiplexed with the quantum signals.

• GAP, the applied physics team at the University of Geneva, provided a coherent one-way system belonging to the novel class of devices utilizing distributed phase reference protocols.

• Anton Zeilinger's group at the University of Vienna and the Austrian Institute of Technology used another aspect of quantum mechanics, entangled photons, as a key approach. Using polarization entanglement, the investigators achieved long-term automatic operation based on concurrent active stabilization of optical elements.

• A consortium of CNRS, Thales Group and Université Libre de Bruxelles devel-

OPTICAL DESIGN SOFTWARE

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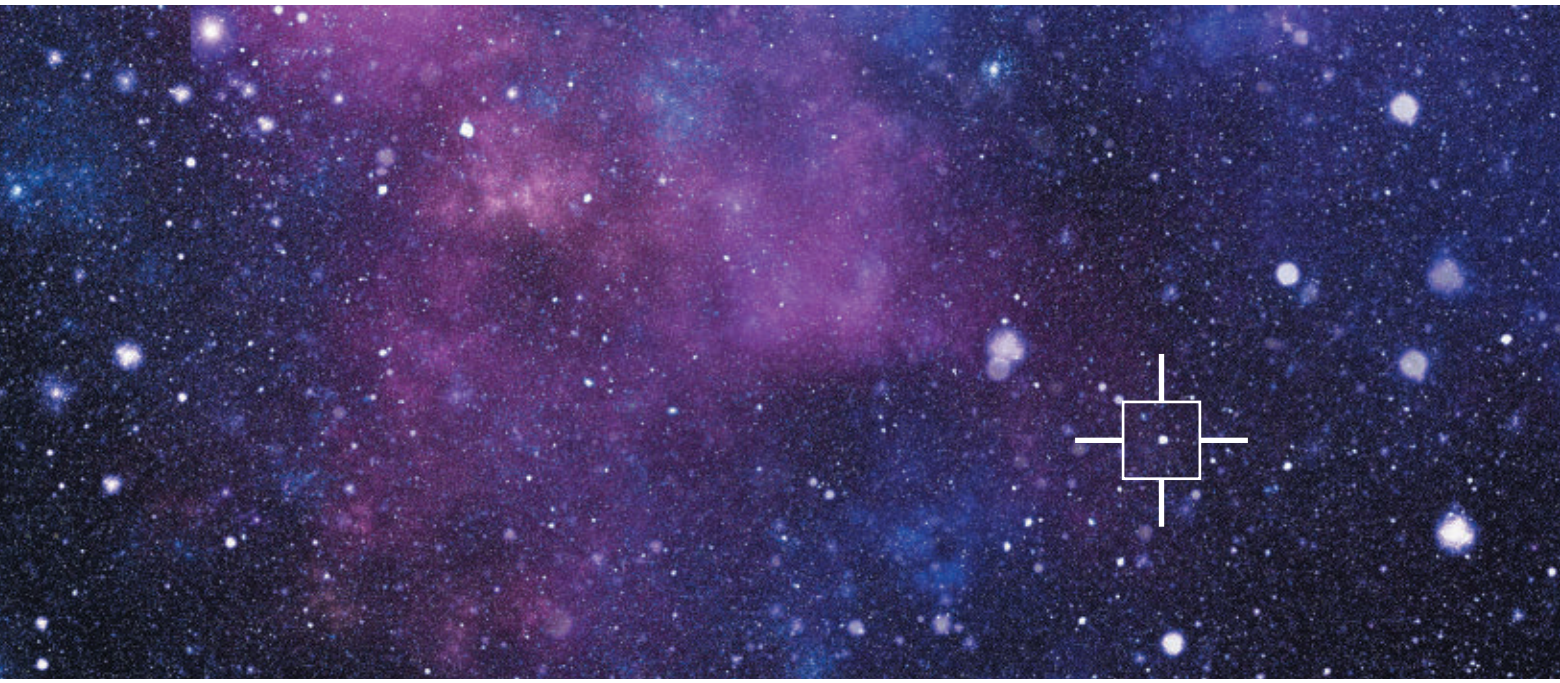

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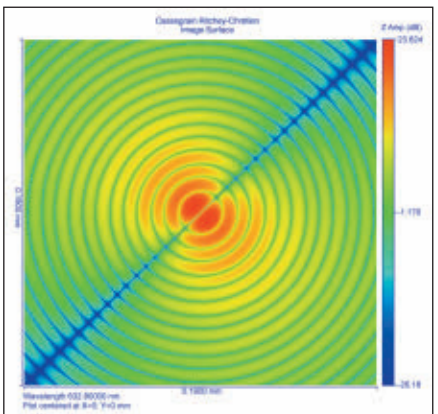

BSP supports full-vector field propagation. This decibel-scale plot shows the Z-component of the focal plane intensity of a Ritchey-Chrétien telescope for linearly polarized light.

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oped a so-called continuous variables system with Gaussian modulation, reverse reconciliation and homodyne detection of the coherent light pulses.

• An access-free space link set up by Ludwig Maximilians University of Munich, Germany, demonstrated a QKD for a typical "last mile" application.

More detail, including a list of all other partners, is available in a recently published online article that can be found at http://stacks.iop.org/NJP/11/075001. A follow-up test bed called SwissQuantum was installed recently in Geneva, with more information available at www.swissquantum.com.

Jörg Schwartz
j.schwartz@europhotonics.com

Wish upon a star

MUNICH, Germany, and MONTREAL – When searching outer space for sharp images of remote stars, large-scale astronomical telescopes employ adaptive optics to actively compensate for atmospheric disturbances. However, these devices need control mechanisms in the form of "guide stars," which can be generated by sending a laser beam into the atmosphere. The guide star, when observed with the same telescope optics as real stars, can yield information about the aberrations induced by atmospheric turbulence. Now new types of lasers are being developed for this job.

Although nowadays telescopes can be mounted on space stations, large terrestrial telescopes are still important tools for astrophysicists when it comes to researching the universe. The size of the optics matters, because large dimensions can help gather photons at extremely low light levels from remote galaxies.

Another benefit of large-size optics is improved resolution – at least in theory. Unlike space-mounted devices, however, Earth-based telescopes have to cope with atmospheric disturbances, even though most high-end observatories, like the European Southern Observatory (ESO) facilities in the Atacama Desert of Chile, have been built in regions with very clear air. When there are atmospheric disturbances, increasing telescope diameters to more than 25 cm does not improve resolution, explains Dr. Axel Friedenauer of Toptica Photonics, "unless adaptive optics are used." This technology works so well that larger observation apertures allow a terrestrial telescope to achieve resolution better than that produced by space-based equipment.

To produce the control mechanism based on a reference to known distortions that is required for adaptive optics, the atmospheric sodium layer, at a height of 90 km and with a thickness of 10 km, is resonantly excited by powerful laser sources to

generate strong resonance fluorescence using orange light (Na D_2 line). The resonance spot in the sky is then observed with the same telescope optics used for the stars in the background. Precise information about the aberrations induced by the atmospheric turbulence on the artificial star allows a deformable mirror in the optical train of the telescope to be controlled such that it compensates for those aberrations.

Special laser needed

The laser needed to do this job must be resonant with sodium ions. In addition, it must offer a narrow linewidth, high power, excellent beam quality and stability, high reliability and turnkey operation, avoiding the need for a laser physicist to operate the device.

The approach developed by Munich, Germany-based Toptica Photonics, together with the Montreal company MPB Communications, combines fiber laser and Raman amplification technologies to generate more than 20 W at 589 nm in a TEM_{00} beam. It commercializes a fiber laser and Raman fiber amplifier concept designed by ESO scientists and presented at the CLEO Europe conference in June 2009.

"The design uses a master oscillator/power amplifier configuration," says co-author Friedenauer, with Toptica's 100-kHz-linewidth diode laser serving as the seed for two Raman fiber amplifiers generating 1178-nm radiation. Raman amplification of a narrowband 1178-nm signal to high powers in a single-mode optical fiber is challenging because of an unwanted nonlinear process known as stimulated Brillouin scattering. It tends to limit the forward-traveling signal power by reflecting it backward. The Raman expertise of MPB Communications was used in developing fiber amplifiers with stimulated Brillouin scattering suppression, to allow amplification of linearly polarized narrowband 1178-nm signals to very high output powers. More than 20 W of linearly polarized continuous-wave light has been demonstrated at 1178 nm from an all-fiber polarization-maintaining Raman fiber amplifier with an emission linewidth narrower than 4 MHz.

A laser guide star is generated by high-power laser radiation sent to the 90-km-high sodium layer in the atmosphere. Fluorescence emission generated there helps to compensate for optical aberrations caused by atmospheric turbulences.

For the complete guide star laser system, two such signals are coherently combined for power scalability. The combined beam is then injected into a resonantly enhanced frequency doubler using second-harmonic generation in a lithium-triborate crystal to output up to 25 W at 589 nm. This corresponds to an overall conversion efficiency of more than 80 percent.

"The reduction of complexity in comparison to former solutions for guide stars can now be combined with scalability," said Toptica President Dr. Wilhelm Kaenders.

Until now, dye lasers and sum-frequency lasers have been used to generate laser guide stars. These devices can be cumbersome and high-maintenance. The goal of the Toptica/MPB Communications consortium bid is to replace these lasers with compact, low-maintenance narrowband and scalable high-power turnkey laser systems. Raman offers an advantage over other candidate technologies by providing a gain per length that is proportional to pump intensity, but without physical limits, as well as a technology that has been well established by telecom applications.

Jörg Schwartz
j.schwartz@europhotonics.com

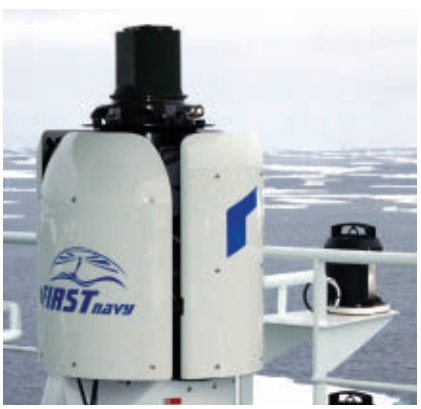
Whale spotting via IR

Two humpback whales visit the Polarstern during one of its recent expeditions. Courtesy of Alfred Wegener Institute.

BREMERHAVEN, Germany – Whales are difficult to spot because they spend most of their life under water. And even when they surface to breathe, spouting a column of air and water vapor that rises from 1 to 10 m, only a portion of their body can be seen.

Now, a specially designed thermal imaging camera from Rheinmetall Defence Electronics GmbH of Bremen is using the heat generated by the spout to "see" the whale. The system is being tested on the research vessel Polarstern by Oceanic Acoustics, a research group at Alfred Wegener Institute that initiated the Marine Mammal Perimeter Surveillance project in early 2009.

Dubbed First Navy, the camera overcomes the challenge of obtaining 360° visibility and compensates for the ship's constant movement. And because the spout is



A thermal imager installed on the Polarstern's crow's nest at a height of approximately 28 m scans the ocean for surfacing whales. The sensor head (green) sits on a highly stabilized platform (white basis) and rotates at 5 rps. Courtesy of Lars Kindermann, Alfred Wegener Institute.

visible for only a few seconds – and potentially from a great distance – high-resolution lenses similar to those used in animal photography are employed.

Installed in the ship's crow's nest at a height of approximately 28 m, the system sits on a stabilized platform so that the upper edge of the image is always aligned with the horizon, and the surrounding water surface is always in view. It generates five thermographic all-round images per second with a resolution of 7200 × 563 pixels of approximately 4 megapixels each, producing about 1 TB of data each day.

The hardware, however, is only half the story.

Dr. Olaf Boebel, head of the project, said that the group is developing software to search "the stream of pictures for whale spout in real time." Its aim is to generate information about the direction and distance of a whale sighting together with video sequences so that a ship's command can view it in real time.

Once tests are completed, the camera could help ships avoid collisions with whales and help users of hydroacoustic instruments take evasive action to avoid interference with marine mammals or interrupt seismic measurements. It also could directly support projects studying whale populations and migratory patterns in the scarcely researched Antarctic regions.

Other applications for the thermographic imager are ship security, including avoiding collisions with small icebergs – or growlers – and sea ice research. Being able to measure ice coverage at small scales is of interest to researchers, especially to those studying that of the diminishing Arctic, which often is seen as an indicator of the degree of climate change.

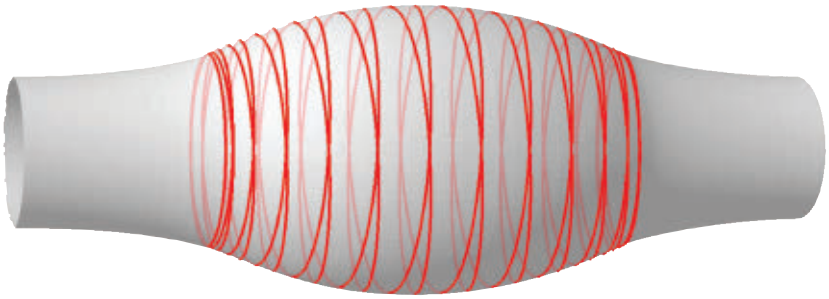
Jörg Schwartz
j.schwartz@europhotonics.com

Catching photons in a bottle

MAINZ, Germany – Physicists at Johannes Gutenberg University have developed a bottle-shaped, monolithic microresonator that captures light and tunes it to arbitrary optical frequencies. To do this, they stretched a glass fiber until it reached about half the diameter of a human hair and, with the help of a CO_2 laser, created a bulge-shaped structure.

Inside the resonator, photons with a certain frequency are trapped by continuous reflections and cannot escape; this quality is seen as offering numerous possibilities for technology and research applications. Today, microresonators perform filtering and switching functions in optical communications and sensing, and they are used as a stepping stone toward building microscopically small lasers. But researchers also see these devices as a controlled means of enhancing and studying the interaction between light and matter.

That said, there are a few issues with making good microresonators for this purpose, as professor Arno Rauschenbeutel, the lead researcher, explains. First of all, the "mechanical" design has to be small for confined interaction/mode volumes and high field densities. Similarly important is how successfully the light is held hostage, or the quality of the resonator, which requires high reflectivity at the surfaces and good stabilization. This puts mono-



The light in "bottle modes" harmonically oscillates back and forth along the resonator axis between two turning points. Stretching the shape along its axis offers tunability.

lithic devices with no moving parts in a good position; however, another important requirement is tunability – the stored light frequency's ability to interact with a specific type of atom.

This is a key shortcoming in what's been used to date, namely equatorial whispering-gallery-mode microresonators. They capture the light in a narrow ring along the equator of a circular structure via total internal reflection. While these devices offer small mode volumes and large frequency spacing between modes, tuning is difficult. Their size means that they come with a large free spectral range, and neither the temperature nor the strain dependence of the refractive index is large enough to tune across it.

Rauschenbeutel and his team have overcome this limitation by using a clever design that they have now demonstrated (and published in the July 28, 2009, issue of *Physical Review Letters*). They applied a two-step "heat and pull" process on standard glass fiber to create a microtapered fiber waist by using a focused CO_2 laser, controlled by a microscope and customized image analysis software. The desired shape is referred to as a "bottle microresonator." Somewhat similar to the motion of a charged particle stored in a magnetic bottle – i.e., a spatially varying magnetic field of similar shape – the light oscillates back and forth inside the structure between two turning points that are defined by a so-called angular momentum barrier. At those points, the particles can't move farther into the bottle neck, as they must gain energy to be fast enough for smaller radii. As a result, the light is forced into "bottle modes" and oscillates back and forth along the resonator axis between the turning points.

Because the standing waves are no longer specified by the diameter of the microresonator but also have an axial component, it turns out that tuning the resonator via stretching has become a viable option. Having access to a high-quality, tunable microresonator should facilitate new quantum electrodynamics experiments – for example, creating a quantum interface between light and atoms.

Why are those needed? "To make quantum computing work," says Rauschenbeutel. "Since superposition works against us here, photons alone do not interact with each other."

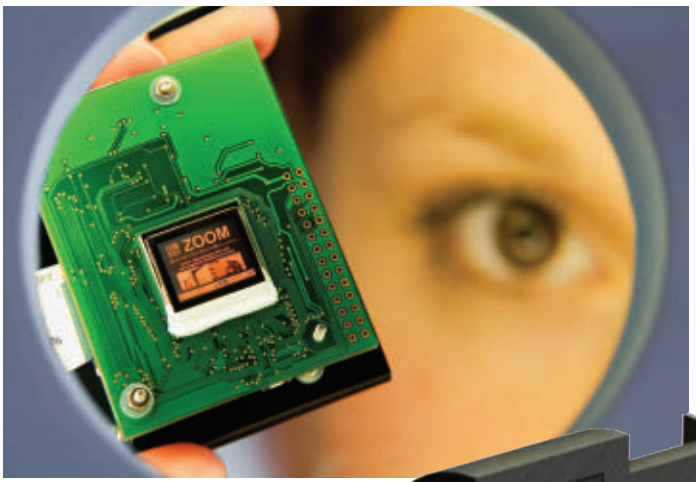
Jörg Schwartz
j.schwartz@europhotonics.com

Errata

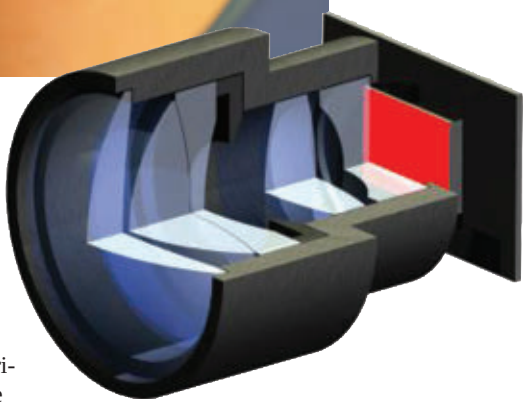
In the article titled "Meeting the Need for Speed and Precision in Optical Measurement," which appeared in the April/May issue of *EuroPhotonics*, the system offered by Trioptics GmbH of Germany that should have been mentioned in the article and that should have appeared in Figure 3 is called the ImageMaster. Incorrectly, the Trioptics system called OptiSpheric was mentioned in the article and pictured in Figure 3 on page 18. However, the figure caption does correctly identify the system shown.

In the article titled "New lasers could enable digital projectors inside mobile phones" (June/July *EuroPhotonics*, p. 14), Technical University of Berlin was omitted as a member of the research team. TU Berlin was the developer of quantum dot gain media for the European Commission's NATAL (Nano-Photonics Materials and Technologies for Multicolor High-Power Sources) project.

A screen for all places



A miniature projector would enable users to display images from their cell phones on a larger surface. Courtesy of Fraunhofer-Gesellschaft.



This OLED microdisplay could mean the end of watching videos on tiny cell phone screens. Courtesy of Uwe Vogel.

JENA/DRESDEN, Germany – Cell phones and PDAs have become more than just communication devices – they also are multimedia entertainment tools. It no longer seems unusual to view photos and video clips through them, or even to watch entire television shows and movies. However, their small screen size makes sharing the viewing experience a difficult task – either everyone crowds around the device, or it is passed around while the clip or image is displayed repeatedly. A simple, portable way to share the experience with friends and family in a larger format surely would be popular.

A team of researchers at Fraunhofer Institute for Applied Optics and Precision Engineering, in collaboration with other members of the European Union-funded HYPOLED (High-Performance OLED-Microdisplays for Mobile Multimedia HMD and Projection Applications) project, has developed a miniature projector designed for integration into cell phones and PDAs. The prototype is 2.5 cm long and 1.8 cm in diameter, does not require an additional light source and uses only a small amount of energy to operate. It has a working distance of between 300 and 500 mm, and the projection system magnifies the image by 12× to 15×.

The device employs an organic LED (OLED) display that was developed at Fraunhofer Institute for Photonic Microsystems in Dresden to produce the images. It projects monochrome images with a microdisplay brightness of 10,000 cd/sq m, and color images at about half that brightness.

Stefan Riehemann, leader of the research group, said this level of brightness can be put into perspective by realizing that a typical computer monitor produces between 150 and 300 cd/sq m.

The image produced by the OLED display is projected through a series of five lenses onto any chosen flat surface. The prototype uses glass lenses, but investigators are trying to create plastic lenses that could be easily mass-produced to perform the same function. This change would make commercialization of the product more feasible.

But there is still work to be done in refining the concept before releasing the product onto the market. Uwe Vogel of the Fraunhofer Institute for Photonic Microsystems and coordinator of HYPOLED, said, “Very high brightness OLED microdisplay[s] can just be reached by monochrome emitters, so full color is more demanding.”

Rebecca C. Jernigan
rebecca.jernigan@laurin.com

Shown is STMicroelectronics' VD6725 ultrasmall imaging single-chip camera sensor for cell phones.

Imaging: The big picture

From cell phones to digital cameras, consumer applications account for the lion's share of the image sensor market.

BY MARIE FREEBODY
EUROPEAN CORRESPONDENT

The image sensor market has enjoyed phenomenal growth in recent years. According to market analyst Tom Hausken of Strategies Unlimited in Mountain View, Calif., it reached $7.2 billion in 2008 after several years of strong double-digit growth. But in these dark economic times, few markets are immune from the financial fallout, and the image sensor market is no exception. In fact, this year, the formerly thriving market is expected to drop 11 percent.

However, the good news is that, compared with many other markets, it is expected to recover quickly but will be replaced by a more cyclical behavior.

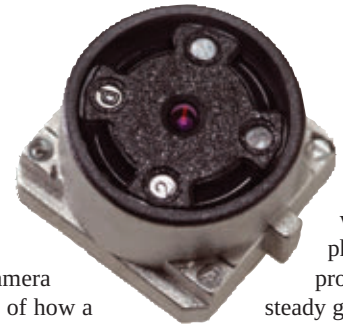
Consumer applications have dominated overall sales in the image sensor market for many years. Today, this includes cameras in cell phones, digital cameras, webcams, security cameras and, to a lesser extent, automotive.

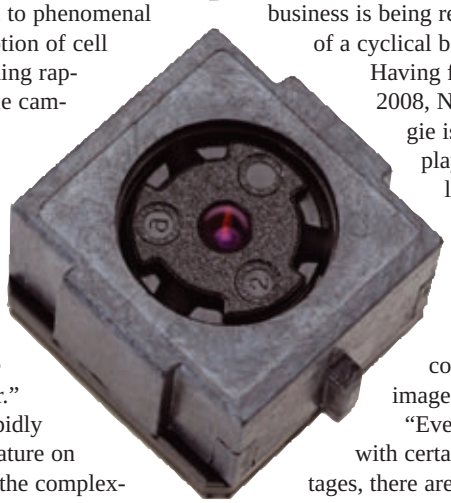
The camera phone segment is now so large – about 40 percent of the market – that whatever happens there seems to dwarf most of the other segments. The webcam is important because, as with camera phones, it has become a standard feature in a common

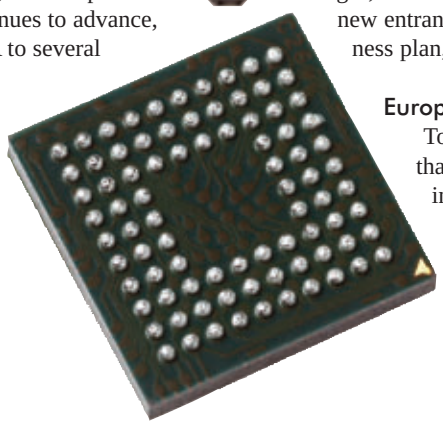
product: the personal computer. Although the automotive market has great potential, it is part of a much slower moving process.

Hausken said that the camera phone is a classic example of how a perfect convergence led to phenomenal growth. "First, the adoption of cell phones was still expanding rapidly worldwide when the camera phone emerged as a feature earlier this decade. Second, consumers found the feature so appealing that the take-up rate grew, even though it didn't bring the revenue that the cell phone carriers were hoping for."

Although cameras rapidly become a "checkoff" feature on cell phones worldwide, the complexity of the camera continues to advance, progressing from VGA to several megapixels and, at the same time, improving image processing and shrinking pixel size.







STMicroelectronics' STv0986 advanced image signal processor was designed for high-end mobile applications.

Surviving the downturn

When you consider the huge consumer demand for camera phones, digital cameras, webcams and security cameras, it is no surprise that the image sensor market has thrived. But with consumer spending down, how are the suppliers reacting?

One wafer-level packaging provider, Nemotek Technologie SA of Rabat, Morocco, is optimistic. "Camera penetration in cell phones is growing as demand from emerging markets/countries grows," said CEO Jacky Perdrigeat. "What's more, requests for secondary cameras on the front face of cell phones for video applications are also growing."

With the combination of increased demand and lower manufacturing costs, Perdrigeat predicts a compound average growth rate of between 15 and 20 percent in volume in the next five years for cameras using wafer-level technology in portable applications.

But Hausken anticipates a new chapter in the story. "Cell phone adoption is becoming saturated worldwide, and the camera phone feature itself is approaching some stability. The steady growth in the image sensor business is being replaced with more of a cyclical behavior."

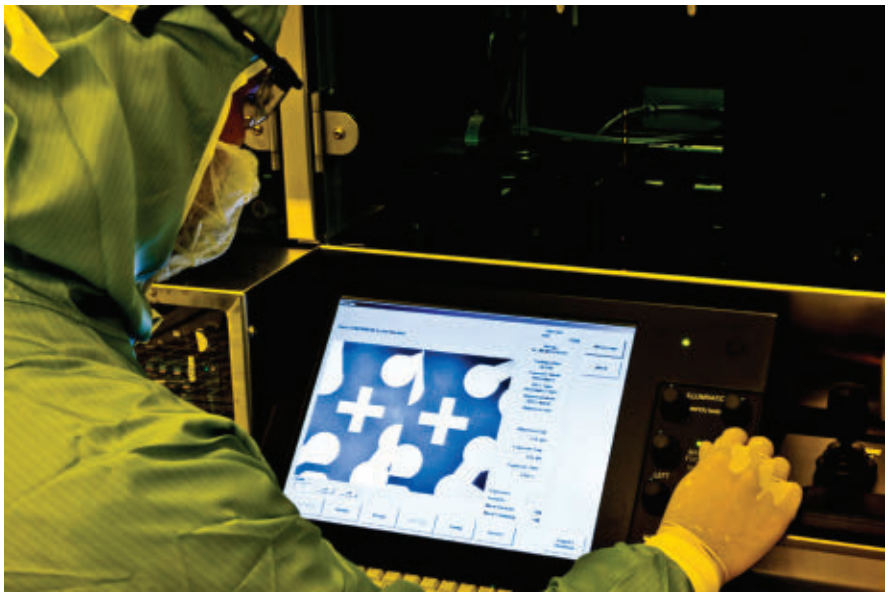
Having formed in May 2008, Nemotek Technologie is a relatively new player in the field and licenses its technology from Tessera Inc. of San Jose, Calif. This kind of thinking is what Hausken believes continues to drive the image sensor business. "Even in a large market with certain volume advantages, there are opportunities for new entrants with the right business plan," he said.

European niche

Today there are more than 50 companies in the image sensor market, a number that has remained steady for six years. Samsung of Seoul, South Korea; OmniVision of Santa Clara, Calif.; Aptina Imaging Corp., a subsidiary created by Micron Technology Inc. of Boise, Idaho; and STMicroelectronics NV of Geneva are arguably the leading players in the camera phone market.

STMicroelectronics is the only European company that competes against the top firms. This comes from its strengths in commodity electronics and in making analog chips as well as in its working with special customer groups such as handset maker Nokia Corp. of Espoo, Finland.

"STMicroelectronics has developed a unique tool set, including CMOS image sensor process and design; optical package and camera module design; optical design and image processing algorithms; as well as expertise in large volume production," said Jean-Luc Jaffard, Imaging Div. deputy general manager and future technology director at STMicroelectronics.



Nemotek Technologie SA's state-of-the-art class 10 cleanroom, located in the Rabat Technopolis Park, a hub for technology development in Morocco, serves as the center for the design and manufacture of wafer-level packaging (WLP), wafer-level optics (WLO) and wafer-level cameras (WLC) to be used in camera phones and other portable devices.

"The combination of all these elements allows us to master the complete imaging chain and, therefore, offer more optimized products to the market."

But with so many of the leading handset makers based in Asia, is Europe struggling to hold its own? Hausken believes that, although Europe does not dominate the market, it has carved out an important niche for itself. "Europe is strong in high-end applications of electronic imaging, such as in health care and security. So, while it doesn't have a regional name in image sensor manufacturing, Europe has an important place in certain high-value points in the supply chain, which is a good place to be."

Japanese image sensor makers, on the other hand, are falling behind, in part because of their relative weakness in CMOS sensors and because of the weakness of their internal customers. Although Japanese companies are not selling as well worldwide in the handset business, strong global players include Samsung; LG Electronics Inc., also of Seoul; Nokia; and Motorola Corp. of Schaumburg, Ill.

Looking ahead

With the image sensor market now 10 times the size it was when Strategies Unlimited first started tracking it in 1997, Hausken believes that it is entering a brand new phase. "Swings in the end market, like camera phones and digital cameras, will swing image sensors with it, and it becomes more of a market share game than ever. The very steep growth phase has ended, and there will be more emphasis on seizing market share now that the pie is not growing as fast."

There are a lot of specific opportunities in this multibillion dollar business. The most obvious up-and-coming segment is in automotive. Advocates like to point out that imaging can be used in many places in vehicles, for both human and machine vision. Night vision and blind spot detection are just two examples.

"The challenge is that application development is very slow in the automotive industry, and it takes a special kind of company to supply to it," Hausken said. "A company with deep enough pockets to wait it out as well as the ability to work with automotive parts suppliers to meet their stringent goals."

Although electronic imaging may appear elementary compared with some of the new optical technologies on the horizon, such as optical flow, computational optics and image processing, Hausken believes that it has a firm place in our future.

"New technologies won't turn the existing designs upside-down, no matter how elegant they may be from a technical point of view," he said. "Rather, they will enter first at the margins, such as in scientific or highly specialized applications. Meanwhile, the conventional image sensor remains practical, if not optimum, for the vast range of applications for the indefinite future."

mariefreebody@physics.org

ECOPhotonics

Make green energy, not war

A solar farm under construction near the towns of Lieberose and Turnow-Preilack, near Cottbus in Germany's federal state of Brandenburg, has become the world's second largest solar power plant– and Germany's biggest– with the installation of the 560,000th solar panel of the project by German Infrastructure Minister Wolfgang Tiefensee and Brandenburg's Minister President Matthias Platzeck.

The utility-scale project, which was realized by Wörrstadt, Germany-based juwi Group and First Solar Inc., based in Tempe, Ariz., has a total investment volume of more than €160 million and, upon completion, will deliver an output of about 53 MW. It covers an impressive area of 162 hectares, corresponding to the size of more than 210 football pitches. The farm is scheduled to be fully operational by the end of this year. Upon completion, about 700,000 thin-film modules, predominantly from First Solar's nearby Frankfurt/Oder factory, will produce enough electricity to meet the power needs of about 15,000 households, saving approximately 35,000 tons of carbon dioxide emissions per year.

The land it is being built on has its own history. It used to be the largest military training site of the Soviet army in Eastern Germany, including its center for chemical agents – many of which, along with other ammunition, were left behind when the Red Army left in 1992. When operational, the solar farm not only will pay for itself and generate green electricity but also will be profitable enough to pay an attractive lease to the state of Brandenburg, the landowner. This money will go into restoration of the entire site, including the removal of metal and soil contaminated by leftover grenades, shrapnel and munitions.

It looks like photovoltaic electricity generation has become so profitable that it can pay its bill in full and still compete with other methods of power generation – well, not quite. Although continuous technological progress has improved the efficiency of solar cells and prices have come down as a result of increasing volumes and cheaper production methods, another major reason why the business model works is the very favorable subsidy of solar electricity in Germany. Unlike in other countries, there is no cap on a funding scheme that guarantees anyone feeding electricity generated by renewable sources into the grid a certain price – which is usually a multiple of the actual market price. When finished, the solar farm is expected to be sold to an investor, who will be paid back in no more than 15 years. After the end of the 20-year lease period, the solar farm can be removed, the cells recycled and the land restored to its natural state: being green.

Jörg Schwartz
j.schwartz@europhotonics.com

A utility-scale solar farm is being built near Lieberose in Germany on a former military training site, giving the land a new use and helping clear it of debris and contamination.

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PRODUCT PREVIEW

▼LED Backlighting

Two white versions of the Oslon LX LED from Osram Opto Semiconductors are now available for backlighting LCD panels. Measuring 3 × 3 × 1.6 mm, the 1-W LED is suitable for side injection into lightguides with thicknesses of 2 to 4 mm. Available for two color spaces, the multiwhite version covers 100% of the sRGB color space and has a typical light output of 75 lm, while the ultrawhite version covers 80% of the color space, with a typical light output of 90 lm. Its lens is optimized for maximum light extraction, and its beam characteristic ensures a high injection efficiency of almost 80%.

Osram Opto Semiconductors
support@osram-os.com

Laser Stacks ▲

Dilas has announced high-power vertical diode laser stacked arrays available at 915, 940 and 980 nm with 150-W output power, continuous-wave (CW) per bar. The water-cooled stacks are available with up to 30 stacked bars with collimation for fast- and slow-axis configurations. They feature low thermal resistance CW and quasi-CW operation, a spectral width of <6 nm and a slope efficiency per bar of >1.08 W/A. The stacks are suitable for diode pumped solid-state laser, materials processing, defense and medical applications.

Dilas
sales@dilas.com

All-in-One Microscope ▼

Olympus Life Science Europa GmbH now offers the all-in-one FSX100 fluorescence and FluoView FV10i confocal laser scanning microscope systems for creating high-end research images. Designed to remove the complex steps involved in setting up and using advanced fluorescence and confocal microscopes, the systems ensure that users can concentrate on the images and data. All components are motorized and controlled via software, with automation for focusing, exposure, fluorescence wavelength selection and coverslip thickness correction. The self-contained units deliver advanced imaging processes, including time lapses, Z-stacks and multiposition image capture, that combine to provide multidimensional imaging.

Olympus
microscopy@olympus-europa.com

▼Polarization Microscopy

The Axio Imager 2 high-resolution microscope system from Carl Zeiss MicroImaging GmbH provides all contrast and measuring techniques used in polarization microscopy. Featuring touchscreen operation with automated functions and an encoded nosepiece, the system comprises nine stand versions and includes upgrades such as the ability to combine reflected and transmitted light. Among its applications are geology, metallography, petrography and forensic science.

Carl Zeiss
g.vogel@zeiss.com

▲ Beam Combiners

A line of dichroic laser beam combiners has been introduced by Edmund Optics Inc. to combine or separate multiple laser beams at a 45° angle of incidence. The combiners feature reflection of >98% and transmission of >95%, while yielding low loss. They are polarization-insensitive and available at six cutoff wavelengths, making them suitable for combining or separating lasers between 375 and 785 nm. Constructed from low-autofluorescence substrates with dense, ultradurable coatings, they are suitable for multilaser fluorescence imaging and measurement in medical, laboratory and industrial settings.

Edmund Optics
medmund@edmundoptics.com

◀ Vacuum Pump

Edwards has announced the iXL line of dry vacuum pumps for solar cell and flat panel display manufacturing. The iXL 500, the first member of the family, is a compact and efficient pump designed for load-lock applications where high gas throughputs and fast pump downtimes are crucial. It offers a pumping speed of 1800 m^3/h, consuming 7 kW of power. Its low inertia booster shortens load-lock evacuation times with faster, more efficient pumping at higher inlet pressures. The company offers multipump systemization for multiple pumps on a single chamber. It features intelligent monitoring and is fully compatible with the company's FabWorks network system.

Edwards
info@edwardsvacuum.com

Alignment Detection

Applied Scintillation Technologies Ltd. has announced several additions to its Visualize range of credit card-style and disk products for profile measurement and component alignment of laser and laser diode modules. The new products include a dedicated card for 1064-nm operation with Nd:YAG lasers, a card that fills the gap between 1600 and 2000 nm, and cards for specific wavelengths between 100 and 400 nm. Clear card versions on which the target area is imprinted also will be available.

Applied Scintillation Technologies
s_quinn@appscintech.com

Laser Bar

Jenoptik Laserdiode GmbH has released laser bar JDL-BAB-30-19-808-TE-20-0.6 for 808-nm applications. Featuring a resonator length of 0.6 mm and width of 9.8 mm, the bar has an optical output power of 20 W with a pulse wavelength of 805 nm and a spectral bandwidth of 2 nm FWHM. Designed to pump solid-state lasers with low power, it is suitable for medical uses, including hair removal, and for printing, defense and security applications.

Jenoptik
jold@jenoptik.com

Ruby Laser

Klastech Karpushko Laser Technologies GmbH has launched the Crescendo continuous-wave diode-pumped solid-state ruby laser. Besides the company's Denicafc double-enhanced laser technology, the laser features a new proprietary method for pumping the ruby crystal. Available in 100- and 150-mW versions, it produces a pitch-perfect single-longitudinal-frequency linewidth of <1 MHz with a coherence length greater than 100 m. It exhibits near-perfect Gaussian beam performance coupled with <10 µrad/°C beam pointing stability and noise down to <0.05% rms.

Klastech
r.brueggemann@klastech.de

Rod Fiber

NKT Photonics A/S has released a new version of its Crystal Fibre series of double-clad rod-type fibers. The DC-200-85-Yb-ROD, developed using patented air-clad technology, features low photodarkening and is used in output stages of amplifier chains for pulsed laser amplification. It has a 65-µm mode field diameter ytterbium core, and its 200-µm pump core diameter accepts light at numerical aperture values up to 0.54 for pumping at 915 to 976 nm with absorption of 30 dB/m at 976 nm. Designed for OEM use, the fibre can be used also with existing fibre amplifiers or as a replacement for traditional crystalline rods. It is available in various forms, including bare fibre, end-sealed, cleaved or end-capped.

NKT Photonics
fiber_sales@nktphotonics.com

Industrial Laser Modules

Photonic Products Ltd. has unveiled a range of variable focus industrial laser diode modules that withstand harsh conditions and demanding applications. Designed to be a complete OEM laser solution for heavy-duty manufacturing processes including micromachining, marking, cutting, drilling, welding, forming and soldering, the devices feature boresight accuracy of <0.25˚, wavelengths from 635 to 830 nm, output power from 5 to 30 mW, straight-line precision, adjustable focus and 45°, 60° or 90° full fan-angle line output. A scratch-resistant sapphire window protects the lens.

Photonic Products
sales@photonic-products.com

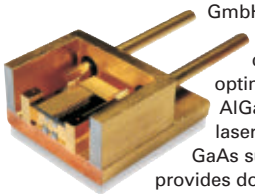
Radiation Controller

The Radikon from Scitec Instruments Ltd. provides control depending on the value generated by a detector, such as a radiation or pressure sensor. If the value drops below a set point, a relay that can be used to switch a valve or an alarm buzzer is activated. The device can read a variety of input signals, and it outputs 0 to 10 V. The controller also is suitable for industrial developers who must match it to different output signals and for developers or manufacturers of small production runs.

Scitec Instruments
sales@scitec.uk.com

Industrial Laser Chip

The LU1064U170 manufactured by Lumics GmbH is a laser chip on a U-mount, containing an optimized GaInAs/AlGaAs quantum well laser structure on a GaAs substrate. The chip provides double-emitter 400-µm pitch and operates at 1064 nm. Mounted on a copper base, it is electrically isolated.



Each chip is individually serialized for traceability and is shipped with a specified set of test data. It is suitable for solid-state fibre laser pumping, illumination, plastics welding, marking and printing applications.

Lumics
sales4@lumics.com

3-D Software

Hitachi High-Technologies Corp. has introduced a software option for its TM-1000 tabletop microscope. The 3DView analysis package enables production, manipulation and recording of three-dimensional visualizations of a specimen and makes comprehensive measurements of 3-D surface characteristics without the need for specimen tilt. Measurements are obtained using a section profile, and the range of measurements that can be made with the software include height, surface area and roughness measurements. Mouse-controlled zoom and rotation of the image are provided, and animations of image manipulations can be recorded.

Hitachi
michael.dixon@hht-eu.com

10-mW Green Laser

Sanyo Electric Co. Ltd. has added a low-noise laser module to its DLX range of 532-nm diode-pumped solid-state lasers. The DLX-9756-11 green laser module features 10-mW output power and 0.5% rms noise level. Its integrated thermoelectric cooling enables stable operation over a range of temperature levels between 0 and 50 °C, providing constant optical performance and wavelength precision for applications including laser marking, leveling, patient alignment, bioanalysis, flow cytometry, biomedicine and instrumentation.

Sanyo Electric
info@photonic-products.com

Fiber Laser

SPI Lasers UK Ltd.'s redEnergy is a 40-W pulsed continuous-wave fiber laser that provides >20-kW peak power, 25 selectable waveforms with a full power range of 30 to 500 kHz, a reduced power range of 1 to 30 kHz and output stability of 5%. Beam diameter is 3.1 mm, and peak emission wavelength is 1062 ±3 nm. The instrument is suitable for use in applications including black anneal color marking on stainless steel, paint layer removal on mobile phone keypads and marking integrated circuits. Users can tune peak power, pulse energy and pulse frequency. Other applications include solar cell and silicon processing, ablation, scribing, thin-film cutting and dual-head marking. The high-speed device is bitmap-marking compatible.

SPI Lasers
pr@spilasers.com

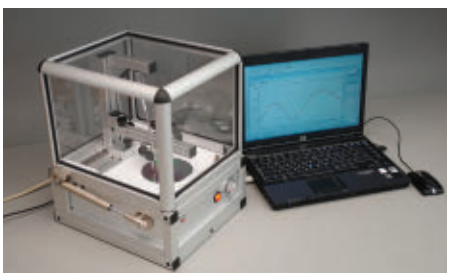
Dimensional Measurement

Stil SA's Stil Duo sensor provides two optical principles for simultaneous dimensional measurement: the "confocal chromatic" and the "white light spectral interferometry." With a

wide range of optical pens, the former's measurement dynamics range from 20 µm to 25 mm and can be performed on any type of material, including opaque, transparent, reflective and diffusing. The spectral interferometry process allows access to subnanometric resolutions for topography measurements that can be performed within a scale of up to 150 µm. The sensor is insensitive to vibrations.

STIL
contact@stilsa.com

Real-Time Measurement



ThetaMetrisis has launched FR-tools, turnkey solutions for real-time measurement and characterization of stacks of transparent and semiabsorbing thin and thick films. Providing reflectance, absorbance and transmittance measurements at the point of interest, they are based on white-light reflectance spectroscopy. Shipped ready for measurement, they include a light source, a spectrometer, a reflectance probe, optical fibre, a sample stage and Windows software.

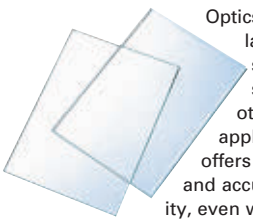
ThetaMetrisis
info@thetametrisis.com

PRODUCT PREVIEW

CW Fiber Laser

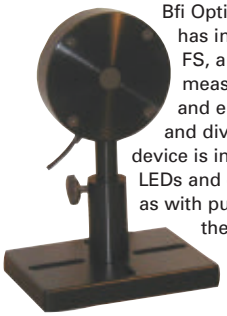
The Laser Division of GSI Group Ltd. has enhanced its JK line of fiber lasers with the introduction of the 400-W continuous-wave JK400FL. With double the power of other models in the series, the laser processes faster and can cut and weld thicker materials. It features typical peak-to-peak long-term output power stability of ±1.5%, a linewidth of <5 nm, and a minimum rise and fall time of 5 µs. Unpolarized and water-cooled, it also offers a maximum modulation frequency of 50 kHz and unlimited pulse shapes, ramping and process cycles.
GSI Group
sales.laserdivision@gsig.com

Solar Filter



Optics Balzers AG has launched the SoFi solar filter for sun simulators and other photovoltaic applications. The filter offers long-term stability and accurate reproducibility, even when manufactured in large volumes, and customer-specific nonstandard spectral characteristics can be accommodated. It increases the performance of solar simulators by converting the radiation of a technical light source into a spectral distribution equivalent to that of sunlight. It also delivers 400 °C temperature stability, provides conversion independent of glass thickness and is adaptable to customer-specific light sources and various solar spectra.
Optics Balzers
info@opticsbalzers.com

Low-Energy Sensor



Bfi Optilas International SAS has introduced the 3A-P-FS, a sensor designed to measure very low power and energy light sources and divergent beams. The device is intended for use with LEDs and diode lasers, as well as with pulsed or CW lasers in the 0.19- to 20-µm range. It features a 12-mm numerical aperture and a fused silica window to prevent air currents and long-wavelength background heat from distorting the measurements. Optical power can be measured from 60 µW to 3 W, and energy from 20 µJ to 2 J.
Bfi Optilas
info@bfioptilas.com

Data Transfer

The PALM VisDat (virtual slide data transfer) module from Carl Zeiss Ltd. works with the company's PALM RoboSoftware, enabling users to connect molecular and digital pathology. Useful in molecular biology, medicine and pathology, the module makes it possible to transfer information about marked areas on digitized tissue sections to the company's MicroBeam systems for microdissection. The digital images can be accessed via the Internet, where they can be shared, discussed and marked in up to four colors.

Carl Zeiss
micro@zeiss.co.uk

Measurement Technology

Docter Optics GmbH has combined stripe projection technology with software for the evaluation and use of measurement data to speed up the prototype to production process. The technique, which can be used for optical components including spheres, light pipes and prisms, measures prototype

optical components at 1 million points with a resolution up to 1 µm. The company says that this streamlines and speeds up the process and should also improve quality.

Docter Optics
sales@docteroptics.com

Multiaxis Controller

PI (Physik Instrumente) LP has unveiled the E-616 multiaxis controller for piezo-based steering and stabilization mirror platforms. The device is available in closed- and open-loop versions as well as benchtop and OEM models. It offers three integrated amplifiers that provide up to 10 W of peak power. The controller also features front and rear panel connections: a 25-pin sub-D piezo and sensor connector, and a 32-pin connector, respectively.

PI
photonics@pi-usa.us

Fiber Splicing

Vytran has released the PSX-3000, a portable fiber splicing workstation for use in the manufacture of fiber lasers. The system can be set up as a simple splicer or as an integrated system with a combination of cleave, clean, splice and recoat capabilities. It uses graphite filament fusion technology to provide minimal heating in high-power applications and better control of the thermal process. It offers a Windows-based laptop interface for process control and for recording splicing data.

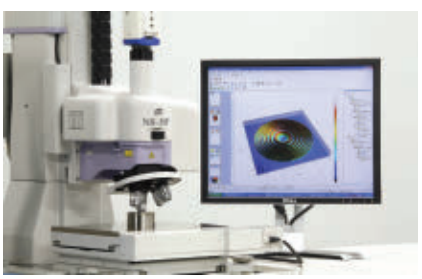
Vytran
salesinfo@ams.de

LED Spot

IB/E Optics has introduced a series of LED illumination spots ranging in wavelength from 590 nm (amber) to 5500 K (white). Depending on the wavelength, the device's DC current constant maximum is 1000 or 1540 mA, and its pulsed current constant maximum is 1000 or 2200 mA. Designed for use in industrial environments, the LEDs are available with a variety of attachments, including a C-mount adapter with or without a line target, a fiber coupler and a turnable polarizing filter. In addition to amber and white, the LEDs are offered in red-orange, red, royal blue, blue, cyan and green.

IB/E Optics
ibe@ibe-optics.com

Surface Analysis



Mitaka Kohki Co. Ltd. and Digital Surf SARL have announced that the MitakaMap surface analysis software, based on the latter company's Mountains Technology, will be supplied with Mitaka's NH series laser probe 3-D measuring instruments. The software creates a surface analysis frame by frame in a multilanguage desktop publishing environment. It provides subsurface analysis and analysis of 3-D surface evolution with respect to a fourth dimension such as time, temperature, pressure or magnetic field.

Mitaka Kohki
sales@mitakakohki.co.jp

Laser Diodes

The ML5xx71 and ML5xx54 series laser diodes from Mitsubishi Electric Europe BV emit high-intensity red light at 638 nm. They provide output power up to 300 mW, or 110 mW in fundamental mode with continuous wave operation. The ML5xx71 is designed for use in illumination-based projectors, while the ML5xx54 has applications in holographic and laser-scanning projectors.

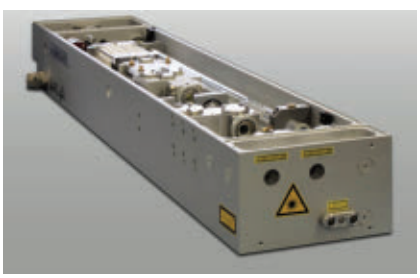
Mitsubishi Electric
semis.info@meg.mee.com

CCD Camera

Hamamatsu Photonics UK Ltd. offers the C10990 series OEM CCD board-level cameras suitable for low-light-level ultraviolet imaging, Raman spectrometry, semiconductor inspection, DNA analysis, biomedical instrumentation, fluorescence spectroscopy and in-line industrial inspection. They feature high sensitivity and resolution, and they include a 1.3 million-pixel ⅔-in. progressive-scan interline front-illuminated CCD, circuitry and a lens mount, all on one board. They also feature low noise, antiblooming, 12-bit digital output and a pixel clock rate of 12.5 MHz. They connect to a USB interface and an external power supply. Sample software is available.

Hamamatsu
europe@hamamatsu.com

SLM Laser



The Spitlight Passiv SLM flashlamp-pumped single-longitudinal-mode (SLM) laser with a passive Q-switch and double amplifier transition is now available from InnoLas Laser GmbH. The laser's central element is a phase-conjugated mirror that enables quality loss-free double amplifier transition. Its flattop beam profile makes its beam source suitable for all applications that require high quality and focus. It also is suitable for holography applications, including pulse compression.

InnoLas
kelnberger@innolas.com

Ethernet Cameras

A series of Gigabit Ethernet cameras has been released by The Imaging Source. Available in 27 models, the cameras ship in robust industrial casing with a C/CS lens mount and optionally with a trigger and digital input/outputs. The software support and integration into existing applications make programmers and end-users comfortable. Drivers for LabView, Halcon, DirectX, TWAIN and WDM models are included. All camera parameters and settings can be set via the shipped software, and a variety of automatic modes are available to guarantee optimal image quality in varying light conditions. The color, monochrome and Bayer models are available in VGA, XGA and SXGA resolutions.

The Imaging Source
info@theimagingsource.com

Industrial Cameras

Basler Vision Technologies GmbH will unveil a variety of new cameras at Vision 2009 in Stuttgart. The ace series industrial Gigabit Ethernet cameras consist of four CCD models in monochrome and color, each with a small footprint and Power over Ethernet. The aviator area-scan family has gained two models that produce 2-megapixel resolution, operate at up to 65 fps and include a GenICam-compliant C/C++ programming API.

Basler Vision Technologies
vc.sales@baslerweb.com

CO_2 Laser

The Diamond E-150 slab discharge CO_2 laser from Coherent Inc. has applications in the processing of textiles, organic materials, plastics and thin metals. At a 1-kHz repetition rate, the device delivers 150 W at a wavelength of 10.6 µm. Its beam quality is M^2 <1.2, and its output stability is ±<7%. The laser is based on the company's G-Series platform and comes with a 24-month warranty.

Coherent
tech.sales@coherent.com

Slide Scanner

The Leica SCN400 slide scanner from Leica Microsystems GmbH offers an alternative to the microscope for examining histological samples in pathology, research and teaching applications. The device's custom-tailored high-resolution lens ensures that the image on the screen, including its color fidelity, is as good as a microscope's. The scanner can load and scan four specimens at a time at a rate of 100 s per 15 × 15 mm at 20× magnification. Users can load new samples or remove finished scans without interrupting the process. Once a sample has been digitized, it can be retrieved, processed and made available to a defined group of database users.

Leica
blagovesta.wegner@leica-microsystems.com

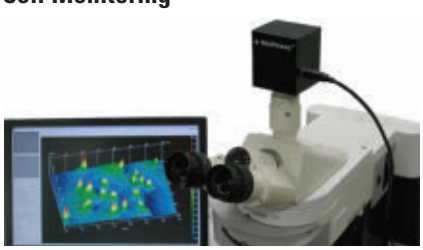
GigE Cameras

Baumer Ltd. has released the TXG Multi-I/O cameras, which feature input/output ports with customizable pulse width-modulated signals. The ports provide a direct connection between the camera and the illumination source, eliminating the need for PC-controlled lighting. Each port provides a current of 100 mA. The cameras are available with resolutions ranging from VGA to 5 megapixels, and with frame rates of up to 90 fps.
Baumer Optronic
sales@baumeroptronic.com

Machine Vision

MVTec Software GmbH has enhanced its Halcon 9.0 machine vision software with the addition of the 9.0.1 release. The software's usability and speed have been improved, and it can now process images as large as 32 × 32 k pixels. The new release provides a silent installer, enabling the installation of the runtime version under Windows without user interaction. It also adds a 3-D visualization mode suitable for interactively inspecting distance images.
MVTec
info@mvtec.com

Cell Monitoring

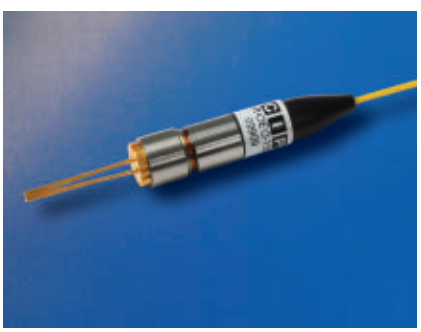


PhaseView has announced the BioPhase imaging device for in situ stain-free cell monitoring. It can simultaneously capture intensity and phase data at high resolution, providing qualitative cell imaging and quantitative measurements. The camera is compatible with any optical microscope that has a video port and bright-field objectives. Fluorescence, confocal or total internal reflection fluorescence images can be acquired using the same objective.
PhaseView
contact@phaseview.com

Digital Interface

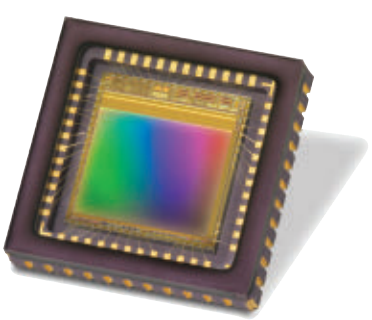
BMC Messsysteme GmbH's meM-INC digital interface for incremental encoders enables signal pulses to be counted and frequencies to be measured via the USB interface. The device can connect up to three encoders and can sample frequencies up to 64 kHz, making it suitable for measuring the speed of rotating shafts or machines. Three selectable gates are provided, allowing the user to select the size of frequency changes to be detected.
BMC Messsysteme
info@bmcm.de

Reflective SOA



CIP Technologies has added the SOA-R-OEC-1550-CO to its family of semiconductor optical amplifiers (SOAs). The high signal gain reflective SOA is coaxially packaged in a pigtailed TO-56 can and can operate uncooled over an extended temperature range of –10 to 70 °C. The device uses a proprietary buried InP heterostructure design and offers more than 20 dB of signal gain across the C-band.
CIP Technologies
info@ciphotonics.com

CMOS Sensor



The EV76C560 1.3-megapixel CMOS image sensor from e2v is suitable for use in industrial machine vision, bar-code scanning, surveillance and other imaging applications. It features "true global" and "rolling" shutter modes, image analysis algorithms and multitasking video applications. The 1280 × 1024

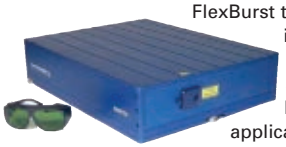
imager comprises 5.3-µm pixels and provides global shuttering of 3000:1. It outputs full-resolution images in 10-bit parallel format at 60 fps.
e2v
sylvie.mattei@e2v.com

Laser Line Generator

The Lasiris Powerline laser from StockerYale Inc. is a line generator developed for industrial machine vision and scientific applications. The thermoelectrically cooled device emits uniform laser lines at powers up to 2 W at 810 nm and 500 mW at 670 nm. It can be operated in environments with temperatures ranging from –20 to 55 °C, and it is protected against overvoltage, reverse polarity of the power supply, overtemperature and electrostatic discharge.
StockerYale
lasers@stockeryale.com

Burst Generation

Time-Bandwidth Products has introduced the FlexBurst technology for its 10-W Duetto and 50-W Fuego lasers. With applications in picosecond micromachining, the technique enables the generation of bursts with full user control of the pulse energy distribution. The repetition rate of the bursts can be set in the range of 50 kHz to multimegahertz, with burst energies of more than 200 µJ.



Time-Bandwidth Products
info@tbwp.com

Electronic Testing

Seica SpA has released the PTE-100, a portable break-out box designed to provide troubleshooting for electronic systems. The device combines the typical features of an automatic test system, including voltage, current and waveform generators, amperometers, frequency meters and oscilloscopes. Equipped with a mid-range power relay matrix of 500 V at 2 A, it offers switching and interrupt functions for up to 256 input/output channels. It is suitable for identifying and diagnosing in-field faults aboard helicopters, trains and planes.
Seica
sigillo@seicausa.com

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Bucks, HP 11 1 BJ UK
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penny.pretty@photonics.com

David Round, Advertising Associate
19 Pine Ridge, Carshalton
Surrey SM5 4QQ, UK
Phone: +44 208 773 9944
Fax: +44 208 181 6178
Email: david.round@photonics.com

USA
Timothy A. Dupree, Regional Manager
Phone: +1 413 4990514
Fax: +1 413 4423180
tim.dupree@photonics.com

Rebecca L. Pontier, Regional Manager
Phone: +1 413 4990514
Fax: +1 413 4423180
becky.pontier@photonics.com

Joanne C. Gagnon, Advertising Associate
Phone: +1 413 4990514
Fax: +1 413 4423180
joanne.gagnon@photonics.com

China
Hans Zhong
Phone: +86 755 2157 3066
Fax: +86 755 2872 6973
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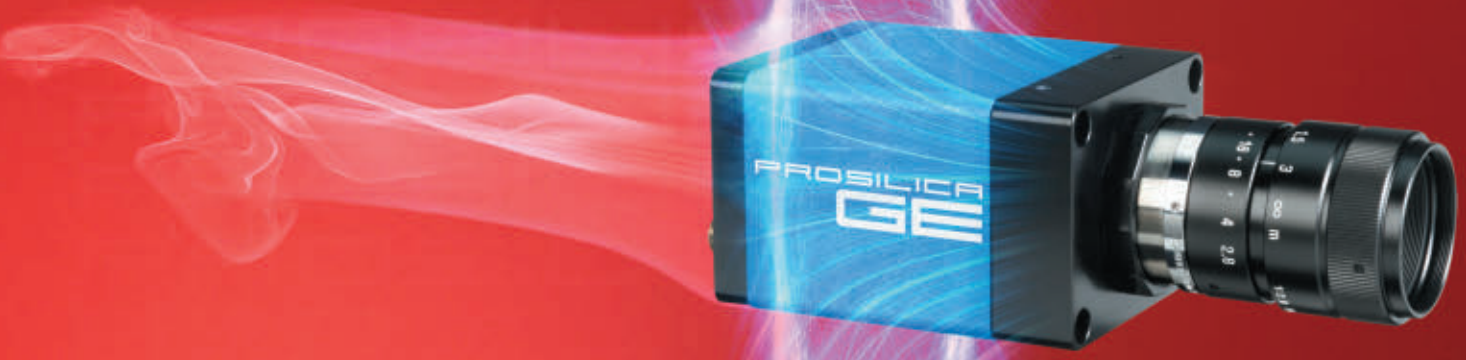

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GreenLight

Making energy personal

BY ANNE L. FISCHER
SENIOR EDITOR

A plan sketched out on the back of a paper placemat may one day result in portable, personal power.

It all began when Arunas A. Chesonis invited MIT professor Daniel G. Nocera to lunch and asked him what he would do with $10 million from the Chesonis Family Foundation – which funds renewable energy projects – to address the world's energy needs. The response Nocera outlined resulted in The Solar Revolution Project, which was launched in April 2008 and now includes at least 30 researchers working on myriad solar and energy storage projects.

One project involves a process similar to photosynthesis in that it stores solar energy in the form of fuel cells. It has been about a year since Nocera announced a major breakthrough in the work: the discovery of a catalyst that can convert water to oxygen gas. (A catalyst for hydrogen gas existed previously.)

Now that work has taken another giant step. The process uses the sun's energy to split water into hydrogen and oxygen gases, which can be recombined inside a fuel cell to create energy. In photosynthesis, light is captured and converted into a spatially separated single electron-hole pair. Nature's method and Nocera's both split water into oxygen the same way; the major difference is in how hydrogen is made. Last year, when Nocera's first breakthrough was reported, the researchers were using platinum, a fairly expensive element. Since then, they have replaced the platinum with a cheap cobalt alloy.

Plain water

They also have discovered that they can use just plain water – or even wastewater – with their cobalt catalyst and that, furthermore, the catalyst is self-healing. What that means is that, as in the process of photosynthesis, some of the catalyst naturally falls apart and is reconstructed from solar energy.

Nocera believes that this method has great potential for providing energy in places far off the grid, such as in poor villages in Africa. It would work by feeding surplus energy from a photovoltaic (PV) module into a system with the water-splitting catalyst to generate hydrogen and oxygen. When the sun wasn't out and the PV module wasn't generating energy, the stored hydrogen and oxygen could be recombined in a fuel cell to provide the electricity needed to power a home, cook food, run water-purifying systems and more.

In fact, Nocera said, the tiny energy station could draw water from the sea or a natural river stream and output fresh drinking water. Or it could draw from disease-ridden wastewater "and give pure water back."

Daniel G. Nocera's group at MIT uses the sun's energy to split hydrogen and oxygen from any kind of water, using a cheap metal alloy as a catalyst. Photo by Donna Coveney, MIT.

Potential applications also exist in developed areas of the globe, he noted, such as for various medical uses – "anywhere you'd want hydrogen and oxygen in a very concentrated way."

The bottom line is that this personal solar energy storage method will provide a few hundred watts of useful, clean energy very inexpensively, he said.

anne.fischer@laurin.com

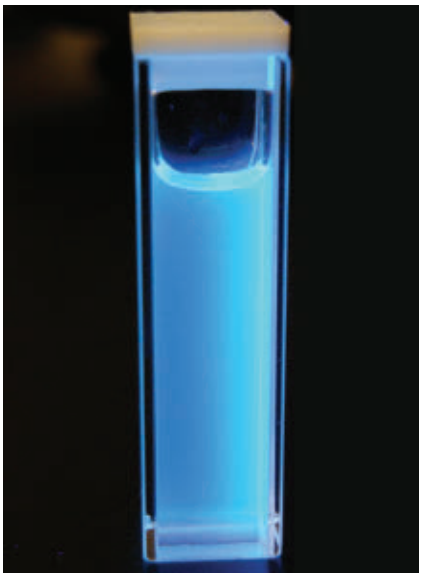
Blue light and carbon capture with MgO

Before Jeffrey J. Urban began studies on the concentration, separation and sequestration of carbon, he was greeted with a big surprise. Prior to performing physical characterization, he did "the chemical step," which, in this case, meant looking at the absorption emission spectra of magnesium oxide.

The surprise, he said, was the discovery that MgO (magnesium oxide) nanocrystals have bright blue photoluminescent properties (bulk MgO is a nonemissive, wide-bandgap insulator).

He obtained absorption spectra with a UV-3600 UV-VIS-NIR spectrophotometer from Shimadzu Scientific Instruments of Columbia, Md., and recorded photoluminescence spectra on a Fluorolog 3 spectrofluorometer from Horiba Jobin Yvon of Longjumeau, France. He used an integrating sphere to measure absolute quantum yields.

Urban, a staff scientist at Lawrence Berkeley National Laboratory in Califor-



An intense blue photoluminescence is emitted when nanocrystals of magnesium oxide are excited by UV light. Courtesy of Dr. Hoi Ri Moon, Lawrence Berkeley National Laboratory.

nia and a member of the new Energy Frontier Research Center for Nanoscale Control of Geologic CO_2, said that the finding is significant because solid-state blue light has been difficult to produce – a major challenge to the solid-state lighting industry because it takes red, green and blue to make white.

After finding that MgO nanocrystals provide a stable blue dye, researchers at the Inorganic Nanostructures Facility at the lab's nanoscience research center discovered a mechanism for controlling the size of the nanocrystals. Their work may provide a source of inexpensive bright-blue luminescence in bioimaging, solid-state lighting or other applications.

Carbon capture

After step one of Urban's research unleashed a whole new body of investigation, he moved on to the next steps involved in using MgO nanoparticles and other minerals that help form carbonate minerals when CO_2 is pumped underground. Successful sequestration of carbon requires the ability to seal geochemical reservoirs deep below the Earth's surface without allowing gases or fluids to escape.

He noted that the carbon storage the investigators are modeling is really not unlike that which occurs in nature when sea coral captures and stores CO_2. The nanocrystals grown at the lab provide a simple model that enables them to study the process.

Although every scientist hopes that his or her work will have a positive impact, Urban said, he believes that his group's work will provide some of the "detailed physical constants that help us model these processes."

anne.fischer@laurin.com

The greening of plastics

Plastics have changed the way we live, making possible such items as disposable diapers and lightweight, inexpensive camera lenses. But plastics also can do harm to the environment, especially when their toxic chemicals work their way into the ground, the oceans, the air or our food.

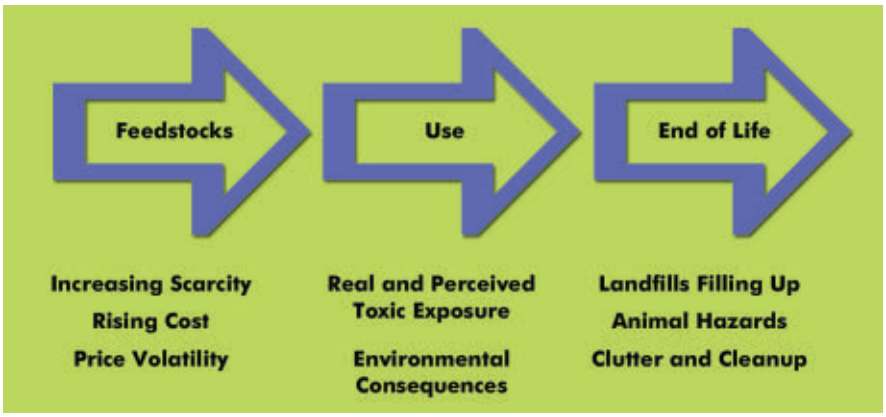
Now new biologically derived materials, called biopolymers, hold the promise of plastics, but without the deleterious effects.

Lux Research of Boston recently released a report titled "Growing Tomorrow's Green Materials," which looks at the role of biopolymers in the marketplace. Included is the work being conducted on green materials by a number of giant chemical manufacturers.

For example, BASF of Ludwigshafen, Germany, is working on plant biotechnology, optimizing crops for raw materials. It also is looking at producing polymers through fermentation and biocatalysis – an important subspecialty of white biotechnology – for industrial use.

Bayer MaterialSciences is exploring ways of developing plant-based feedstock for polycarbonates and polyurethanes. Archer Daniels Midland Co. of Decatur, Ill., formed a joint venture with Metabolix Inc., a biosciences company in Cambridge, Mass., to develop microbes that create polymers from plant sugars. And Tokyo-based Mitsubishi Chemical is developing a biodegradable polyester.

The report points to these developments as evidence of corporations embracing the need for ecological materials and the move away from "petropolymers."



Conventional polymers are a problem from start to finish, from the scarcity and cost of the fossil fuels with which they are made right through to disposal. Chart courtesy of Lux Research.

Although several variations of biopolymers are emerging from the lab and entering the market, questions remain as to how they will fare in certain applications, what they will cost and how green they really are. The report provides detailed analysis of green polymers, such as polylactic acid, in a variety of applications and compares them with petroleum-based materials such as ethylene vinyl acetate, acrylonitrile butadiene styrene polyester and others.

Each material was evaluated using chemical, industrial and economic data together with interviews with materials manufacturers. Data on performance included temperature tolerance, physical strength, crystallinity and hardness. Also evaluated were economic competitiveness and ecological profiles. With dozens of properties that may be relevant to particular applications, it's not possible, however, to specify which alternative will succeed in which application.

Mark Bunger, research director and lead author of the report, noted that, for biopolymers to not be relegated to "tree-hugging consumers willing to pay a premium," manufacturers must ensure that the biomaterials perform equally well or better than the alternatives, that their price is competitive and that they are environmentally sound.

The report concluded that widespread adoption will occur when conventional chemicals can be produced economically from biological materials. In the meantime, research and development must continue in an attempt to scale up the performance and scale down the cost of green plastics.

anne.fischer@laurin.com

US DoE helps flip the switch on LED streetlights

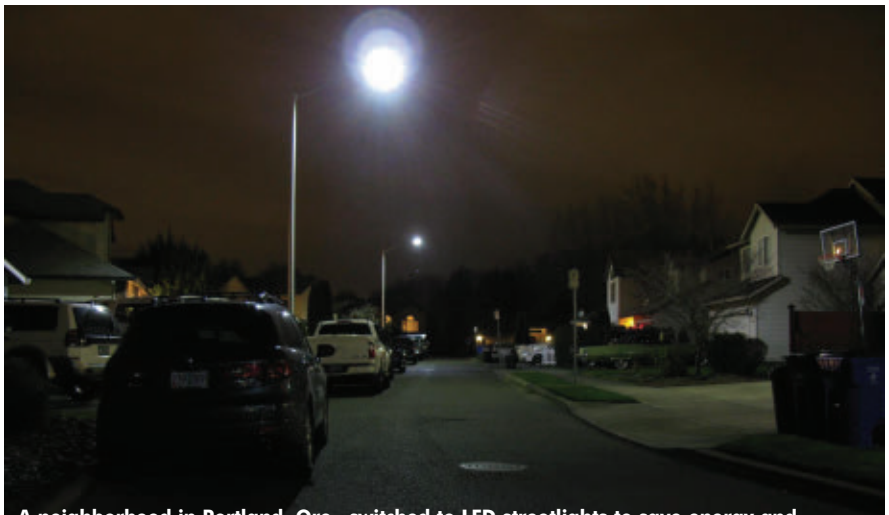
Most streetlights in the US are high-pressure sodium, but the many advantages of LEDs are pushing municipalities to make the switch – or at least to think about it. Because it is such a big chunk of change to lay out at the start, the US Department of Energy (DoE) is forming a Municipal Solid-State Street Lighting (SSL) Consortium to provide a forum for sharing information, knowledge and experience.

Membership is open to municipalities, utilities and energy-efficiency organizations. As the American Recovery and Reinvestment Act funding reaches towns planning these upgrades, the DoE is inundated with requests for demonstrations, explanations and comparisons. The consortium helps municipalities gain insight from experts on SSL issues and share information with others on pilot projects. Some of the SSL issues include lumen maintenance, product reliability and optical performance.

"Basically," noted Marc Ledbetter, program manager of Emerging Technologies

at the DoE's Pacific Northwest National Laboratory in Richland, Wash., "the idea is to help cities avoid mistakes that some will inevitably make." In addition, a greater body of field test data will be collected through information sharing and demonstrations of installations. Common evaluation methods will be used, so those interested in solid-state streetlighting can make valid comparisons across a range of conditions, including climate and cost.

The consortium is open to all municipalities. One city implementing a large-scale switch to SSL is Anchorage, Alaska, which, at the time of writing, had achieved one-third of its goal toward changing all city-owned streetlights to LEDs. Anchorage is part of the Raleigh, N.C.-based Cree LED City initiative.



A neighborhood in Portland, Ore., switched to LED streetlights to save energy and maintenance costs. Courtesy of DoE Pacific Northwest National Laboratory.

The streetlights are made by BetaLED of Sturtevant, Wis., with XLamp LEDs from Cree Inc. The upfront cost of $2.2 million is expected to be recovered in seven years. The city expects to use half the energy with the LED lamps, saving approximately $360,000 annually in energy costs. LED lamps also are expected to last 50,000 h, as compared with 24,000 for high-pressure sodium (see "State of the Streetlight," December 2008 *Photonics Spectra*, p. 38), saving maintenance costs as well.

Other cities with pilot projects in place include Los Angeles, San Francisco and Oakland, Calif. Although manufacturers will not be part of the consortium, the DoE expects to call on them to present information at meetings.

More information can be found on the DoE's solid-state-lighting Web site.

anne.fischer@laurin.com

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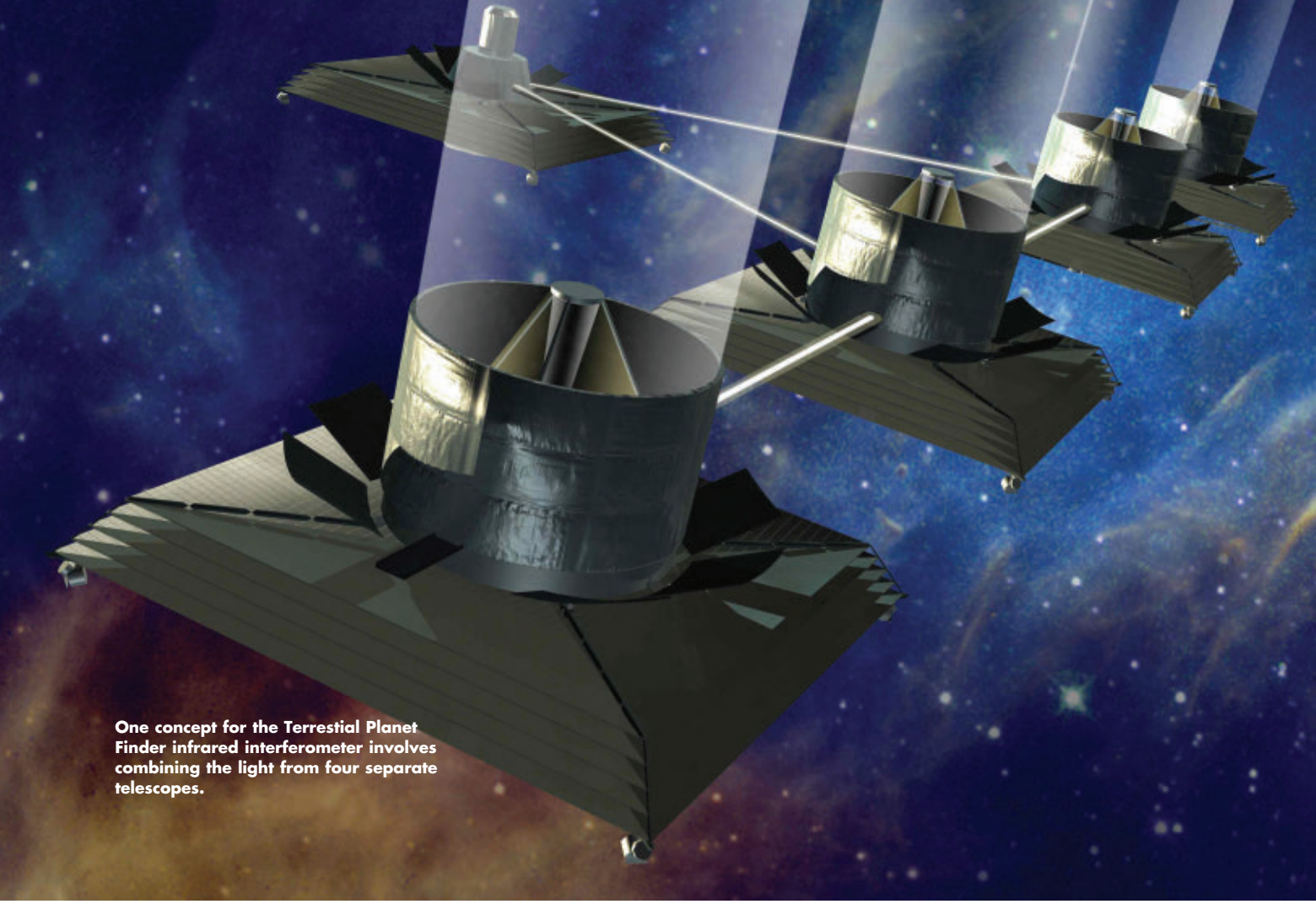

One concept for the Terrestial Planet Finder infrared interferometer involves combining the light from four separate telescopes.

The Search for Other Earths

BY CLAUDE THOMAS WALKER AND DAVE HASENAUER, OPTICAL RESEARCH ASSOCIATES

In recent years, astronomers have discovered more than 350 extrasolar planets, or exoplanets. But typical detection techniques are best suited for finding planets that are very dissimilar to Earth in terms of size and orbital characteristics, and it is unlikely that any of these harbor life.

So how do astronomers look for planets that could support life? NASA has proposed the Terrestrial Planet Finder (TPF) mission specifically to identify and characterize Earthlike planets using spaceborne instrumentation.

TPF mission parameters

The primary goal of the TPF program is to identify planets with masses of 0.3 to 10.0 Earths within the "habitable zones" around nearby stars, where the expected surface temperature of a planet can sustain liquid water over a range of atmospheric pressures. NASA also wants the TPF to be able to detect the presence of an atmosphere and identify its major components, searching specifically for water vapor, ozone and molecular oxygen (The latter is considered to be an indicator of life).

The TPF is intended to survey the 100 to 200 stars within a distance of about 30 light-years from Earth that have a size and brightness similar to the sun's. Stars substantially brighter than our sun won't be investigated because these have relatively short lifetimes (less than 1 billion years), considered insufficient for planets to cool and life to form.

The imaging challenge

Directly imaging a planet whose size and orbital distance from a sunlike star are similar to the Earth's is quite a challenge. The ratio of brightness between a star and a planet is very large (e.g., 10^{10}) at visible wavelengths, while the angular separation between the objects is small. For example, if our own solar system were viewed from a distance of 30 light-years (and the very nearest star to us is more than four light-years away), the greatest separation of the Earth and sun would appear to be about 0.1 arcsec. While this is above the resolution limit of many existing telescopes (For example, the Hubble has an angular resolution of about 0.05 arcsec), the problem is that traditional optical systems image a star as an Airy disk, surrounded by a series of faint diffraction rings. So although the planet might be well separated from the central Airy disk image of the star, even a very faint diffraction ring overlapping the planet image would make it undetectable.

Successfully imaging an Earthlike planet, therefore, requires somehow eliminating virtually all the light from the nearby star, including both the central Airy disk as well as the diffraction rings. Development work on the TPF is being

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The Asia Communications and Photonics Conference and Exhibition (ACP) is the result of a merger between the Asia Optical Fiber Communication & Optoelectronic Exposition & Conference (AOE) and Asia-Pacific Optical Communications (APOC). Well-known as Asia's leading events in photonic research and technologies, AOE and APOC will combine to form one comprehensive conference and tradeshow exhibition.

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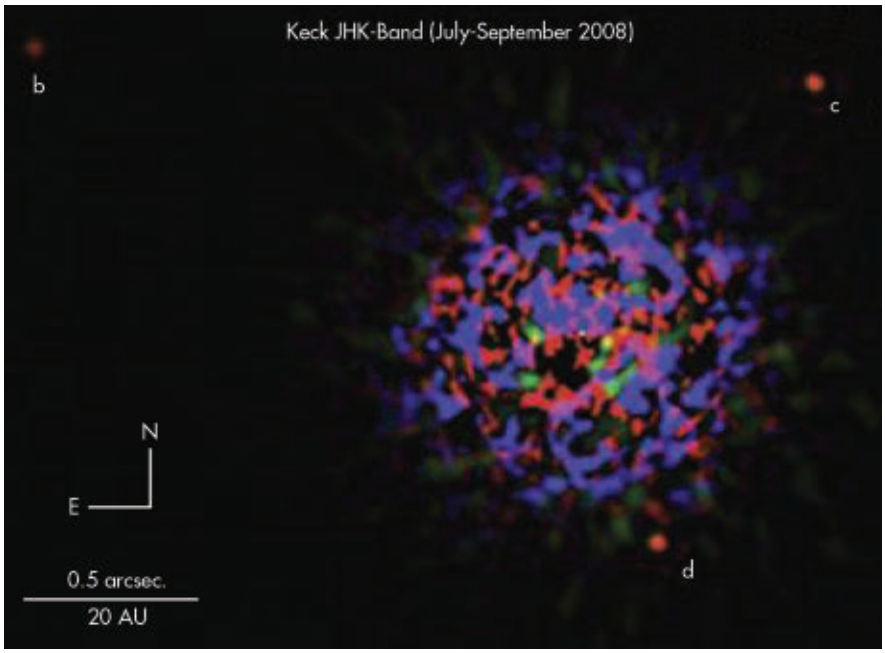
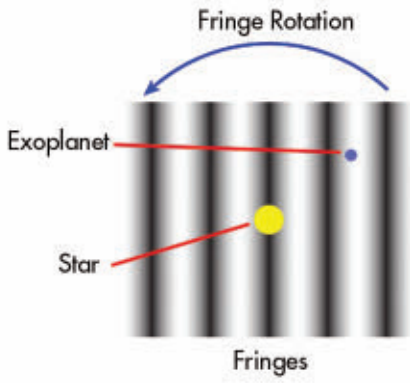
ACP Management Contact:
Tel: +86.755.2583.4722 Fax: +86.755.2583.4922 Website: www.acp-ce.org Email: info@acp-ce.cn
5916, Shun Hing Square 59th Floor, Di Wang Commercial Center, 5002 Shen Nan Road East, Shenzhen, Guangdong 518008, China



The Keck telescope obtained this near-infrared image of three exoplanets (labeled "b," "c" and "d") around the star HR 8799 (nearly 130 light-years distant) using the method of angular differential imaging, coupled with adaptive optics. The planets are estimated to have masses of seven to 10 Jupiters and temperatures of around 1000 K, meaning that they are probably still cooling. Images courtesy of NASA/JPL-Caltech.



In interferometric planet detection, light from multiple telescopes is combined, and the relative phase is adjusted so that the image of the central star cancels out, but exoplanet images do not.

spearheaded by the Jet Propulsion Laboratory (JPL) at the California Institute of Technology in Pasadena, where scientists are currently pursuing two optical approaches to accomplish this end: a coronagraph and an infrared interferometer.

Coronagraph concepts

As the name suggests, the coronagraph was originally developed to enable viewing of the sun's corona. In the simplest type of arrangement, called a Lyot coronagraph, a round occulting disk is placed at the first focal plane of a traditional telescope. When a star is imaged on-axis, the occulter blocks its central Airy disk and, perhaps, the first one or two diffraction rings. However, the hard edge of this occulter causes substantial diffraction, so a second occulting mask, with an annular clear area, is used to block this diffracted light. Off-axis light is mostly unaffected by the masks.

This arrangement still passes too much diffracted light to enable exoplanet imaging, by several orders of magnitude. A more sophisticated coronagraph design is required to eliminate diffraction rings altogether or to somehow preferentially remove diffracted light from the optical system without affecting any exoplanet images.

Several design concepts are under consideration to accomplish this; conceptually, the simplest is the external coronagraph. Here, an opaque shade is placed some distance in front of the main telescope to block the light from the star, but not the area surrounding it. This occulter mask has a scalloped edge to apodize the incident wavefront and minimize diffraction. The main telescope has a conventional optical design.

Practical implementation is another matter. For example, if the main telescope has a 4-m-diameter primary mirror, then the occulter would have to be 50 m in diameter, fabricated to a dimensional accuracy of about 0.1 mm. It would need to be flown and accurately aligned roughly 72,000 km from the main scope.

Because of this, JPL also is investigating several internal coronagraph designs, where components for eliminating the Airy disk and diffraction rings are incorporated within the main telescope optics. One approach is to apodize or reshape the incident uniform wavefront from a star so that it has a Gaussian intensity profile. Because the wavefront at the focus of an optical system is the Fourier transform of the wavefront at the entrance pupil, and the Fourier transform of a Gaussian is a Gaussian, this particular intensity distribution can be focused without any diffraction rings. This type of apodization can be accomplished by placing a complex-shaped binary mask at the telescope entrance pupil. Alternately, in pupil mapping or phase-induced amplitude apodization

More Accurate Diffraction Modeling

Design of the TPF coronagraph requires the ability to model, analyze and optimize an optical system, including both geometrical optical and diffraction effects, with a signal-to-noise ratio of more than 10^{10}. While geometrical ray tracing is an analytically exact process, computer-based diffraction modeling usually involves some approximation. In 2004, Optical Research Associates responded to a Small Business Innovation Research grant issued by JPL for the development of a new approach to diffraction modeling that would meet the needs of the TPF team, since none of the existing commercial techniques could reach the required accuracy.

The resultant beam synthesis propagation (BSP) method in Optical Research Associates' CODE V optical design software decomposes any complex field distribution into a series of beamlets that can be propagated through the system and added coherently to reconstitute the field. This method is more accurate than fast Fourier transform methods, which suffer from sampling issues. BSP uses advanced algorithms to maximize efficiency while determining diffraction effects from beam clipping, apodization and aberrations. These algorithms allow BSP to achieve higher accuracy with fewer beamlets than other beamlet-based approaches, while delivering a solution in a reasonable time frame.

The accuracy of any beam propagation analysis is dependent upon using the right inputs. A major benefit of BSP is its unique pre-analysis feature that automatically recommends appropriate inputs based on the resident lens system and delivers an accurate answer in the shortest amount of time.

(PIAA), warped mirrors can be introduced into the system that concentrate light near the optical axis and make it fainter at the system edges.

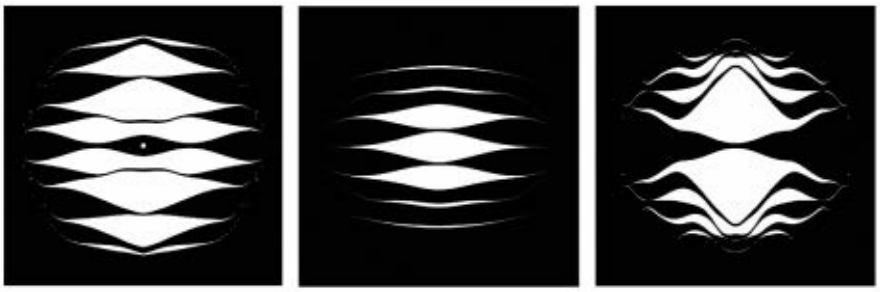
Other design forms extend the basic Lyot configuration by using a series of masks in the focal plane and pupil to deliver higher rejection of light from the central star. These masks can be based on amplitude or phase. One of these techniques uses a phase mask near the image plane to introduce a phase difference of one-half wave over half of the star's image. This causes the on-axis starlight to cancel out, while off-axis light is passed.

Infrared interferometer

The TPF infrared (6.5 to 13 μm) interferometer is intended to be somewhat complementary to a visible or near-infrared coronagraph. In the infrared, the brightness difference between a star and planet is much smaller than in the visible, making exoplanet detection easier. Also, most important atmospheric gases have spectral lines in the infrared, making analysis possible.

The TPF interferometer is currently envisioned as a quartet of flying telescopes with optical delay lines to maintain a precise phase relationship among the arriving wavefronts. There, light is then combined to form a series of fringes, with a null falling on the central star. Rotating the fringe pattern – which requires moving the telescopes themselves – will modulate the signal from any planet, enabling the planet's detection.

In 2004, NASA received funding from Congress for both the coronagraph and infrared interferometer TPF missions. Unfortunately, spending limits imposed by Congress in 2007 put the launch of any TPF mission on hold. But that hasn't lessened the efforts of scientists at JPL and other institutions who are working to develop and refine TPF instrumentation design. It is hoped that the mission will ultimately proceed and bring us closer to finding out whether we have company in the universe.



The Jet Propulsion Laboratory at the California Institute of Technology is investigating several internal coronagraph designs for the Terrestrial Planet Finder, including these possible binary mask shapes. Sample masks of this type have been fabricated using deep reactive ion etching of a 400-m-thick silicon-on-insulator wafer.

Meet the authors

Claude Thomas Walker is vice president and software chief technology officer at Optical Research Associates in Pasadena, Calif.; e-mail: tomw@opticalres.com. Dave Hasenauer is the company's CODE V product manager; e-mail: dhasenauer@opticalres.com.

The road to solar cell supremacy

BY DAVID L. SHENKENBERG
FEATURES EDITOR

The silicon traditionally used to make solar panels is costly and inefficient at converting sunlight into electricity, experts say, yet it remains the material most commonly used to make solar panels.

"This sounds rather ugly, but silicon is the best choice we have at this time," remarked John Benner of the National Renewable Energy Laboratory (NREL) in Golden, Colo., a US government facility responsible for developing and promoting solar technologies. "It delivers the best combination of performance, cost and reliability for most applications," he added.

Someday solar could compete dollar-for-dollar with traditional power plant sources of energy – a dream known as "grid parity." Most experts agree that government support is needed to achieve grid parity, even with the progressive improvement of solar cells, although cheaper and more efficient materials will help significantly.

"Many companies expect to beat the US goal of reaching grid parity by 2015. Some project as early as 2012," Benner said. "With the current economic slump taking margins out of all links in the supply chain, it could happen even earlier."

The primary cause of the economic downturn of the solar industry this year is, surprisingly, its popularity. The "gold rush" spurred a "Wild West mentality among market participants," commented iSuppli principal analyst Henning Wicht. The emergence of competitors caused the supply of solar panels to greatly exceed the demand, and iSuppli projects that one of every two solar panels created will not be sold by the end of this year. Not helping matters is the recent collapse of the once-leading solar market of Spain, due to the discontinuation of subsidies.

Price wars

While the price of solar panels has fallen to $4 per silicon wafer so far, the price of solar-grade silicon has remained at $40 per kilogram on average. Solar cell manufacturers are getting hit from both sides.

The high price of solar-grade silicon is primarily the result of factories producing less silicon than is needed to accommodate the demand from solar cell manufacturers and computer chip makers, which compete for the same raw material.

The lack of production is unexpected given that silicon is one of the most abundant materials on earth, most commonly found in sand and quartz, and given that the method of obtaining silicon is easy in principle: Simply melt some sand or quartz.

On an industrial scale, however, sand typically is melted with carbon in the form of coal in a furnace heated to an extremely high temperature such as 1400 °C (2600 °F). The carbon binds with the oxygen gas to form carbon monoxide gas, and what is left is pure silicon. Variations on this process have been developed, but this is essentially what happens.

Because the purest silicon is also the most efficient at converting solar energy to electricity, solar cell manufacturers demand the highest purity, which bumps up the price.

The silicon in demand is crystalline, which is more efficient than amorphous silicon. Polycrystalline silicon is cheaper and easier to make than monocrystalline silicon, and not much efficiency is sacrificed, which is why pure polycrystalline silicon is the most popular material for making solar cells today.

Continued on p.46

Photo: Solyndra makes tubular CIGS thin-film solar cells for the rooftop market. Courtesy of Solyndra.

A closer look at plastic solar cells

MARIE FREEBODY
CONTRIBUTING EDITOR

Plastic solar cells are lightweight, flexible and, most importantly, cheap to make. But so far, these devices lack one thing: efficiency.

Now researchers at the University of Washington in Seattle believe that they may have the key to unlocking the true potential of plastic solar cells. By taking a closer look at their inner workings at the microscopic and even nanoscopic level, the group believes it could help bring the technology a step closer to fulfilling its promise as a low-cost source of solar energy.

The fabrication of plastic solar cells usually involves blending two materials together in a thin film. They are then annealed, or baked, to improve their performance. In the process, bubbles and channels form, and it is these nanostructures that determine how well the cell converts light into electricity and how much of the electricity actually gets to the wires leading out of the cell.

According to lead researcher David Ginger, the trick to understanding what is happening within polymer solar cells is to think of them not as giant uniform blocks of material with average properties, but rather as networks of many billions of nanoscale solar cells wired in parallel. "Not all of the smaller cells are working as efficiently as they could because they have different sizes, shapes or compositions," Ginger explained.

In the study, which was published in the July 9 online edition of *Nano Letters*, Ginger, postdoctoral fellow Liam Pingree and doctoral student Obadiah Reid used an atomic force microscope to examine a plastic solar cell comprising a blend of polythiophene and fullerene. As the microscope traces back and forth across the cell, it records the channels and bubbles that were created as the material was formed.

What the Washington team discovered came as a surprise. The photocurrents coming out of the polymer/fullerene solar cell were not spatially uniform. In fact, they exhibited heterogeneities on the order of 10 to 100 nm. Ginger realized that if the solar cells could be processed such that all regions of the cell operated as well as the best regions, the overall performance of the cell could be improved.

"We realized that we ought to include this nanoscale heterogeneity into the theoretical models of device operation if we want to understand them better," he noted.

But getting the cell constitution right is no trivial task, and many experts in the field already believe that they know what is needed to achieve maximum efficiency. Two important targets include better harvesting of red and near-infrared light with lower-bandgap polymers as well as better control of the material energy levels to maximize the cell voltage.

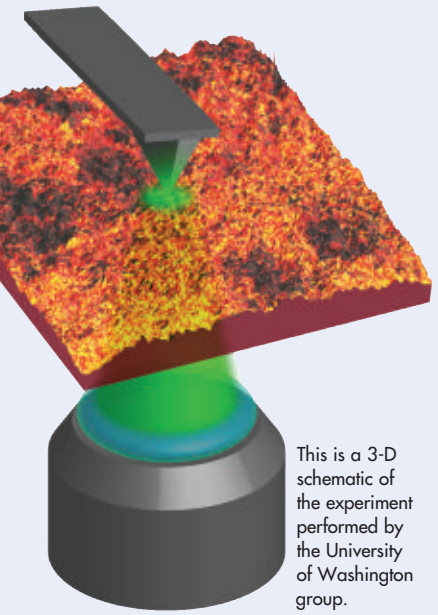
The problem is that, while materials that meet these requirements exist, putting them together does not always render a solar cell as efficient as expected. "You could get the perfect bandgap and energy level offsets in your material, but if you can't get it to form the right-size bubbles and channels on the nanoscale, then it won't work very well," Ginger commented.

Despite the challenges, the team is hopeful that, within the next few years, its technique will not only help others in the field gain a better understanding of polymer solar cells but also will be valuable in related disciplines. For example, nanoscale photocurrent imaging could be useful for laboratory optimization of new materials, for initial scale-up of production and, someday, for quality control during mass production.

In the meantime, the Washington group hopes to improve its imaging technique – making it faster, more user-friendly and less sensitive to surface effects. And along the way it also hopes to image new material combinations to optimize efficiency.

mariefreebody@physics.org

University of Washington doctoral chemistry student Obadiah Reid aligns the laser in a dual optical/atomic force microscope prior to performing photoconductive atomic force microscopy on nanostructured polymer solar cells.



This is a 3-D schematic of the experiment performed by the University of Washington group.

Continued from p.44

Boron typically is added to the silicon before it solidifies, and phosphorus is added to the top surface of the panel. Boron gives the wafer a positive charge, and phosphorus gives the surface a negative charge.

In the sun, photons of light transfer their energy to the phosphorus, and the outer electrons in the phosphorus atoms move down to the boron atoms. This permanent displacement of electrons creates a fixed electric field between the top layer of silicon and the rest of the silicon wafer.

This permanent electric field is another important reason for choosing a semiconductor such as silicon because, in a conductor, the electrons would dissipate, and no permanent electric field would form.

This electric field pushes free electrons to the front of the solar cell for a net 0.5 V of electricity per cell. This minuscule voltage is why solar cells usually are soldered together into a module that generates substantially more electricity.

Battling for thin-film domination

In California, both Solyndra of Fremont and Nanosolar of San Jose sell thin-film solar cell modules made from the alternative semiconductor CIGS ($CuInGaSe_2$), navigating around the use of pricey solar-grade silicon. Thin films reduce the cost of the material because less is needed and because they can be manufactured in inexpensive roll-to-roll processes.

The reported sunlight-to-electricity conversion efficiencies have been up to 10 percent for thin films and up to 15 percent for typical polycrystalline silicon cells, so thin films generally have been less efficient but cheaper.

Nanosolar claims that its efficiency is

Underdeveloped regions of Indonesia have been benefiting from remote solar power supplies for some time. This system has been in place for at least three years. Courtesy of Schott AG.

The Suncatcher solar concentrator marketed and sold by Tessera is made by Stirling Energy Systems. Courtesy of Tessera Solar.

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up to 16 percent, and Solyndra claims that the efficiency of its solar panel is up to 14 percent when rolled out and from 25 to 100 percent when in its tubular modules.

Solyndra CIGS thin films are rolled into a glass tube surrounded by an additional layer of material encased in another glass tube that concentrates the sunlight from all directions. Light that passes through the tubes and is reflected from the roof of the building is collected by the tubes, especially if the rooftop is painted a reflective color such as white. "We designed this for the rooftop as a system," said Kelly Truman, vice president of marketing and business development for Solyndra. Truman added, "In California, there is a legal requirement for the roofs of new buildings to be painted white. We are riding off that."

Whereas conventional solar panels act like sails blowing in the wind and must be tacked down with additional material, the tubular solar cells sold by Solyndra are set down as if on a tabletop.

In 2008, Solyndra's tubular design won a Prism Award for Photonics Innovation from SPIE and the publisher of *Photonics Spectra*. This award was selected by a panel of independent experts.

Truman said Solyndra has been shipping internationally since July 2008 with increasing volume and revenue each quarter. Solyndra has received a US Department of Energy loan to build a second factory.

First Solar claims that it has sold 1 GW of CdTe thin-film panels with a CdS window layer and also that its manufacturing costs are less than $1 per watt. The company said its efficiency at the end of 2007 was 10.6 percent. If the claim of 1 GW is true, then First Solar is the leading producer of thin-film solar cells, followed by United Solar Ovonic of Rochester Hills, Mich., and Sharp Corp.

Plastic stands alone

A year after winning the 2000 Nobel Prize in chemistry with Hideki Shirakawa and the late Alan MacDiarmid for discovering and developing conductive polymers, Alan Heeger became a founder of and chief scientist at Konarka Technologies, maker of conductive polymer solar cells called Power Plastic.

Power Plastic solar cells are lightweight, flexible and easily integrated into other materials. They cost about one-third less than traditional silicon solar cells and, at one to two ounces per square foot, could win a competition in the lightweight category.

Konarka's solar cells can be colored and patterned. This year the company began selling its plastic thin films for consumer applications such as battery chargers for mobile phones and other electronic devices; indoor sensors and labels; and outdoor awnings, tents and umbrellas. The 6.4 percent efficiency of the plastic cells is not quite competitive yet for the rooftop market, although it is notable that this figure was verified independently by NREL.

Tracy Wemett, a Konarka representative, emphasized that Konarka makes Power Plastic using traditional roll-to-roll inkjet printing, as opposed to thin-film deposition in which materials are thrown into the air. Therefore, its process is more environmentally friendly.

Some companies, such as Dyesol of Australia, are selling what are called dye-sensitized solar cells – a semiconductor coated with a dye, usually a proprietary chlorophyll analog. These are currently in mass production.

This solar power system from Schott is in use in Gansu, China. Courtesy of Schott AG.

Other materials – such as carbon nanotubes, quantum dots and black silicon – are promising for solar cell applications but are still in the R&D stage.

Cyrium Technologies claims it has used quantum dots and semiconductor multijunctions – amalgamations of semiconductor materials – to achieve more than 40 percent efficiency and is providing its product on a qualified evaluation basis.

Jim Carey, co-founder of Sionyx, a Boston-area company that makes black silicon, said his product is being provided on a qualified evaluation basis as well. Black silicon absorbs more of the spectrum than traditional silicon and therefore potentially can convert more sunlight to energy. Infrared-absorbing cells could produce energy even after the sun goes down.

Still fighting

Alternatives may be trying to push silicon aside, but silicon is still going to put up a good fight. Suntech and Suniva now claim to have achieved efficiencies of 17.2 and 18.5 percent, respectively, with their polycrystalline solar cells. Concentrators such as dishes and halfpipes with mirrors designed to reflect concentrated sunlight onto solar cells have been demonstrated to increase efficiency up to about 40 percent. Amorphous silicon thin films – not quite as efficient as crystalline silicon, but cheaper – have been developed to compete with some thin-film technologies.

david.shenkenberg@laurin.com

Lasers in solar cell production

A new laser tool improves solar cell manufacturing output and lowers dollar per watt costs.

BY DAVE CLARK
NEWPORT CORP./SPECTRA-PHYSICS

Photovoltaic (PV) solar cells have been around for more than 50 years now, enjoying initial commercial success in familiar applications such as powering satellites in space and, later on, digital calculators and other portable devices. Since the early days, scientists have dreamed of the widespread deployment of photovoltaic cells on rooftops, in deserts and in fields to harness the power of the sun and produce "endless" amounts of cheap, clean electricity. Unfortunately, significant challenges have made progress disappointingly slow.

The "holy grail" for the PV scientist is to produce devices with a low enough cost and high enough conversion efficiency to be competitive with traditional methods of generating electricity. The drive to achieve this has created considerable interest in a range of emerging laser-based manufacturing processes. One of the most promising is laser doping of selective emitters.

Improving front side contacts

Key areas in traditional wafer-based crystalline-silicon solar cells requiring major improvement are the quality and functionality of front and rear surface contacts. The process currently employed is detailed in Figure 1. The traditional screen-printed silicon solar cell manufacturing process has six steps:

Step 1: An acid etch of the *p*-type wafer is used to remove saw damage and to texture the surface, improving the absorption of incident light.

Step 2: Thermal diffusion of phosphorus doping in a furnace with $POCl_3$ gas creates the lightly doped *n*+ emitter region.

Step 3: The hydrofluoric acid etch process removes the phosphor-silicate glass.

Step 4: Deposition of an antireflection thin-film coating of silicon nitride (SiNx) on the front surface.

Step 5: Screen printing of the front surface contacts.

Step 6: Heating or "firing" the contacts melts them through the thin insulating layer of SiNx to make contact with the underlying *n*+ silicon layer.

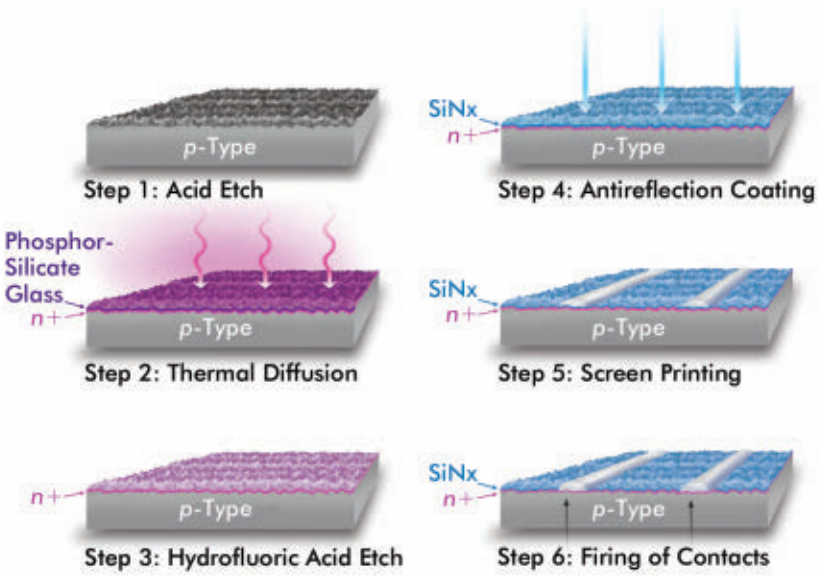


Figure 1. The traditional screen-printed silicon solar cell manufacturing process consists of six steps. Images courtesy of Newport Corp./Spectra-Physics

The existing method of contact formation presents a number of issues. First, the conventional screen-printed metal grid lines and bus bars are quite wide in cross section, around 120 µm. They also have a poor aspect ratio – typically only 13 µm in height. These opaque metal lines obscure the active areas of the silicon cell beneath, causing a reduction in fill factor and what is commonly referred to as "shading losses." This shading effectively reduces the cell efficiency. The second issue is that the firing process does not usually result in optimal electrical contact between the metal of the grid lines and the underlying silicon. This leads to contact over only a small percentage of the area shaded by the metal line and, given the size of the grid lines, a relatively high series resistance. The third concern: The *n*+ doping profile cannot be easily tailored to create low-resistance contact areas directly underneath the metal contacts, so a trade-off must be made by applying a uniform concentration of dopant across the entire cell surface.

To improve upon the traditional screen-printed front contacts, Martin Green's group at the University of New South Wales in Australia devised the laser-grooved buried contact solar cell. They employed a laser to ablate the U- or V-shape grooves that subsequently could be cleaned, doped and plated to create more optimal contacts. This was the basis of the BP Solar Saturn cell, which enjoyed many years of production success.

Figure 2. Newport Corp./Spectra-Physics' Millennia Prime is a field-proven laser and is ideally suited for applications involving laser doping of selective emitters.

However, the laser-grooved buried contact solar cell required high-quality silicon substrates and employed multiple additional process steps in its manufacture; the resulting high unit costs led to its eventual demise. Sadly, BP Solar was forced to end production of this elegant laser-enabled solar cell and recently closed its plant in Madrid, Spain.

A simple method for fabricating much finer front surface contacts with high aspect ratios and excellent contact to the underlying silicon and strongly doped regions directly beneath them was needed. The University of New South Wales scientists again were at the forefront of solving this problem with their more recent work in the area of laser doping of selective emitters. Using lasers in these new solar cell designs promises to offer significantly better performance over the existing screen-printed technologies, and yet the new cells are relatively simple and inexpensive to implement in existing production lines.

The basic process steps for manufacturing the front side contacts for the new design are shown in Figure 3. This technology employs a larger number of much narrower metal finger contacts with heavily doped regions of *n*++ beneath each individual contact. The features and benefits are detailed in the table.

There are seven steps for laser doping of selective emitters. Steps 1 through 4 are the same as for the traditional screen-printed silicon solar cell manufacturing process.

Step 5: A spun-on or spray-on thin, uniform coating of *n*-type dopant (SOD).

Step 6: Laser doping: A laser simultaneously ablates the SiNx and melts the underlying silicon. Phosphor almost instantaneously migrates into silicon while it is in liquid phase to create a shallow, highly doped *n*++ region.

Step 7: Wash off SOD, and electroplate to create self-aligned contacts.

This new, elegant process has been shown to increase cell efficiencies for both mono- and multicrystalline cells by up to as much as 2 percent in absolute terms. This is a 10 percent improvement over more traditional screen-printed cells. Understandably, this has created a huge amount of interest in the industry.

Most of the early process development work on laser doping used Q-switched lasers, often in the green, but limitations on process speeds and quality confined this work to the lab. Thanks to advances in the past few years, mode-locked UV lasers are now being used with some success; they provide a small spot size and faster scan speeds than Q-switched lasers because of their higher repetition rates. However, there are important challenges in integrating such high-power UV mode-locked lasers into production tools. In particular, UV optics and lasers are inherently

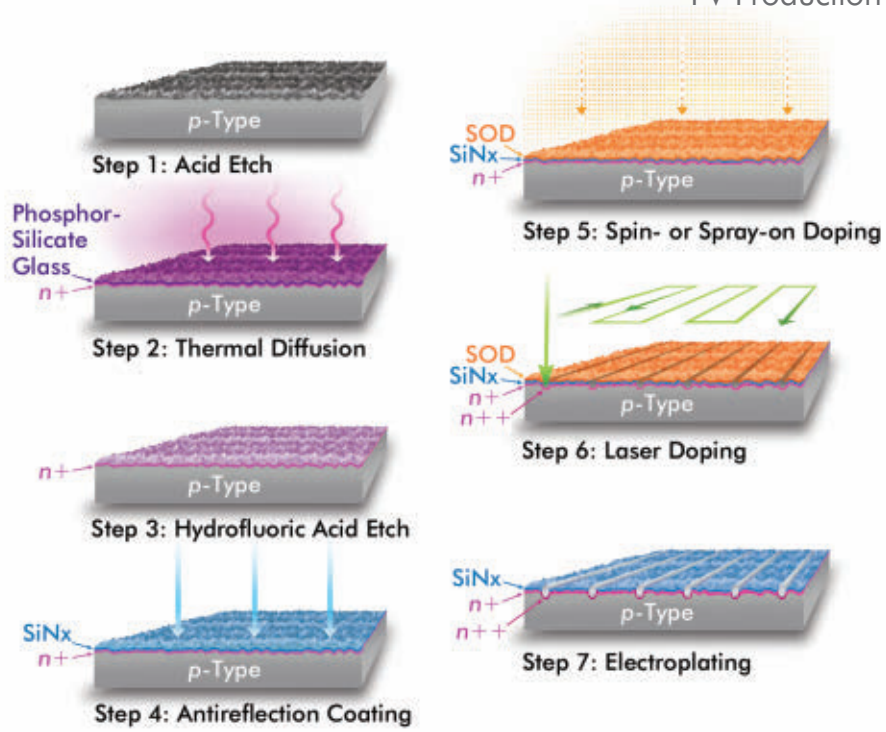


Figure 3. Laser doping of selective emitters involves seven process steps.

Laser Doping of Selective Emitters

Features	Benefits
Narrower fine-metal lines	Less shading loss and higher fill factor
More closely spaced lines	Reduced power loss in emitter
Shallow localized *n*++ junction	Higher J_{sc}
Reduced heavily doped emitter volume	Reduced power loss in emitter
Better metal-silicon contact	Lower contact and series resistance
Fewer furnace steps, localized high temps	Lower-grade wafers can be used
High-aspect-ratio contacts	Good conduction and light reflection

less robust than green or infrared lasers and thus much more expensive. The industry's high cell-throughput requirements are currently driving manufacturers to look at a third option – namely high-power, continuous-wave (CW) green lasers. Newport Corp.'s Spectra-Physics Div.'s CW green laser, the Millennia Prime, has proved ideal for laser doping of selective emitter applications. Recent lab results have shown that this type of laser can scan the entire cell at up to two to five times the speed of existing methods. It also can be integrated into a lower cost and more robust tool with much higher cell throughput, providing a distinct advantage to solar cell manufacturers.

Laser tool considerations

In the solar cell industry, each tool in the manufacturing line must be highly reliable, produce consistently high yields and have a throughput that is balanced to match the rest of the line. In the typical 30-MW production line, this translates to 1100 to 1200 wafers per hour and tools operating 24/7 in factories around the globe. It is critical, therefore, that laser tools be extremely robust and able to process and handle wafers with very low breakage at these high- throughput rates. These requirements create a huge challenge considering that the newest wafers are typically only 200 µm thick and that the takt times are just a few seconds. Additionally, there are significant optical engine and scanner design challenges in processing reliably across the larger wafers without making the production tool highly complex and costly.

Meet the author

Dave Clark is senior director of strategic marketing, photovoltaics, at Newport Corp./ Spectra-Physics in Mountain View, Calif.; e-mail: dave.clark@newport.com.

A New World of Fiber Sensors

BY DR. SAEED REHMAN, FIBERTRONIX AB,
AND DR. ÅSA CLAESSON, ACREO FIBERLAB

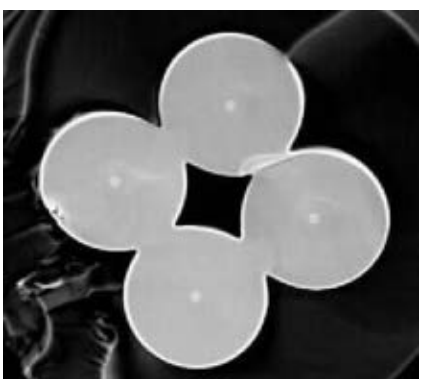
Optical fiber is well-known for its ability to carry information at high speeds over long distances. Twenty years after the first transatlantic fiber optic cable was laid, these strands of ultrapure glass continue to offer unrivaled bandwidths. They have evolved a long way from the first low-loss fiber demonstrated in the late 1960s.

Less often thought of are a multitude of other applications. Fiber optic technologies offer unique features that can be exploited in a variety of ways, such as carrying high optical powers in flexible lightguides for welding stations, transferring images in endoscopes, distributed sensing along pipelines, and for low-weight and high-transmission bandwidth in avionics.

One of today's fastest developing technologies is fiber optic sensing. Over the past few years, fiber sensors have seen increased acceptance and widespread use in many commercial applications, including structural sensing; smart structures and civil engineering; aerospace and security; the marine, oil and gas fields; and health monitoring. One of the most common functions is temperature and strain/stress sensing, but a range of other parameters – such as pressure, magnetic field, voltage, chemical species and others – also can be measured.

> Unlike its cousin, the telecom fiber, the fiber sensor is growing by leaps and bounds

The significant advantages that these sensors have over more conventional ones for distributed sensing and structural health monitoring have long been understood. However, only in recent years has this technology sufficiently matured to find real field applications and to see steady growth in both standard and niche applications. The expansion of fiber optic sensors continues, and their impact on several business sectors will be significant. This article explains the significance of specialty fibers for growing the next generation of fiber sensors.



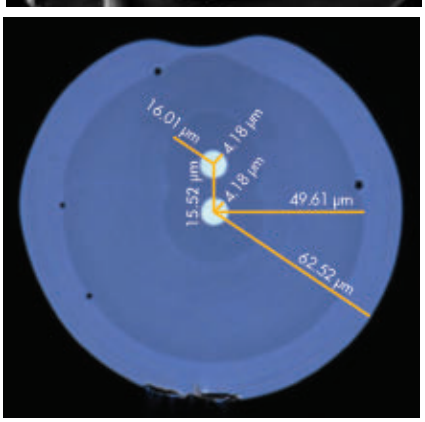


Figure 1. The Gemini fiber integrates ease of splicing and contacting with the concept of multicore fiber sensing. Photos courtesy of Acreo AB.

Specialty fiber for sensing

The term "specialty fiber" is used for practically any fiber except the highest-volume communications type. The specialty fiber market is growing steadily, with industrial, security and military markets making the most impact. Some types of specialty fibers have well-established volume markets; others are still used exclusively in research and development. A substantial portion of the business comes from military/aerospace applications, such as fiber optic gyroscopes, fiber-guided missiles and submarine hydrophones, as well as from oil and gas applications.

Major specialty fiber types include polarization-maintaining fibers (with applications in fiber gyroscopes, current sensors, lasers and pigtailing), polyimide-coated fibers (harsh environments), erbium- and ytterbium-doped fibers (lasers and amplifiers), photosensitive fibers, and multimode fibers for transport of high-power laser light.

In fiber sensors, a specialty fiber is often a key component, acting either as a transducer or an information carrier, and sometimes serving as both. With special coatings such as polyimides, silicones, high-temperature acrylates or hermetic coatings, the specialty fiber may be adapted to a harsh environment. In the final design, additional structures, such as buffer layers or cable designs, along with supplemental strength elements, are frequently needed.

Some fibers are considered more or less industry standard in fiber sensing. They include single- and multimode polyimide-coated fibers for high-temperature applica-

tions, pure silica core ("pure core") fibers, and hermetic fibers for hydrogen-rich and radiation- resistant applications.

Gemini fibers enable practical multicore applications

Besides these "standard" specialty fibers, some new types have been created, thanks to advances in fabrication technology, addressing some unique and complicated sensing solutions. We will give some recent examples of advanced fibers for sensing and explain their potential uses.

Multicore fibers have several sensing applications besides endoscopy. With the information extracted from the light in various cores, a range of physical parameters can be monitored. With the cores integrated into the same fiber, they will experience the same temperature, and it is possible to eliminate the temperature dependence of such sensors by working with the difference between signals from neighboring cores. Such multicore fibers with integrated fiber Bragg grating (FBG) sensors can be employed for temperature-independent bend sensing. The sensor employs two FBGs, one in each core of a two-core fiber. On bending, the two FBGs will experience a strain and a compression, respectively, but they will both see the same temperature shift. The difference in wavelength will provide the strain, independent of the temperature reading.

An obstacle with multicore fibers that restricts their use in practical applications is the input and output from individual cores. Until recently, there was no simple, robust, low-loss and cost-effective way of contacting the individual cores. The Gemini fiber overcomes these coupling difficulties by allowing standard equipment to create all-fused, robust and low-loss contacting of multicore sensors.

In a Gemini fiber, several single fibers are drawn together into a multifiber assembly, as shown in Figure 1. The fibers are independent of each other, except for a narrow connecting glass bridge, and the original individual circular cross sections are maintained. The fibers have a Siamese character and are in proximity to one other. Addressing the individual cores at the input and output ends is possible, through splicing to stand-alone fibers. Although thermal coupling is weaker than in a conventional multicore fiber, the easier access to the cores is greatly advantageous, and the structure is a good compromise for various sensing applications.

Gemini fibers with two and four cores have shown excellent bend-sensing results. The possibility of drawing Gemini fibers with different types of cores, as well as fabricating fused couplers directly using the Gemini fiber, opens a variety of sensor concepts. For example, a Gemini fiber has also been used for constructing an interferometer, with the Gemini structure providing equal arm lengths and a wide-band passband.

Using the Gemini concept, one can devise a sensor that monitors the location of medical probes inside the body during minimally invasive surgery. Such a system could be constructed with an FBG array in a Gemini fiber, which would sense the position of the probe in the body, its path and the various bends. This system could open up cost-efficient and simplified minimally invasive surgical procedures.

Figure 2. These fibers have holes for sensors, lasers and components.

As new applications are found, the complexities of the fiber sensors are increasing. For example, in structural health monitoring, it is imperative to detect the stress not only along the length of the sensing fiber but also in transverse directions to map three-dimensional dynamical stresses. When the fiber is put under an asymmetric stress, the birefringence will be changed. One can then detect the difference in transverse stress in two dimensions, for instance by spectrally distinguishing two reflection peaks associated with orthogonal polarizations. With asymmetric holes in the cross section of microstructured fibers, as in Figure 2, the birefringence response is enhanced and can be detected more easily.

In many fiber sensors, properties of the lightguide itself change, depending upon the measurand. It can be an FBG that changes reflection wavelength on temperature or stress, or an electro-optic fiber that changes its refractive index on an external electric field. In other sensors, the measurand changes the properties of external stress elements (causing loss by microbends in the fiber).

Yet other types of sensors employ special coatings or claddings, adapted to change their physical parameters, depending on the measurand. Examples are coatings that change their optical properties on pH or chemical substances, and coatings that change parameters on external pressure. Microstructural fibers can also be used for chemical detection if the holes are filled with different chemical-sensitive materials. Techniques are being developed to allow for low-loss coupling of liquids and light into fibers with holes, as well as for optical probing of electrophoresis in the holes.

Recently, nanowires have also stirred the scientific sensor community, promising extreme-interaction cross sections of light with liquids and gases. The nanowires are fabricated by tapering fibers into minute wires, so the lightguiding is no longer restricted to the glass but rather extends outside the physical fiber. The evanescent field can then be used for sensing gases, bacteria or other interesting measurands.

With the introduction of new specialty fibers, it is possible to address some old, complicated industrial problems. By defining the problems and using their imagination, end users can find a suitable solution using this ever-growing range of specialty fibers.

Meet the authors

Saeed Rehman is vice president of business development at Fibertronix AB, Hudiksvall, Sweden; e-mail: saeed@fibertronix.com. Åsa Claesson is manager of fiber photonics at Acreo Fiberlab, Hudiksvall, Sweden.

Getting a foot in the door:

The role of photonics in modern security systems

BY HANK HOGAN
CONTRIBUTING EDITOR

In times past, a guard might demand someone entering his domain to "halt and be identified." Today that job is increasingly done by security ID systems using a variety of techniques, including photonic ones such as lasers, optical media and optic sensors. An examination of what is going on shows how photonics plays a role in these systems and what future requirements might be for them.

The demands on ID technologies are growing in many ways. For one thing, there is an increasing need for such systems in traditional settings. For another, identification systems are being employed in more and more areas and for wider and wider uses. As a result, analysts forecast substantial growth.

Charles E. Spear Jr. heads US publishing for IntertechPira in Portland, Maine, a division of Pira International, a market research and technical consulting company in Leatherhead, UK. According to Spear, the group expects the overall market to grow at a compound annual growth rate of just under 12 percent from 2009 through 2014, with smart cards and biometrics growing the fastest.

The company recently published a report putting the worldwide market for personal identification at €4.3 billion ($6.1 billion). This figure includes substrates, bar codes, security inks, digital watermarks, radio frequency ID (RFID), biometrics and smart cards.

Behind this growth are several major trends. One is the increasing world population, which leads to an increased demand for ID documents. Counterbalancing that is the global economic slowdown, which has cut government spending on ID projects as well as consumer spending on travel. Spear added that that interoperability among existing systems, especially for passports and visas, could increase the size of the market.

Security on land and at sea

One reason why the need for security ID systems is increasing is a widening range of increasingly sophisticated applications. Anthony R. Zagami, CEO of Security Identification Systems Corp. (SISCO) in West Palm Beach, Fla., said that his company's credentialing products capture various physical attributes of people, such as their images, fingerprints and retinal patterns. These biometric elements are then incorporated in the ID card or token.

Of these, he said, an old standby may be the best. "The photograph is still the well-accepted criterion for identification, both passively by visual observation as well as machine application."

A photograph doesn't require any contact, as can be the case with fingerprints. It also doesn't require that the subject put an eye up against some sort of device, as must be done with a retinal scan. Moreover, with the advent of higher resolution cameras, higher quality photos become possible, which makes both human and machine matching of individuals to their images more precise. As is the case with other imaging tasks, getting the best results requires the right lighting. At times, that may mean the use of near-infrared.

SISCO is a leader in the maritime market, providing the identification used by passengers and crew as they embark and

Specialized security ID systems (on counter) are increasingly replacing standard sign-in books and generic temporary badges. Courtesy of SISCO.

disembark a cruise ship. This task puts a premium on speed because it requires getting thousands of people through a checkpoint in a few hours' time. That means there are only seconds to process each individual.

These checks involve a bar code, which is best read using a laser. To speed things up, the company has developed hardware to read cards no matter how they are inserted into the scanner. This avoids the slowdown that occurs when someone puts the card in the wrong way, only to pull it out and possibly repeat the mistake.

Such products are not intended for high-security, low-traffic areas. Instead, they are designed for the equivalent of getting people into and out of an office building through a lobby. One trend is that such systems are becoming more commonplace, as the traditional sign-in book and temporary badge are replaced.

As for the future, mobile systems will be increasingly important. That means that the readers should consume little power and be compact, which has implications for the light sources, sensors and optics. There is promising news for the latter two. "We're starting to get some really good quality shots off these smaller cameras, more so than I ever believed you could get out of a lens that small," Zagami said.

One card to rule them all

Security ID systems also are being put to use to make navigating the cyber-physical world easier. For example, Homeland Security Presidential Directive 12, or HSPD-12, mandates a single secure and reliable ID for federal employees and contractors within an agency. This identifier is to be used for physical and logical access. Thus, a sole token will allow entry to a facility and access to computers, databases and networks. Programs that comply with HSPD-12 are currently being rolled out across the US government.

Such a shared ID can eliminate the problem of someone on the outside gaining access using an employee's credentials. "If you're in the building, it won't let anyone use your credentials to connect via the VPN [virtual private network]," said Dilip Sarangan, an industry analyst with Frost & Sullivan, a technology market research firm based in Mountain View, Calif.

Sarangan noted that such a measure would have prevented some of the theft of credit card numbers that has occurred in the past. In those cases, the breach occurred because someone on the outside got into a secure network through a VPN or equivalent using the ID of an employee who was actually at work at the time. Because the system didn't know where the employee was physically, it allowed the logical access.

An advantage of this unified cyber-physical approach is that it gets around some of the problems associated with passwords. Security guidelines say that passwords should be unique to each system or log-in, fairly lengthy, not made up of easily recognizable words or phrases, and changed often. That combination is hard to achieve and to maintain, but a well-designed credential can help.

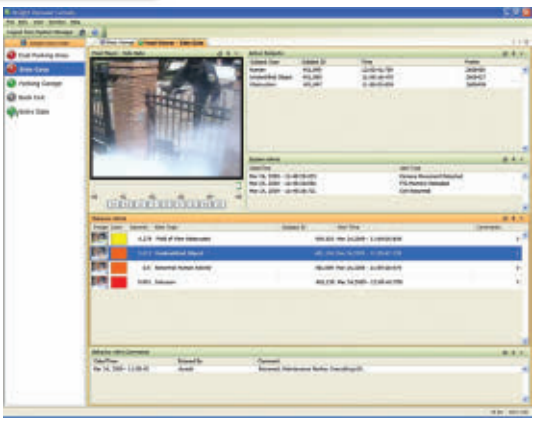
Above, mobile security ID systems scan cards at remote locations, placing a premium on low-power photonics. Courtesy of SISCO. At left, Costa Rica's DIMEX (foreign resident card) features personalized embedded holograms produced by writing a pattern in optical media on the card. This technology makes the card more resistant to tampering and forgery. Courtesy of LaserCard.

A better watermark

A key feature of any such ID is that it be resistant to forgery and tampering. Photonics technologies can help on both fronts.

LaserCard Corp., also in Mountain View, has been in the security ID system business for years, electing to encode information in a write once, read many times optical medium. The reason behind this choice is, in part, that the optical method enables greater storage capacity, said the company's chief operating officer, Christopher J. Dyball.

Today, LaserCard's products offer 2.8 MB of storage, far greater than the approximately 72 kB available in smart cards. That extra room makes it possible to store a complete biometric record in an uncompressed format – and not just the extracted features used for matching. That amount of storage space also makes it possible to keep an image of the cardholder on the card. Thus, in one medium, a machine-readable biometric – such as a fingerprint – can be stored, along with a human-viewable photograph or a human-readable signature.



Thanks to the use of artificial intelligence, video surveillance systems such as AISight from BRS Labs are getting smarter, with the ability to alert with virtually no false alarms. But the technology cannot yet identify subjects at a distance, due in part to imaging capabilities. Courtesy of BRS Labs.

"That image is visible and very difficult to replicate," Dyball said. "It has diffractive characteristics that are very difficult to reproduce by any other method."

The technology used is similar to that employed to burn records onto a recordable compact disc (CD-R) – with some crucial differences. The lasers employed are in the near-infrared, running from 780 to 830 nm, about the same range as in CD-R technology, Dyball said. The biggest difference is that the bit size is

2.5 µm and the track pitch is 12 µm, roughly three to 10 times the equivalent figures for CD-R.

That extra room, along with the use of a large chunk of the possible capacity for error correction, makes the optical stripe much more robust than is the case for the standard office CD-R. That toughness is important, given that LaserCard's products are used as official documents by governments including those of the US, Italy, Saudi Arabia and Angola. These cards must last until they are reissued, a period that can be as long as 10 years.

LaserCard is planning to further improve the security features on its products. The optical medium enables creation of a secondary image, one that will appear only when the illumination is at the correct angle. Although it is possible to view this using nothing more than a laser pointer and a white wall, it would take exceptionally steady hands. So the company is developing a tool to make this easier.

"We will offer a small handheld device with a laser in it, which will allow you to view that secondary diffraction image," Dyball said.

Identification at a distance

Despite their advantages, photonics technologies also have a shortcoming. The cards must be presented to a reader, be it machine or human. The scan can be very fast but it can't happen before then.

But checkpoints can be busy places. An extreme example is the San Ysidro border crossing in the San Diego section of California, used by 17 million cars and 50 million people in 2005. Saving even a bit of transit time can have a large economic impact.

That is one reason why the US has turned to RFID technology, which allows information to be extracted while the ID holder is still in line. Photonics technologies can, of course, make such documents more secure through watermarks and the like.

Photonics technologies have the potential to allow identification at a distance. There are efforts under way to read fingerprints or handprints without contact. It may even be possible to do the same with the face, thereby allowing the use of one of the most unobtrusive methods.

Accomplishing that will not be easy. The face is three-dimensional, but imaging is typically 2-D. Thus, any facial recognition system must transform a 3-D model of the subject's face, captured during enrollment, into a 2-D version that can be compared with what is imaged. The transformation must account for changes in lighting, viewing angle and expression, and for facial alterations such as beards, glasses and movement.

Doing so at a distance requires a high-resolution camera, telescopic optics, plenty of memory and a powerful processor. Things such as gait and body shape also could be used to increase recognition efficiency.

However, even all of that might not be enough. Behavioral Recognition Systems, based in Houston, makes software that learns what is normal in a scene and then reports anything unusual. According to its chief technology officer Eric Eaton, there are distinct challenges to enabling facial recognition at a distance, and today's gold standard systems are not perfect.

"Even people are sometimes tripped up by how similar two different people can look," he said.

hank@hankhogan.com

Taking Semiconductor Manufacturing to the Extreme

BY DAVID L. SHENKENBERG
FEATURES EDITOR

As consumer and enterprise demand for faster computers increases, so will the demand for faster computer chips. The speed of computer chips is directly related to the number of transistors that can fit on a chip.

Transistors work like switches that enable and stop the flow of electricity, which corresponds directly to the binary code of ones and zeroes that underlies all computer functions. The more transistors, the more zeroes and ones are available to make more elaborate codes.

In 1965, Gordon Moore predicted that the number of transistors that can fit on a computer chip will double every two years. This prediction has become known popularly as Moore's Law, and it has been true for 40 years, thanks largely to Intel, the company that Moore founded with Robert Noyce, which is still the world's largest chip maker. However, physical limitations may prevent Moore's Law from continuing to be true.

Transistors are assembled in recessed areas on a chip. Thus, to create more transistors, smaller and smaller recessed areas must be created in a process called photolithography, which is accomplished by shining light uniformly on a mask – a light-blocking material with geometrically patterned spaces cut into it.

The fineness of the spaces in the mask limits all but very small wavelengths of light from passing through. Currently, 193-nm deep-ultraviolet light is used, but researchers want to use extreme-ultraviolet (EUV) light of 13.5 nm to penetrate even finer spaces so that they can assemble even more transistors on computer chips. The light sources of extreme-ultraviolet are the limiting factor in this endeavor.

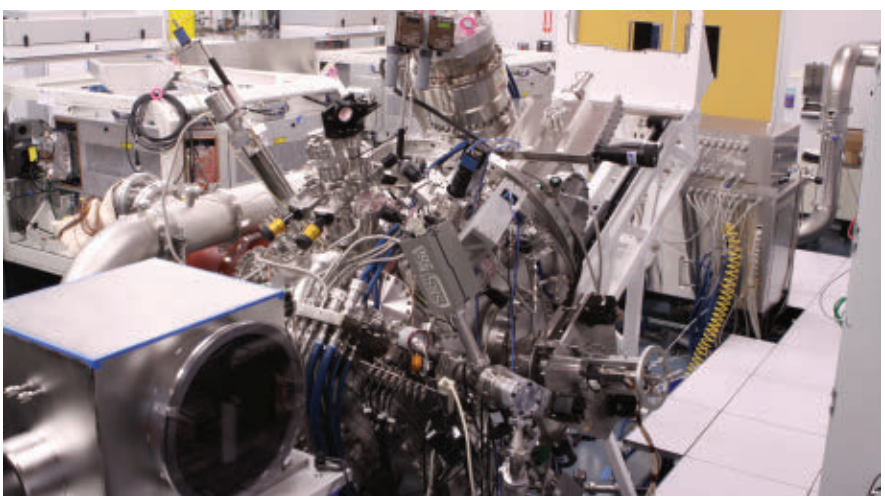
"EUV sources have come a long way from being a lab curiosity," said Vivek Bakshi, the president and founder of EUV Litho Inc. of Austin, Texas, through which he offers consulting services, workshops and an annual meeting in Hawaii on EUV technology.

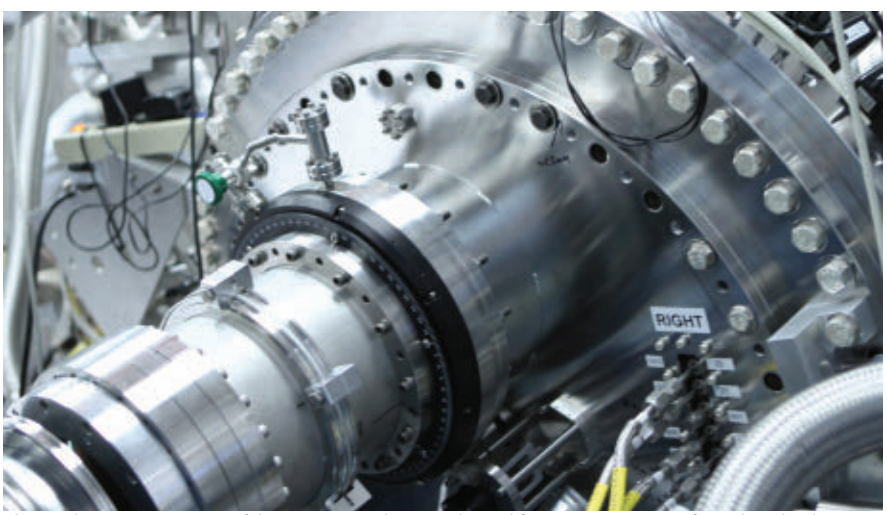
"Today, multiple suppliers around the world … are investing lots of money and effort to make sources that can support high-volume chip making – the stage at which you are making products to sell," Bakshi added.

Inside an EUV source

EUV sources are big, shiny, metal machines that attach onto other big, shiny, metal machines referred to as scanners. The computer chips are placed in these scanners, and EUV light from the sources is routed to the scanners using collector optics such as special mirrors that reflect EUV.

There are two types of power sources: laser-produced plasma and electric discharge-produced plasma. Because the laser sources are significantly more powerful than the electric sources, they are being developed for beta-level scanners, whereas electric sources were used in alpha scanners.





Shown above are two views of the EUV source that was shipped from Cymer to ASML for its beta-level EUV lithography scanner. Courtesy of Cymer.

Bakshi said that Netherlands-based ASML and Tokyo-based Nikon are the leading makers of EUV lithography scanners, and ASML is ahead of Nikon with a beta-level scanner in production.

Laser-produced plasma EUV sources are fabricated by firing a rapidly pulsed infrared laser at molten droplets of tin. These tin atoms can contaminate the computer chips, so a debris filter is necessary. "Integrating an EUV source with a collector and a debris filter to make a system known as a source collector module is a big challenge," Bakshi said.

The goal for a completely integrated beta-level system is about 60 to 100 W of power. A San Diego company called Cymer has provided a laser-produced plasma EUV source for ASML that, in a press release, it said was measured at 75 W.

However, Bakshi said that the power level is meaningful only if the source is integrated completely with the scanner, for the reasons stated above, and the power level must be continuously stable for a long time to meet the demands of industrial-scale production.

David Brandt, senior director of EUV development at Cymer, told *Photonics Spectra* that the 75-W power from its EUV source was measured on a development system in its facility using a NIST-calibrated EUV photodiode to record the plasma emission through a zirconium foil.

The EUV source was operated at 40 percent duty cycle in 400-ms bursts – long enough to expose a full 32-mm field, assuming a 10 mJ/cm^2 resist. The power was run for the course of a day while the parameters were varied to determine the best ones. Once the best parameters were determined, the Cymer engineers ran it for an hour or so.

Alternatives to EUV

EUV is not the only way to break the photolithography limit. The wavelength could be shortened using lenses such as the plasmonic superlens developed by the Xiang Zhang group and put on a flywheel with the assistance of the David Bogy group, both at the University of California, Berkeley, as described in the December 2008 issue of *Nature Nanotechnology*.

Another strategy that could work involves the use of self-assembling polymers such as those described by Thomas Russell of the University of Massachusetts Amherst and Ting Xu of Berkeley in the Feb. 20, 2009, issue of *Science*.

Some scientists have described the use of lasers and other light sources to shape acrylic polymers, which are used frequently as photoresists on computer chips. Similar techniques based on this premise have been developed independently by the groups of Robert McLeod at the Univer-

Will the economy kill Moore's Law?

Faster computers require faster computer chips. Although the global economic recession has reduced the demand for computer chips, the semiconductor industry and the economy as a whole have shown signs of recovery. The Semiconductor Industry Association President George Scalise has said, "The fourth consecutive monthly increase in sales is one indicator the industry is returning to normal seasonal growth patterns."

sity of Colorado at Boulder, John Fourkas at the University of Maryland and Rajesh Menon at MIT.

"As opposed to EUV techniques, ours can be conducted in ambient atmosphere rather than under vacuum conditions," Fourkas said. "In addition, it is far easier to work with near-infrared light than EUV, and the optics are far less expensive."

All three methods are detailed in the May 15, 2009, print issue of *Science*. According to the papers, the inspiration for all of the techniques was stimulated emission depletion microscopy, in which fluorescent molecules are excited by a fluorescent laser pulse, and then a second laser pulse of a substantially longer wavelength is used to de-excite the molecules through stimulated emission.

Essentially, all three groups used an acrylic resin mixed with a dye and shined two laser beams on the mixture. One beam caused the resin to harden in certain areas, while the other beam prevented hardening.

The Menon and McLeod groups used UV and visible light, and the Fourkas group used two infrared Ti:sapphire lasers, one pulsed and the other always on. The McLeod group also used LED and mercury lamp light sources, which are cheaper than lasers.

According to McLeod, "The main advantage of our technique is that it uses two single-photon processes. That means we can potentially scale to commercially interesting throughput. Two-photon absorption is very, very inefficient …."

The Fourkas technique is called RAPID (resolution augmentation through photo-induced deactivation). "RAPID was chosen as an easy-to-remember acronym, but it is a serial technique currently and therefore is not tremendously fast," Fourkas said. "We are working on a considerably more parallel version," he added.

Fourkas continued, "RAPID offers significant advantages over [the McLeod] technique for 3-D fabrication and also only requires a single color of light. In addition, the photo-initiator is regenerated in RAPID, whereas in [the McLeod] technique, both the initiator and inhibitor are used up upon exposure. Under some conditions, this can lead to difficulties in fabrication, particularly in thicker samples. However, their method is very good for 2-D fabrication in thin samples."

Industrial scale

Although Bakshi is interested in all of these alternatives to EUV, he is skeptical about any of them achieving industrial-scale throughput. He pointed out that, once it is developed, EUV can be adapted to existing systems, but that the other techniques probably will need more extensive adaptation to existing industrial systems. He added that the technology needs to come out at the right time. For instance, 157-nm photolithography was invented but never caught on because of poor timing.

Just what is the current volume of wafer processing at industrial speeds? "Currently, a lithography scanner needs to print at least five hundred 300-mm wafers per hour," Bakshi said. "This means it takes about 36 seconds to print one wafer." The Intel dual-core Atom processor, for instance, contains 47 million transistors. Imagine printing one of these chips with 47 million transistors in 36 seconds.

Ultimately, time will tell which of these methods gets adapted to industrial-scale lithography. This area of research and development is extremely competitive. May the best technology win.

david.shenkenberg@laurin.com

Instant Revenue: Marketing and Mergers

How can companies generate revenue right now? An industry expert shares his advice.

BY MILTON CHANG
INCUBIC MANAGEMENT LLC

Given the current state of the economy, any practical discussion of marketing and business development should focus on revenue generation, here and now. What can photonics companies do right away to increase their bottom lines?

It is wise to examine the job descriptions for the people who handle sales, marketing and business development to know who is responsible for what, so that nothing falls through the cracks. My personal belief is that work demarcation should be blurred: Everyone in the company should be working as a team to get the job done – in this case, to make more sales.

The center of sales activity is direct customer interaction. Marketing reps are in touch with customers, too, for sure – to understand trends – but that is one step back in the selling process. Marketing is responsible for building the brand, deciding on new products, getting the word out to customers, and doing whatever is necessary to gain customer acceptance and start the buying process.

Business development, which makes it possible for the company to conduct business in the future, is even further back. People in business development think about long-term strategy and decide what direction the company should take, such as what markets it should enter, what strategic alliances it should form and what companies it should acquire.

My belief has always been that every product must carry its own weight. That is, we should never forget that a good business is the result of having good products. But if you already have good products, what can you do to increase revenue?

The quickest way to increase sales is to crank up your sales force. You can debate whether or not this works for the photonics industry. I have always believed that people in this industry buy what they need and are knowledgeable enough to know whom to call. Also, out of respect for my customers as colleagues, I always used to

be reluctant to "bug them" or to prompt them to place an order, thinking it wouldn't sway them anyway. Not so! When we hired a CEO to run New Focus, sales increased at least 20 percent simply because we followed up more actively.

Promotional materials

In the near term, marketing can make a big impact on revenue in a matter of a month or two just through advertising and promotion. Getting the word out is an important first step in the sales cycle. Customers can't think of buying your product if they are unaware of its existence and certainly won't buy unless the product's merits are known.

This is such an important aspect of marketing – and, frankly, I think this is an area where our industry can use some improvement. I enjoyed making ads when I was running both Newport and New Focus for close to 30 years, and here is what I learned.

Arguably, print ads may be the most direct form of advertisement because they put information in front of customers. Their effectiveness can be further enhanced by connecting them to your Web site. That is, you can provide interesting tidbits in the ad as a hook. This can get a reader to pick up the phone to start the sale, or to click onto your Web site to find out more. If your ad is really interesting, it could even spread the word to begin what might be the most effective marketing tool: viral marketing. And then your message can spread like wildfire.

Remember, when you prepare an ad, its sole purpose is to prompt readers to take action. With that, anything else you get – such as name recognition – will be a bonus.

I find that many ads in our industry are either too busy or they are irrelevant. Many are jammed so full of information that they become unattractive, rendering them ineffective. Less is definitely more in this case: Readers will skip over unattractive ads. Some advertisers try so hard to make ads creative that they wind up making them irrelevant. Do I need to look at an elephant to realize the product is compact? Valuable space that could have been used to convey a meaningful statement is wasted. Of course, you must have a "clean" and visually pleasing ad to imply that the company is a class act, and you want to repeat the message multiple times so it can sink in.

An ad has to be brief, simple and straightforward, because no one in this age of information overload has spare time to read a convoluted argument about why the product is clever. No single ad can convince a customer to place an order without further interacting with the company, but customers are one click or one phone call away, really, if you give them a good reason to act. To me, that's a fair exchange: useful information for their attention.

My all-time favorite advertisement is a long-ago Rockport ad with just a snapshot showing a pathetic-looking guy in running shorts wearing a pair of leather shoes. The banner simply stated something like, "I just ran the New York Marathon in my DresSports." Intrigued, I quickly went to a shoe store to see if that shoe could keep my feet from being sore when I had to stand all day at trade shows. Had it been a pitch about how well the shoe is constructed to solve my sore foot problem, I would not have read it. But the ad created what professional marketing people call "a pull" for me to come up with my own reasons to buy the product.

Partnering and acquisition

These are unusual times. The US federal funds rate and the London Interbank Offered Rate, or LIBOR, may be very low, but credit is really tight and hard to get, which makes corporate borrowing expensive.

One way to get around this problem and to keep business development active is through partnering. This, in essence, allows participating parties to make more effective use of existing resources and infrastructure – with the hope that the sum is more than the parts.

In the case of combining two established businesses, the decision is relatively straightforward. The major consideration is that financial numbers have to be accretive. Most importantly, the per-share earnings should increase by being more effective in the operations, sometimes by eliminating duplications.

Getting acquired makes sense for an embryonic business because it eliminates the need for a major infusion of investment capital to build out the business, in addition to avoiding the resultant dilution of ownership. The reality is that technology is now quite mature in the photonics industry, which implies that businesses are competing less on technology and more on execution: branding and marketing, and operational efficiency. Innovations often are achieved by adding incremental product features instead of developing new technology. At this stage, size and financial muscle do matter. This means that it is harder for start-up companies to compete with established ones.

In the case of an acquisition, an established company can enter a new market quickly, with both technology and market risks resolved by acquiring an early-stage company, sometimes at a lower cost than would be involved in developing the technology in-house. Revenue can be obtained without having to make a big investment in business infrastructure by adding onto existing operations. It's a win-win, especially when the cost of capital is high.

There is so much to gain by partnering, and there is no downside that I can see. Partnering, or growth by acquisition, has proved successful in many industries, including photonics. Synopsys, a leading semiconductor design automation software business that employs more than 5000 workers, has acquired 15 companies in its 23-year history, for example.

Partnering obviously is already going on in the photonics industry. The question is: Could there be more? I envision us as a community – a business ecosystem where established companies play a nurturing role to incubate technology in universities and start-up businesses, sometimes with the help of government grants. We're not there yet, but this ideal is possible.

Business is not a zero-sum game because opportunities are open-ended. By working together – instead of wasting energy beating each other down – we can build on each other's ideas to develop more applications opportunities. By pooling resources, we can make effective use of funds that in recent years have been limited in the photonics industry. And we will all be better off with a stronger photonics industry.

Meet the author

Milton Chang is semiretired, working with portfolio companies and mentoring entrepreneurs. He has been an investor in the photonics industry and was CEO and president of Newport Corp. and New Focus Inc. prior to forming Incubic, a venture capital firm. He is a fellow of the IEEE, LIA and OSA, and he is past president of LIA and LEOS. He is a Caltech trustee, a member of the Committee of 100 and a director of Precision Photonics; e-mail: miltonchang@incubic.com.

The Photonics Industry Shines in France

BY CAREN B. LES
NEWS EDITOR

"With more than 400 manufacturers of cutting-edge photonics technologies and a solid R&D base, French [photonics] companies have continuously delivered innovative new products that have ensured their strategic position in the global market," said Samuel Bucourt, president of the Association Française de l'Optique et de la Photonique (AFOP).

And, he added, these strengths have translated into relative stability for the industry, with very few companies experiencing difficulties and most continuing to develop steadily. "Even with the current economic downturn, exports count for near 50 percent, on average, of French photonics companies' income."

"The French photonics industry is extremely diverse, producing goods for consumer, industrial and scientific markets," said Bucourt, who noted that key industry- driving technologies include fiber optical networking equipment for ultrahigh-speed communication, lasers for a wide range of applications, LEDs, OLEDs, lighting, and sensors and detectors. "One of the key challenges in maintaining innovation and competitiveness is the continued participation in European and international collaborative projects."

Targeting growth sectors where photonics technologies may offer an economic, ecological or functionally superior alternative to other technologies – defense, energy, security, medicine and scientific instrumentation – will be important for the French photonics industry's future, he said.

All-optical communication is poised to be a major growth market over the next few years: There are several manufacturers of ultrahigh-speed fiber optical equipment in France, and numerous research projects are under way to secure the companies' competitiveness in this domain, he added.

French companies are positioned to play a strong role in the optics sector, particularly in the area of providing instrumentation for large ground-based telescopes. In the domain of medical and fiber lasers, several companies recently announced new, patented laser technologies that have overcome the limitations of the commercial lasers currently available, Bucourt said.

On medical imaging and optical diagnosis, he said that strong collaborative efforts between industry and academe are yielding impressive results and a common understanding of the "race to the market" and are driving the sector in a number of domains, including confocal microscopy and ultrahigh-resolution nonlinear imaging.

Bucourt named the areas of nanotechnology, biophotonics, metrology, imaging, medicine, defense and security as the major application areas for French photonics technologies in upcoming years.

"Manufacturers in lasers, life sciences imaging, photovoltaics, industrial thermography and many other domains have recently unveiled truly innovative products that have tremendous market potential. Among the major goals of the French photonics industry is to develop public awareness of photonics' potential to be the 'industry of the future,'" he said.

Although the French photonics market is essentially composed of small companies well-known for their individual expertise and the quality of their products, he said, it is rare that these enterprises develop into major international players. The industry must increase the number of technology transfers and ensure that research yields marketable products, he noted. "We need to foster both intercompany and public-private collaboration on the national and international levels."

The photonics production volume in France is valued at €5.4 billion, representing 12 percent of the European production volume and about 2.5 percent of the world market, according to the March 2009 report *Photonics in Europe: Economic Impact*, published by the European Technology Platform Photonics21, based in Düsseldorf, Germany.

John Dudley, chairman of the Quantum Electronics and Optics board of the European Physical Society, based in Mulhouse, France, and also a laboratory researcher with close links to industry, believes that the European Union's strategic research policy of promoting photonics as an enabling/pervasive technology is leading to a diversity of applications where photonics is embedded.

Balancing act

Jay Liebowitz, executive vice president of Teem Photonics SA of Meylan, France, and president of Teem Photonics USA of Lafayette, Colo., said his company specializes in passively Q-switched Nd:YAG solid-state microchip lasers, whose pulse widths of hundreds of picoseconds place them in a niche between nanosecond actively Q-switched solid-state and <10-ps mode-locked lasers. The lasers have a broad variety of applications; among them, materials processing, Liebowitz said.

"We are always asking ourselves whether we should be controlling spending even more carefully or whether we need to accelerate development of new lasers," he said. He added that the company is constantly developing ways to maintain the design simplicity and low cost of its lasers while increasing frequency control and average power.

Selectivity is key

Based in Besançon, France, Photline Technologies offers optical modulation products that are based on its lithium niobate modulators and radio-frequency electronics modules.

"Applications for the offerings are in all the areas where fiber optics are used," said Philippe Le Roux, the company's sales and marketing director. For telecommunications, Photline supplies quadrature phase-shift keying modulators to systems integrators and telecommunications R&D laboratories, as well as customized 40-Gb/s modulation units. Defense is another segment where

Paris

the need for optical modulation is high, he said.

"As Photline Technologies gains recognition, it is offered more projects, and a major issue is becoming selective," he said. "The demand for new products and projects is growing faster than our internal human resources."

High-power lasers and life sciences imaging

Imagine Optic SA's component line includes the Haso family of high-precision Shack-Hartmann wavefront sensors, deformable mirrors for wavefront shaping and correction, and software. Based in Orsay, France, the company offers turnkey systems that integrate its component technologies with its expertise in wavefront analysis and adaptive optics.

The company is collaborating with several research groups, said Bucourt, who also is CEO of Imagine Optic. Research areas include the ILE (Extreme Light Institute) project, in Palaiseau, France, which is a prototype, smaller version of the soon-to-be-built ELI (Extreme Light Infrastructure) ultrapowerful laser. Among other research areas, the company is cooperating to produce commercially available nonlinear microscopes equipped with adaptive optics that will offer features such as higher resolution, improved image quality, enhanced focal depths and greater image contrast.

The company plans to give high priority to applications in life sciences imaging and industrial process control, particularly in the areas of optical component and surface characterization.

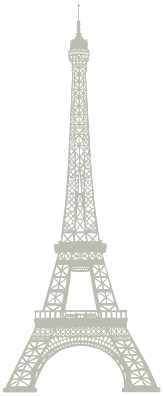
Imagine Eyes, sister company of Imagine Optic and also based in Orsay, supplies wavefront analysis and adaptive optics products for ophthalmic applications, according to Mark Zacharria, the company's director of marketing communications. The company's primary challenge is to bring a cellular-level retinal camera to the clinical market as soon as possible, he said.

Life in the imaging market

"E2v semiconductors SAS of Saint-Egrève, France, is one of the six design, development and manufacturing facilities of e2v [technologies plc], a component and subsystem specialist group based in Chelmsford, UK," said Christophe Robinet, business development manager for the company's Imaging Devices Div.

The division consolidates activities in CCD and CMOS sensors and subsystems for applications in space, astronomy, machine vision, the life sciences, the medical field and automated data collection. "The engineers in Grenoble, France, along with the teams in Chelmsford, contribute to the overall knowledge base for the demanding requirements we serve," he said.

Among the innovative prod-



ucts recently released are the following: a plug-and-play USB CMOS integrated x-ray dental intraoral sensor; high-speed machine vision multiline cameras; and low-noise but high-data-rate cameras for ophthalmology.

Robinet said that e2v remains well positioned to operate as a key partner and supplier in the high-end imaging market in Europe and the US and in the emerging Asian market.

Global technology supplier Thales AS, based in Neuilly-sur-Seine, France, recently merged

Besançon

its lasers and optronics businesses. Located in Élancourt, France, the combined operation, called Laser Solutions Unit, Thales Optronique, will enable Thales to develop its laser business by investing in specific technical and industrial facilities and by exploiting synergies with the optronics business, said Denis Levaillant, managing director of the new entity.

The company's Gaia-R Nd:YAG lasers open new possibilities in the industrial application of laser shot peening, and its Etna series lasers have applications in photovoltaics and microelectronics manufacturing. Thales uses nanosecond lasers, including the Gaia-R, to pump its femtosecond systems – such as in its petawatt offerings, which are used in research laboratories worldwide, Levaillant said. "For the longer term, the company is developing new products for military applications, he added.

The Thales laser business is set to achieve 20 percent growth per year over the next three years, he noted.

Challenges for French photonics researchers

The role of CNRS, the French National Center for Scientific Research, is about to change: Much of its research activity will be transferred to universities, according to Patrick Meyrueis, scientific director of the Laboratoire des Systèmes Photoniques, which is located at the site of École Nationale Supérieure de Physique de Strasbourg in Illkirch, France.

The problem is that many photonics teams, which tend to be smaller in number, will be integrated into larger laboratory teams dedicated to electronics, robotics or telecommunications, he said. As a result, photonics teams could lose opportunities for fundamental photonics research, which could result in the development of fewer photonics breakthroughs, he warned.

"Unfortunately, the number of doctoral degrees conferred in photonics in France annually is slowly decreasing, which will eventually lead to fewer engineers who will consider photonics as a possible resource for solving electronic and mechanical problems," Meyrueis said.

caren.les@laurin.com

Machine vs. USPTO

To patent or not to patent discoveries from artificial intelligence, that is the question

By using the scientific method – careful observation, formation of hypotheses, experimentation, interpretation and reproduction of the results – a researcher has given us a better understanding of the genomics of the yeast *Saccharomyces cerevisiae*, including new information about gene sequencing and the encoding of orphan enzymes. But what is particularly new is that the researcher was not a human but a robot named Adam.

Meet Adam

Adam was created by a team led by Ross D. King, a professor in the computer science department at Aberystwyth University in the UK. Working autonomously, the robot formulated and tested 20 of its own hypotheses in connection with 13 orphan enzymes and observed 6,657,024 optical density measurements. It also designed and initiated more than 1000 new yeast strains and defined growth medium experiments lasting up to five days. Adam's most important discovery was that three genes (YER152C, YJL060W and YGL202W) encode the enzyme 2-aminoadipate:2-oxoglutarate aminotransferase (2A2OA), which catalyzes a reaction in lysine biosynthetic pathways of fungi. To confirm Adam's conclusions, King purified the protein products of the genes and applied them to in vitro enzyme assays.

Knowledge of gene-encoding enzymes remains incomplete, but Adam's use of systematic bioinformatics and phenotypic analysis marks a turning point for researchers, as they will be able to explore comparative genomics in detail.

Laying down the law

In a letter published in the May 22, 2009, edition of *Science*, registered patent attorney Robert W. Stevenson and colleagues from Caesar, Rivise, Bernstein, Cohen & Pokotilow Ltd. in Philadelphia questioned whether ideas generated by a machine could be patented. They cited 35 U.S.C. Section 102(f), which states that a "*person* shall be entitled to patent." The code also states that an inventor cannot obtain a patent if "he did not himself invent the subject matter sought to be patented."

It seems, therefore, that under US law, only discovery by a human being can be given full protection under the law; an idea from a different informant – e.g., a machine – may not obtain valid patent protection.

In this situation, one also could apply Section 101, which says that "*who*ever invents … may obtain a patent," not "*what*-ever," further specifying that patents are issued to human beings.

Stevenson brings up another issue related to patentable subject matter: the requirement of nonobviousness. "If a machine can come up with a theory based on how it's programmed, would the court consider the invention obvious?" An obvious invention is an idea that would be evident to a person with ordinary skill in the subject matter at hand, much as King's knowledge of gene sequencing enabled him to create a robot that can analyze genes.

There is a certain amount of "care that should be taken when applying these technologies," Stevenson said. At least by supplying your own theories to the machine and allowing it to confirm the development later, "the idea is still yours, and there shouldn't be any problem with the patent law that would exclude you from obtaining a valid patent," he added.

It is hard to speculate whether the US Patent and Trademark Office (USPTO) would ever grant patentability to discoveries such as Adam's or whether the inventions would become freely available without patent protection. Nevertheless, in an age where robotics technology is advancing at an exceedingly fast rate and computers are increasingly becoming a staple in scientific experimentation, it is quite probable that machines akin to King's robot could redefine the term "inventor" or even rewrite the book on patent law.

Amanda D. Francoeur
amanda.francoeur@laurin.com

Method for Gas Chromatography Under Patent

US Patent No. 7,422,625, titled "Methods and Systems for Characterizing a Sorbent Tube," has been awarded to PerkinElmer Inc. of Waltham, Mass., a health and safety service provider. The new method provides gas chromatographers with more accurate results when using automated thermal desorption gas chromatography, an air monitoring system used for examining soil, water, biofuels, polymers, packaging materials and pharmaceuticals, among other applications.

Spatial Heterodyne Spectrometer Assembly Patented

Dr. Christoph R. Englert, a space scientist at the Naval Research Laboratory in Washington, has been awarded a patent by the US Patent and Trademark Office for his compression assembly design for spatial heterodyne spectrometer interferometer applications. The methods can be used for high-resolution space- and ground-based spectroscopy of diffuse sources, including atmospheric emissions or trace gas absorptions. The system is cost-efficient and robust, and it provides design flexibility with the option of various spacer materials.

Optech Patents Underground Cavity Monitoring System

Optech Inc. of Toronto, a developer and manufacturer of laser-based survey instruments, has acquired the intellectual property rights of Noranda Inc.'s underground cavity monitoring system (CMS) for monitoring mines. Originally called a mast volumetric laser, the CMS scans elevations continuously with a rotating laser rangefinder and can be deployed into underground cavities.

BRIGHT IDEAS

Vertical Diode Laser Stack

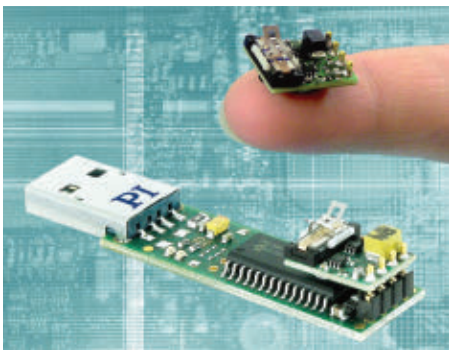
Dilas has introduced compact quasicontinuous-wave vertical diode laser-stacked arrays in wavelengths from 808 to 9xx nm, with power of up to 300 W per bar and optional fast-axis collimation. The AuSn-soldered devices are designed to operate in high temperatures for use in applications such as defense and diode-pumped solid-state lasers. Conduction-cooled, they are available in one-, seven- and eight-bar configurations with up to a 4% duty cycle at 200 W per bar. Advanced packaging and high-precision optic mounting enable fast-axis stack divergence down to 6 mrad. The standard models can be customized to accommodate requirements for interfaces, beam propagation and mechanical dimensions, and custom devices are available upon request.

Dilas
sales@dilas.com

Miniature Ceramic Motor

The patented P-653 piezo motor linear slide manufactured by PI (Physik Instrumente) LP operates at 200 mm/s with millisecond responsiveness. Travel range is 2 mm, and force generation is to 0.15 N. The developer's kit plugs into a USB port and is supplied with control software. The nonmagnetic miniature ceramic motor is a true linear motor slide and produces no rotary conversion losses. It is self-locking, preassembled and mounted on a printed circuit board running on 5 VDC. The piezo motor drive is 8 mm long and comprises only four parts.

PI
photonics@pi-usa.us



CCD Cameras

Princeton Instruments has added a front-illuminated, a back-illuminated and a back-illuminated deep-depletion model to its Pixis line of CCD cameras. The Pixis 1300 series cameras are based on a proprietary 1340 × 1300-pixel sensor with an imaging area measuring 26.8 × 26.0 mm. Features include 20-µm pixels, dual 100-kHz/2-MHz digitizers, multiple gains, multiple output amplifiers, read noise of 2 e^- rms, all-metal hermetic seals, a USB 2.0 interface and a single optical window design. The cameras offer flexible binning and region-of-interest capabilities and are supported by WinView software.

Princeton Instruments
moreinfo@piacton.com

Large-Format Lens

For use with full-frame 11- and 16-megapixel sensors, Navitar Inc. has announced its 50-mm large-format machine vision lens. The Raptar lens covers a 43-mm-diagonal sensor with a field of view of 50 mm and a focusing range from 0.5 m to infinity. Features include a manual iris and focus control with positive single-point focus and iris locks. Lens aperture range is from f/2 to f/22, and angular field is 46° diagonal and 37° horizontal. The lens is supplied with an F-bayonet, with M42 and C-mount available as options. Applications include veterinarian digital x-ray, food and plastics sorting and inspection, and inspection of film, paper and plastics defects.

Navitar
info@navitar.com

Infrared Temperature Sensors

The FT series digital infrared sensors have been launched by Keyence Corp. of America for noncontact detection of surface temperatures ranging from 0 to 1350 °C. Measurement can be performed from distances of up to 3000 mm, enabling the sensor head to be mounted away from harsh environments. The optional air purge enclosure eliminates dust buildup, and the ergonomically designed amplifiers can be panel- or cabinet-mounted. Response time is 10 ms, and field of view is 1.5 mm. Analog output from 4 to 20 mA can be scaled to a user-defined range, and up to four sets of discrete upper- and lower-limit outputs and emissivities can be stored.

Keyence
keyencepr@keyence.com

Photovoltaic System

Craic Technologies Inc. has launched its QDI 2010 Film, a microspectrophotometer designed to rapidly and nondestructively measure the thickness of thin films of photovoltaic cells. Combining microspectroscopy with software, it enables the user to measure film thickness by either transmission or reflectance of many types of materials and substrates. Sampling area ranges from >1 to >100 µm. When combined with the company's contamination imaging capabilities, it can test the transmissivity of photovoltaic cell protective covers. Contamination analysis and transmissivity testing can be added easily to the instrument.

Craic
sales@microspectra.com

Industrial Laser

The Spectra-Physics Lasers Div. of Newport Corp. has released the Pulseo 532-34, a Q-switched diode-pumped solid-state industrial laser that outputs >34 W at 532 nm with a pulse width of <30 ns at a repetition rate of 120 kHz. Applications include electronic package and printed circuit board singulation, ceramic scribing and edge isolation of c-Si wafers. Peak power is >13.5 kW, beam divergence is <0.3 mrad, asymmetry is >85%, and astigmatism is <0.2. The laser delivers a Gaussian TEM_{00} beam with M^2 <1.3. Power stability over 8 h at constant temperature is ±2%, operating temperature is from 18 to 35 °C, and power consumption is 1.1 kW.

Spectra-Physics
tim.edwards@spectra-physics.com

Mini Laser Bars

Osram Opto Semiconductors has introduced the SPL BF series mini laser bars, which operate from 910 to 1020 nm for pumping fiber lasers and for direct micromaterials processing such as marking and microwelding. The light beam leaves the laser aperture at a defined angle and can be coupled into a 200-µm fiber core diameter with a restricted acceptance angle and a numerical aperture of 0.22. The bars' very large optical cavity epitaxial structure and proprietary mirror coating technology produce high brilliance. Fill factor is 10%, output is 8 W per emitter at an emit-

ter width of 100 µm, and slow-axis divergence is <7°.
Osram Opto Semiconductors
support@osram-os.com

LED Driver

National Semiconductor Corp. has extended its product line to include the LM3530 LED driver, a white light-emitting diode driver with display backlight control. The device drives up to 11 high-current LEDs in series, illuminating larger displays in portable media devices, including smartphones. It employs sophisticated ambient light-sensing algorithms and content-adjustable backlighting to optimize the display, saving up to 55% compared to when the backlight is driven at constant brightness. It also features a 1000:1 dimming ratio and 90% efficiency.
National Semiconductor
new.feedback@nsc.com

Laser Scanner

Leica Geosystems Metrology has announced the T-Scan TS50A, a handheld laser scanner that interfaces with the company's Absolute Tracker to deliver higher data acquisition rates, point density and accuracy. It features self-adjustment to lighting conditions, the ability to scan all types of surfaces, whether shiny or dark, and reduced system noise. It is suitable for automotive, aerospace, wind power, shipbuilding, defense and heavy equipment applications.
Leica Geosystems
info@leica-geosystems.com

Digital Cameras

Vision Research Inc. has expanded its v series digital high-speed cameras with the introduction of the CMOS-based Phantom v710 and 210 models. The former achieves a maximum recording speed of 1.4 million fps at reduced resolutions, and 7530 fps at maximum 1280 × 800-pixel resolution. Active pixel size is 20 µm, shuttering is down to 300 ns and programmable in 18-ns increments, and straddle time is 500 ns with no image lag. The v210 delivers a maximum rate of 2000 fps at full resolution, and 300,000 fps at reduced resolutions. The 2-ms global electronic shutter lessens motion blur. Both are compatible with the company's CineMag memory magazine system, and both are available with a color or a monochrome sensor that supports 8- and 12-bit pixel depths.
Vision Research
phantom@visionresearch.com

Laser Profile Sensors

The CrossCheck precalibrated laser profile sensors introduced by Bytewise Measurement Systems perform 3-D high-resolution profile measurements and include real-time shape tools to measure thickness, height, width, angle, radius, location and other shape-based parameters. They can be installed in-process or off-line to qualify product and part dimensions, to output pass/fail trigger alerts and to interface to control loops. All models offer a profile rate of 30 Hz and thermal stability of <0.03%/°C, and they operate at temperatures from 5 to 45 °C. The visualization software displays graphical measurement results in real time.
Bytewise Measurement Systems
sensors@bytewise.com

Fiber Laser

GSI Group's Laser Div. has expanded its JK family of fiber lasers with the introduction of the JK400FL 400-W continuous-wave model. Operating at 1080 ±10 nm, it has a linewidth of <2

nm, minimum rise and fall time of 5 µs, maximum modulation frequency of 50 kHz and a TEM_{00} beam with M^2 <1.1. It features a stable single resonator and built-in pulse shaping and, because of the absence of free-space optics, requires little maintenance. The single-mode output fiber delivers a near-diffraction-limited beam that is consistent and stable across the power range. Wall plug efficiency at maximum power is better than 25%. The laser includes built-in backreflection protection, proprietary graphical user interface software and a user-customizable machine control interface.

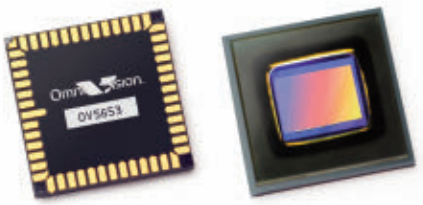
GSI Group
sales.laserdivision@gsig.com

Print Quality Inspection

The IntegraVision PQ print quality inspection system launched by Lake Image Systems Inc. provides "golden template" matching of all pages printed on a web, comparing each page to how an ideal image should look. It offers commercial printers and label manufacturers consistent repeatability for pharmaceutical, medical and food packaging applications. A high-resolution line-scan camera images 100% of the print produced, at speeds up to 1000 ft/min. Print errors are identified in real time. Detectable errors include streaks and voids; out-of-position and out-of-alignment images; and controlled document verification. Defects as small as 0.04 mm can be detected.

Lake Image Systems
phoskins@lakeimage.net

5-Megapixel Image Sensor



For use with digital still cameras and digital video, OmniVision Technologies Inc. has released the OV5653 CMOS 5-megapixel color image sensor based on OmniBSI (backside illumination) technology. It delivers 720 pixels at 60 fps and full high-definition 1080 pixels at 30 fps. Features include automatic expo-

sure control, automatic 50/60-Hz luminance detection and automatic black level calibration. Programmable user controls include image quality, formatting and output data transfer, mirror and flip, cropping, windowing and panning. The sensor has 256 bytes of embedded one-time programmable memory for storing information such as calibration parameters, and it supports horizontal and vertical subsampling and 2 × 2 binning. The integrated 1.5-V regulator eliminates the need for additional power components.
OmniVision Technologies
sfoster@ovt.com

Machine Vision Cameras

The Piranha ES (extended sensitivity) camera family has been announced by Dalsa Corp. for flat panel, semiconductor and printed circuit board inspection; and for low-light, large web, and high-performance document scanning applications. The bidirectional cameras offer responsivity up to >30 times higher than that of traditional line-scan cameras and a line rate up to 110 kHz, as well as selectable-area mode of operation for easy alignment or for regular operation. They feature flat-field correction with four sets of coefficients for each direction, up to 32 time delay and integration stages, and programmable features including direction and gain and offset control.
Dalsa
sales.americas@dalsa.com

Reactive Ion Etching

Plasma Etch Inc. has introduced a reactive ion etching (RIE) version of its BT1 plasma system. The BT1-RIE performs fast anisotropic removal of photoresist, nitrides, oxides, polyimides and diamondlike carbon films. It includes a water-cooled RIE electrode for processing multiple substrates up to 1 sq ft per load cycle. The system uses a 1250-W 13.56-MHz radio-frequency power supply with automatic matching for high-rate etching. It is supplied standard with two mass flow controllers for two gases, with up to four gas channels available optionally. Up to 20 process sequences can be stored, and dual steps can be programmed for automatic processing. Two-stage vacuum pumping is included, with blower packages optional.
Plasma Etch
sales@plasmaetch.com

3-D Surface Measurement

For use in the precision engineering and R&D markets, Zemetrics has unveiled the ZeMapper, an interferometric optical profiler that provides

3-D surface maps with high lateral and vertical resolution and subangstrom height accuracy. Repeatability is <0.008 nm rms, and precision is <0.08 nm rms. Vertical scan range is 40 µm, and extended scan range is 25 mm. The 4-megapixel sensor has a large field of view. The system performs nondestructive and noncontact area measurements in applications including defect review, surface characterization and volume displacement for data storage, optics, microelectromechanical systems, tribology, and materials and biological sciences. ZeMaps acquisition and analysis software is included.

Zemetrics
info@zemetrics.com

Air-Bearing Actuators

Airpot Corp. has introduced the Airpel-AB air-bearing actuators, which combine air cylinderlike linear actuation with zero-friction air-bearing technology. The devices have applications in the semiconductor, optical, medical, and test and measurement industries. They are available in metric models with four bore diameters and 10 standard strokes, which provide precisely repeatable driving or supporting forces ranging from 2 g to 58 kg at pressures as low as 5 psi. They can operate at temperatures from −20 to 90 °C.

Airpot
sales@airpot.com

FINAL CALL FOR PAPERS

7th International Conference on Optics-photonics Design & Fabrication (Co-located with LENS EXPO 2010)

ODF'10 Yokohama

"ODF '10, Yokohama"
April 19–21, 2010

Optics-photonics ODF Design & Fabrication

Pacifico Yokohama, Japan

Organized by
The Optics Design Group (ODG) of OSJ

Sponsored by
Optical Society of Japan (OSJ; an affiliate of the Japan Society of Applied Physics)

INTRODUCTION

The 7th International Conference on Optics-photonics Design & Fabrication, "ODF'10, Yokohama," will be held on April 19–21, 2010 at Pacifico Yokohama, Japan. Optics-photonics design and fabrication will continue to play a significantly important role in the 21st century, achieving harmony between technology and the environment. ODF'10 is intended to provide an international forum for original paper presentations and discussions of optics-photonics design- and fabrication-related technological and scientific topics, including theory, design, fabrication, testing, applications and others.

Collaboration and Competition make progress.
Join us at ***ODF'10, Yokohama!***

LENS EXPO 2010 will also be held April 21–23 at the conference site. For more information please visit the website below.
http://lens.optronicsjp.com/

SCOPE OF THE CONFERENCE

ODF'10 is an international forum for engineers and scientists in the field of Optics-photonics Design and Fabrication to exchange their ideas and achievements with the goal of future mutual progress. The conference will consist of sessions on optics-photonics design, simulation, optical components, optical systems, and optical technology. These sessions will cover the fields of optical theory, fabrication and testing, software, DOEs, micro-optics, nano-optics, photonic crystals, near-field optics, thin films, waveguides, MEMS, lasers, fiber communications, information optics, optical storage, optical lithography, microscopy, displays, bio-medical optics and others. A special session on "Reflection Control by Nano-structures" is also planned.

PREPARATION OF ABSTRACTS AND MANUSCRIPTS

A limited number of original papers will be accepted for presentation. Authors are required to submit a 35-word abstract and a 2-page manuscript. Papers must be submitted online. Please see the ODF'10 website for details of the submission procedure.

Abstract & Manuscripts will be accepted:
July 20 – October 20, 2009
ODF'10 website: http://www.odf.jp/

b BRIGHT IDEAS

Photon Detector

SmartQuantum Inc. has unveiled the SQLightSensor family of low-noise near-IR single-photon detectors, which have applications in spectroscopy, lidar and quantum cryptography. Each device includes a Geiger-mode InGaAs avalanche photodiode and a thermoelectric cooler. The detectors cover the spectral range from 900 to 1600 nm, with a detection rate from 0 to 10 MHz. They are available with one or two channels, and with either single- or multimode fiber.
SmartQuantum
photonics@smartquantum.com

Power Supplies

UltraVolt Inc. has released two lines of its microsize, micropower products in the XS and US series. The volumes for the devices are 0.08 in.^{3} and 0.35 in.^{3}, respectively. They offer output voltages of 0 to 100 V up through 0 to 500 V at 100-mW output power, with output current ranging from 200 µA to 1 mA. They are designed for use in applications using avalanche photodiodes, silicon photomultipliers and multipixel photon counters.
UltraVolt
csd@ultravolt.com

Fiber Optic Analysis

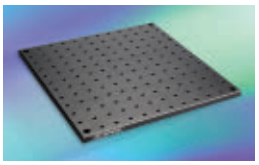
The Prolite-75 launched by Promax Electronica SA is a fiber-to-the-home analyzer that is optimized for the analysis, installation and maintenance of fiber optic networks that are based on gigabit-capable passive optical network architecture. It provides filtered measurements, both individual and simultaneous, for the 1310-, 1490- and 1550-nm wavelengths. The device also offers a visible fault locator that emits a laser light to assist in locating damage in a specific fiber.
Promax Electronica
promax@promax.es

Mid-IR Laser

NovaWave Technologies has introduced the Iris 1000, a mid-IR laser system that can be used in

greenhouse gas monitoring, combustion diagnostics, industrial gas sensing and as a replacement for lead-salt lasers. The turnkey, broadly tunable, cryogen-free system is available in the 3.2- to 3.6-µm region and offers TEM_{00} mode quality and an approximately 2-MHz linewidth. It has a built-in copropagating visible alignment laser for simple setup, an onboard computer system and a touch-screen interface.
NovaWave
sales@novawavetech.com

Aluminum Breadboards



The LABasix SA2 series breadboards for photonics research and OEM optical assemblies have been released by Newport Corp. Machined from solid 0.01-m-thick 6061 aluminum, they provide a stable, durable and lightweight platform for optical components and subassemblies. The standard grid of tapped holes extends to within 0.01 m of the plate edges, increasing the mounting surface. In-grid counter-bored holes and deep-edge chamfers facilitate lifting, aligning and integration onto standard optical tables. The imperial standard models feature ¼-20 tapped holes on a 0.03-m grid; metric models feature M6 tapped holes on a 25-mm grid. Both are anodized deep black to minimize surface reflections. Other finishes are available upon request.
Newport
warren.booth@newport.com

Temperature Controllers

The 585 Series TECPak temperature controllers manufactured by Arroyo Instruments are compact fully integrated OEM modules that offer 0.004 °C stability and 24- and 55-W standard configurations, with custom configurations available. The ArroyoControl software enables operation from a PC, with no programming required. The devices support password-protected limits to control operation in production and educational applica-

BRIGHT IDEAS

tions. They feature a USB and an RS-232 interface as well as an analog interface for full control without a PC.
Arroyo Instruments
sales@arroyoinstruments.com

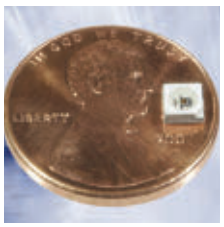
Machine Vision Cameras

Progressive-scan Gigabit Ethernet CMOS machine vision cameras that feature an adjustable frame rate via binning, subsampling or area of interest have been launched by Edmund Optics Inc. Packaged in an ultracompact housing, they include a software interface that enables users to set up a specified area of interest, gain, exposure time, frame rate, trigger delay, and digital output delay and duration. The user can set the exposure, gain and white balance to a specified level, or the camera will adjust those parameters automatically. Proprietary software enables capture of still images in jpeg and bmp, and of video in AVI format. It also performs edge enhancement, hot pixel correction, and image mirroring and binning in the vertical directions.
Edmund Optics
medmund@edmundoptics.com

LED Package

TT electronics Optek Technology has developed a miniature half-watt surface-mount LED package. The OVS5MxBCR4 measures 3.5 × 3.5 × 1.2 mm and is available with white, warm-white, blue, green, red, amber and yellow LEDs. It features a 120° viewing angle and a water-clear lens. Power dissipation at 150 mA is 0.48 W for the white, warm- white and

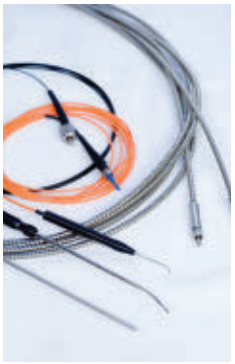
blue, 0.51 W for the green, and 0.33 W for the red, amber and yellow. Typical luminous intensity is 4000, 4500 and 5000 mcd for the red, amber and yellow LEDs, respectively. Luminous flux for the white, warm-white, blue and green models is 25, 25, 6 and 25 lm, respectively. Operating temperature ranges from −40 to 100 °C.



Optek Technology
visibleled@optekinc.com

Fiber Bundles

CeramOptec Industries has increased the temperature specification of its drop-in replacement silica fiber bundles and assemblies that now can work from 600 to −190 °C, making them suitable for use in a variety of spectrometer systems. The company uses a patented plasma chemical vapor deposition process to create high-grade fibers with numerical apertures from 0.06 to 0.66, high radiation-resistance levels and a variety of profiles and dopants. They are drawn in-house before being assembled into fiber optic bundles and are suitable for use in light-limited applications and in those with extremely high or low temperatures.



CeramOptec
salesengineering@ceramoptec.com

Area-Scan Cameras

Beginning with September 2009 production, Basler Vision Technologies is enhancing its 10 pilot and more than 50 scout area-scan cameras with new features. Added will be very short exposure times, a trigger delay feature, a combined auto gain and exposure feature, and a mirroring function at full grabbing speed. The free pylon driver package will add multicast support that makes camera image data available on more than one PC. Because of the company's compliance with the GenICam standard, existing users can take advantage of the new features without changing their software.

Basler Vision Technologies
vc.sales@baslerweb.com

b BRIGHT IDEAS

Fiber Optic Amplifiers

The SU18 and SU19 plastic photoelectric fiber optic amplifiers introduced by Pepperl+Fuchs feature multiple detection modes, selectable timing functions, remote teach, and proprietary and patented 4-in-1 output, which delivers four output options from a single sensor. A locking lever secures the fiber optic cable to the sensor, and a press-and-click feature facilitates DIN rail mounting and removal, without the need for tools. The SU18 series is available in push-button teach or potentiometer adjustable models and features crosstalk protection when used in high-resolution mode. The SU19 can be gang-mounted with up to 18 amplifiers.
Pepperl+Fuchs
sales@us.pepperl-fuchs.com

High-Speed Camera

The svs340, a high-speed camera for machine vision applications, has been unveiled by SVS-Vistek GmbH. The 640 × 480-pixel Camera Link camera can be accelerated up to 400 fps and, with a Gigabit Ethernet interface, reaches 264 fps. The ⅓-in. CCD is read out via two taps. The analog CCD signal is processed via correlated double sampling, and digital signal conversion ensures a good signal-to-noise ratio. The internal microcontroller provides various ways of adjusting operating mode, exposure time, gain and offset. Synchronization of image capture to an external event can be user-adjusted. Exposure time can be modified by the serial Camera Link interface or by trigger pulse width. The camera is available in monochrome and color.
SVS-Vistek
info@svs-vistek.com

Short-Pulse Diode Driver

OptiSwitch Technology Corp. has announced the PLDD-50-SP, a short-pulsed diode driver for rangefinding, remote sensing, and defense and security applications. Measuring 68.6 × 33.0 mm and weighing <14 g, the all-solid-state pulsed current source is designed to drive single- or multichip laser diodes. At 50 A of peak current, it de-

livers <5-ns pulse widths with pulse repetition frequency variable from single-shot to 15 KHz. Laser diodes can be mounted on the edge of the driver or vertically through mounting holes. The current monitor output provides real-time monitoring of the laser diode current.
OptiSwitch Technology
sales@optiswitch.com

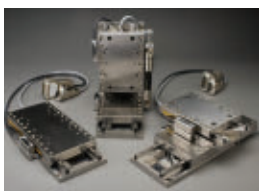
CCD Camera

The ICR890-2000 released by Sick Inc. is a CCD-based camera system that reads the 1- and 2-D bar codes used in sorting systems in the retail distribution, food and beverage, automotive, and parcel, postal and airline baggage-handling industries. An integrated real-time jpeg encoder provides high-quality images that take up less storage space. The camera system is designed on a modular platform that permits separation of camera and illumination. The illumination is fully integrated, and the output is self-monitored to provide even lighting in a variety of reading situations, without ever requiring adjustment. Mean time to repair is <10 min, and mean time between failures is 80,000 h.
Sick
info@sick.com

High-Definition Video Camera

Sony Europe's Image Sensing Solutions Div.'s EVI-HD7V pan/tilt/zoom camera delivers cinema-quality high-definition video to the conferencing and professional audiovisual markets. The 1080-pixel camera operates at 60 fps, pans at 300°/s, tilts at 125°/s, and has a 10× optical zoom and a 40× digital zoom. It can work in light levels down to 15 lx. Signal-to-noise ratio is 50 dB, maximum power consumption is 26.4 W at 12 VDC, and operating temperature is from 0 to 40 °C. The camera is equipped with a ⅓-in. CMOS sensor. Applications include distance learning, corporate training and courtrooms.
Sony Europe
matthew.swinney@eu.sony.com

Motor Stages



Dover, a Danaher Motion Company, has introduced the MMG Mini-Mag line of precision linear motor stages. Available with

25, 50, 100 or 150 mm of travel, the four models provide uncompensated accuracy ranging from 2 to 8 µm. Their resolution ranges from 1 µm to 5 nm, and each model delivers repeatability to ±0.4 µm. The devices feature an anti-creep linear guideway that can increase uptime by as much as 15% in high-duty-cycle applications. They are rated for an 8-kg load capacity and can be used in constant velocity or high-throughput point-to-point applications, in OEM metrology, and in photonics and laser machining applications.
Dover
lou.elias@danahermotion.com

LED Lamps

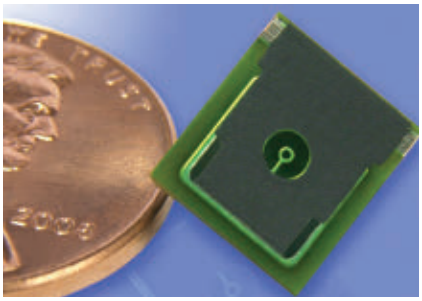
LEDtronics Inc.'s G15 globe-style DécorLED lamps consume <1 W and replace 10-W incandescent bulbs. The DEC-G15E12 series solid-state devices are available in extra pure white (5000 K) or extra warm white (3000 K). Each contains 18 discrete LEDs, configured to shine in an omnidirectional 270° beam. Each LED produces illumination between 25.4 and 27.4 lm. A molded polycarbonate, UV-protected, shatter-resistant 1.9-in.-diameter globe protects the LED cluster. The company says the lamps perform especially well in applications prone to voltage surges or dips.
LEDtronics
webmaster@ledtronics.com

Three-Axis Scan Head

The 3XB, a dual-wavelength large-field three-axis scan head from Nutfield Technology Inc., offers small spot diameters and works with both 532- and 1064-nm lasers. Users can adjust the device's scan field and spot size by turning a knob, enabling them to experiment and dial in the best combination for their applications. The device can produce scan fields of up to 2 × 2 m and can be used in scanning applications including scribing, grooving, edge deletion, cutting and marking.
Nutfield Technology
sales@nutfieldtech.com

Sensors and Modules

A line of fully integrated capacitive temperature and humidity sensors and sensing modules is now available from Saelig Co. Inc. Offering 0.25-s rise times, the sensors are unaffected by condensation or water immersion and have applications in meteorology, air conditioning,



home appliances, aeronautics, archival conservation and military laboratories. They are stable in temperatures ranging from −90 to 85 °C, and their passive sensing elements are fully interchangeable. Stand-alone sensing modules also are available as plug-in microsystems with digital output.
Saelig
info@saelig.com

Metrology System

Rudolph Technologies Inc. has unveiled the S3000S metrology system for in-line process control of advanced diffusion and fab-wide thin-film applications. The system enables simultaneous measurement with multiwavelength, multiangle focus beam ellipsometry and deep ultraviolet reflectometry, and is built on the Vanguard-II automation platform. A MAControl module, which provides one-step nondestructive removal of the molecular airborne contamination layer on thin films, is available as an option.
Rudolph Technologies
virginia.becker@rudolphtech.com

Streak Camera

The Streakscope C10627 from Hamamatsu Corp. has a maximum sweep frequency up to 20 MHz for use in capturing fluorescence lifetime measurements of weak, short-lifetime samples excited by a compact laser or LEDs. The device offers a digital CCD readout of 150 fps and photon counting acquisition with a dynamic range of more than five orders of magnitude. According to the company, these abilities have given the C10627 an acquisition time that is 50 times faster than that of the previous model. The camera has applications in the semiconductor, photophysics and biology fields.
Hamamatsu
usa@hamamatsu.com

HAPPENINGS

NOVEMBER

IMAPS 2009 (Nov. 1-5) San Jose, Calif. The International Microelectronics and Packaging Society's 42nd International Symposium. Contact IMAPS, +1 (202) 548-4001, Ext. 0; imaps@imaps.org; www.imaps.org.

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

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

12th Annual Directed Energy Symposium (Nov. 2-6) San Antonio. Contact Donna Storment, Directed Energy Professional Society, +1 (505) 998-4910; donna@deps.org; www.deps.org.

ACP: Asia Communications and Photonics Conference and Exhibition (Nov. 2-6) Shanghai, China. Contact ACP General Information, +86 755 2583 4722; info@acp-ce.cn; www.acp-ce.org.

Vision 2009 (Nov. 3-5) Stuttgart, Germany. Contact Landesmesse Stuttgart GmbH, +49 711 18560 0; info@messe-stuttgart.de; www.messe-stuttgart.de/vision.

Laser Florence 2009 (Nov. 6-7) Florence, Italy. Contact Secretariat, International Academy for Laser Medicine and Surgery, +39 05523 42330; info@laserflorence.org; www.laserflorence.org.

Eighth International Conference on Nano-

PAPERS

SPIE Scanning Microscopy (May 17-19) Monterey, California
Deadline: abstracts, November 2
Organizers of SPIE Scanning Microscopy encourage researchers to contribute their recent findings in areas of technology, including backscattering electron diffraction, the characterization of nanoparticles, nanotechnology and nanofabrication, and confocal and other microscopy techniques, in application areas such as forensics, food analysis, the medical field, and health and safety. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; www.spie.org.

SID 2010 (May 23-28) Seattle
Deadline: abstracts, December 1
The Society for Information Display invites original papers on all aspects of the research, engineering, application, evaluation and utilization of displays. The Display Week 2010 Symposium will address special topics of interest, including touch-screen technologies, novel 3-D display approaches, energy-efficient display devices, and solid-state lighting, including OLED and LED technology. Contact Bill Klein, symposium coordinator, Palisades Convention Management Inc., +1 (212) 460-8090, Ext. 204; wklein@pcm411.com; www.sid.org.

Biomedical Optics and 3-D Imaging (April 11-14) Miami
Deadline: December 3, noon, EDT (16:00 GMT)
Papers are sought for the 2010 Optical Society of America Optics and Photonics Congress, which encompasses the topical meetings Biomedical Optics (Biomed) and Digital Holography and Three-Dimensional Imaging (DH). Topics to be considered include bio-optics in clinical applications, biological and drug discovery imaging, diffractive optics and optical data storage. Contact OSA, +1 (202) 223-8130; info@osa.org; www.osa.org.

imprint and Nanoprint Technology (Nov. 11-13) San Jose, Calif. Contact Princeton University, +1 (609) 258-2544; chouasst@princeton.edu; www.nntconf.org.

Modern Optical Testing (Nov. 12-13) St. Asaph, UK. Contact Sonja Hardy, OpTIC Technium, +44 1745 535 140; sonja.hardy@optictechnium.com; www.optictechnium.com.

Photon Recherche Industrie (Nov. 18-19) Reims, France. Contact Mark Zacharria, +33 1 46 28 03 13; mz@elucido-partners.net.

SPIE Lithography Asia – Taiwan (Nov. 18-20) Taipei, Taiwan. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; www.spie.org.

Photonica Expo 2009: Second International Exhibition on Photonics and Optoelectronics (Nov. 25-27) Milan, Italy. Collocated with PV Tech 2009, Vacuum Tech and Coating Expo 2009, Nano Future Expo 2009, Vision World 2009 and others. Contact Artenergy Publishing Srl, +39 0 266 30 6866; www.photonicaexpo.eu.

2009 MRS Fall Meeting and Exhibit (Nov. 30-Dec. 4) Boston. Contact Materials Research Society, +1 (724) 779-3003; www.mrs.org.

DECEMBER

Introduction to Optomechanical Design (Dec. 1-2) St. Asaph, UK. Contact Sonja Hardy, OpTIC Technium, +44 1745 535 140; sonja.hardy@optictechnium.com; www.optictechnium.com.

PowerMEMS 2009 (Dec. 1-4) Washington. Contact Preferred Meeting Management Inc., +1 (619) 232-9499; info@powermems.org; www.powermems.org.

Sixth Annual Printed Electronics & Photovoltaics USA Conference and Trade Show (Dec. 2-3) San Jose, Calif. Contact Chris Clare, +44 1223 813 703; c.clare@idtechex.com; www.idtechex.com.

Fourth Rio de la Plata Workshop on Laser Dynamics and Nonlinear Photonics (Dec. 8-11) Piriapolis, Uruguay. Contact Cristina Masoller, cristina.masoller@upc.edu; or Igal Brener, ibrener@sandia.gov.

JANUARY

IS&T/SPIE Electronic Imaging (Jan. 17-21) San Jose, Calif. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; www.spie.org/electronic-imaging.xml.

Photonics Japan (Jan. 20-22) Tokyo. Includes Internepcon Japan; Electrotest Japan; IC Packaging Technology Expo; International Electronic Components Trade Show; Printed Wiring Boards Expo; Material Japan 2010; International Automotive Electronics Technology Expo; and EV Japan 2010. Contact Hajime Suzuki, Reed Exhibitions Japan Ltd., +81 3 3349 8502; photonics@reedexpo.co.jp; www.photonicsjapan.jp.

SPIE Photonics West (Jan. 23-28) San Francisco. Encompasses the conferences BiOS: Biomedical Optics; LASE: Lasers and Applications in Science and Engineering; OPTO: Integrated Optoelectronic Devices; and MOEMS-MEMS: Micro- and Nanofabrication. Contact SPIE, +1 (360) 676-3290; customerservice@spie.org; www.spie.org/photonicswest.

Advanced Solid-State Photonics (Jan. 31-Feb. 3) San Diego. Part of the OSA 2010 Optics & Photonics Congress and collocated with Applications of Lasers for Sensing and Free-Space Communications, and Laser Applications to Chemical, Security and Environmental Analysis. Contact Kristin Mirabal, kmirab@osa.org; www.osa.org.

Applications of Lasers for Sensing and Free-Space Communications: Topical Meeting and Tabletop Exhibit (Jan. 31-Feb. 4) San Diego. Contact Optical Society of America, +1 (202) 223-8130; info@osa.org; www.osa.org.

Laser Applications to Chemical, Security and Environmental Analysis: Topical Meeting and Tabletop Exhibit (Jan. 31-Feb. 4) San Diego. Contact Optical Society of America, +1 (202) 223-8130; info@osa.org; www.osa.org.

The 'Me-Me Switch': A remote possibility

Ear buds fitted with infrared sensors and connected to a microcomputer that can control electronic devices could offer hands-free remote control for changing the music on an MP3 player, for turning room lights on and off, for starting up a washing machine or for some other everyday activity.

One such gadget, invented by Kazuhiro Taniguchi, a researcher at the University of Tokyo's School of Engineering, could have more practical and serious applications as well, including helping the physically disabled remotely operate electronic apparatuses – cameras, computers, air conditioners – or monitoring the elderly for signs of declining health or medical emergencies.

"I was inspired by iPod, YouTube, Nintendo Wii and Windows ME to call my invention the 'Me-Me Switch,'" Taniguchi said. His device is designed, in a sense, to mimic the facial movements of the wearer. The sensors measure tiny involuntary movements inside the ear that result from intentional facial movements such as a wink, a smile or a raised eyebrow.

The machine can be programmed to run with a variety of facial expressions, he said. With a twitch of your mouth, for example, you could start the music on your iPod. With its capacity to monitor the natural movements of the face in everyday life and accumulate the data, the device could "know" a person to such an extent that it could operate automatically to change to more cheerful music if there is an indication of sadness, he added.

The Me-Me Switch generates signals for controlling the electronic devices, or subject machines, corresponding to intentional movements of the face – biocommands – by first sensing the resulting ear movements with an optical distance sensor and then processing the sensing signals with a single-chip microcomputer. Generated signals are converted by amplifier circuits and other devices into signals suitable for the electrical characteristics of the subject machine.

The microcomputer in his gadget incorporates an analog-to-digital converter with a sampling frequency of 1 MHz and 10 bits. The 5-VDC power to actuate the switch is supplied from the subject machine. The optical distance sensor outputs 0 to 5 V, corresponding to distances from ear skin to the sensor. Because the switch is in the ear, the optical sensor is unaffected by sunlight.

The switch carries out machine control by reacting only to the intentional actions of the user. It does not react to daily actions other than these biocommands, Taniguchi said. During experimentation, the subject machine operated only when biocommands were applied, he noted.

"Currently, the Me-Me Switch has some problems that need to be solved," Taniguchi said, adding that, "the success, or recognition, ratio of the biocommands is as low as 70 percent." This ratio represents the number of times that a user's biocommands succeeded in controlling the machine.

He and his fellow researchers plan to develop an algorithm with a higher recognition ratio of biocommands to meet the needs of a broad range of people, on bases such as analyses of the switch's application environments, and sampling data on ear movements of various potential user groups, such as younger and older people.

Caren B. Les
caren.les@laurin.com

Photo courtesy of Kazuhiro Taniguchi.

www.shimadzu.eu
shimadzu@shimadzu.eu

Shimadzu Europa GmbH
Albert-Hahn-Str. 6-10
47269 Duisburg, Germany

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