Tuesday, February 5, 2013

SPIE

Photonics West® Show Daily

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BiOS hot topics: from OCT to optogenetics

Diagnostic advances, control of brain activity and opportunities in medical robots all featured in the showpiece session.

Optogenetics pioneer Ernst Bamberg Photo: Amy Nelson/SPIE.

Photonics West delegates poured into a jam-packed hall for the now-traditional curtain-raiser of the week — Saturday evening's BiOS Hot Topics session. Optogenetics was among the buzzwords in the exhibit hall, and it's not hard to see why: the ability to control biological cells, particularly those in the brain, with light is now emerging as a major theme.

In the first of the quickfire Hot Topics presentations, Ernst Bamberg from Germany's Max Planck Institute said that defining what optogenetics can do is deceptively simple. Work to insert opsin genes into neurons and then using light to trigger or inhibit their firing has been gathering pace since initial discoveries were published a decade ago. But that pace has picked up dramatically since the ability to precisely deliver irradiation via optical fibers was pioneered in 2007, and potential applications are now expanding rapidly.

Bamberg described how the technique can map the motor cortex of a mouse's brain, structures buried sufficiently deep that scattering effects

continued on p.30

MOEMS plenary: nano-optics coming of age

"Devices built around the nano-scale behavior of light have been promised for some time, but the prospects have mostly been based on simulation and theory, rather than practical demonstration. That has now changed." So said Bozena Kaminska of Canada's Simon Fraser University, opening the MOEMS-MEMS plenary session by describing how nano-optics is moving towards commercial applications and products.

Nano-hole arrays are known to enhance light transmission, through coupling of the light with surface plasmons; Kaminska described how additional structural features beneath the holes, such as nano-scale cavities or disks, can further improve properties.

"Enhancement of electric field intensities in the vicinity of the new features could help to augment surface-enhanced Raman spectroscopy, or produce single- and multi-pass spectral filters," she said. "But a new fabrication method suitable for real-world manufacture was essential."

That has been tackled through a new production process, combined with a roll-to-roll manufacturing set-up, to cut total fabrication time by a factor of three — and could ultimately achieve even better results.

DON'T MISS EVENTS

OPTO PLENARY SESSION
8:00 to 10:00am

- **Light in a Twist: Optical Angular Momentum;** Miles J. Padgett, Univ. of Glasgow
- **Quantum Optomechanics;** Markus Aspelmeyer, Vienna Ctr. For Quantum Science and Technology, Univ. of Vienna
- **Group IV Photonics for the Mid-Infrarared;** Richard Soref, Univ. of Massachusetts Boston

INDUSTRY PANEL SESSIONS

- **Silicon Photonics and Photonic Integrated Circuits** 2:00 to 3:00pm
- **Emerging Growth opportunities in Sustainable Technology** 3:30 to 4:30pm

See Technical Program and Exhibition Guide for details. Registration fee applies for Plenary Session.

INSIDE

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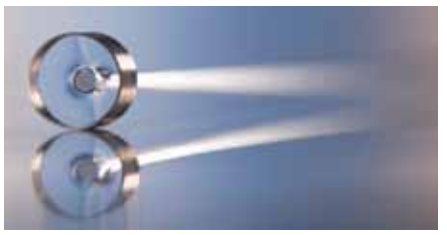
Toptica chose Photonics West to announce that it had snapped up the Berlin-based laser diode manufacturer eagleyard Photonics, effective January 1. The deal sees Toptica become more vertically integrated, with eagleyard regarded as a leading producer of precision and high-power gallium arsenide diodes emitting at wavelengths between 650nm and 1120nm. From left: Dr. Wilhelm Kaenders (Toptica), Dr. Thomas Laurent (eagleyard), Dr. Goetz Erbert (FBH), Jörg Muchametow (eagleyard), and Dr. Thomas Weber (Toptica). See Toptica at booth #8623 and eagleyard at #1500. Photo: Toptica Photonics.

NKT fibers boost ultrafast power

Denmark-based NKT Photonics used the weekend's BiOS exhibit to showcase its new "aeroGAIN" rod fibers, products designed to raise the average power output of femtosecond laser pulses to an unprecedented 100W. Up until now, the typical average power of an ultrafast fiber laser has been limited to only a handful of watts, before nonlinear optical effects take over.

Developed largely in-house and reflecting a new core design that the company has been working on for years, the ytterbium-doped photonic crystal fibers (pictured) are based on a large core diameter of 85 microns and offer a peak power level in the megawatt regime without sacrificing beam quality or stability. A 55 micron alternative is also available.

Speaking on the BiOS show floor,

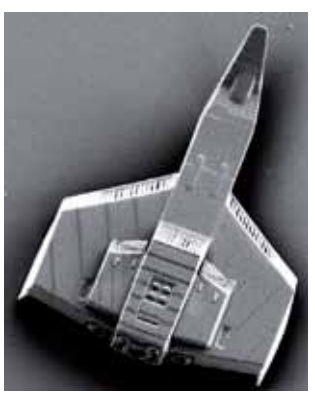


Kim Hansen from the company said that the technology would enable femtosecond fiber lasers to enter truly industrial applications in materials processing, as well as in medicine.

Hansen is also seeing strong demand for the firm's supercontinuum sources for use in optical coherence tomography (OCT), benefiting from a trend towards higher-resolution imaging and the availability of optical components that make full use of the ultra-wideband light sources. And the global product line manager is also hopeful of a major uptick in interest from the oil and gas sector, where improved phase noise and ultra-robust performance mean that the lasers are now increasingly seen as a viable technology for pipeline and reservoir monitoring. Over the next five years, says Hansen, this market could take off. *NKT Photonics is at booth #417.*

3D laser nanoprinting: now 100 times faster

Karlsruhe, Germany spin-out Nanoscribe chose the BiOS exhibition for the global launch of its new and much faster tool for 3D nanoprinting. The company's Photonic Professional GT system, shown off for the very first time inside the Moscone South Hall, now incorporates ultra-high precision galvanometers that have increased the speed at which polymer nanostructures can be fabricated by two orders of magnitude.



CEO Martin Hermatschweiler says that existing customers can also buy the new technology in the form of an upgrade, and that the first deliveries of the system should take place in the third quarter of 2013. The table-top system now offers what is claimed to be the highest-resolution commercially available 3D printer. Hermatschweiler said that the system had produced a micron-scale replica of a Hellcat jet (pictured) in only a minute.

Though the novel lithography technique, which uses two-photon polymerization, is not yet being used for industrial applications, research laboratories are expected to use the kit to make novel devices for microoptics, biological cell scaffolds and in microfluidics. *See Nanoscribe at Photonics West booth #222.*

Tornado whirls in with ultra-compact OCT

Toronto-based Tornado Spectral Systems used the BiOS exhibition to launch the commercial prototype of its compact interferometer and detector package. Known as "OCTANE" for short, Tornado says it is the first to employ a "nanophotonic engine" for use in optical coherence tomography (OCT) imaging equipment.

The two-year-old company has developed the technology through intellectual property on integrated optics licensed from Michal Lipson's nanophotonics research group at Cornell University. It says that OCTANE is poised to disrupt the fast-growing OCT sector by combining the spectrometer and detector elements within a product footprint the size of a small paperback book, and weighing less than a pound.

OCTANE features a standard center wavelength of 860nm, provided by a superluminescent diode source, and a spectral range of 350nm. Custom versions at wavelengths ranging between 400nm and 1100nm are also available.

The nanospectrometer chip at the heart of the package has been developed in collaboration with Cornell's semiconductor foundry service, but Tornado is currently transferring production to A*STAR in Singapore, where the devices can be made using standard 8-inch wafer processing steps. The company, which expects to release a full commercial version before the end of 2013, says that the technology is scalable to thousands of units.

Aside from existing OCT applications in ophthalmology and cardiovascular screening, the nanophotonic engine could also help the technique break into non-destructive testing, for example of MEMS-based pressure sensor devices, bringing the twin advantages of a very compact footprint and mass production to bear in a more cost-sensitive market than medical imaging.

Last month, Tornado signed a new design, manufacturing and distribution deal with Netherlands-based Avantes, and it has also been shortlisted for one of this year's Prism Awards. *See Tornado Spectral Systems at booth #5311.*

BiOS exhibitors add speed and depth to OCT

As well as being a hot topic at the BiOS conference this year, optical coherence tomography (OCT) was a clear target for many of the show exhibitors, with a wealth of new components and systems aimed at the growing market. New swept-source designs were a particular focus.

Santec, San Jose, CA, which makes tunable lasers, optical instruments and OCT products, was demonstrating the HSL-20, its new integrated MEMS-based, high-speed swept source. Its proprietary design is said to offer the industry's fastest swept rates of up to 100kHz, while maintaining long coherence length and stable operation. The laser is also designed for OCT systems where image acquisition speed is key, and comes equipped with k-trigger and start-trigger for system synchronization.

Jonathan Evans, director of optical systems at the firm, said: "Our customers have been using our lasers for a long time but they now want a faster scanning range and a longer coherence length. Benefits of this laser's high speed are two-fold: it causes minimal interference with the patient and it freezes any motion for detailed analysis."

Switzerland's **Exalos** presented its swept-source OCT engine (known as EOE), an integrated system comprising a swept-source module, an FPGA-based data acquisition card in a commercial PC, and proprietary software that enables real-time OCT signal acquisition and processing. This OCT engine integrates a two-channel high-speed (500 MS/s, 12-bit) DAQ card with an on-board FPGA for real-time acquisition and processing of the OCT fringe signal and the k-clock reference signal.

Exalos' VP of sales Gene Covell said, "We will be selling the EOE to medical systems integration companies, basically to all companies that develop OCT equipment. It allows customers to take a new OCT system to market faster because they don't have to do as much product development; the EOE would be attached to the customers' scanning/sensing scopes and will do the data processing."

Saturday's BiOS exhibit in full swing. Photo: Stacey Crockett/SPIE

Thorlabs, Newton, NJ, in partnership with **Praevium Research**, Santa Barbara, CA, is another to have developed a high-speed swept laser source, specifically designed for OCT. It is based on a patented MEMS-tunable VCSEL designed for optimal performance in OCT applications, and used by James Fujimoto's MIT group to produce some record-breaking results including a coherence length in excess of a meter. The laser provides single mode, mode-hop-free operation over a tuning range in excess of 100 nm, and Thorlabs says that the associated MEMS-VCSEL is highly adaptable.

UK-headquartered **Gooch & Housego** introduced its ultra-wideband fused couplers, reflecting a move towards increased source bandwidths for OCT. G&H says the fused fiber coupler has become the component of choice for designers of compact interferometer modules.

Senior VP Andrew Robertson said, "While the majority of OCT market demand can be covered with couplers having 30-40nm operating bandwidths in the 850nm region, we are beginning to see the emergence of systems designed with optical sources which may have three or four times this bandwidth. We recently shipped components operating over 260nm bandwidth centered on 1050nm."

Toptica eyes terahertz

Outside of OCT, terahertz performance was one focus of **Toptica Photonics**, Munich, Germany. The company, which develops and manufactures diode and fiber lasers, announced two major new launches at BiOS — including a terahertz spectroscopy solution.

Toptica's "TeraFlash," a complete time-domain terahertz spectroscopy platform on a tabletop, combines established 1.5 micron femtosecond laser technology with the latest InGaAs antennae. Due to its precise delay stage, the TeraFlash can achieve a peak dynamic range of more than 70 dB.

The company also launched "TopMode," a high-coherence, high-output diode laser, described as Toptica's answer to the quest for the "blue HeNe laser." Available at six wavelengths (405, 445, 488, 515, 633 and 685 nm), TopMode achieves what Toptica describes as the highest single-frequency output power of any direct diode-based system while being as easy to operate as a HeNe.

UK-based **Fianium** introduced its new "WhiteLase UV," said to be the first mode-locked, high power supercontinuum laser to extend into the UV range. It has a guaranteed cut-in wavelength at below 390nm, and extends to 2400nm.

Partnering the supercontinuum source is the company's WhiteLase LLTF Contrast laser line tunable filter, which uses a high-resolution bandpass filter to turn a supercontinuum source into a tunable picosecond laser. The filter transmits, with high-efficiency, a single laser line while blocking unwanted lines with "excellent" out of band suppression.

Raman gets compact

B&W Tek, Newark, DE, showed off its compact ExemplarR plus "smart" spectrometer, which utilizes a low stray light unfolded Czerny-Turner spectrograph. It features a highly sensitive TE-cooled, back-thinned CCD detector, linearly summed for high dynamic range. A long focal length, coupled with a high quantum efficiency detector provides data over the entire 190-1100nm spectral range. B&W describes it as ideal for low-light applications, with features including a built-in shutter allowing for dark scan measurements, even while illuminated.

Applications sales engineer Parag Borgaonkar commented, "This spectrometer's on-board processor is la crème de la crème, and communications are speeded over USB 3.0 links. All of the elements are customizable to suit different user needs and it operates over a wide wavelength range so can be used for different sorts of spectroscopy, whether absorption, transmission, reflectance or fluorescence imaging."

Bayspec, San Jose, CA, hailed its new "Agility" Raman spectrometer, said to offer high sensitivity and repeatability of sampling and analysis in a ruggedized, battery-operated package. The Agility, said spectroscopy product manager Lin Chandler, is available in 532, 785, and 1064 nm wavelengths with single or dual-band options.

She added: "The Agility is the smallest desktop Raman spectrometer on the market, and offers interchangeable multi-media sampling options, whether liquid, solid or fiber interface."

MATTHEW PEACH

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Welcome to Photonics West 2013

We've heard so many times—really too many times—in recent years that our economy and even the global society "are at a crossroads," though standing at a crossroads while also standing at the edge of a cliff, fiscal or otherwise, would surely be tricky. Well, in my native Ireland, the phrase brings to mind the idea of "dancing at the crossroads." And that's more like the spirit of Photonics West. So, one-hundred-thousand welcomes to the more than twenty thousand who will leave our great gathering with ideas, leads, and orders.

"Even Newton on the shoulders of giants could see so much further today with the optics and imaging systems this community — you — have devised."

The field of photonics is infused with innovative energy across its many branches. Think of the power you have put in the hands of physicians, of the vision and tools you have invented for manufacturing enterprises providing for the planet's seven billion people, of the ability you have given researchers to look out at the Martian landscape or into the depths of time. Even Newton on the shoulders of giants could see so much further today with the optics and imaging systems this community—you—have devised.

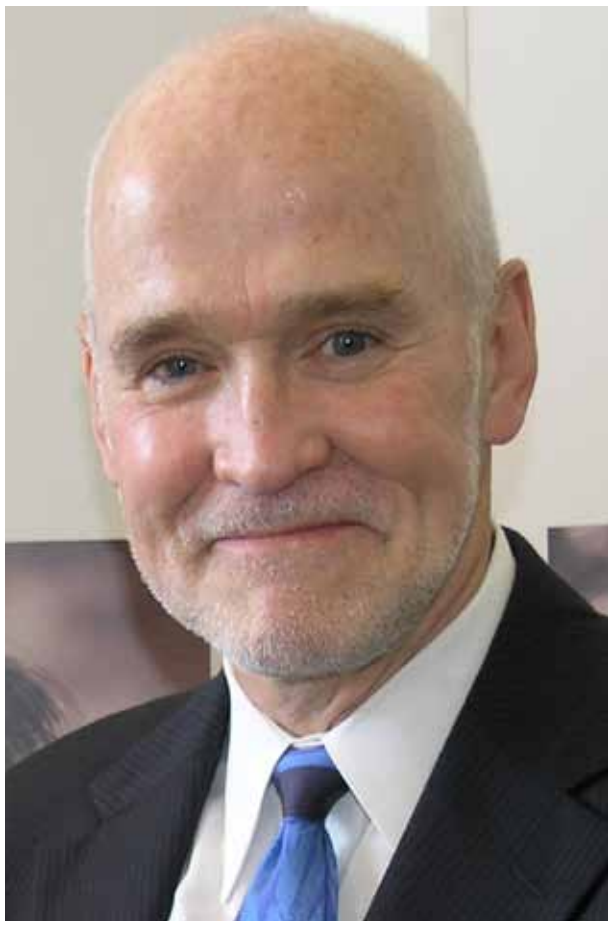
We are only 13 years into the century of the photon, with so much more to come. The rich potential of photonics may be sidelined in the current financial slough. But this too will pass, and photonics will play a key role in the economy of the future.

On Thursday I'll be talking about the National Academies report, "Optics and Photonics, Essential Technologies for our Nation," at the exhibitors' breakfast. The title of the report states the obvious to many of us, although "essential technologies for our world" might have been more accurate. This report is not a marketing piece from those of us with a vested interest. It is from the United States advisors to government: the National Academies. The report identifies areas demanding advancement, needing new inventions, new products. Amongst them are faster internet, more life- and money-saving photonics in medicine, and advancing manufacturing with optics and photonics. (It may be interesting to note that the shares of 3DSystems, a significant player in the photonics manufacturing revolution, gained 238% in 2012—rich potential being realized!)

Out of the 18,000 total papers expected to be published by SPIE in 2013, more than 4,500 will be presented this week at Photonics West. Many attendees will be in conference rooms gleaning as much information as possible; others may be too busy in the 1,200+ company exhibit to notice. Some of us will see the connection of thousands of minds, others will see current or future customers, colleagues, our new inventors, or the educational architects of the future.

As photonics grows so does the interest from the financial community who will be here to invest in ideas or help inventors reap the rewards (increases in company valuation of 238% tend to draw attention). Our Startup Challenge, where entrepreneurs pitch their light-based technology business plans, and Prism Awards banquet recognizing the best products of 2012 will give glimpses of the ferment of invention in our space.

Take advantage of the creativity here, of the many who will come to Photonics West seeking materials, components, tools, or photonics manufacturing capacity! Enjoy the success of photonics. There is much more to come.



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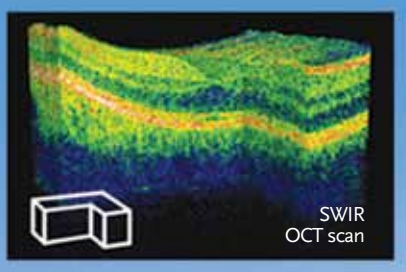
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Industrial lasers get ultrashort

LASE symposium co-chairman Andreas Tünnermann identifies some of the highlights at this year's event.

What is the main focus of the LASE sessions at this year's Photonics West?

One of the main themes of the LASE symposium at Photonics West this year will be the development of high-power lasers and their application in advanced laser material processing. An important driver for this is the increasing use of lasers in the industrial sector.

Today, lasers are indispensable tools for sustainable "green" production. The recent development of solid-state lasers based on fiber and disc geometry equipped with high-power and high beam quality not only enables energy- and material-efficient manufacturing but also increases production speed; enables the production and application of advanced lightweight materials and improves recyclability.

What new technologies and applications will be discussed this year?

From my perspective, there have been important advances in novel high-power ultrashort-pulsed lasers, as well as in the scaling of high-performance lasers enabled by the coherent combining technique.

Additional news will come from emerging application areas. For example, there are many new contributions this year discussing the use of ultrashort-pulsed lasers for low-damage modification of metal and dielectric materials.

Is there one event in the LASE program that you would say is not to be missed?

I would highly recommend visiting the LASE interactive poster session, which is held on Tuesday evening at 6-8pm. Visitors will have the opportunity to speak directly with the researchers and discuss their latest scientific results. This sort of interaction is vital as it helps to foster scientific knowledge exchange on an international level. Also, do not forget to visit the three-day laser exhibition, which from my point of view is the most important one in North America.

What do you view as the highlights of this year's LASE symposium?

The LASE symposium runs over several days and offers a full program that covers both basic and applied research into laser physics and technology. In Wednesday morning's plenary talks (10.20am to 12.30pm) given by Wim Leemans, Martin Wegener, and Geert Verhaeghe, we will see excellent examples of how lasers have risen to prominence in both academia and industry.

First, Wim Leemans from Lawrence Berkeley National Lab, US, will report on laser-based particle acceleration and the path to TeV physics and compact x-ray and gamma ray sources. Then, Martin Wegener from Karlsruhe Institute of Technology followed by Geert Verhaeghe from Faurecia Autositze GmbH will show just how versatile a tool lasers have become by discussing the manufacture of photonic nanostructures and macroscopic lightweight structures in automobile manufacturing respectively.

I am personally looking forward to seeing the latest results describing the performance scaling of fiber- and solid-state lasers. I expect major improvements in the reliable creation of high peak-power ultrashort-pulsed lasers operating at high average powers.

How critical has the automotive sector become for industrial lasers?

Lasers are now an indispensable tool for sustainable automobile production. And, from my point of view, there is no doubt that the impact of lasers in the automotive industry will only increase further.

Lasers give the automotive industry the opportunity to process new materials like high-strength steel. In turn, this opens up novel avenues for lightweight constructions that lower fuel consumption and increase safety for the passenger.

However, it is not only cutting and welding that has led to advances such as lightweight materials in the car-body manufacturing process. Today, lasers are also used for trimming, grooving, hardening, coating, and drilling components along the whole production line. These methods reduce kinetic friction, increase energy efficiency and facilitate quality control in production, as well as lower fuel consumption in operation. All of these aspects lead to a truly green production circle.

"Lasers are now an indispensable tool for sustainable automobile production."

Remote manufacturing technologies also play a key role in automotive production, however, further developments on the component level, as well as on the system level for scanner modules and projection optics, are required.

What new results are your research teams from Jena presenting?

At the Institute of Applied Physics at Friedrich Schiller University Jena and the Fraunhofer Institute for Applied Optics and Precision Engineering in Jena, our research topics include the development of high performance fiber laser systems in continuous and pulsed operation. Researchers from both institutes will give several conference talks about their latest scientific results.

We are particularly proud of our work to create a high-average-power fiber laser system for attosecond science [paper number 8601-48] as well as a 4-channel coherently combined femtosecond fiber CPA system [8601-42]. A scientific highlight will be a passively Q-switched Nd:YVO_4 microchip laser delivering femtosecond pulses [8599-44]. This concept has the potential to revolutionize the creation of ultrashort pulses.

What advice would you give someone attending Photonics West for the first time?

Those going to Photonics West for the first time should make an attempt to attend presentations within all of the technical conferences: BiOS, LASE, OPTO, MEMS-MOEMS and Green Photonics.

To get a good overview, a first-time attendee should focus on plenary talks, keynotes, and invited talks. I would also recommend visiting the various exhibitions and really taking time to discuss any new advances. I highly recommend Photonics West as a platform to gain a broad overview about new developments within laser technology and its diverse applications.

JACQUELINE HEWETT

Andreas Tünnermann is the director of the Fraunhofer Institute for Applied Optics and Precision Engineering in Jena, Germany. He is co-chairing this year's LASE symposium with Bo Gu from Bos Photonics. Credit: IOF Jena.

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Bet your life on laser sintering

Additive layer manufacturing enabled by lasers is delivering new production strategies and economic models, discovers Andy Extance.

"On a white powder bed system, it's like watching the invisible man walking through the snow." So says Richard Davies, specialist engineer in the Centre for Additive Layer Manufacturing (CALM) at the University of Exeter, UK. He's describing the seemingly mysterious appearance of a pattern on the surface of a polymer powder-filled chamber as a carbon dioxide laser beam dances across it.

The pattern forms as the laser's energy melts layers of polymer particles together, then disappears as it's completed and masked by a fresh, 0.1mm-deep, powder layer. The process repeats, the layers pile up, and the three-dimensional objects Davies has told his machine to make gradually emerge from this laser sintering method.

"Virtually everything that you can trust your life with is laser-driven."

—Richard Davies, specialist engineer
Centre for Additive Layer Manufacturing (CALM)

This may sound like a novelty, but laser sintering is already being used in applications as diverse as making airplane parts and dental crowns. It adds to the tools that industry already has available for production, bringing new capabilities and financial models. The European Regional Development Fund therefore wants CALM to help make sure small and medium-size enterprises in its region of south-west England get the chance to benefit from the technology too. And in doing so, it will rely on laser sources to unobtrusively, traceably and reliably make laser sintering a simple production process.

While these principles might be new to many, additive manufacturing (AM) processes have been around for over 30 years, Davies emphasized. Today, CALM still employs tools based on original stereolithography methods, which use a UV-wavelength laser to solidify liquid photopolymer, for prototyping. But interest in AM has grown quickly as it has become a practical possibility for commercial manufacturing, thanks to methods that fuse solid particles. "The boom's come, I think, with the material choices available in laser sintering now," Davies says.

"3D printers" marketed towards consumers don't have those choices, notes Stuart Jackson, regional

Sparkling smiles: Laser-sintering can be used to make dental crowns and bridges from EOS' CobaltChrome SP2 material.
Credit: EOS GmbH

manager for UK and Ireland at Munich, Germany, based laser sintering equipment, material and "e-manufacturing solution" provider EOS. "Home printers are fantastic at making attractive models, but they're not functional-level materials," he says. Equipment prices make the distinction obvious.

A simple home 3D printer might cost $1,600, but CALM is armed with one of only five approximately €1 million ($1.3 million) EOSINT P800 tools in the world. In its process chamber CALM engineers initially heat $500/kg polyether ether ketone (PEEK) powder, which can potentially replace metallic components in some applications, to a 360°C baseline. Once at temperature, two 50W carbon dioxide lasers then input the extra energy needed to raise the powder to its bonding temperature, scanning at 6m/s.

Primed for take-off: Lightweight components made by laser sintering, like this aircraft air inlet cover, are well suited to the aerospace industry. Credit: CALM

Beam benefits

Powders used on other machines include nylon, which is also heated prior to laser sintering. For metals such as aluminum, steel, titanium, bronze, nickel and cobalt-chrome alloys, nearly all the heating energy comes from the laser source. The pivotal function of lasers means that suppliers must meet strict specifications.

"The big processing requirement is that the laser energy is stable throughout the whole build," Jackson says. "If you've got any fluctuation, you could embed a weakness in the middle of the part — you're not fully melting, and will not get the properties needed. The most critical thing is that the lasers have reached a beam quality, reliability and intensity point that allows us to produce what we do now. It's a monumental step, a massive change."

Despite that role, the laser sources are ultimately simply a commodity for both the engineers and toolmakers. "It's about how it affects the output of the system," Davies says. "If a laser lasts twice as long, that's great for us. If we've got a higher-power laser you can do thicker layers on the metal machine, and you can build more quickly."

One example of longer lifetimes is in metal sintering, where EOS has recently replaced the 250W carbon dioxide lasers in its EOSINT M 280 machines. Now, it uses 200W or 400W ytterbium fiber-lasers such as those made by IPG Photonics in Oxford, Massachusetts. "The ytterbium fiber lasers have a much longer lifespan, so although they're more expensive [up front] the relative cost is much cheaper," Jackson says.

That has also allowed EOS to provide online laser power monitoring, he adds. "It means that we have traceability of the energy output from the laser — not actually in the build chamber itself, but at least monitoring constant performance levels. And traceability is the number one parameter that everyone is after."

And though higher power could be desirable, there are multiple barriers to its adoption, Jackson adds, some of which might go beyond laser technology's capability to solve. "The quality of the beam on kilowatt lasers has not been consistent and stable enough," he says. "The other restriction is the materials. Metals will only melt and solidify at a certain rate. It doesn't matter how much energy you put in there, you cannot change that."

Building from the bottom up

Laser sintering might produce objects with practically desirable properties, but it still has to establish itself alongside against better-known fabrication technologies. Its costs and capabilities are best suited to making moderate volumes of complex or highly functional components, rather than higher volumes of simple or large parts. Davies notes that exploiting this requires a mindset change from subtractive machining techniques. CALM is therefore trying to bring this to its region through training and collaboration in a wide range of applications. "AM design starts from assessing the required function of the part," he says. "The method of manufacturing is less of a consideration due to the design freedoms offered by AM."

One such example came when a company producing castings for impeller blades approached CALM, explains research and application engineer James Bradbury. They initially asked for an exact AM replica of a stainless steel casting normally machined to remove material to yield a final structure. Bradbury advised the company that it would probably cost twice as much to make the existing design, but that this might be acceptable if the impeller's function was improved. "The blades were very simple aerofoil shapes,

continued on p.14

Laser sintering

continued from p.13

so we optimized that shape and incorporated cooling channels," he says.

Though the end result still cost more than the cast blades, Bradbury convinced the company to adopt a hybrid casting-plus-AM approach. "There's only a twenty per cent increase in costs, but this almost triples the efficiency in their application," he says. And despite the lack of awareness of the technology's potential, the number of companies now looking to adopt the technology for manufacturing is growing fast, Bradbury adds.

AM also brings a unique costing structure, where the reaction chamber must be as full as possible, but every item produced can be completely different. "We'll group together as many parts as we can fit into whichever system we're running to make it more cost effective," Davies explains. "If I build just one part on its own, it might cost £90 ($145), whereas thirty simultaneously, might be £3 each. But I can build thirty customised parts and they're still £3 each."

Custom customers

Consequently, custom part manufacturers are among the earliest AM adopters for commercial production. For example, EOS machines made 7.5 million cobalt-chrome metal copings for dental crowns in the 2011-2012 financial year, Jackson says. "It's real production, every single one different," he says. "By 11am each day our customers will receive the CAD data, and the following day they ship them out into the laboratories to then finish their process." The same benefit is used by Makie Dolls, whose purchasers can design their visual features on a website before the physical toy is printed by laser sintering. Such customization is also proving valuable in jewellery and medical implants, among other applications.

Bottom-up manufacturing also makes aircraft producers interested in AM — so interested, that CALM is part-supported by European aerospace giant EADS. "If you can reduce an aircraft's weight by 1kg that is worth $25,000 over its lifetime," Jackson says. "Designing bottom-up makes components light-weight, and is more sustainable, especially on reducing metal waste like the titanium that's machined away." For widespread use, AM parts have been in testing for several years as producers build up performance data, he adds. "Engines are probably one of the most advanced in taking it forward, whereas structures are further behind."

The ability to make optimized parts to order is another motivation behind one of AM's best-known existing aerospace uses. Ducts on the F/A-18 Hornet fighter aircraft were formerly made from aluminum, despite the metal being difficult to weld. But for the past ten years they have been made as single plastic components by AM to avoid that problem.

AM owes much of its current status to the automotive industry, which has long used it for prototyping purposes. For example, when EOS was founded in 1989 it provided stereolithography equipment to BMW, a connection it retains today. "We now have machines in all German car companies, even some French ones, Jaguar Land Rover, Bentley, Ford, GM — it's across the board," Jackson says. And though it's typically only low-volume, high-value producers who are known to use laser sintering in production models today, use in automobiles underlines its capabilities.

"What's the difference between that £1000 hobby 3D printing machine and that £120,000 manufacturing system?" Davies asks as he points out the various AM tools at CALM's production facility. "Well, I don't trust my life on that, [but] I trust my life with that. I've worked with the technology, I've designed the parts for my motorbike, I've put them on it, and I ride it every day." That difference is enabled by lasers, Jackson emphasizes. "Laser-based additive technologies are the manufacturing route," he says. "Virtually everything that you can trust your life with is laser driven."

ABOUT THE AUTHOR

Andy Extance is a freelance science and technology journalist based in Exeter, UK.

New capabilities: CALM replicated this foam structure in metal partly to show laser sintering can be used to build things that are impossible to make in any other way.
Credit: CALM

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optics.org product focus

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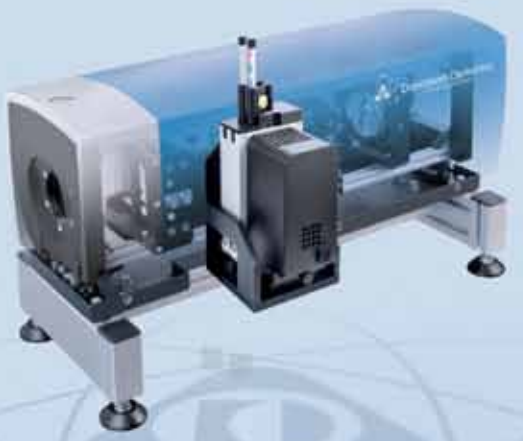

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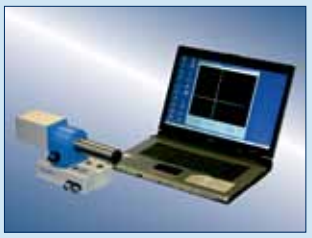

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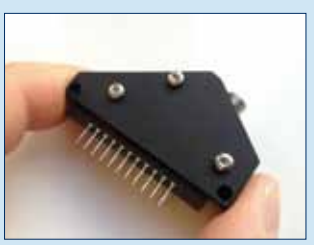

Contact Details

Ibsen Photonics
Ryttermarken 15-21, DK-3520 Farum
Denmark
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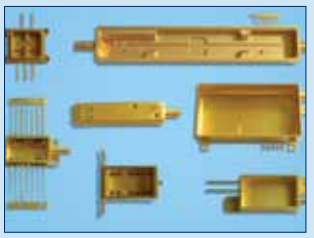

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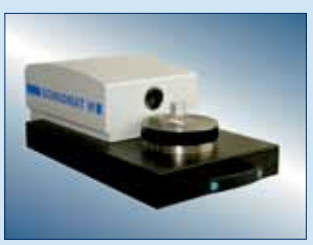

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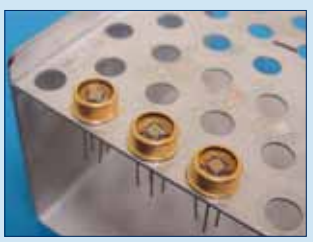

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GPD Optoelectronics Corp
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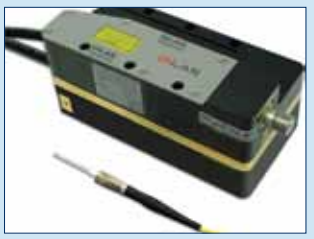

Contact Details
DILAS Diode Laser, Inc.
9070 South Rita Road, Suite 1500
Tucson, AZ 85747, USA
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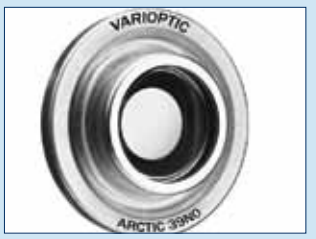

Contact Details
Varioptic - a BU of Parrot SA
24B rue Jean Baldassini
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2013 Photonics West: first-time exhibitors

Highlighting the start-ups and spin-offs making their debut trip to Photonics West this year.

FROM LEFT: Dominykas (CEO), Augustinas (COO) and Kristijonas Vizbaras (CTO) — the three brothers behind Lithuania-based Brolis Semiconductors.

The Photonics West exhibition goes from strength to strength, and this year's floorplan features close to 1300 companies hailing from all corners of the world. Of those, around 60 are exhibiting their products and services at the show for the very first time. Here's our selection of twenty of the start-ups, spin-offs and other first-timers making their Photonics West debut at the Moscone Center in 2013.

Brolis Semiconductors (HQ: Vilnius, Lithuania): optoelectronic components

BOOTH: 5423 (North Hall D)
CONTACT: Augustinas Vizbaras (augustinas.vizbaras@brolis-semicon.com)

Hoping to make an impression in their Photonics West debut are three brothers from the Lithuanian company Brolis Semiconductors. Brolis — which simply means "brothers" in Lithuanian — was started up by physicists (and twins) Augustinas and Kristijonas Vizbaras in 2011, and is working to commercialize mid-infrared lasers based on GaSb material.

COO Augustinas and CTO Kristijonas provide the technical know-how, having both studied at first Vilnius University in Lithuania, then the Royal Institute of Technology in Sweden and finally working towards their PhDs at the Technical University of Munich in Germany. CEO Dominykas, who is four years the twins' senior, provides the business experience — and Augustinas admits that his older brother is on something of a steep "learning curve."

Thus far, Brolis has managed to establish a small compound semiconductor fab operation in double-quick time. Founded just over a year ago, the company took delivery of production molecular beam epitaxy (MBE) kit from Veeco Instruments in November 2012 and Augustinas says that initial engineering samples of lasers should be ready by the end of February.

The company's type I mid-IR emitters offer room temperature emission at wavelengths ranging between 2 and 4 microns, combining high optical gain with low operating voltages — seen as a major advantage over competing quantum cascade lasers (QCLs) in that wavelength range.

Augustinas attributes the rapid setup to the surprisingly fast attraction of €5 million in venture capital finance, via the Baltic investment fund LitCapital. That was made possible thanks to the European Investment Fund, and along with more European Union funding the cash has been used to provide much of the key capital equipment at Brolis, including the Veeco MBE reactor and other key device processing kit.

As a result, many of the back-end processing and device packaging steps can be carried out at Brolis. Although they are unlikely to be quite ready for this year's exhibit, Brolis' first GaSb laser diodes will be manufactured on 3-inch substrates, with the potential to switch to a larger 4-inch wafer format in the future — something that will help to bring down the cost of the devices.

As well as lasers, Brolis' expertise in quaternary and quinternary layer deposition and device processing can be used to produce other optoelectronic structures such as mid-IR photodetectors and thermopho-

continued on p. 20

First-time exhibitors

continued from p.19

tovoltaic cells and electronic devices like high-speed transistors.

Augustinas says that gas sensing will likely be the first commercial applications of the mid-IR lasers, though as sales and marketing chief he is concentrating initially on users in the research community. Photonics West 2013 will provide a launch pad for those commercialization efforts, with Brolis seeking to establish new contacts in both the research and industrial sphere.

Currently with six employees, the company should expand to a workforce of ten in 2013 — while Augustinas and twin brother Kristijonas are also set to complete their PhD studies.

FiberLAST (HQ: Ankara, Turkey): fiber lasers
BOOTH: 2602 (South Hall ABC)
CONTACT: Veronika Ciernikova (ciernikova@fiberlast.com.tr)

Haphit Ltd (HQ: Shanghai, China): fiber-optic components
BOOTH: 4114 (North Hall D)
CONTACT: Kevin Jones (kjones@haphit.com)

InfiniLED (HQ: Cork, Republic of Ireland): LEDs
BOOTH: 5234 (North Hall D)
CONTACT: William Henry (william.henry@infiniled.com)

INSiAVA (HQ: Pretoria, South Africa): silicon photonics
BOOTH: 6072 (North Hall D)
CONTACT: Pieter Rademeyer (pieter.rademeyer@insiava.com)

Litron Lasers (HQ: Rugby, UK): industrial and scientific lasers
BOOTH: 4742 (North Hall D)
CONTACT: David Clarke (dclarke@litron.co.uk)

Lumetrics (HQ: Rochester, NY, US): industrial metrology
BOOTH: 528 (South Hall ABC)
CONTACT: Steve Heveron-Smith (sheveron-smith@lumetrics.com)

Mach8 Lasers (HQ: Breda, The Netherlands): beta DFB diode laser
BOOTH: 5414 (North Hall D)
CONTACT: Michael Engelmann (michael@mach8lasers.com)

Maradin Ltd (HQ: Yokneam, Israel): 2-dimensional MEMS scanning mirror
BOOTH: 3082 (South Hall ABC)
CONTACT: Ron Dagan (ron.dagan@maradin.co.il)

Mesa Photonics (HQ: Santa Fe, NM, US): ultrafast laser pulse metrology
BOOTH: 5107 (North Hall D)
CONTACT: Suzanne Garney (sgarney@mesaphotonics.com)

Mirrorcle Technologies (HQ: Richmond, CA, US): MEMS mirrors for beam steering
BOOTH: 5537 (North Hall D)
CONTACT: Christian Thiel (christian@mirrorcletech.com)

Nanocerox (HQ: Ann Arbor, MI, US): transparent optical ceramics
BOOTH: 2641 (South Hall ABC)
CONTACT: Michael Kelly (mkelly@nanocerox.com)

Nüvü Caméras (HQ: Montreal, Canada): low-noise EMCCD cameras for single-photon imaging
BOOTH: 4401 (North Hall D)
CONTACT: Félicien Legrand (flegrand@nuvucameras.com)

Omega Optics (HQ: Austin, TX, US): diagnostic microarrays — seeking large-company collaboration
BOOTH: 6074 (North Hall D)
CONTACT: Swapnajit Chakravarty (swapnajit.chakravarty@omegaoptics.com)

Open Photonics, Inc. (HQ: Orlando, Florida): photonics commercialization through collaboration
BOOTH: 2104 (South Hall ABC)
CONTACT: Jason Eichenholz (jason@open-photonics.com)

Optofluidics (HQ: Philadelphia, PA, US): optical "nanotweezers"
BOOTH: 4232 (North Hall D)
CONTACT: Robert Hart (hart@optofluidicscorp.com)

Single Quantum (HQ: Delft, The Netherlands): superconducting nanowires for single-photon detection
BOOTH: 5204 (North Hall D)
CONTACT: Floor van de Pavert (floor@singlequantum.com)

Thermacore (HQ: Lancaster, PA, US): thermal solutions for OEM applications
BOOTH: 5505 (North Hall D)
CONTACT: Sue Shaw (s.j.shaw@thermacore.com)

Xonox Technology (HQ: Hüttenberg, Germany): interferometers
BOOTH: 5534 (North Hall D)
CONTACT: Lisa Carvalho (l.carvalho@xonox-tec.com)

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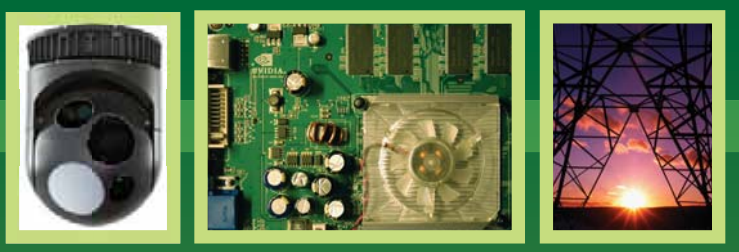

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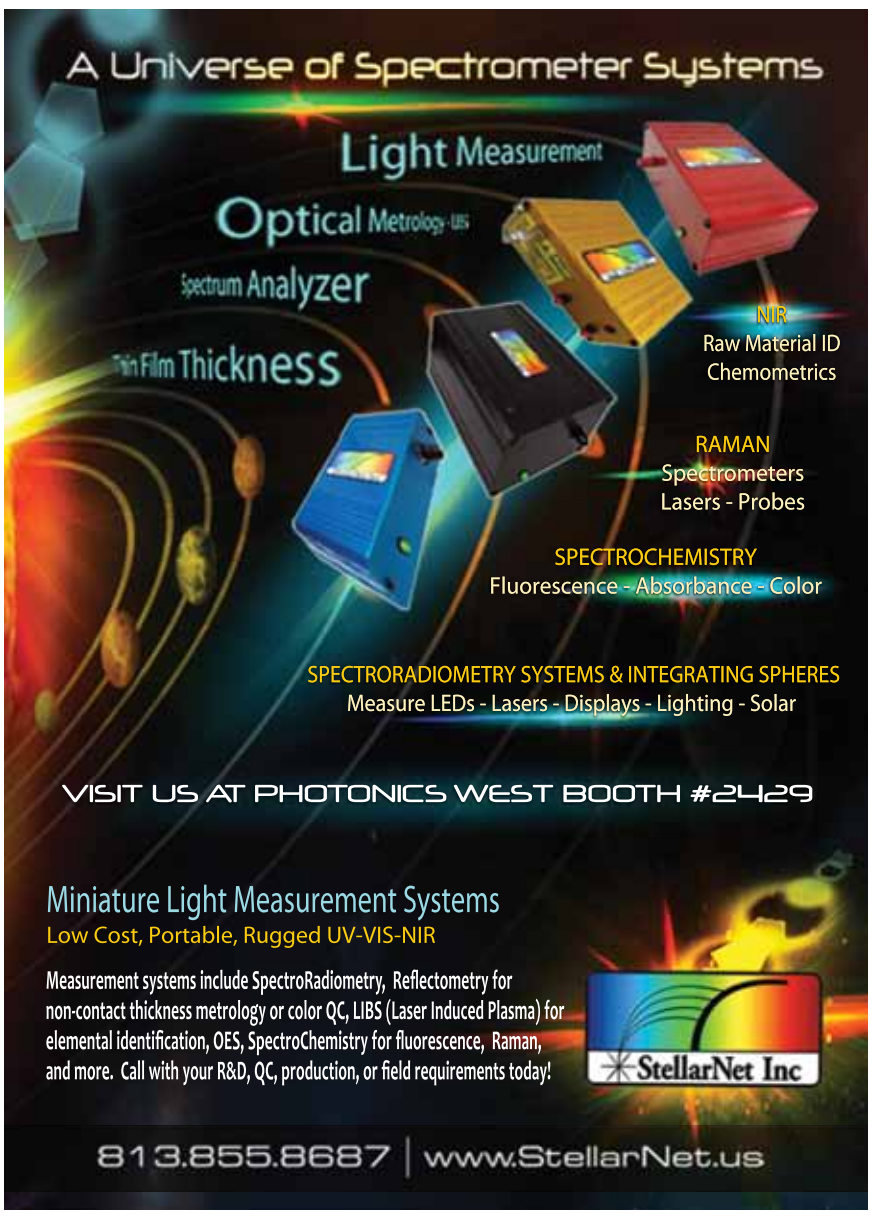


Everything's gone green…

…and photonics is at the heart of much of it. Steve Eglash explains the thinking behind the "virtual" Green Photonics symposium at Photonics West.

How far-reaching is the scope of the Green Photonics symposium?

The Green Photonics symposium has incredible breadth. Green photonics is all about the pursuit of sustainability and using photonic technologies in a way that will allow future generations to live a similarly healthy and comfortable life to our own. As you would expect, we have presentations on the latest technical developments in solar energy, but the scope of the symposium extends much further than photovoltaics (PV).

Attendees will find Green Photonics presentations split into four categories: solid-state lighting (SSL) and displays; laser-assisted manufacturing and micro/nano fabrication; communications; and renewable energy generation: fusion and photovoltaics.

Just to give a flavor, we have papers discussing high-power ultraviolet LEDs emitting at 260nm [paper number 8641-37]; consumer-grade SSL [8641-44]; intelligent management of wind turbines [8601-100]; ultra-thin solar cells [8620-10] and natural daylight illumination systems [8620-67 and 8620-68].

It is both the best of times and the worst of times for the solar industry.

How important was it to introduce the Green Photonics symposium into the Photonics West program?

Green photonic technologies and sustainability have become hot topics in recent years, and interest in this area spans the optics and photonics community in general. We realised, however, that the work being done overlapped with all of the traditional BiOS, LASE, OPTO and MOEMS Photonics West symposia.

Rather than launch an entirely new symposium, the virtual Green Photonics symposium was created. This gives attendees a single portal from which to hear about every paper related to green photonic technologies, regardless of what traditional strand of Photonics West they are a part of.

How do you assess the current state of the global solar industry?

It is both the best of times and the worst of times for the solar industry. It is the best of times because several manufacturers of silicon solar panels, mostly in China, are producing some of the world's best and most efficient panels at some of the lowest costs and prices that we have ever seen. In fact, the energy generated from such panels is now very close to grid parity.

We are seeing an explosion of solar energy projects worldwide because of the availability of these cheap panels. So for utilities, consumers and developers, the solar energy industry has never been better. The rate of installations in the US right now is more than doubling every year.

But on the other hand, it is the worst of times for solar panel manufacturers that don't have competitive cost and performance with the industry-leading Chinese manufacturers. For these manufacturers, including most in Japan, the US, and Europe, it is a very difficult time indeed. They can't sell as much of their product as they would like, and what they can sell, they can only sell at a loss.

Steve Eglash Credit: Stanford University

What's your prognosis for the solar sector?

I think we will see more of an explosion of a truly worldwide PV industry, much like today's automotive industry. By that I mean that the different components of a PV module will be manufactured and assembled where it makes the most sense to do so. This rests on innovation and invention driven by science and engineering as well as smart decisions about manufacturing and assembly.

Many innovative technologies, such as the development of ultra-thin solar cells and lasers to make manufacturing processes more efficient, will be discussed at Photonics West. In addition, we may be seeing the very early trends of manufacturing coming back to the US. In December, there was a lot of publicity when the CEO of Apple announced an investment of $100million to bring the manufacture of Apple computers partially back to the US.

Which technologies do you see solar companies currently investing in?

Many of the largest companies in the US, such as GE, DuPont and Corning, are taking a long-term view and are continuing to make major investments in solar energy despite the tough times wherever possible. These investments are twofold. First, into thin-film technologies, and these may turn out to be the wave of the future.

Second, there is an investment into particular parts of the module that can be used to enhance the performance of silicon solar cells. You do not need to be a completely vertically integrated manufacturer of entire PV modules to play in this field. A company can play in the PV industry without building the entire module. As large as the solar industry is now, it is likely to grow to 10 or 100 times its current size in the years ahead.

Solid-state lighting (SSL) is another key "green photonics" topic: is it now just a question of reducing cost, or is there still a need for innovation?

Today, there is no doubt that the penetration of LED-based SSL will continue to expand and that prices will continue to come down. It is no longer a debateable subject in my eyes. We are past the tipping point and it is now just a question of the rate at which volumes will go up, prices will come down and exactly how the industry will evolve. While there is still a need for research, all of this is now aimed at enhancing and improving what is already a viable product.

JACQUELINE HEWETT

GREEN PHOTONICS SYMPOSIUM HIGHLIGHTS:

Green Photonics Awards — awards recognizing green photonics research in four distinct application areas will be presented at the OPTO and LASE plenary sessions.

OPTO Awards (Tuesday morning):
- Solid State Lighting and Displays
- Communications
- Renewable Energy Generation: Fusion and Photovoltaics

LASE Awards (Wednesday morning):
- Laser-assisted Manufacturing and Micro/Nano Fabrication

Panel session — Energy Growth Opportunities in Sustainable Technology:
Tuesday 5 February, 3:30-4:30 pm

Moderator:
Stephen J. Eglash

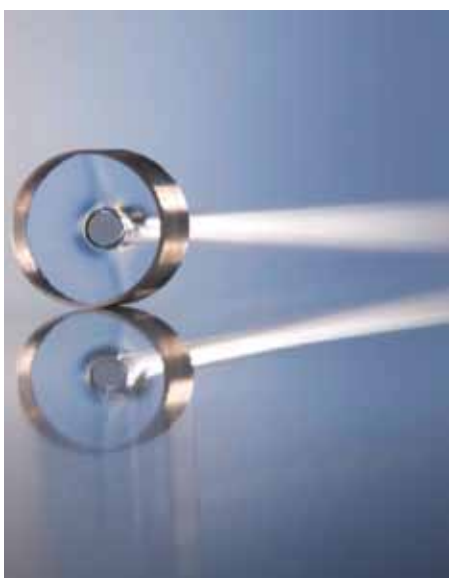
Panelists:
Patricia Glaza, Arsenal Venture Partners
Thomas Baer, Stanford Photonics Research Ctr.
Aaron Knobloch, GE Global Research
Jyoti Bhardwaj, Philips Lighting Lumileds
Eric Crosson, Picarro Inc.

NKT Photonics aeroGAIN-ROD gain fibers ready to revolutionize the ultra fast laser market

The new aeroGAIN-ROD fibers from NKT Photonics are a new generation of ytterbium gain fibers designed specifically for the ultra-fast fiber laser marked.

They offer the highest peak power capability in the industry while keeping pristine mode quality and robust coupling, making them the ideal gain media for the next generation of high-power ultra-fast fiber lasers.

Fiber lasers has long been displacing solid state and gas lasers in the CW and slow pulse segments but the fiber revolution now moves towards ultra fast systems in the picoseconds and femtosecond regime. In this segment, nonlinear effects are the major limitation for output power and fiber systems has typically been limited to a few Watts. Bigger cores and shorter fiber are traditionally the go-to solution but often with compromises in mode quality and stability to follow. Not anymore. Utilizing the latest PCF technology, the new aeroGAIN-ROD fibers offer rock solid performance with long lifetime and they can handle peak power in the mega Watt regime while keeping a perfect near-diffraction limited beam quality; ideal for direct processing at 1µm or for further frequency conversion.



The aeroGAIN-ROD is available in a PM55 and a PM85 version with 55 and 85 µm polarization-maintaining cores, respectively. Each model is available in a Standard and a Power version designed for different power levels so that you can chose exactly the fiber you need.

The aeroGAIN line is already being used by several of the leading laser OEMs in the industry.

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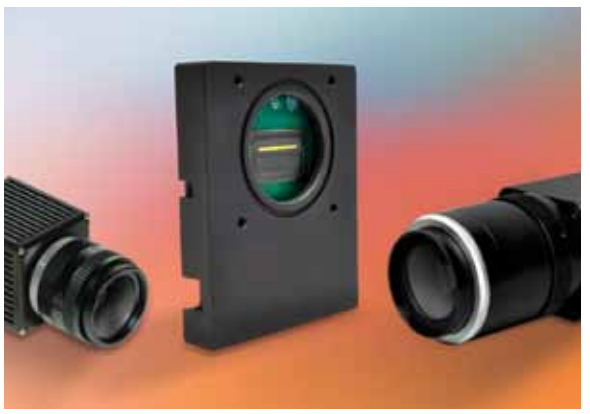

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DRS Technologies expands Tamarisk® product line with introduction of high-resolution infrared camera core

DRS Technologies, a Finmeccanica Company, expands the popular Tamarisk® line by introducing the high-resolution, feature-rich Tamarisk®640, which is designed for original equipment manufacturers (OEMs) to incorporate into their products.

The Tamarisk®640 uncooled thermal imaging camera provides an improved level of performance while maintaining its compact size. With a camera core weighing less than 60 g, the Tamarisk®640 offers remarkable performance, generating large, detailed analog and digital thermal images with a resolution of 640 x 480 pixels from its 17 µm focal plane array.

The Tamarisk®640 core measures 46 x 40 x 31 mm and draws less than 1.5 watts of power. Six Athermalized lens options are available from a wide field of view (FOV) of 44° to a narrow FOV of 9°, as well as a no lens configuration allowing OEMs to mount their own specialized optics. Performance improvements include: a wide dynamic range from -40°C to +80°C, improved pixel saturation logic to maintain image quality at temperature extremes, Dynamic Image Contrast Enhancement (DICE) for greater image detail in both low and high contrast scenes and color output via Camera Link®.

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DRS Technologies, headquartered in Arlington, Va., is a leading supplier of integrated products, services and support to military forces, intelligence agencies and prime contractors worldwide. The Network and Imaging Systems (NIS) Company of DRS Technologies manufactures and supports advanced electro-optical sensor systems, and develops innovative networking capabilities that integrate these sensors in a broader tactical C4 environment.

With operations in Melbourne, Fla., Huntsville, Ala., Dallas, Tex., Cypress, Calif., Columbia, Md. and the UK, DRS NIS is the prominent provider of infrared technology and sensors, embedded diagnostics, information solutions and operational energy for military agencies and industry partners alike. NIS combines proficiencies in the areas of design and production of infrared sensor systems, test and diagnostics, ground and airborne reconnaissance and targeting systems and platform C4 electronics to provide comprehensive and complete solutions to our Customers. These solutions deliver a technological advantage in target detection, recognition, identification, countermeasures and communication.

DRS Technologies is a wholly owned subsidiary of Finmeccanica S.p.A. which employs more than 70,000 people worldwide. For more information about DRS Technologies and the Tamarisk® family of products, please visit the company's website at www.drsinfrared.com.

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Photonics-based components and multi-µ-functional devices

Optical device manufacture requires command of interdisciplinary microfabrication.

CDA GmbH (Suhl, Germany) is a specialist manufacturer of optical components and solutions in plastic for photonics-based applications. CDA also provides their customers with access to several high-end technologies for the development and manufacture of complex miniature devices incorporating printable electronics components and microfluidic channels.

Optical elements

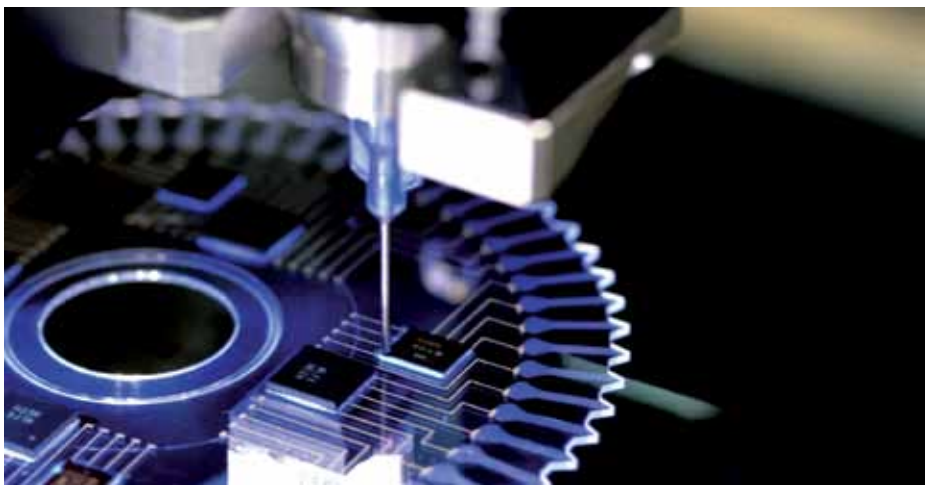
Optical elements can be designed with spherical, aspherical or even non-rotationally-symmetric freeform surfaces, and arranged in any 2D array desired. Each individual element can comprise refractive structures exhibiting diffraction-limited performance, or binary/multi-level diffractive structures optimized to provide the best efficiency for the intended application. Both types ensure optimal optical performance in a broad range of real-world applications.

The primary intended uses for these components are for general illumination tasks, for example as diffusors or for improving efficiency in light emission from (3D) displays and OLED panels. Further applications include imaging systems for multi-channel cameras or for improving the effective fill factor of CMOS image sensors, or as projection optics for LED, VCSEL and fiber arrays.

While silicon and glass remain important material options, the vast majority of applications are served exceptionally well by various types of plastics, such as polycarbonate, PMMA and cyclo-olefin-copolymers. These materials provide all of the performance aspects required in most applications, but are lighter, lend themselves to high volume replication via injection molding, and are more cost efficient.

Application diversity through added functionality

CDA is additionally a champion of more complex devices that integrate several functions on a single chip. So-called ›lab-on-a-chip‹ and other compact but sophisticated and sensitive devices are becoming increasingly important, for example, where physical chemistry, electrical and/or optical properties need to be tested on a small scale. Appropriate devices lend themselves well to high levels of parallelization, bringing cost reductions into a design but their manufacture does require a fully integrated process chain and command of several cutting-edge microfabrication technologies.



The manufacture in plastic means producing highly complex and functional microstructures with extreme precision, and doing so very cost efficiently under mass production conditions. The CDA approach is so attractive because of the number of available process steps and due to the nature of the functionalities – optical, electronic, microfluidic – that can be combined freely so as to optimize the performance of a device for the intended application. Finally, coatings can enhance specific optical performance or induce other specific physical properties, such as hydrophilic or hydrophobic behaviour.

According to Pia Harju, Business Development Manager at CDA, "We believe the market for both micro-optical elements and for integrated devices is absolutely global and we are targeting a range of industries including machine vision, lighting, medical devices, environmental applications and food production."

Contact

Pia Harju,
Business Development Manager
CDA GmbH, Am Mittelrain 11,
98529 Suhl, Germany
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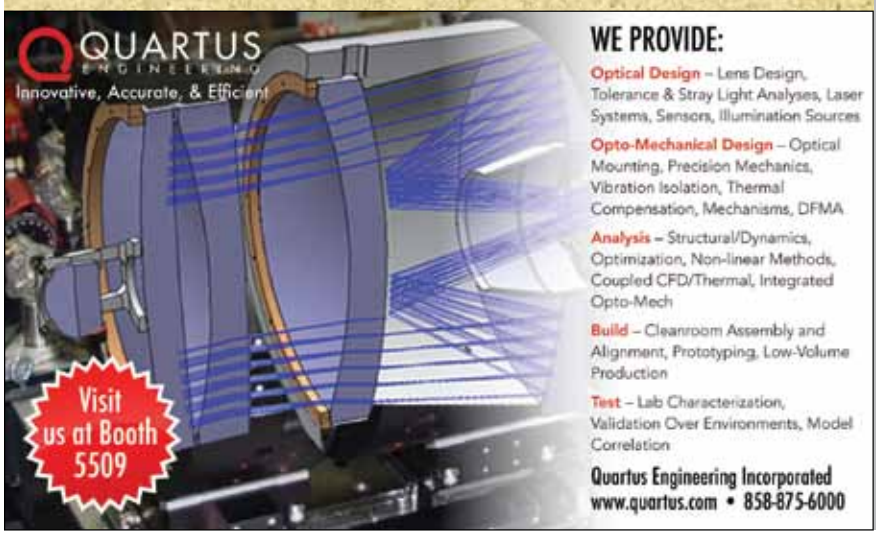

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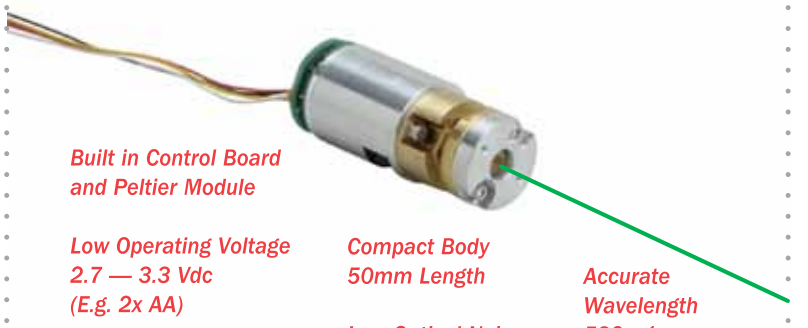

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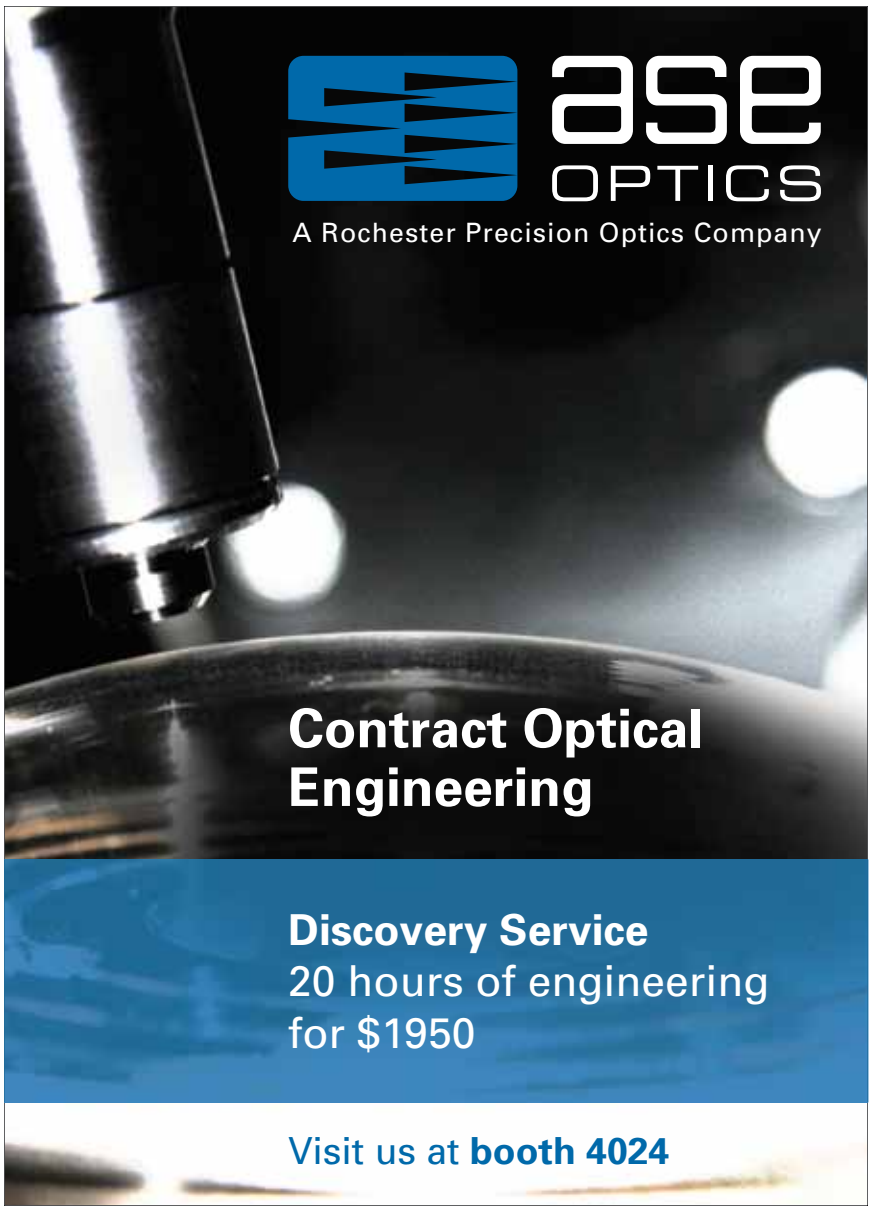

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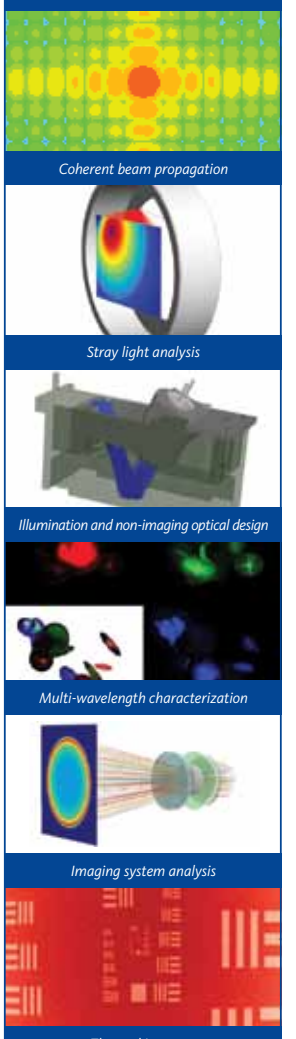

Optogenetics: shedding light on depression?

A standing-room-only audience heard Karl Deisseroth of Stanford University, the man affectionately referred to by another speaker as the "in-house genius" of optogenetics, describe the strides now being made in that field and some of the implications for the understanding of behavior.

Current advances exploit developments in both the biochemical markers added into neural circuitry, and the optical methods used to then activate or regulate them — the twin principles on which optogenetics is based.

Originally derived from studies of algae, the modern variants of these markers can have highly complex chemical structures that directly influence how they respond to irradiation. Deisseroth described an extreme case of markers which remain activated for several minutes, after irradiation measured in milliseconds.

"Developing markers which respond faster to the action of light is a molecular engineering task," he noted in a keynote presentation to open the new BiOS conference *Optogenetics and hybrid-optical control of cells*. "We have found that the time taken for the markers to deactivate after irradiation is a critical factor; the faster this deactivation happens, the less sensitive they become to irradiation in the first place. On the other hand, we can exploit this by deliberately slowing down the deactivation, and hence greatly increasing the sensitivity."

Some of the most fascinating work involves mapping the neural dynamics accompanying the manifestation of certain depressive symptoms, a potentially profound area of study.

Deisseroth described apparatus which humanely suspends a rodent in water until it passes from active and struggling behavior into a more passive, "hopeless" stage. A fiber-optic system uses optogenetic methods to monitor the activity in certain neurons in the frontal cortex during the transition, neurons already associated with states of "hopefulness" in human beings.

"High-speed optical stimulation of the relevant neurons gives a causal understanding of what is happening in circuit-dynamic terms, for example identifying the exact point when neuron activity ramps up," he said.

Once the neural circuitry involved is mapped, it might then be possible to affect those mental states by changing the behavior of the neurons. Deisseroth described how similar optogenetics approaches were now shedding light on the influence of dopamine on risk/reward behavior, and on the significance of certain neurons to cocaine addiction.

"It is still early days with a great deal left to understand about the causal dynamics involved in these states of mind, but it is a very interesting area. And it is still surprising that this understanding ultimately stems from those first studies of algae."

TIM HAYES

Inspired by insects

The new BiOS conference covering *Bioinspired, Biointegrated and Bioengineered Photonic Devices* kicked off in lively fashion early on Saturday morning with a keynote talk from University of Illinois at Urbana-Champaign's John Rogers.

Rogers' team at UIUC has been working on new types of electronic cameras inspired by nature – from the human retina to the compound eyes found in insects — for several years, and has developed hydraulic hemispherical devices that bend and stretch elastically to change focus.

Cameras like this can outperform conventional flat planar detectors that need relatively complex optics, and deliver better focusing at the periphery of the image.

Most recently, the UIUC researchers have produced a compound insect eye based on a stretchable microlens array coupled with a silicon-on-insulator (SOI) photodetector array. Although the elastomeric array is stretched into the familiar bulging shape of an insect eye, the vast majority of the strain in the material system is confined to the areas between the microlenses and photodetectors — meaning that good focusing performance is maintained.

With only a few hundred elements, Rogers described the team's engineered insect eye as "more ant than dragonfly" (dragonfly eyes comprise tens of thousands of optical elements). And although the technology requires plenty more development before it can be used in applications, perhaps to protect individual detectors receiving stray light hitting adjacent microlenses, it could have potential uses in defense and biomedicine.

UIUC's John Rogers kicks off a new BiOS conference. Photo: Stacey Crockett/SPIE.

For example, said Rogers, DARPA has a long-standing interest in the development of night vision goggles, and the compound eyes could help to reduce the weight of the goggles carried by soldiers currently. In medicine, a compound eye could be used in endoscopy.

The keynote was followed up with talks from TU Dresden's Malte Gather, part of the team that in 2011 created the very first laser based on a living biological material — a human cell and a jellyfish protein — and Harvard University's Mathias Kolle, on replicating the optical properties of the shiny blue fruit from South America *Margeritaria nobilis* and the color-changing butterfly *Pierella luna*.

That represented just the start of the new BiOS theme, and Gather is hopeful that in the future this conference could feature such advanced bioinspired devices as self-healing lasers and *in vivo* light sources.

MIKE HATCHER

Bringing STED to the masses

Substituting for nanoscopy pioneer and listed BiOS keynote speaker Stefan Hell on Sunday morning were colleagues Johann Engelhardt and Matthias Henrich from the German Cancer Research Center in Heidelberg, who described two ways in which Hell's ground breaking approach to microscopy is being developed for wider use.

The "Quadscanner" is designed to make stimulated emission depletion (STED) microscopy equipment, used to defeat the optical diffraction limit, far more compact and convenient.

Using an "EasySTED" half-wave phase plate, a two-axis scanner and an adjustable pivot in the objective lens, it does away with the need for a special scanning lens, and enables a shoebox-sized STED add-on that can be mounted to the side port of a conventional microscope. Engelhardt said that the tool is able to image down to 4.1nm with a 100x objective, offering a 5ns time resolution and a field size of 80 microns.

Following up, Henrich described efforts to replace the bulky and expensive lasers typically found in a STED microscope with semiconductor sources. In the past, that has been regarded as something of a dead-end, because of the combination of high repetition rate, picosecond pulse width and, in particular, the high laser intensity that is required to "switch off" dye fluorescence — the way that STED beats the diffraction limit.

By using time-gated STED, it is possible to use semiconductor lasers in place of the usual Ti: sapphire, parametric oscillator or fiber lasers, provided that trading off some resolution is acceptable.

Using a 765nm diode laser and a tapered amplifier, it was possible to yield images with a resolution of 60nm — suggesting that, for some applications, the approach might be suitable.

Compared with the conventional setups, he said that STED microscopes featuring the semiconductor sources were "potentially orders of magnitude less expensive." He concluded: "We think that this laser architecture could lead to STED being introduced into many more biology labs."

MIKE HATCHER

Hot topics

continued from p.01

limit the effectiveness of conventional optics to do the job. More dramatically, optogenetics could allow 'remote control' of the pacemaker cells in an intact heart and control its beating, as studies of zebra fish have demonstrated. The approach even holds the tantalizing prospect of treating loss of vision. "Macular degeneration leaves a residual cell body behind," said Bamberg. "Activating that cell body by using a light-driven protein such as halorhodopsin might help us to return the cell back to what it used to do."

One requirement of optogenetics is extremely fine control over the locations where the irradiating light and opsin proteins interact — otherwise the goal of establishing the roles of specific neurons becomes considerably more difficult. Dan Oron of the Weizmann Institute explained that temporal focusing, a non-linear phenomenon allowing patterned multiphoton excitation, could be the best answer.

SPIE President Bill Arnold hands BiOS conference co-chair James Fujimoto the 2013 Britton Chance Biomedical Optics Award. Photo: Amy Nelson/SPIE.

"Axial confinement of the illumination onto small excitation areas is not automatically beneficial for some applications, but it can be for this one," he said. "Two-photon excitation, in which the excitation probability scales with the peak intensity of illumination, is a solution." The version of this technique known as temporal focusing involves the use of a diffraction grating operating on the image plane of the objective lens, a method first applied to wide-field two-photon microscopy and now finding use in optogenetics.

Oron showed how temporal focusing was used to maintain image quality through 500 microns of turbid tissue, something that a potential such as adaptive optics could not achieve. "Temporal focusing helps us get closer to the original intention, of exciting just one single neuron at a time," he commented.

Next-gen OCT

With MIT's James Fujimoto welcoming the crowds to the event alongside BiOS co-chair Rox Anderson, it was no surprise to see optical coherence tomography (OCT) on the agenda. But what MIT's Ben Potsaid — a colleague of Fujimoto's presented shows just how far the technology has progressed since Fujimoto's breakthrough research in the mid-1990s.

The swept-source variant of the OCT technique described by Potsaid, enabled by a MEMS-tunable 1310nm vertical-cavity surface emitting laser (VCSEL) provided by Thorlabs, promises to add another dimension to OCT imaging — literally.

While spectral-domain imaging added speed to the early promise of the original time-domain approach, the technique's fundamental weakness has remained the inability to see beyond a depth of two or three millimeters, restricting OCT to surface analysis.

That is set to change. The swept-source approach developed at MIT has shown an unprecedented coherence length in excess of a meter — a fifty-fold improvement on commercial OCT. As a result, it could now be used to image not just the retina, but the eye's entire structure. And thanks to the rapid switching speed of the electrostatic MEMS chip, an "ascan" rate of 1.2MHz is now possible. That is 25 times faster than spectral-domain OCT, and represents another world-best.

Jonathan Sorger, the director of medical research at Intuitive Surgical, highlighted what appears to be a fast-growing opportunity for photonics in the world of medical robots. With some 500,000 surgical procedures using robots in the US last year, from hysterectomies to minimally-invasive heart bypasses, surgeons stand to benefit hugely from optical technologies that can assist them by helping to guide the robot, show the full extent of tumors, or the presence of nerve tissues.

But Sorger stressed that surgeons would not want anything to hold them up, so for any photonics technologies to be used in a clinical setting with surgical robots, speed is of the essence. "Surgeons don't like waiting more than 100 milliseconds," he said.

One major opportunity could be in prostatectomies. At present, surgeons tend to remove the entire organ when treating prostate cancer, with a very high risk of side effects because of the large number of nerves present within the prostate tissues and the difficulty in distinguishing diseased cells from healthy ones.

New imaging modalities

Two imaging modalities set to move out of the laboratory and into the clinic could bring significant benefits for clinicians and patients, thanks to their ability to image blood flow and hemodynamics more accurately than conventional optics. Laser speckle imaging (LSI), in which the speckle effects caused by temporal fluctuations are integrated over a long enough time period to yield quantitative imaging data, is not a new technique, but is now finding new applications in surgical procedures where blood flow mapping is critical.

"There is potential for using LSI in image-guided laser surgery, providing real-time guidance on blood flow to the surgeon," said Bernard Choi of the Beckman Laser Institute. Examples could include removal of port-wine stain (PWS) birthmarks, where inefficient treatment of all relevant blood vessels can mean the condition subsequently returns.

One issue with LSI can be the effect of local optical effects on speckle contrast measurements, but a solution is to combine LSI with the second technique, coherent spatial frequency domain imaging (cSFDI). cSFDI measures both absorption and scattering properties of tissue, and in combination with LSI can give absolute quantization of blood flow in *in-vivo* systems. "In the future, both LSI and cSFDI will move towards point-of-care use with simple optical equipment, perhaps even a DSLR camera," said Choi.

Mapping the functional connections playing a part in spontaneous brain activity used to require making an animal carry out a particular task and mapping what happened in the functional cortex while it did so. "Now we think the 'noise', the background brain activity that is always present, can also contain important information," said Joe Culver of Washington University in St Louis.

One technique for analyzing this information is functional connectivity optical intrinsic signal imaging (fcOIS), which monitors changes in the intensity of light reflected from the surface of tissues as blood flows through them. This method has now revealed the first functional connectivity maps in mice, perhaps allowing study of how Alzheimer's disease progresses in the animal.

Another promising new modality is high-definition diffuse optical tomography (HD-DOT) using near-IR illumination, deliberately addressing a regime where light propagation is dominated by multiple scattering effects. This can identify the active regions of the brain during activities such as speaking, hearing or even visualizing in the imagination. The challenges here are now field of view, resolution, and wearability in a clinical context. "Can this technique ultimately achieve all we would wish? Yes it can, and in about three years," enthused Culver.

Flow cytometry: a next-gen blood test?

Rounding up the Hot Topics session was the University of Arkansas' Vladimir Zharov, with an intriguing presentation of the potential to introduce an entirely new kind of blood test based on photoacoustic flow cytometry. Whereas the familiar blood test involves taking a small sample to analyze, what Zharov's work suggests is the ability to test a patient's entire blood volume — and therefore picking up on the presence of any cells that could easily be missed using the conventional approach.

Zharov said that the optical *in vivo* blood test had shown the ability to detect circulating tumor cells — indicating the movement of a dangerous metastatic cancer around the body — far more quickly than conventional tests in animal experiments.

MIKE HATCHER AND TIM HAYES

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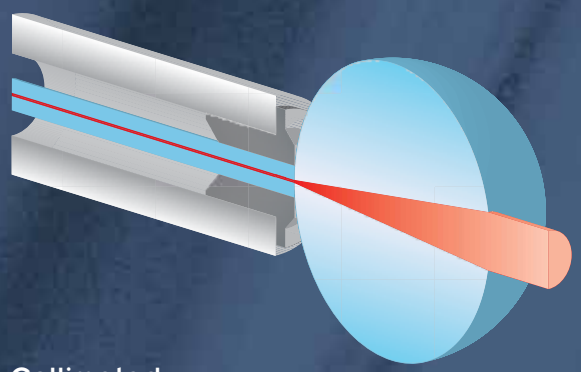

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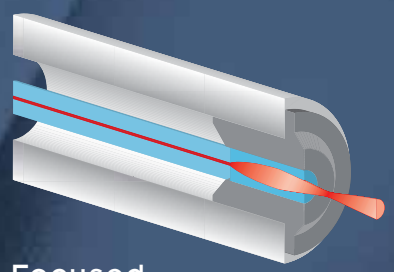

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