Photonics West® Show Daily

TUESDAY EDITION

Naomi Halas, recipient of the 2014 SPIE Biophotonics Technology Innovator Award

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Inspired by nature

John Rogers interview

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COMPACT AND ULTRAFAST

Femtolasers Produktions' "Integral core" Ti: sapphire laser, pictured at the weekend's BiOS expo. The ultrafast source is a finalist in this week's Prism Awards. See Femtolasers at booth #423, and more on the BiOS expo on page 29. Credit: Joey Cobbs/SPIE.

TODAY'S NEWS

BiOS Hot Topics: research to clinic

Optical tools that can image at the macroscopic, microscopic and molecular levels continue to provide new insights into the form and function of complex human organs like the brain.

Leading international researchers at Saturday evening's BiOS symposium Hot Topics session provided updates on breakthroughs in the technologies and applications that are changing our ability to diagnose and treat disease and understand the inner workings of the human body.

"This symposium gets a little better, broader and deeper every year," said R. Rox Anderson, BiOS co-chair. It is a reflection of how "we are all trying to help people."

And for commercial success, Eric Swanson of *OCT News* paid tribute to innovative researchers, government support and an "entrepreneurial spirit" for their role in making optical coherence tomography (OCT) the most successful biomedical optics product to date.

First introduced into ophthalmology clinics and, more recently, cardiology practices, OCT technology is the basis for more than 40 companies worldwide today and is being used in surgery, microscopy, the oral cavity, bronchoscopy, gastroenterology, dermatology, gynecology, neurology and pathology, Swanson noted.

"Over the last decade, more than half a billion dollars has been invested by government agencies, and the ROI on

continued on p.30

Don't miss

OPTO Plenaries* (8:30-10am)

- Pushing the boundaries of silicon photonics (Lipson, Cornell Univ.)
- The previously unbelievable performance of ultrafast thin-disk lasers (Keller, ETH Zurich)

Nano/Biophotonics Plenary* (2-3pm)

- Direct laser writing: Biomimetic photonics and superresolution nanolithography (Gu, Swinburne Univ.)

Industry Events

- Photonics West Exhibition (10am-5pm)
- ITAR and other international trade regulations (10:30am-12:30pm)
- Magnifying your IP IQ: (1-5pm)
- Silicon photonics and photonic integrated circuits (PICs): An industry perspective (2-3pm)
- Green photonics: A solar revolution (3:30-4:30pm)

See the technical program and exhibition guide for details on daily events.

All industry events are open to all registration categories.

* Conference registration required at Plenaries.

Inside this issue

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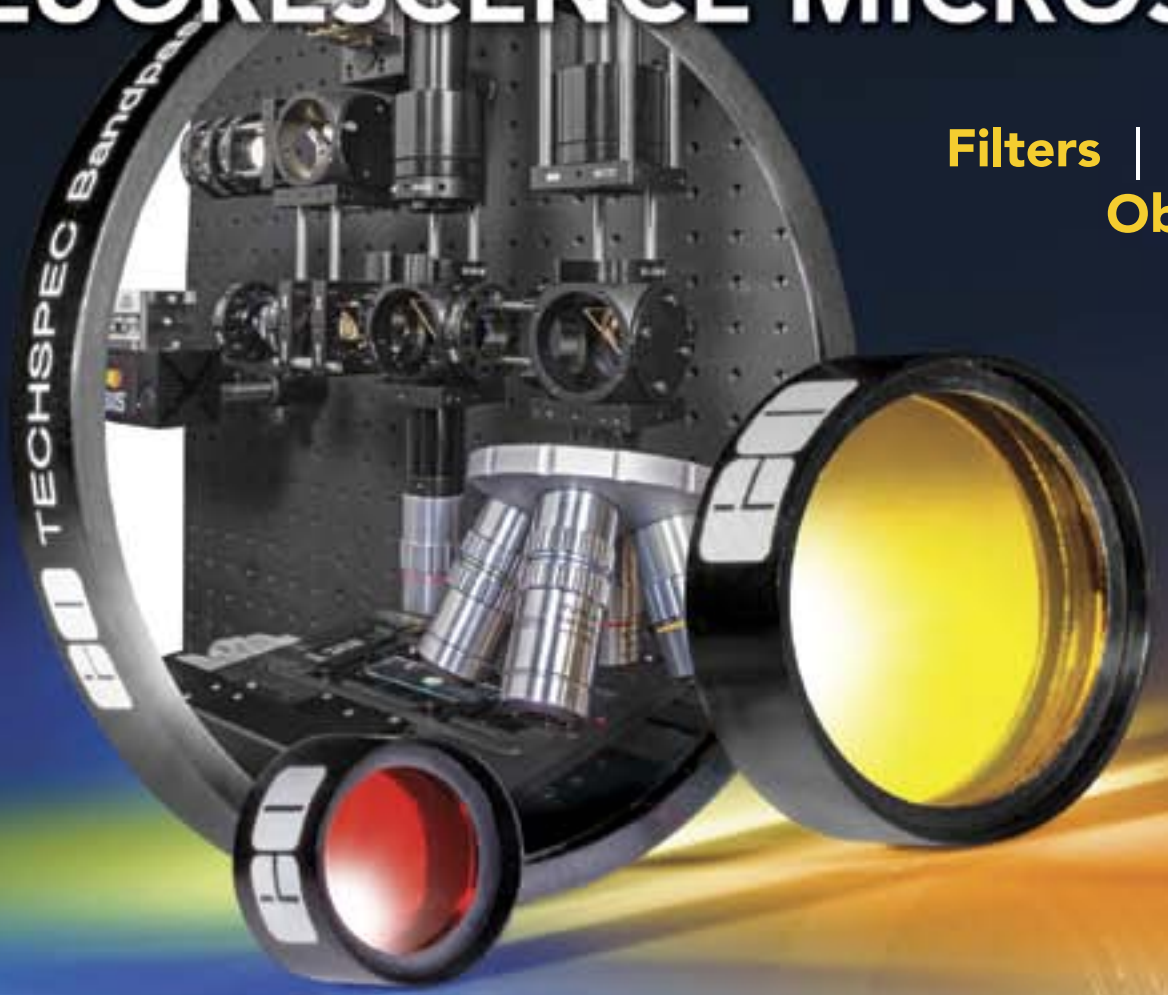

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MOEMS-MEMS plenaries target novel biomed applications

Nanoscale fabrication techniques are enabling new applications in the biomedical sector, from holographic optical tweezers to wireless miniature brain probes and cameras that mimic an arthropod's eye.

"We are looking to nature for inspiration," said John Rogers of the University of Illinois at Urbana-Champaign during his Monday MOEMS-MEMS plenary session talk, "Bio-Integrated and Bio-Inspired Optical Microsystems."

The decreasing size of transistors has had a transformative effect on technology, Rogers noted. "We are seeing continued miniaturization, with computers coming closer and closer to your body. These devices are always built on rigid planar surfaces, which is not really a problem if you want to keep your iPhone in your pocket. But what if you want to use it in other ways? Nothing in biology looks like a silicon wafer."

The future as he and his research group envision it is "stretchy, curvy and bio-integrated." So they have been working to develop materials and methods to enable devices that leverage this new way of thinking about form and function. The goal is to create silicon nanomembranes for flexible silicon integrated circuits and flexible micro LEDs. Such bio-inspired devices require thin sheets of silicon with a very small bending thickness (about 200 nm).

"We can build integrated optical systems that offer a natural way to scale down to very tiny geometries," Rogers said. "By using lithographic interconnection schemes, you don't have to do wire bonding to establish the interconnects, which then also serve as heat sensors."

These devices can be integrated with biological processes that can probe much deeper into the human body than current devices and thus better explore the form and function of complex organs such as the brain, he said.

For example, Rogers and his group have been working to develop brain-injectable micro-LEDs that can enhance the use of optogenetics to study behavioral responses to light. In research published last year in *Science*, they demonstrated how a multifunctional, cellular-scale, wireless optoelectronic device could be injected safely into a mouse brain and used to manipulate the animal's behavior.

"Thermal management is incredibly important because you are basically inserting a lightbulb into the brain," which can only tolerate about a one-degree increase in temperature, he said. See more on John Rogers' work on page 12.

Optical manipulation — aka "optical tweezers" — has also benefitted from the increasing miniaturization of technology, noted Cornelia Denz of Westfalische Wilhelms University Münster in her plenary talk on tailoring light for optically guided nano- and microassembly.

Microscopy labs want to tweeze particles in fluids, gases or cells in organisms. This requires novel tweezer tools.

"Increasingly, microscopy labs want to tweeze particles in fluids, gases or cells in organisms, which requires novel tweezer tools," she said. "So how do we manipulate, move and arrange matter at the nanoscale by light? Complex light landscapes are needed."

For example, Denz and her colleagues have developed a holographic optical tweezer (HOT) workstation that can create up to 100 traps at a time. They use HOT to study biological self-propelled micromixers and self-propelled biohybrid microrobots that can identify pathological situations in cells, including metastasis, inflammation and infection, and observe how the cells change over time.

Finally, in his talk on nanoelectromechanical (NEMS) switch technologies, Roger Howe of Stanford University emphasized that NEMS switches offer several advantages over nanoscale CMOS switches, including zero leakage, infinite sub-threshold slope, high temperature operation, radiation-hard operation and compatibility with other substrates, including glass and plastics. But some key issues need to be addressed before NEMS is ready for broad commercial production.

"NEMS switch technology is a work in progress, and surface physics and chemistry at the contact are key factors," he said. Microshell encapsulation is absolutely essential for reliability and reproducible behavior, he added.

KATHY KINCADE

Who wants to be a photonics entrepreneur?

Photonics industry insiders gave job interviewing tips, a crash course in feasibility analysis, and their perspectives on entrepreneurship and other non-academic careers to about 100 students attending one of several industry events at Photonics West Sunday.

Simon Poole, director of new business ventures for Finisar in Australia, advised optics and photonics experts who want to start their own business to "identify the opportunity, get into the market fast, and iterate. Listen to the market and do things ten times better."

The serial entrepreneur, who turned to the commercial side of photonics after running an academic research group for seven years, emphasized the importance of speed in many areas of a new business, such as getting to market rapidly and quickly firing employees who don't work out. But Poole also recommended taking time to hire the right people — and to "smell the roses."

Andrea Belz, CEO of Belz Consulting, and Jim Fisher, vice president of optical components and the vibration control group at Newport, also underscored the importance of finding a good work-life balance.

Job seekers must be able to "ask the right questions to the right people," Fisher said, but they should first take the time to answer the most important questions: What really drives you and where do you want to end up?

Andrea Belz, CEO of Belz Consulting, Simon Poole, director of new business ventures at Finisar Australia, and James Fisher, vice president of optical components and vibration control group at Newport, gave career advice during a talk to about 100 students on Sunday. Credit: Kathy Sheehan

The three, however, joked about their own career paths starting off very different from where they ended up. Belz, for instance, received a PhD in nuclear and particle physics before going to the "dark side" in industry where she has helped numerous companies start up, turn around and improve operations. She is also a professor of internship now at the University of Southern California.

The panel discussion, "Charting a Course in the Photonics Industry," is part of an expanded industry program at Photonics West that includes the Prism Awards for Photonics Innovation, the SPIE Startup Challenge, and several talks on marketing, intellectual property and measuring the photonics market. See page 4 for information on the economic impact of optics and photonics throughout the world and page 29 for more on financing a new biophotonics venture.

KATHY SHEEHAN

Exhibitors "worth $84 billion" in core photonics sales

SPIE's industry and market strategist Steve Anderson told a cluster reception event held on Monday evening that an analysis of exhibitors at this year's BiOS and Photonics West events showed that they generate $84 billion in sales of core photonics components annually.

The analysis was based on the 1008 exhibitors with sales and employee data compatible with the Dun & Bradstreet business information database (out of a total 1506 exhibitors), and also showed that these 1008 companies employed some 337,000 people. Extrapolating from that figure on the assumption that Photonics West exhibitors represent around one-fifth of the entire market for photonics products, the SPIE data suggest a global photonics product market of some $480 billion.

Of the companies exhibiting at the Moscone Center this week, the 40 firms with photonics revenues exceeding $500 million were found to account for more than three-quarters of the $84 billion total. But the "long tail" of the photonics industry was evident in the data: no fewer than 757 companies with annual revenues below $10 million accounted for just 2.5 percent of the total.

Unsurprisingly, the US turns out to be the biggest employer among the countries represented at Photonics West, with just under 131,000 working in the sector. Japan ranks second, with 121,000. Perhaps surprisingly, France ranks third on this metric with 28,500, just ahead of Germany with 26,000.

Anderson also updated delegates on the latest progress with the US National Photonics Initiative (NPI). A policy document in the key application area of data centers and high-performance computing has just been completed, with similar work on high-power lasers, healthcare and sensors for energy about to begin. The next steps for the NPI will include Congressional visits on March 25-26, which are designed to educate members of Congress about the NPI and sustained R&D funding.

Corning showed off its multi-colored light diffusing fiber, just re-launched under the "Fibrance" brand name, at the weekend's BiOS exhibition. Initially aimed at decorative applications, Corning believes that the silica fiber, which allows a controlled diffusion through nanostructures in the fiber, could also find use in photodynamic therapy. Credit: Joey Cobbs/SPIE.

Andor polishes up spectroscopy portfolio

Belfast, Northern Ireland based Andor — currently in the process of a £176 million ($290 million) takeover by fellow UK company Oxford Instruments — is demonstrating two new systems at the Moscone this week: its Holospec F/1.8 imaging spectrograph; and the iDus 416, which the company claims is the most sensitive near-infrared CCD platform available.

Based around a volume phase holographic grating, the Holospec is designed to collect more light than rival Czerny-Turner spectrographs, and achieve a better signal-to-noise ratio more quickly — critical for applications such as micro-Raman mapping, microfluidics and real-time medical diagnostics.

John Alford, Andor's senior sales engineer in South Windsor, CT, told *Show Daily*, "The design of the Holospec enables superior photon collection efficiency when combined with Andor's ultrasensitive detectors, such as our new iDus 416 and single-photon-sensitive Newton EMCCD series of detectors."

The iDus 416 is Andor's other big announcement at Photonics West this year. It combines low dark noise with a quantum efficiency of up to 95 percent, offering high sensitivity in the near-infrared region. This makes it suitable for Raman and photoluminescence applications, reducing acquisition times and removing the need for liquid nitrogen cooling.

Alford commented, "The unique 2000 x 256 array of 15 micron pixels allows extended, broadband and high-resolution spectral acquisition, while the fringe suppression technology virtually eliminates the optical etaloning at the higher wavelengths."

Visit Andor at booth #717

IPG Photonics goes "eco" with high-efficiency lasers

Among a raft of products launched by fiber laser specialist IPG Photonics at this year's trade show is a new family of kilowatt-class systems with wall-plug efficiencies exceeding 40 percent. The "ECO" range also boasts an estimated operation time between service interventions of close to five years under normal operating times and conditions, says the company.

On top of that, IPG is showcasing its "MEGA Pulse" line of nanosecond fiber lasers for the first time, said to yield a pulse energy of up to 100 mJ and an average power up to 5 kW. New single-mode green fiber lasers offer up to 500 W average power in CW and QCW modes, combined with a wallplug efficiency above 15 percent.

IPG is also showing off industrial-grade ultraviolet fiber lasers operating at both 355 nm and 266 nm, in pulsed or CW configurations, as well as entire new families of industrial ultrashort-pulsed fiber lasers. The latter includes both picosecond and femtosecond sources, while IPG is also unveiling what it describes as the "first practical femtosecond laser source" to operate in the mid-infrared 2400-2500 nm spectral range. It is based on a Cr:ZnS polycrystal.

IPG Photonics' CEO Valentin Gapontsev said: "We are unveiling a group of products that provide a multitude of new solutions to customers, all are designed with industry-leading product performance, reliability and cost of investment and ownership."

He adds that the expanded selection should increase the available markets for the IPG's fiber lasers, including emerging areas such as 3D cinema and 3D printing.

See IPG Photonics at booth #1714

Tunable Raman laser uses Element Six diamond

Synthetic diamond material from booth #4308 exhibitor Element Six is behind two new milestones in the development of novel Raman lasers at the University of Strathclyde.

Photonics researchers at the university have demonstrated both the first ever tunable diamond Raman laser and the first CW laser based on the material. According to them, the achievements prove diamond's viability as a material for solid-state lasers in even the most demanding intracavity designs.

Alan Kemp and colleagues at Strathclyde used the high-quality synthetic diamond for its extreme thermal conductivity and transparency over a broad range of wavelengths. The senior research fellow said:

"Although continuously operating and tunable Raman lasers have been demonstrated in the past with other materials, these materials have very poor thermal conductivity, which severely limited the output powers that could be generated. Diamond removes this barrier and has paved the way for multi-watt output powers at wavelengths that are difficult to generate with conventional lasers."

Kemp worked with team leader Jennifer Hastie and Institute of Photonics director Martin Dawson on the project, with Dawson adding: "The successful demonstration of a diamond Raman laser indicates that diamond is now a viable material for solid-state laser engineering even in the most demanding applications. It is this potential that we hope to exploit in the future in continued partnership with Element Six."

Another exhibitor, M-Squared Lasers, has also adopted Element Six diamond in its "Dragonfly" semiconductor laser source, where it is used for intracavity cooling.

The university team used a tunable semiconductor disk laser to tune the Raman laser's color. With a single-crystal diamond heat spreader, it provided several watts of tunable output power.

Applications that could benefit include spectroscopic detection of trace gases and certain demanding medical procedures, such as ophthalmic surgery.

Adrian Wilson, head of the Element Six technologies division, said. "We have only scratched the surface as it relates to high-optical quality diamond in solid-state laser engineering."

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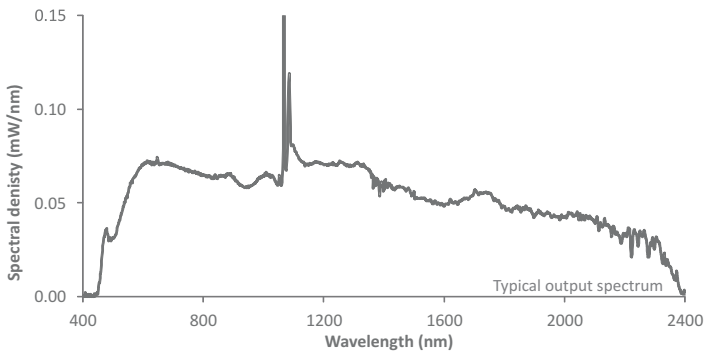

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Photonics is strong — for now — your help is needed to build support for the future

SPIE's CEO Eugene Arthurs. Photo: SPIE.

Welcome to Photonics West 2014 — a year that begins with positive indicators for the photonics industry. Thanks for being here and helping set yet another new record for this great event.

It is fashionable today to use conditions in 2007 as a gauge for the economic health of nations and enterprises. For many important measures — global GDP, US automobile sales, and so on — we are finally ahead of where we were in 2007, although not at the levels predicted by trends before the "Great Recession."

Through this difficult period, global photonics sales proved remarkably resilient, not succumbing to the sharp dips seen in other sectors and in general outperforming the anemic recovery seen in the "advanced" economies.

At this year's Photonics West there is more attention on how to make research truly fruitful.

Analysis of the global photonics market supports the assertion that this is indeed the century of the photon, and that we have the great fortune to be working in a vibrant area of science and technology, in a field that is expanding in so many ways, on so many fronts.

It is a source of great satisfaction that many of the technologies underpinning the medical advances and photonics economy of today were nurtured in SPIE meetings, some long ago, and some, like optical coherence tomography (OCT), more recently. I believe that Photonics West 2014 offers a window on some key opportunities for future business and for advances in the war on disease.

So what weighs on this worry-prone Celtic mind?

We scientists and technologists have neglected or given up on communicating about our very real contributions, and as a result there is little or no public sentiment in many regions to support photonics. And as Abraham Lincoln observed, "Public sentiment is everything. With public sentiment, nothing can fail. Without it, nothing can succeed."

Of major concern in many regions is the weakening of federal support of science and technology, the source of so many advances. Yes, we will save money in the short term, and yes, we can and should make the innovation infrastructure more efficient. But the wavering on investment in science that we see across many of the advanced economies will eventually cost us dearly.

We in the photonics community must each play our part to revive public sentiment to support investment for the future.

SPIE, your society, is busier than ever working on this, led by the society's leadership and driven by its visionary members. We have stepped up our public policy communications efforts to inform decision makers everywhere of the extraordinary contribution you have made, and the enormous potential for what you can make in the future. And, jointly with OSA, we have engaged a lobbying and PR firm to further support our work toward this effort.

With your help, we will communicate better to young people as well, about opportunities in photonics. In these days of horrific student debt and appalling youth unemployment, a recent comprehensive survey showed that many young people are entering, and in some countries paying dearly for, educational programs that will not provide career return-on-investment. At the same time, many employers in our field bemoan the lack of appropriately skilled workers. Now, education is not all about the money, but SPIE's surveys consistently show our field to be fulfilling and financially rewarding. We all should help make parents and educators more aware of how blessed we are to work, to play, in the photonics sandbox.

We will strive to play a greater role in increasing the impact of your research and development. At this year's Photonics West there is more attention on how to make research truly fruitful. There is much to be said for the great addition to knowledge that research brings; however, we also want to see your life's work applied to improving the health of people throughout the world, generating worthwhile jobs, and resulting in more exciting life-enhancing products. We have some new programs focusing on this. Let us know what more we can do.

So have a great Photonics West, and follow up by spreading the word!

Translational research: the path from bench-top to bedside

Cultural and administrative hurdles often hinder the progress of biophotonics technologies towards commercialization, but researchers are starting to recognize the problems.

Bruce Tromberg, chairman of the inaugural Photonics West virtual symposium on translational research.

This year sees a new "virtual" symposium on translational research take place at Photonics West, launched with the aim of helping novel biophotonics technologies make a smoother transition to becoming accepted medical procedures. But what exactly can attendees at the 200-paper conference expect?

"Translational research takes different forms for different situations," explains Bruce Tromberg, director of the Beckman Laser Institute at the University of California, Irvine, and symposium chair for 2014. "So I like to simplify things. My operating definition, as it applies to photonics techniques, is that translational research is the process by which technologies can be brought into clinics and applied to actual patients."

This definition helps to indicate why translational research is an increasingly essential factor in the development process for new biophotonics tools. It also hints at some of the barriers that lie in the way. "The process presents some unique challenges for us in the photonics field, and for our culture," commented Tromberg.

"We like to develop technologies and try them out on biologically relevant molecules; our normal approach is essentially to measure one variable as frequently as possible and describe everything about a system. It can be tough to then take the next step and gain approval for pilot studies or feasibility assessments, where the protocol might instead be to take one observation from each of a million people, and see if a new device actually works."

Battling risk aversion

The ideas underpinning translational research are under discussion in other fields as well as photonics, but developers of optics-based diagnostic systems might be among those to benefit most from smoother paths to market.

That's partly because photonics technologies have proven to be exquisitely sensitive to changes in physiology, metabolism and biology; it's no coincidence that state-of-the-art studies of basic biology are increasingly based on optics technologies. However, this explosion of activity and tremendous generation of knowledge has coincided with dramatic changes in corporate culture.

"There is a severe risk-aversion," noted Tromberg. "Hardly any company is now doing their own research. Instead, the model is essentially to look around for interesting technology and acquire work that's already done, to mitigate the risk."

A further necessary hurdle is meeting the relevant regulatory requirements; not always straightforward, when US Food & Drug Administration (FDA) procedures are focused on approving incremental improvements made to existing platforms.

"Put these factors together and it can be difficult to see how some of our technologies can get into clinics to prove whether or not they can really affect patient outcomes," Tromberg commented.

Culture clash

Translational research doesn't provide a magic wand, but Tromberg has drafted a road map that might assist developers trying to assess the best options available. It consists of a sequence of distinct development phases, from "Phase Zero" — the design, calibration and testing of a technology, a phase that could take five years on its own — through Phase Three, efficacy trials on suitable patients, and beyond.

In particular, Tromberg's schema flags up potential "valleys of death", like the difficult step between "Phase One" pilot feasibility schemes and "Phase Two" multi-center validation trials.

"… it can be difficult to see how some of our technologies can get into clinics to prove whether or not they can really affect patient outcomes."

"This general approach to development has always been out there, but the length of time each step can take if not tackled correctly can be daunting," he said. "If a technology treats something cosmetic, such as wrinkle removal or depilation, then it could be a relatively rapid process. If it aims to detect breast cancer or a neurodegenerative disease, where the risk of misdiagnosis or misinterpretation is greater, then the standard of expectation is higher and the time taken is quite different — perhaps decades."

Another factor for developers to ponder is the different cultures of the fields involved. In ophthalmology, which by definition uses optical methods to characterize an optical system, novel photonics-based technologies are ideally matched with the practice of the discipline, which assists their acceptance. Even here, though, Tromberg observes that it took optical coherence tomography (OCT) several years to become widely commercialized, despite being a good fit with the problems and culture of the ophthalmology community.

In a field such as cancer imaging, the cultural hurdles will be even more substantial. Although optical technologies are ubiquitous wherever image-guided surgeries are employed, they are not currently used as conventional radiological techniques. However, several novel techniques show promise for analyzing tumor structure, and could ultimately lead to techniques that need not be controlled by radiologists, instead being widely disseminated to all practitioners — if the techniques can make it through the development process.

"These areas can be a scary clash of cultures, where people think differently and have different expectations," said Tromberg. "Unless you speak that language, the pressures may prevent your technology developing much beyond phase one. As it happens, we need phase zero and phase one to be very robust, because that's what gives photonics its creativity and innovation. But other strong ideas that could have an impact can't afford to be left until the right academic paper is read by chance in the right corporate office."

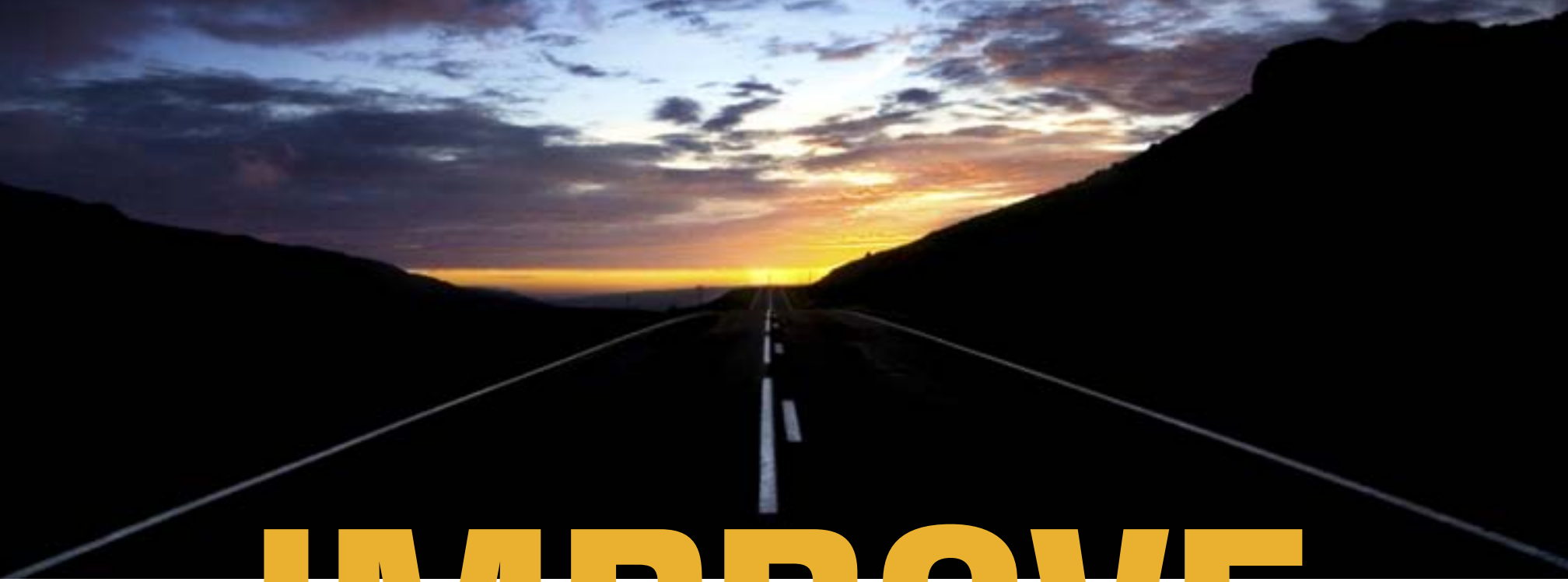
Translational research at Photonics West

Having recognized the value of translational research at Photonics West 2014, SPIE has created a virtual symposium on the topic, chaired by Tromberg. A group of around 200 papers presented within the BiOS conference have been selected as examples of the latest photonics technologies which also show a high potential for successful clinical use.

Tromberg intends the symposium to act as a demonstration that, while the challenges facing biophotonics innovators may be substantial, a route forwards is always possible.

"A lot of developers get stuck in the initial phase, where they know that they are on to something but don't know how to go about proving definitively that their technology is going to change people's lives," he said. "I want to highlight some of the studies and groups that have figured that path out. Because it's not easy."

TIM HAYES



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Drawing inspiration from nature

Photonics West plenary speaker John Rogers heads a research group at the University of Illinois at Urbana-Champaign working on bio-inspired and bio-integrated devices.

In spring 2013 a camera based on the structure of an arthropod's eye made a splash in the pages of *Nature*, thanks to its wide-angle field of view and almost infinite depth of field. The optics inside it and its striking outward appearance were the work of a research group headed by John Rogers at the University of Illinois at Urbana-Champaign (UIUC), which is honing the development of both bio-inspired and bio-integrated optoelectronic structures.

"I'm interested in both optical and optoelectronic materials, and in combining the two to build systems distinctly different from technologies that are out there in the commercial world," explained Rogers. "And we try to stay off the beaten track a little bit." At the heart of the group's research is the creation of materials and manufacturing processes that are free from the existing paradigm of planar semiconductor wafers. The goal is a move into a world of curvilinear three-dimensional shapes and elastic optoelectronic materials, which in turn creates opportunities to draw inspiration from many designs in the natural world.

The results could be either optical structures with properties that are difficult to achieve using conventional materials, or optoelectronics devices more readily adaptable to use in biological systems. "Evolution is a powerful source of innovation, but often it does not drive systems towards alignment with the requirements of man-made devices," noted Rogers. "We try to abstract some of the key engineering principles from biology, and implement them in a scalable fashion with the materials already serving as the foundations for the analogous man-made systems."

In the case of the arthropod-inspired camera, military applications and drone vision systems were rapidly spoken of as potential applications. Rogers' group does draw funding from the US Department of Defense, but he sees equal if not greater impact for these technologies in other areas.

The two grand challenges as I see them are to develop solutions to human healthcare, and provide ways to achieve energy conservation

"The two grand challenges as I see them are to develop solutions to human healthcare, and provide ways to achieve energy conservation. With healthcare in particular, the ability to make highly functional semiconductor devices that interface with the body in ways that were previously impossible will open up all kinds of new treatment modalities, saving both cost and time."

Injectable LEDs

One striking example could hold the solution to an existing challenge in the growing field of optogenetics. "We have previously investigated how to put high-quality optoelectronics onto the surface of tissues, either onto the skin or on internal organs such as the heart or the brain," explained Rogers "Most of the work in the past has examined the use of very thin flexible sheets of the active devices, attached directly to the surfaces of the organ."

But the complex function of these organs ensures that there will be a limit on what can be done from a surface access point. So Rogers' group looked into ways to deliver these optoelectronic devices into the depth of the organ in question. This immediately brought optogenetics into the picture. In this rapidly growing field of study, careful genetic modification creates photosensitivity within specific neural circuits in the brain of model animals, enabling the neurons' natural function to be either stimulated or inhibited when illuminated — effectively using light as a means to turn them on or off.

John Rogers was due to speak at Monday's MOEMS-MEMS plenary session. Credit: UIUC.

The difficulty has been in delivering the light to those neurons. Previous attempts have commonly used a fiber-optic cable attached to an adjacent area of the animal, effectively tethering it by its skull. Rogers has found a better solution. "We developed an injectable cellular-scale class of optoelectronic technology, that allows us to deliver LEDs and other components down into the depth of the brain, so that we can then can illuminate the neurons wirelessly and without a tether," he explained.

These ultra-miniaturized LEDs are based on indium gallium nitride and are thousands of times smaller than commercial devices. Once introduced via an injection operation involving specially designed micro-needles, they could offer a much less invasive method to perform optogenetics trials compared to the optical fiber approach.

Inspired by nature: the "arthropod" eye designed by the Rogers research group. Credit: UIUC.

"This is the first time any kind of semiconductor device has been embedded in the brain of a living animal, and for a purpose: now we can trigger neurons for optogenetics purposes without all the hardware," commented Rogers. The tiny injectable LEDs could also prove readily applicable to other areas of study in basic neuroscience. Critical therapies such as deep brain stimulation for treatment of Parkinson's disease could be greatly simplified by a means to deliver full electric circuits into the brain. Rogers expects this to be an area where his group will be very active.

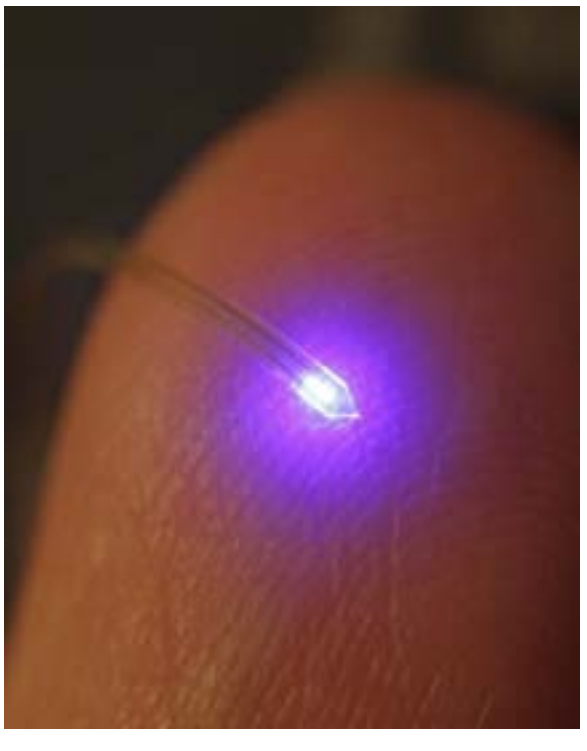
Through a fly's eye

Taking inspiration from biological designs has in turn involved the development of novel manufacturing processes. The arthropod-inspired optical system, with its hemispherical structure, required a fresh approach to the whole question of assembling optoelectronic components. "This is an example of breaking away from the use of conventional electronics and brittle semiconductor wafers, and instead developing technologies that involve soft elastic mechanics," said Rogers.

Doing so posed considerable challenges. A flat lens array on a silicon wafer will crack as soon as any attempt to deform the wafer is made, so the team developed a means to form the micro-optics out of a transparent elastomer: rubber lenses, sitting on rubber cylindrical posts, joined into an array by a rubber membrane. The resulting monolithic single-piece optical subsystem was then bonded in an aligned configuration to an array of photodetectors, each of which was connected to its neighbour by a deformable wiring structure able to accommodate the strains involved in shaping the structure.

The net result is an integrated system with its mechanics dominated by the elastomer, and configured in a way which avoids fracture when the structure is subsequently inflated into the final hemispherical shape.

"A lot of tricky mechanical engineering was involved in joining the soft rubber lens array to a hard functional photodetector material in a way that allows this type of elastic mechanics, without breaking or distorting the lens alignment," commented Rogers. "But once it was done we could make real working cameras with the key attributes of a fly's eye that can still operate in the digital world, and are compatible with silicon technology."



Optogenetics solution? These ultra-miniaturized LEDs devised by the Rogers group are tiny in comparison to commercial devices, and could be used to trigger neurons in the future. Credit: UIUC.

A lot of the work we have done in the last five years is now moving into the commercial realm, and I would love to see that translation be successful

Rogers predicts that these attributes will prove valuable in surveillance operations, but also in endoscopy procedures, where the ability to see equally in all directions offers key advantages. Other practical applications should soon follow.

"A lot of the work we have done in the last five years is now moving into the commercial realm, and I would love to see that translation be successful," he said. "My attention now is on open-ended research into where these bio-inspired and bio-integrated technologies might go next in the real world. It looks very promising, but there is a lot of work still to be done."

TIM HAYES

Super-resolution microscopy: peering deeper into cells

A range of different approaches can now persuade imaging systems to resolve beyond the diffraction limit, as Photonics West delegates will discover.

Fluorescence microscopy has proven its worth in the examination of biological systems, helping researchers to understand the behavior of cells and tissues in a number of experimental situations. But as the technique looks increasingly closely at the constituent structures of organic systems, one physical barrier has been ever-present: the diffraction limit.

In optical microscopy, spatial resolution between two points will be limited to a distance governed by the wavelength of illumination used, as per the equation determined by Ernst Abbe in 1873. In practice this limit is around 200 nm.

Since rules are made to be broken, biophysicists have found ways to tease imaging systems into seeing beyond this notional limit, lured by the prospect of a far deeper understanding of several important questions in cell biology that may result.

These efforts form the expanding field of super-resolution microscopy, a family of techniques taking several different approaches to the problem but aiming to achieve similar ends.

"Super-resolution microscopy is still developing, and the field is very much going places," commented Ann Wheeler, facility manager and scientific adviser at the Blizard Advanced Light Microscopy Facility (BALM) in London, UK.

Part of the Blizard Institute, itself a research and teaching center within Queen Mary, University of London, BALM investigates novel methodologies for the use of light microscopy in cell biology. Funded partly by the UK's Engineering and Physical Sciences Research Council, its portfolio includes super-resolution microscopy, and Wheeler's group has developed its own version of the technique with potential advantages over other contenders.

Challenges to solve

"Biologists are interested in certain questions that could not be addressed by the super-resolution techniques that we have," said Wheeler. "There was a gap, and we needed to fill it."

BALM's technique builds on existing super-resolution methods called PALM (or photo-activated localization microscopy), and STORM (stochastic optical reconstruction microscopy), both of which utilize sequential activation and time-resolved localization of photo-switchable fluorophores to create high resolution images.

Wheeler's team combined this technique with a spinning disk confocal microscope, an approach to confocal microscopy that selectively illuminates one focal plane with light passed through thousands of pinholes and effectively removes any out-of-focus light.

"The problem with PALM and STORM methodologies is that they can only really examine structures within 100 nm of the bottom of the coverslip used in the experiment," noted Wheeler. "Our spinning disk super-resolution imaging (SDSI) technique can see much deeper into the cell, including all the way to the nucleus, with a resolution of 80 nm."

This helps to tackle what Wheeler describes as one of the significant limitations still facing super-resolution imaging: the need to look beyond the surface and see deep into a cell. "Looking into the middle of the cell has been really tough, and to an extent researchers have shied away from it. But biologists are very interested in what happens there, particularly in the light of the Human Genome Project."

The other current challenge is imaging live dynamic cell systems, which some super-resolution techniques fare better at than others.

"As a biomedical scientist I'm interested in looking at both individual cells and larger groups of cells, and I need to see them dynamically changing," Wheeler commented. "At the moment there's nothing that satisfactorily addresses the problem. But that's what makes it an exciting opportunity."

Three dimensions

Other research groups and commercial vendors are tackling the opportunities offered by super-resolution microscopy through different approaches and other novel optical platforms.

Carl Zeiss, based in Jena, Germany, has developed its ELYRA system to make two super-resolution technologies available to researchers on the same platform. ELYRA comes in two different modules: one version employs PALM to examine photo-switchable fluorescent proteins; a second is designed to use an alternative technique called super-resolution structured illumination microscopy (SR-SIM), in which resolution is boosted through illumination with patterned light and examination of the resulting Moiré pattern.

The overall ELYRA platform is designed to allow researchers to capture highly resolved structures of a whole cell in three dimensional detail, and to do so in just one shot.

It uses fiber-coupled lasers at four different visible wavelengths — 405, 488, 561 and 642 nm — to excite and bleach molecules, along with a back-thinned iXon 897 electron-multiplying CCD camera from UK-based Andor Technology for image detection.

According to Zeiss, ELYRA can produce images with a lateral resolution of 20-30 nm and an axial resolution of 50-80 nm.

"With ELYRA, researchers can investigate the structural arrangement of one or multiple proteins and reveal the ultra-structure of cell organelles in 2D and 3D, as well as map and count molecules within a structure," said Klaus Weisshart, product manager for ELYRA, at the launch of the system. "Sophisticated algorithms relate photon statistics to precision information in all directions, so researchers can display their structures fully rendered in 3D."

TIM HAYES

the business of photonics

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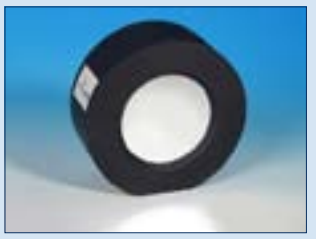

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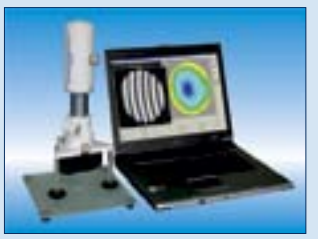

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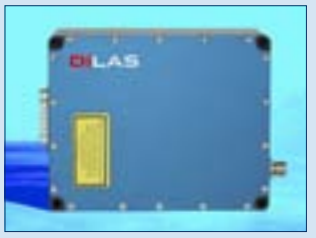

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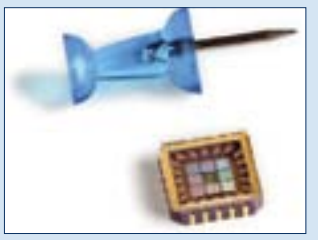

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Dickensian to Darwinian: PV moves into evolutionary phase

Photonics West Green Photonics virtual symposium chair Steve Eglash on the changing fortunes in PV, and what to expect this week in San Francisco.

When *Photonics West Show Daily* talked to Steve Eglash a year ago, the mood in the solar industry was — at best — a mixed one. Paraphrasing the opening line of Charles Dickens' historical novel *A Tale of Two Cities*, the Green Photonics virtual symposium chair described it as "both the best of times and the worst of times".

He was referring to the paradox that, while certain manufacturers — largely Chinese — were producing solar panels at such low costs that the price of the technology was rapidly approaching grid parity in many places, those who were unable to compete were being forced out of business.

There was also the looming prospect of a trade war between China, the US and Europe, while previously stellar companies like Q-Cells stood on the brink of bankruptcy and the stock prices of major players such as First Solar and SunPower were stuck at historic lows.

Twelve months on, and that mood has changed for the better. Consider some of the fundamentals: global PV installations soared in 2013 as governments in Japan and China made major investments, and the stock prices of First Solar and SunPower rose 371 per cent and 73 per cent respectively between the start and end of the year. On the other hand Suntech Power — until recently the largest of the giant Chinese producers — has been forced into bankruptcy proceedings while Q-Cells has been saved but reduced in scale, and now forms part of the giant Korean engineering group Hanwha.

PV can have a huge impact — combined with LEDs and batteries — replacing kerosene lamps used for lighting.

So what does Eglash, executive director of Stanford University's Energy and Environment Industrial Affiliates Program and formerly CEO of a PV start-up, consultant at the National Renewable Energy Laboratory (NREL) and a venture capitalist, make of it all? "The mood has changed from Dickensian to Darwinian," he says. "The story is that some companies are executing well, and some are going out of business because they are unable to compete."

Winners and losers

As part of the Green Photonics virtual symposium, Eglash will again be hosting a panel session, and this year it will be focused on PV. "That wasn't a strategic decision, but more of a response to an interesting story that we think attendees will be interested in hearing," he explains. "The message is that there has been a lot of hand-wringing about the PV industry, but in the past year it has become clear that there are winners and losers, and that this hand-wringing is simply not appropriate."

"Researchers have done some great work, and there are profitable businesses out there — it's not all Chinese module manufacturers relying on subsidies. The panel session is recognizing that."

While the virtual symposium will this year feature more than 200 papers on four different themes ranging from "green" manufacturing with lasers to solid-state lighting, nuclear fusion and energy-efficient communications, PV is — as usual — a key area. "There are a *lot* of papers on PV this year," Eglash says.

And if there is one paper that he is looking forward to more than any other, it is the one from Martin Green's renowned University of New South Wales (UNSW) research group on the topic of silicon tandem cells, a technology that promises to blend the dramatic cost reductions seen in silicon PV cell production with the kind of efficiency levels usually associated with much more exotic and expensive materials.

Steve Eglash, chair of the Green Photonics virtual symposium at Photonics West 2014 and executive director of Stanford University's Energy and Environment Industrial Affiliates Program. Credit: Steve Eglash/Stanford.

Entitled "Silicon tandem cells: the ultimate photovoltaic solution?", the UNSW presentation will focus on the potential for high-performance silicon-based tandem cells to approach efficiency levels as high as 40 per cent — previously only achieved by concentrating sunlight onto tiny, high-performance multi-junction devices based on compound semiconductors.

Efficiency/cost trade-off

Eglash is excited by that prospect, which he points out would also have a hugely beneficial impact on the "balance of system" cost, which includes everything but the solar module.

"The really good stuff currently is in the efficiency versus cost trade-off, and

continued on p.20

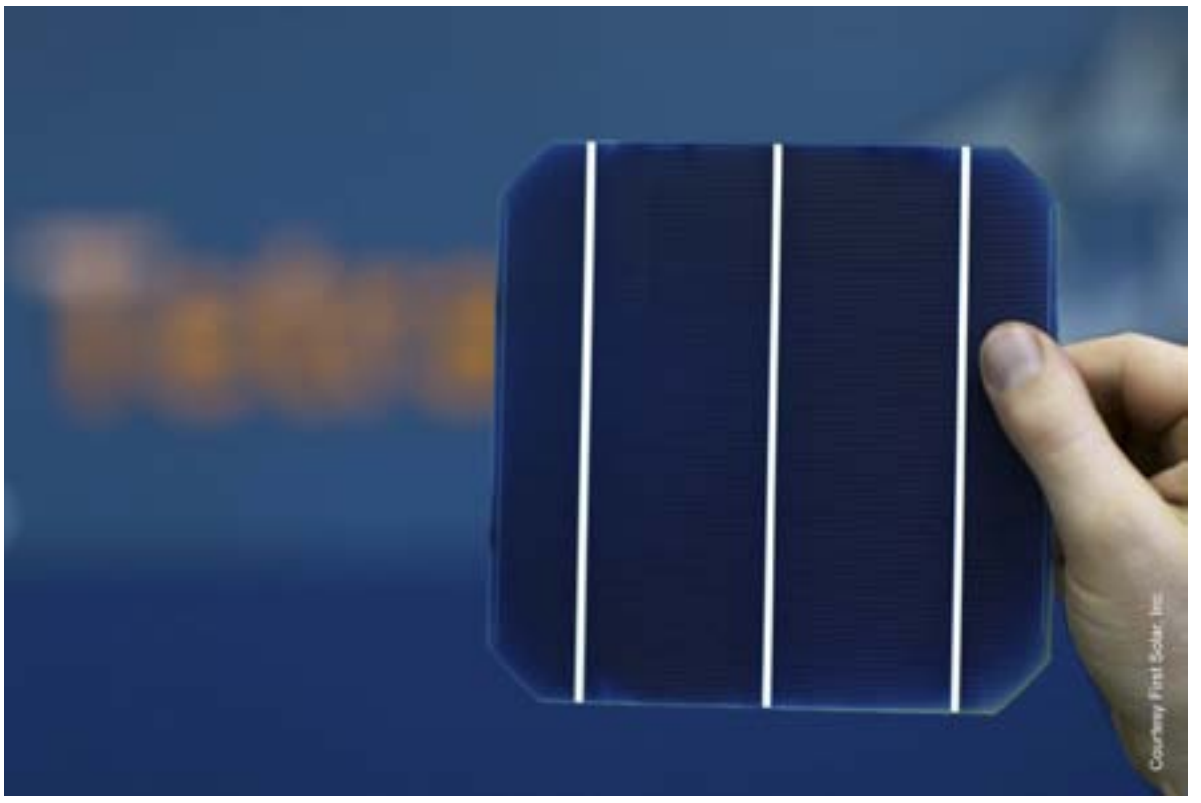
Evolutionary Phase

continued from p.19

any work that is going to be commercially relevant has to improve that," says the conference chair. He sees silicon-based tandem cells as one of three approaches that are particularly important. Another key approach is to make incremental improvements to existing silicon cells, although Eglash admits that it is increasingly difficult to do this outside of major producers such as Yingli and SunPower.

The third potential area of innovation will be to produce cells of modest efficiency at an astonishingly low cost. "We're not talking about 6-8 percent efficiency here, but more like the 10-15 percent range," he says. "So if cadmium telluride cells can be made at a cost of $0.10-$0.20 per watt, with an efficiency of 10-12 percent, that would be really interesting."

Thin-film cadmium telluride (CdTe) cells are of course very much the domain of First Solar, the Arizona company that strode the solar industry like a colossus before the meltdown of 2012, and which now appears to be rebounding strongly if stock prices are a reliable guide. The company's chief technology officer, Raffi Garabedian, is set to appear in Tuesday afternoon's "Green Photonics: a Solar Revolution" panel session, where he will speak alongside Martin Green and Homer Antoniadis, global technology director of DuPont's photovoltaics solutions business unit.



A TetraSun solar cell. Industry giant First Solar acquired the start-up's high-efficiency, but potentially low-cost technology in summer 2013. Credit: First Solar.

"First Solar is doing a great job in this area, [and] it is determined for PV to play a major role [in electricity generation] by increasing efficiency and reducing cost," says Eglash. Having recently acquired the silicon-focused California start-up TetraSun, First Solar is evaluating all the available PV technologies and materials for this purpose, and Garabedian may reveal some insights into the influential company's current thinking.

PV and the developing world

Rather than the earlier focus on countries with generous support schemes, a central element of First Solar's current strategy is to bring PV to those parts of the globe with the most abundant solar resources. That is often going to mean installations in the developing world, and it is in some of the world's poorest regions where Eglash sees great potential for PV to transform lives.

"In terms of the developing, off-grid, world, PV can have a huge impact — combined with LEDs and batteries — replacing the kerosene lamps used for lighting," he explains, pointing to the work of companies like Angaza Design, who are offering a "pay as you go" platform designed to reduce dramatically the up-front cost of PV installations for those who can least afford it.

"The challenge has always been to find a payment model that allows the up-front cost of these systems to be overcome, but this is now happening and companies are deploying these technologies in the developing world. In time they will be used not just for lighting and charging cell phones, but irrigation and more."

Eglash is also excited by developments in battery technology, another topic that will be touched on at Photonics West, but concedes that any deployment of very large-scale battery storage suitable for grid deployment remains at least five years away. "There are some initial projects now happening, but these are more about gaining data at the moment as the technology is still too expensive," he says. "Any substantial deployment would be towards the end of the decade — at the earliest."

Large-scale batteries may have to wait, but it seems that as far as Eglash is concerned, the outlook for PV is already much brighter than it was a year ago. Or, as Dickens might have it — the beginning of the end of *Hard Times* and a return to *Great Expectations*.

Steve Eglash will host the Green Photonics virtual symposium panel session "A Solar Revolution" today at 3.30pm in Room 130.

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This product will change the way you think about hexapod applications. Application examples include laser machining, cutting, drilling that allows for smooth cut "zero kerf" features. Ideal for applications such as medical devices (stent cutting), 3D printer movement from 3D to "6D" printing to enable higher throughput and higher accuracy of printed prototype parts. Laser drilling applications can provide a more perfectly round hole without kerf for such applications as fuel injectors.

ALIO Industries was founded in 2001 with the focus of building precision products with unmatched quality and reliability by implementing unique designs for precision manufacturing. This in-depth focus on current and future industry needs of nano-precision has led to the development of another ALIO innovation; the Hybrid Hexapod®

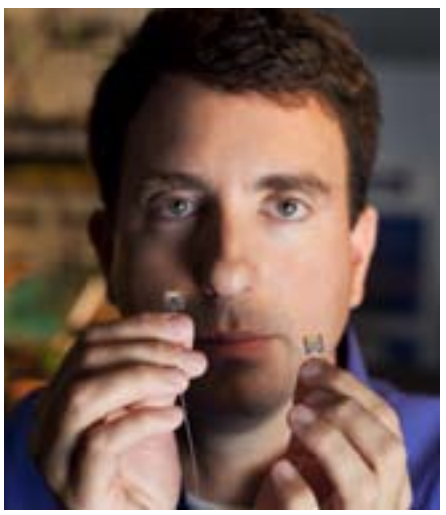
Device performance and foundry use reflect solid progress in silicon photonics

Hailed as a "next big thing" for several years, could silicon photonics make a significant commercial breakthrough in 2014?

Silicon photonics is a field that has undergone rapid growth and dramatic changes in the past five years. According to the MIT Communications Technology Roadmap, which aims to establish a common silicon photonics architecture platform across diverse market sectors "with a potential $20 billion in annual revenue", this technology is now rapidly transferring from the lab to the marketplace.

Emphasizing its growing importance in the real marketplace, silicon photonics technologies are the subject of numerous presentations at Photonics West 2014, many under the umbrella of the three-day Silicon Photonics IX series, part of the OPTO conference and running Monday through Wednesday at the Moscone Center.

Topics include: silicon nanophotonics integration for chip-scale optical communication; tunable silicon photodiodes; compact and low-loss silicon waveguides; silicon photonic integrated devices for datacenters; Tuesday morning's "pushing the boundaries of silicon photonics" OPTO plenary presentation by Michal Lipson from Cornell University; and the now-traditional silicon photonics panel session taking place Tuesday afternoon.



Intel's Mario Paniccia, one of the most prominent figures in the development of silicon photonics, will appear in a Photonics West 2014 panel session dedicated to the topic. It is scheduled for 2pm Tuesday, and will take place in room 130 of the Moscone Center. Credit: Intel.

Semiconductor giants Intel and IBM have shown their commitment to the enormous potential of this technology with substantial investments, complemented by DARPA and efforts in Japan, Korea, and Europe

In November 2013, the University of Southampton's new Zepler Institute hosted a conference to showcase the UK's silicon photonics research and development program. It is led by Graham Reed, head of Zepler's Photonics, Systems, Circuits and Sensors group and also a co-chair at Photonics West.

"Silicon photonics offers an opportunity to revolutionize a range of application areas by providing excellent performance at moderate cost," Reed said. "This is due primarily to the fact that silicon is a thoroughly studied material, and is unsurpassed in quality of fabrication with very high yield due to decades of investment from the microelectronics industry."

Beyond comms

At the same event, MIT's Lionel Kimerling spoke about how to achieve the necessary convergence between electronic and photonics technologies — as well as between hardware and software architectures. He cited Cisco's forecast of the arrival of zettabyte traffic (10^{21} bytes/s) bandwidth demand by as early as 2015 as a likely justification for the communications sector needing data handling chips based on silicon photonics. But that's not all.

"Datacoms is a big driver for silicon photonics but what are the other drivers?" Kimerling asked. "Soon, every system is going to be self-aware and controlled — from the automobile to the cell-phone networks — so there will need to be intelligence everywhere, and sensors everywhere."

Roel Baets from Ghent University, and also IMEC's Center for Nano- and Biophotonics, said that silicon photonics is moving beyond telecom and datacom applications. These include a variety of biological and gas sensing applications, as well as laser Doppler vibrometry and optical coherence tomography for biological and structural analysis, including so-called "spectroscopy-on-a-chip" developments.

"Besides communications applications," said Baets, "silicon photonics makes a lot of sense in at least three other situations: high-volume markets with extreme performance/cost ratios, such as active optical cable, data centers, and single-use biosensor chips."

It is perhaps at Intel, though, where the most excitement about silicon photonics has been generated. And much of that emanates from Mario Paniccia, general manager of the company's photonics technology operation and regular member of the panel session at Photonics West.

Corning's "ClearCurve" LX multimode fiber transmits 1310 nm light (the wavelength used by Intel's silicon photonics modules) at 25 Gb/s with low optical loss, at distances of up to 300 meters — three times further than current technologies. Credit: Corning/Intel.

After a decade of tuning silicon chips to work with light-wave properties, Paniccia and his team have made several silicon photonics breakthroughs and some developments are already helping the likes of Facebook to redesign data centers to cope with a dramatic growth in traffic.

"Across the industry, most people believe that silicon photonics is the longer-term development path now," Paniccia told *Show Daily*. "I look at the data center and the cloud, where developing high-volume solutions such as interconnects at 100G and above based on silicon photonics makes a lot of sense.

"At Intel, we see a transition happening out there with lines going from 10Gb/s to 25Gb/s. The limitation of how far you can push copper at 25Gb/s is shrinking to a few meters but no one is debating copper over ten meters at 25Gb/s because it is not viable. The next question is can we develop a photonics technology that is cost-effective enough to displace copper?"

In order to accelerate the industry's transition to cloud computing and big data, Intel and Corning have developed the MXC Optical Connector and ClearCurve LX Fiber to support future Intel Silicon Photonics Technology products. The combination of these technologies is expected enable massive data rates, up to 1.6Tb/s, at lengths of up to 300 meters.

Foundry services

Another prominent figure in the silicon photonics community is Michael Hochberg, a founder of Luxtera who in 2011 established the Optoelectronic Systems Integration in Silicon (OpSIS) foundry service, which allows users to share fabrication costs with multi-project wafer shuttle runs.

He told *Show Daily*: "We have delivered silicon photonics prototypes to around 100 users of the OpSIS service. This is generally devices and small systems that people have designed themselves using our library, and we understand that for the most part these new developments are working. At OpSIS we already have about 150 users signed in — about half corporate and half academic.

"What has surprised me over the past year at OpSIS is that we have produced modulators in silicon that can go head-to-head against lithium niobate equivalents — and win. When we put the silicon photonics modulators into relatively long links we can already actually get better performance out of the silicon.

"Overall, I believe that in 2013 we moved silicon photonics forwards significantly, and it is almost inevitable that it will become commonplace some time in the future. Although we will probably not see it as a pervasive technology for at least three or four years — the product cycles almost guarantee that — there will clearly be some specific vertical application areas that will play to the strengths of silicon photonics.

"2018 or 2019 is a realistic target for silicon photonics to hold significant market share — and I'm still sticking by my 2010 prediction that silicon photonics will be a billion-dollar revenue generator by 2020."

MATTHEW PEACH

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Optoelectronic components and microfunctional optofluidic devices in plastic

CDA GmbH (Suhl, Germany) is an established manufacturer of custom components and solutions in plastic. CDA's technology portfolio includes polymer optical elements and arrays for use in optoelectronics, automotive and other high-tech fields, as well as additional high-end microfabrication technologies such as printed electronics components and microfluidic structures. All of these can be flexibly and individually combined in order to realize complex miniature devices for clinical point-of-care, diagnostics, environmental monitoring and biochemical/forensic screening applications.

A multifunctional optofluidic demonstrator chip. Blue fluid is pulled left by pillars in a channel on-chip to complete a circuit (electrodes, left) with an external light source, thus illuminating a DOE (green spot right) and projecting an image. The additional fabrication features necessary included printed electronics and component bonding.

Optical elements

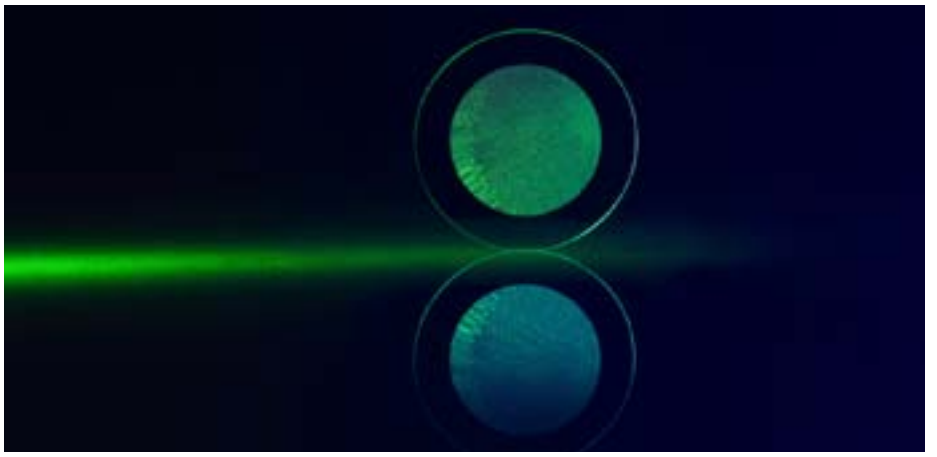
Individual elements can comprise diffraction-limited refractive structures or diffractive structures optimized to provide the best efficiency for the intended application. Current products include:

- DOEs (binary and multilevel, see photo)
- gratings, line generators, etc.
- collimators, Fresnel lenses, custom lens arrays
- diffusors and mirrors
- optical encoders

A recent development is the ability to stack multiple optical layers in order to further customize performance.

Microfluidic structures for ›lab-on-a-chip‹

CDA additionally provides the integration of high-tech microfluidic structures into sophisticated, compact and sensitive devices, (›lab-on-a-chip‹). Such devices are becoming increasingly important where physical chemistry, electrical and/or optical properties need to be tested on a small scale. Tried and tested structures and options include:



A polymer DOE lens

- channels for separation and mixing
- hydrophobic and hydrophilic surfaces
- combining these with microoptics and printed electronics (see photo)

Appropriate devices lend themselves well to high levels of parallelization, thus reducing costs, but their manufacture does require a fully integrated process chain and command of several cutting-edge microfabrication technologies.

Manufacturing services

According to Pia Harju, Business Development Manager at CDA, "The opportunities for both microoptical elements and for integrated devices are truly global. Our manufacturing services – prototyping, assembly and volume mass production – are designed to benefit our customers' global strategy."

Contact
Pia Harju,
Business Development Manager
CDA GmbH, Am Mittelrain 11,
98529 Suhl, Germany
Booth: North Hall 5221
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The **Zafiro®** family of cooled thermal modules employ DRS' advanced Mercury Cadmium Telluride (MCT) detector and patented Stirling cryogenic cooler to produce unparalleled infrared imagery operating in the mid-wave infrared (MWIR) spectrum. The rugged, compact Zafiro® design and 12 µm pixel pitch detector provide a long-range surveillance solution that is widely deployed on Unmanned Aerial Vehicles (UAV) and other demanding situational analysis requirements. Zafiro® modules are available in 640x480 resolutions and a 1280x720 High-Definition model.

Continuous Innovation

DRS Technologies has been a leader in the evolution of the next generation of low power, compact sized, high reliability and high performance thermal imaging components and sensor systems. With nearly half a century of infrared innovation, DRS Technologies is exceptionally well-positioned to meet the needs of rapidly growing thermal imaging applications world-wide.

Expansion into high-volume, low-cost manufacturing and ground-breaking technological advances have allowed for the development of powerful, yet affordable infrared imaging modules and camera systems to address emerging infrared imaging and detection markets. Underlying these advances is DRS' commitment to collaborate, both internally and externally, to develop the best possible solutions; to help Customers achieve operational advantages; and to transform military and commercial capabilities through superior product offerings.

DRS Technologies, Inc.

DRS Technologies is a leading supplier of integrated products, services and support to military forces, intelligence agencies, commercial partners and prime contractors worldwide. The company is a wholly owned subsidiary of Finmeccanica SpA (FNC.MI), which employs approximately 70,000 people worldwide. DRS is proud to produce the Commercial Infrared Systems (CIS) line of advanced electro-optical sensor systems to include thermal surveillance systems, cooled and uncooled infrared camera modules, and thermal detectors.

Visit DRS Technologies at Booth #2417 or online at **www.drsinfrared.com**.

Logitech's highly automated sample preparation system delivers new levels of performance in material processing capabilities.

Material processing is a time consuming task and takes many years to develop the knowledge and skill required to achieve repeatable results. With over 50 years of experience in material processing, system design and knowledge transfer the team at Logitech fully understand how to achieve the accuracy and repeatability required for a wide range of applications, such as; Silicon, Silicon Carbide, Gallium Arsenide, Gallium Nitride, Sapphire, Diamond, Germanium and Indium Phosphide.

Driven by client demand to reduce the level of user expertise , guesswork and time spent on their application processes, whilst maximising surface finish and repeatability. Logitech created a working group to consider how we incorporate solutions to these issues within our systems. The outcome from this was a number of key technology changes, increased controllability and software driven automation. These features are showcased in Logitech's new lapping and polishing machine, Akibis-air: Intelligent Sample Preparation System.

Basic Lapping and Polishing Concepts

To ensure these new features did not compromise the high level of surface finishing expected from a Logitech system. the team setup a process matrix to establish the stability and repeatability of a number of processes, to guarantee conformance with Preston's Law. The basic formula for predicting the amount of material that will be removed in a given time in both a Lapping and Polishing Process is:

PRESTON'S LAW

M = α * p * v * t + C (y = mx + c)			
Material = Constant * Processing * Plate * Processing + Constant			
Removed	Pressure	Speed	Time
(um)	(g/cm2)	(rpm)	(mins)

We can analyse the Prestonian behaviour of removal rate in a process to confirm process stability.

Preston's equation states that the removal rate is proportional to the product of the processing pressure and plate speed.

The results achieved from these trials confirm that Akribis-air offers the accuracy, repeatability and control to confidently deliver the optimum in surface finish to precise geometric tolerances.

However this was only one stage in the development process as Logitech endevoured to remove the "black magic" from application processing and decrease the processing time.

Removing the black magic from sample preparation

It is a very skilled job to achieve the accuracy and surface finish that many of these demanding applications require, particularly due to the high levels of manual set-up and control. The increasing cost of materials and lose of expert staff adds additional pressure to these departments.

With this in mind the design team at Logitech developed a software platform and a number of automated controls that significantly reduces the amount of manual input required during set-up, processing and clean-up operations. These new features have been so successful that they can reduce processing time by as much as 40%. Features include:

- Automatic wafer thickness control for the highest degree of geometric precision, flatness and parallelism.
- Software driven set-up for faster processing times and more reliable results.
- Extensive parameter control for the processing of highly complex and fragile materials or devices.
- Increased plate speed for faster removal rates and higher throughput.
- Plate flatness control for higher quality and accurate of the samples.
- Metered abrasive feed supply for optimal processing and reduced consumable waste.
- Auto-wash feature for minimal clean-up time and increased user safety.

Air Jig Technology

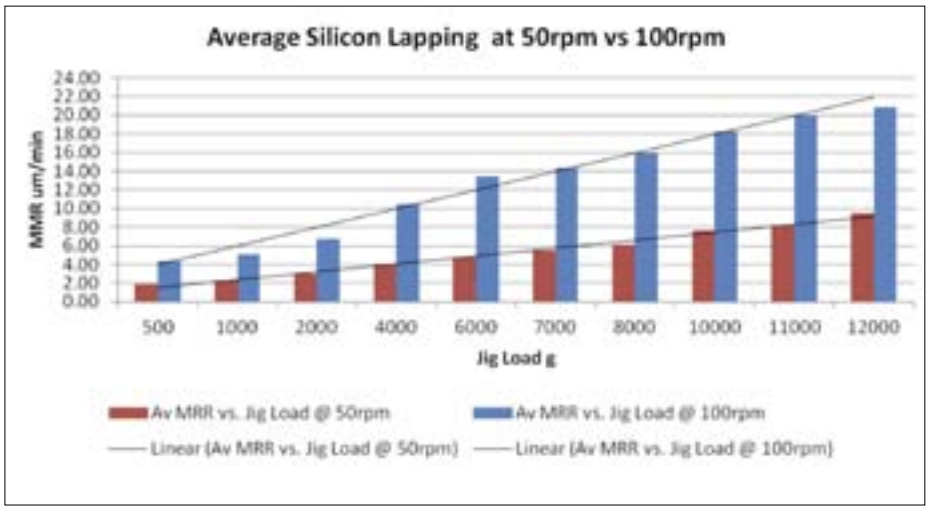
A key aspect of the system success is the introduction of an air driven jig. The jig ensures that the sample or substrate is held in place during the lapping and polishing processes. Key advances in this jig includes;

- Dynamic load control for faster, more responsive processing across single and multi stage processes.
- Bluetooth connectivity for real time data and higher levels of control.
- Increased load range for higher Material Removal Rates (MRR) while maintaining low Total Thickness Value (TTV).
- Integrated jig cleaning station for minimum handling, safety and time saving.

Superior results

The exceptional results achieveable with all Logitech equipment is respected across the world. With the introduction of easier, faster and more reliable results, Logitech is ever increasing the competitive gap and client confidence.

Lapping trials using a silicon substrate with an Akribis-air system and a standard Logitech lapping and polishing machine can be seen below.



This shows a material removal rate of 18-22 microns per minute with the Akribis-air compared to 7-9 microns per minute with a standard system. When added to the substantial time savings and accuracy provided with the automated set-up and control platform and the internal clean up facility, it is easy to see why the Akribis-air offers time savings of up to 40%.

You will find Akribis-air and our team in the North Hall, Booth #5319.

About Logitech

Logitech are recognised as world leaders in many aspects of materials processing, shaping and surface finishing technology.

This position has been reached through many years expertise in materials processing and in the design and manufacturing of precision equipment.

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✓ Semiconductor materials processing

✓ Opto-electronics surface finishing

✓ Optical materials processing

✓ Geological science thin section preparation

✓ Test & measurement of materials

✓ Materials processing consumables

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Logitech's core business is in the design and manufacture of precision sawing, lapping, polishing and CMP equipment. This equipment is aimed at research based applications with the need for high specification surface finishes, prepared with precise geometric accuracy.

For further information please go to **www.logitech.uk.com**

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SPIE Career Center

The $11 billion puzzle: finding the funding

Some $3.6 billion in private dollars went to biophotonics-related companies last year, and the pool was $8 billion in public offerings. But securing early money is costly — "angels" can seek returns of 10 or 20 times the investment. A blue-ribbon panel on Saturday showed how to navigate these waters. A few of the secrets shared: Lower the risk. Build trust. Cultivate friendships.

The panelists gave an audience of about 75 entrepreneurs, inventors — many with patents — and others, reason for optimism. Although the current market will keep the numbers of competitors low, they said, those who do succeed will thrive.

That heavyweight panel included Jim Haack, now senior VP at Citibank; Jeremy R. Salesin, VP of acquisitions at Intellectual Ventures; Faz Bashi, Life Science Syndication Chair at Angel Capital Association; and Jonathan Wyler, Venture Partner at SV Life Sciences Advisers. They were moderated by Linda Smith, president of Ceres Tech Advisors.

Among the panelists' tips were: be prepared to give equity in return for early financing. Angels want to share in the diligence. "We prefer equity over debt. We want to be involved. We want a position on the board," Bashi said.

But entrepreneurs must choose their active investors wisely. "Don't think they'll write a check and you're on your way," Wyler warned. "They will work with your company to increase value, to mitigate risk, to validate opportunity, to create enduring value by overcoming barriers, and to position a company to attract potential acquirers."

They will also help to hire a CEO and get talent for the team. "We work with investors with credibility, who can in turn bring in the next level of investors," Wyler said. "We meet with the acquirers of a company, to facilitate the exit. It's an expensive habit, but that's the reality."

Remember that an angel investor looks for a big return upon their exit. Bashi said his group has seen eight exits so far, with a return of $14 million. Early money wants an early exit.

Create a model that goes beyond "buy low, get a great return," Salesin suggested. Can you create a platform on which others will build? Can you address a very large market with a unique way to solve a problem?

Demonstrate that you're the rare gem, the diamond in the rough. "We look at 400 or 500 deals, and do one," Wyler said, adding that it is important to find a mentor, someone who's done it before. "You need others who have made these critical decisions," he advised. "You can't start a biotech company without clinicians and scientists on board."

Bashi also warned against the increasingly popular crowd-funding approach. If 100 investors each committed $10,000, it would take just one to file a lawsuit and "it all unwinds." He said, "We are not interested in a deal with crowd-funding already in it."

What he is interested in is people. "We want friendship, and trust. That's what makes a good investment."

Looking on the bright side of today's tougher investment environment, Wyler concluded: "There are fewer investment firms, and the funds are getting smaller. But in the long run, there will be a positive effect. We will see fewer but better companies being started."

Spectra-Physics' Talon targets micromachining

Newport laser division Spectra-Physics has introduced a new family of ultraviolet and green Q-switched diode-pumped solid-state (DPSS) sources called "Talon" at Photonics West. They offer more than 12 Watts of ultraviolet power, in combination with over 240 microJ of pulse energy, and a repetition-rate of up to 500 kHz. A green version delivers more than 20 Watts.

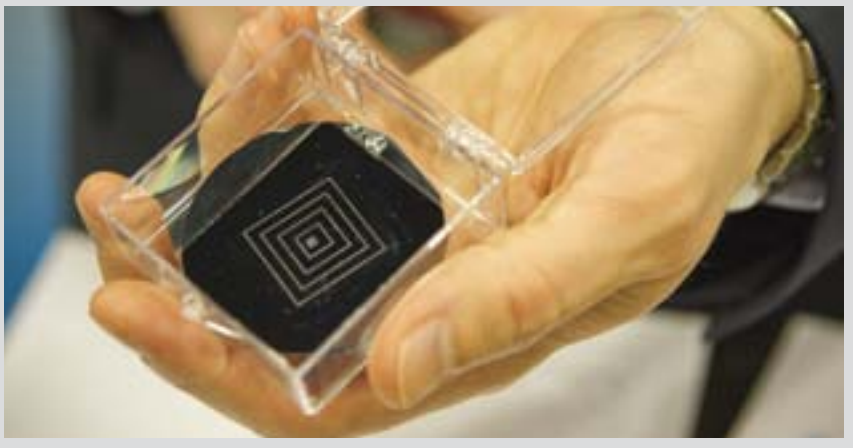
Talon enables new micromachining applications that require lowest cost-of-ownership with no compromise in performance, says Spectra-Physics. It is targeting applications such as PCB cutting and drilling, semiconductor, LED and ceramic scribing, thin-film patterning of ITO and solar cells, and glass cutting and drilling.

Spectra-Physics general manager Dave Allen said: "Talon transforms the market for UV laser micromachining by delivering far and away the best combination of performance, reliability, and cost. Our customers clearly recognize the compelling cost-performance of Talon, and we are seeing incredible demand for these new lasers as we rapidly ramp volume production."

The same company is showing off an updated version of its "Quasar" UV laser at the Moscone this week. Now with more than 60 Watts and pulse energies in excess of 300 microJ, the upgrade is said to be an "astonishing leap forward" in performance by Scott White, senior manager of product marketing at Spectra Physics.

A hybrid fiber source, the Quasar was first unveiled at last year's Photonics West show, and is aimed at applications in microelectronics and mobile device production.

Newport Spectra Physics is at booth #1301



BiOS exhibitor Nanoscribe showed its Photonic Professional GT 3D laser lithography printer, which has been shortlisted for a Prism Award at this year's event. CEO Martin Hermatschweiler says that the company delivered its first GT system in November. With new focusing optics and faster operation it is now capable of producing millimeter-scale structures with nanometer-scale precision in a couple of hours. This image shows a micro-optical structure produced by the same machine. Credit: Joey Cobbs/SPIE.

NKT makes supercontinuum source super affordable

NKT Photonics, Birkerød, Denmark, is demonstrating its new SuperK Compact supercontinuum fiber laser, which it calls "the most affordable supercontinuum laser available". If you want to buy one at the show it actually has a price tag of $8195 (or €5995), but head of marketing Kim Hansen told *Show Daily* that this cost could be reduced considerably for bulk purchases.

The source offers single mode, fiber-delivered light across the 450-2400 nm range and, unlike most supercontinuum sources on the market, can be triggered externally and synchronized with low jitter from single shot up to 20 kHz.

Hansen added, "The SuperK Compact will take a supercontinuum source into volume applications that are usually dominated by single-line lasers, lamps and superluminescent LEDs. Now you can replace several of these sources with one SuperK to reduce system complexity and cost. Add to that a maintenance-free lifetime of thousands of hours and the cost of ownership for this broadband system is the lowest available."

This source is powered by NKT Photonics' patented photonic crystal fiber (PCF) technology. Built on the same platform as the larger SuperK Extreme sources, the new version is compatible with the existing range of supercontinumm accessories such as the SuperK Split wavelength splitter and the tunable variable bandpass filter, SuperK Varia, all of which can all be controlled directly from the source or through the bundled control software package. Typical applications would be in areas such as fiber and grating characterization, CWDM/DWDM component testing, spectroscopy, optical coherence tomography (OCT) and 3D-displacement systems.

The NKT booth also features a high-resolution OCT system, driven by the company's own low-noise supercontinuum source. Hansen said that it offers both a broader spectrum and higher resolution than other OCT systems, resolving detail down to below 2 microns with applications in industrial and non-destructive testing, pharmaceutical manufacturing, and ophthalmology.

The company's third major announcement at Photonics West is the Aeropulse line of high-power picosecond lasers, a family of industrial-grade, mode-locked fiber lasers also based on NKT's PCF platform. Delivering up to 40W of output power, the Aeropulse line is designed for applications within semiconductor inspection, bioimaging and material processing.

NKT Photonics is at booth #711

US BRAIN initiative relies on optics

The US-based BRAIN initiative (Brain Research through Advancing Innovative Neurotechnologies) has already made great strides towards revolutionizing spatial and temporal brain mapping since its launch in April. Optical approaches provide multiple advantages over older, electronic methods and even newer fMRI techniques.

Darcy Peterka of Rafael Yuste's group at New York's Columbia University started off the Optogenetics conference of BiOS on Saturday by describing some of these benefits as well as recent advancements by the initiative and Yuste's group.

There are many structural similarities among mammal brains, leading groups like Yuste's to look for a common basic computational element that could explain how the components of the brain interact and function. This "singular cortical microcircuit" can be thought of as "the DNA of the brain," Peterka says.

A main motivation of these optical mechanisms lies in the scale at which cortical activity is monitored. Sharp electrode measurements of neural activity interrogate neuron by neuron. Newer techniques such as fMRI map more macroscopic brain activity in full regions.

Microscopy, however, allows imaging at the "modular" scale of the proposed "DNA," looking at the activity of 10^4 – 10^5 neurons at a time.

Using two-photon IR fluorescence microscopy with dyes reactive to the Ca^{++} signatures that follow neuron action potentials, Peterka provided real time movies of a live (and relatively unscathed) mouse and its brain activity as it reacted to stimuli.

This second-order method provides optimal spatial localization while the long-wavelength light also scatters less, permitting minimally invasive probing up to a few centimeters into the mouse's brain. With both wavefront coding and beamsplitter-based directive optics, the researchers can see 3D, simultaneous images of multiple areas of activity.

JULIA H. MAJORS

Credit: Amy Nelson/SPIE

SPIE President H. Philip Stahl presented Naomi Halas of Rice University with the 2014 SPIE Biophotonics Technology Innovator Award. Brian C. Wilson, of the Ontario Cancer Institute in Toronto, is the recipient of the 2014 SPIE Britton Chance Biomedical Optics Award.

BiOS

continued from p.1

that investment has been outstanding," Swanson said.

"The clinical translation of OCT has been impactful scientifically, clinically and economically," he added.

Brain research

Several presentations focused on optical tools helping improve our understanding of neurological structures and processes.

Massachusetts General Hospital's David Boas, editor-in-chief of the new SPIE journal *Neurophotonics,* discussed how advances in microscopy are providing new details about how oxygen is delivered and consumed in the brain and elsewhere in the body. But microvascular oxygenation is a very complicated process, he noted, and "We need methods to measure blood flow in the capillary networks."

He and his collaborators are using multimodal microscopy to study microvascular blood flow and map oxygen throughout the vascular network. "What we found is that significant oxygen is extracted from the arterioles — in fact, 50 percent of oxygen being distributed is coming from the arterioles, and this is a new finding," Boas said.

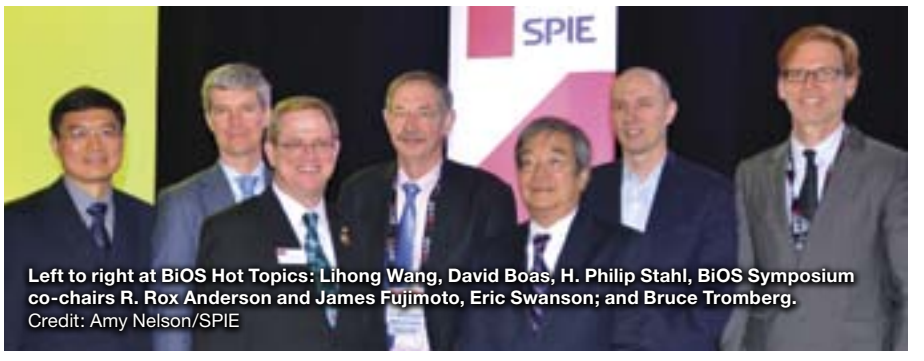
Meanwhile, Paul Selvin and colleagues at the University of Illinois at Urbana-Champaign have developed quantum dots that provide super resolution imaging of AMPA receptors (AMPAR) and support structures at live neuronal synapses.

Using PALM (photo-activated localization super-resolution microscopy) and the PALM cycle to achieve 10-20 nm resolution, they have measured the exact distance between pre-synapse and post-synapse and observed the volume change of synapses. They did this by creating quantum dots (~8 nm) that can fit inside the synapse and big quantum dots (~20 nm) that can bind to them.

"We can get 3D fluorescence imaging with 10-20 nm resolution," with photostable dots, Boas said, "and gather totally new information about synapse function."

As part of the European Union's Human Brain Project's efforts to build a whole-brain imaging infrastructure, Francesco Pavone and collaborators at the European Laboratory for Non-Linear Spectroscopy have combined two-photon correlative microscopy and light-sheet microscopy to enhance the ability to image the brain and its processes.

"Two-photon microscopy can only acquire superficial layers, so we correlate with confocal light sheet microscopy to reconstruct the entire brain and trace single processes," Pavone explained.



Left to right at BiOS Hot Topics: Lihong Wang, David Boas, H. Philip Stahl, BiOS Symposium co-chairs R. Rox Anderson and James Fujimoto, Eric Swanson; and Bruce Tromberg.
Credit: Amy Nelson/SPIE

Over the last decade, more than half a billion dollars has been invested by government agencies in OCT technology, and the ROI on that investment has been outstanding.

Cancer diagnostics

Bruce Tromberg of Beckman Laser Institute in California described a multi-center clinical trial studying diffuse optics methods for assessing breast cancer chemotherapy — the first optics trial supported by the American College of Radiology.

"In breast cancer over the last 10-15 years, there has been tremendous growth in use of pre-surgical neoadjuvant chemotherapy for stage 2-4 tumors," explained Tromberg, founding editor of the SPIE *Journal of Biomedical Optics*. "There is a clinical need to predict the pathological response as early as possible."

Tromberg's group has been working with a combination of frequency domain phase modulation and continuous-wave diffuse infrared spectroscopy for monitoring neoadjuvant chemotherapy.

Another talk covered developments in scanning fiber endoscopy, which offers clinicians both an improved method of guided intervention and a higher-resolution diagnostic capability, according to Eric Seibel of the University of Washington.

Coherent fiber bundle technology is a mainstay for imaging very small ducts, but the resolution is only about 100 pixels across, Seibel explained. "Really, you are legally blind when you are using that scope," he said, which is an issue with sophisticated procedures in small ducts.

Seibel's group has focused on developing ultrathin widefield high-resolution endoscopy for imaging the bile duct for biopsy. "It is very important to get high-res images for this, and we had never seen these kinds of images before," he said.

Meanwhile, a decade of research has pushed photoacoustic computed tomography (CT) to the forefront of molecular-level imaging, according to Lihong Wang, a professor at Washington University, St. Louis and current editor-in-chief of the *Journal of Biomedical Optics*.

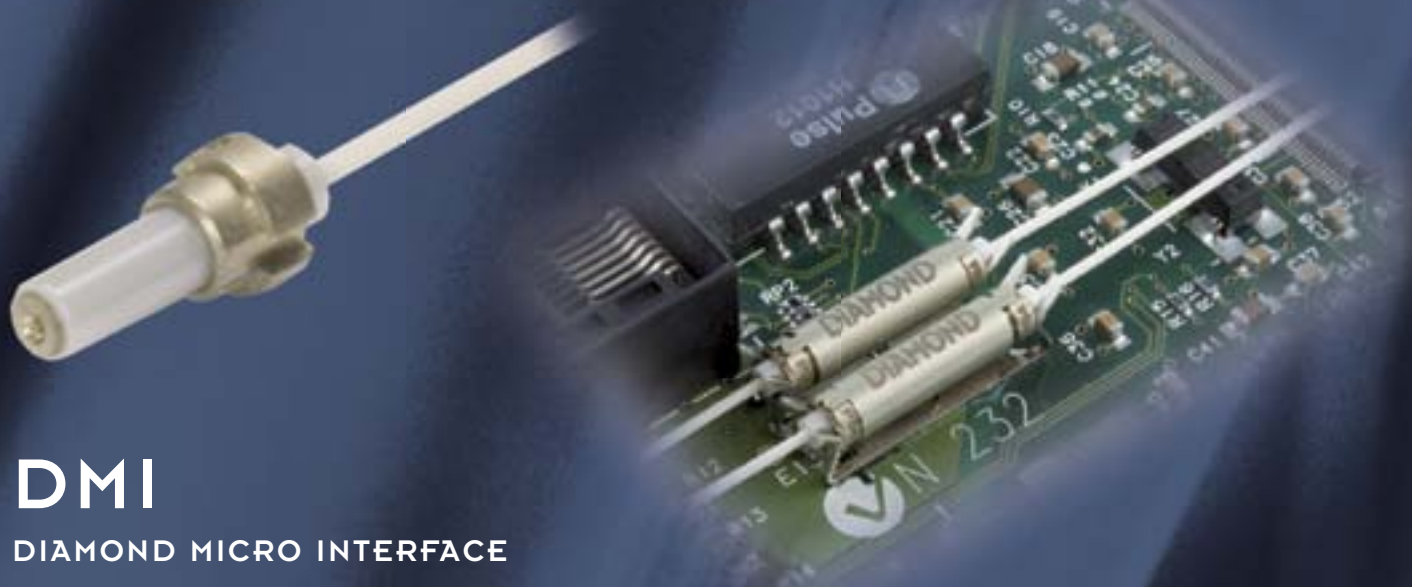
Modern optical microscopy has resolution and diffraction limitations, he noted. But noninvasive functional photoacoustic CT has overcome this limit, offering deep penetration with optical contrast and ultrasonic resolution of 1 cm depth or more — up to 7 cm of penetration in some cases, such as evaluating sentinel lymph nodes for breast cancer staging.

A nanoscale photonic probe built using semiconductor manufacturing methods is enabling researchers to probe single cells for days at a time, according to Gary Shambat, a member of Jelena Vuckovic's group at Stanford University and a senior scientist at Adamant Technologies.

"We wanted to take an optical fiber and insert it into a single cell without too much damage" to measure nanocavity resonances in the cell, Shambat explained. They attached the fiber with epoxy to a GaAs membrane and tested the nanoprobe on common cancer cells (PC3). The process was "minimally cytotoxic" to the cells, with about 75 percent of the cells surviving. This means the probe could be used to measure long-term cell behavior; in early experiments they observed cells containing the probe for eight days.

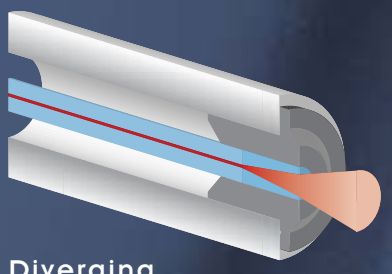
KATHY KINCADE

THE LEADER IN FIBER OPTIC CONNECTOR TECHNOLOGY

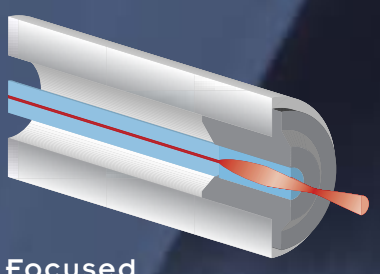


DMI

DIAMOND MICRO INTERFACE



Diverging



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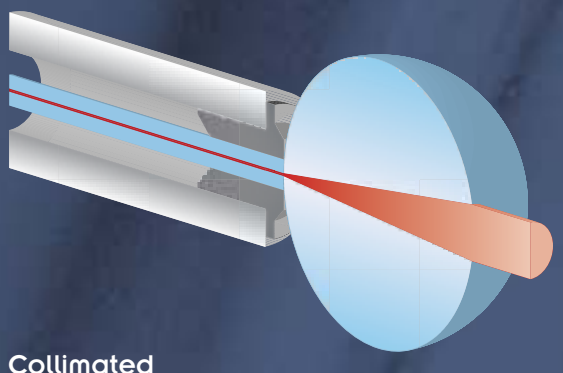

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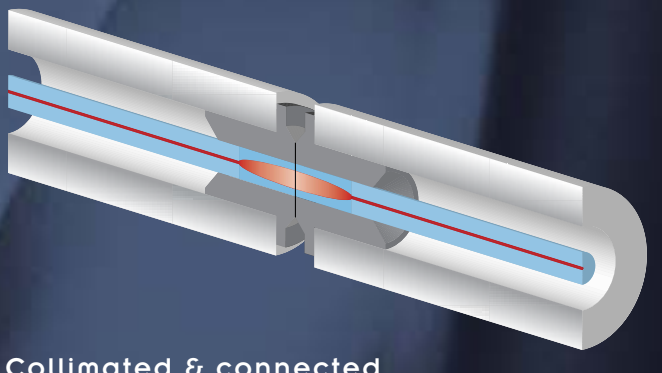

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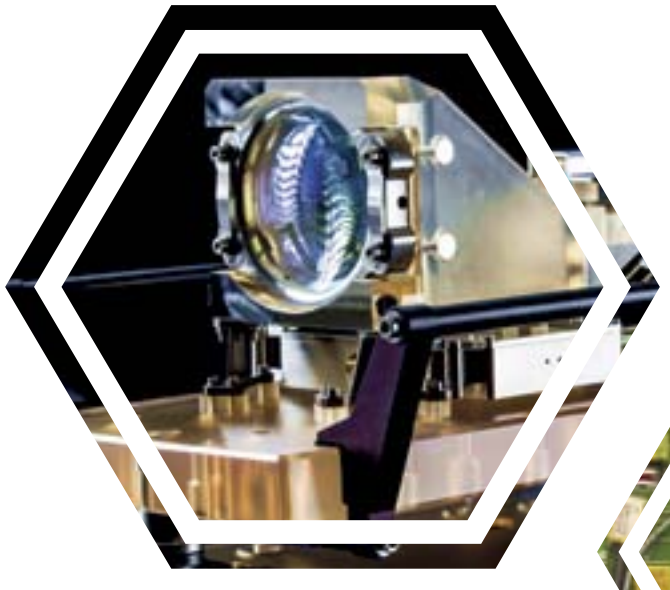

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