

# PHOTONICS WEST. SHOW DAILY

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Rock star status: 2014 Nobel laureates Eric Betzig (l) and William "W.E." Moerner at Sunday night's inaugural BiOS Nobel plenary. Co-laureate Stefan Hell appeared by video link. Photos: Amy Nelson.



## DON'T MISS THESE EVENTS TODAY

### PLENARY SESSIONS

**NANO/BIPHOTONICS**  
10:30-11:30 AM, ROOM 134

Gabriel Popescu (Univ. of Illinois at Urbana-Champaign)

**NEUROPHOTONICS**  
2-2:45 PM, ROOM 310

Thomas C. Südhof (Stanford Univ. School of Medicine)

### INDUSTRY EVENTS

**SPIE Job Fair** (10 AM-5 PM, South Exhibition Hall)

**Financing life sciences and health care businesses** (8:30-10 AM, Room 134)

**ITAR workshop** (10:30 AM-12:30 PM, Room 101)

**3D printing panel** (12:30-1:30 PM, Room 134)

**Silicon photonics keynote and panel** (1:30-3 PM, Room 134)

**Intellectual property workshop/course** (1:30-3:30 PM, Room 101)

See the technical program and exhibition guide for more details on daily events. Conference registration may be required. Industry events are open to all registration categories.

## TODAY'S NEWS

# Chemistry Nobels wow BiOS crowd

The closest that the world of photonics has to rock stars played to a packed house at Sunday evening's special plenary event on super-resolution microscopy. Introduced by co-chair Bruce Tromberg as the very first BiOS Nobel session he predicted: "more will follow."

Tromberg recalled the combination of excitement, pride and a little organizational panic as fellow session chairs Ammasi Periasamy from the University of Virginia and PicoQuant's Rainer Erdmann volleyed upwards of 50 emails back and forth in

preparation for the big night.

Those who packed the Moscone's room 134 to hear the 2014 chemistry laureates did not leave disappointed. Stefan Hell, honoring a long-standing speaking commitment, appeared by video message. And the saxophone-playing microscopist hit the right note when he said that the personal stories of the three laureates were quite different. For William "W.E." Moerner, it has been a relatively conventional route to the Nobel. For Eric Betzig, not so much. His compelling tale

involves quitting Bell Labs in the 1990s and a period in the scientific wilderness before building a super-resolution microscope from spare parts in best friend Harald Hess's living room. What all three had in common, said Hell, was a passion to work on things that "could not be done — supposedly."

The story of super-resolution begins with another Nobel winner — 1933 physics laureate Erwin Schrödinger, who declared that the idea of observing individual molecules

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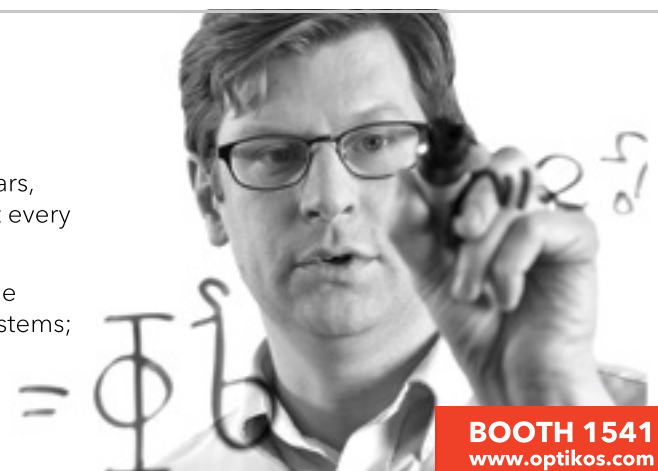
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# Contact with the real world: the key to an industry career

Charting a course from academia to a job in the photonics industry isn't a direct path for many. Three successful professionals in the industrial sector shared their winding journeys from graduate school to the executive office at a professional development session over the weekend.

The three, Castor Optics co-founder Caroline Boudoux, Edmund Optics CEO Sam Sadoulet, and Aaron Weinroth, VP of technology commercialization at Tornado Spectral Systems, said they advanced their careers by acquiring the right skillsets inside and outside of academia and by taking advantage of every opportunity to solve problems and network with others.

"I have never charted my course in the photonics industry," Weinroth told a group of mostly students at a Photonics West professional development workshop called "Charting a Course in the Photonics Industry." Yet, he learned marketing skills at a small company that didn't have a marketing department, became a shipping expert when his employer needed someone to make a key shipment to a customer, and generally took on new responsibilities whenever he saw a need.

There's no right way to plan your career, he told the audience. "Whatever you come up with, you will probably be wrong," Weinroth said. "No amount of planning survives contact with the real world."

While their job histories reveal much on-the-job training, the three agreed there are some things that young professionals can — and perhaps should do, especially in light of one report showing that only 12 percent of PhDs attain academic positions.

Sadoulet advised grad students, early career professionals, and post-docs to keep their options open at every phase of their career. He suggested getting involved in extracurricular activities at school; being ready and willing to adapt to new situations; and making it a point to learn how to listen to others. "If I had to break down my day, it's 90 percent listening," he said.

Boudoux, who is also a professor at École Polytechnique Montréal, likewise counseled keeping an open mind to possible career options and changes, and to be fearless about learning new things. Although her education and expertise is in medical imaging, Boudoux said she wound up learning all about fiber optics, electronics, and manufacturing in her role at Castor, which has developed a double-clad fiber coupler for medical imaging.

"For two and a half months, our startup studied glue," she said with a laugh. "You never know when this expertise in glue will be helpful."

KATHY SHEEHAN



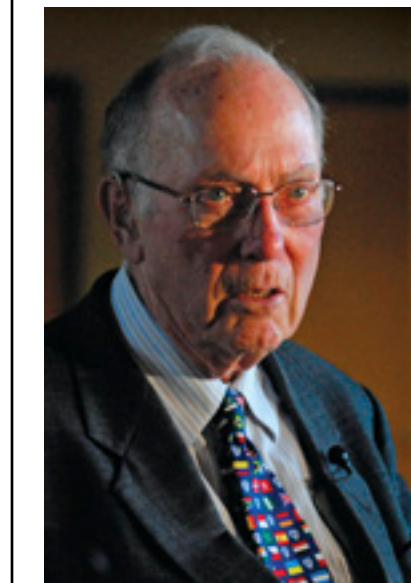
Left to right: Caroline Boudoux, Sam Sadoulet, and Aaron Weinroth. Credit: Kathy Sheehan

**Chemistry Nobels** continued from page 01 was fanciful. It was as likely to happen as man was to raise dinosaurs, he said.

By the 1980s, the inquisitive young research minds of Hell, Betzig and Moerner were starting to think about ways to prove Schrödinger wrong. Thirty years on, and with the various flavors of super-resolution microscopy now revealing secrets of cell biology that literally could not be seen before, Hell summed up the collec-

tive achievement with this: "Nothing is more powerful than an idea whose time has come. And maybe one day somebody will raise dinosaurs..."

As for the future, Betzig sees a growing role for adaptive optics, in combination with lattice light sheet and super-resolution techniques. "We can really get at the guts of what is going on in living cells in their normal environment," he said. Whether he personally sticks around re-



Credit: Photo by Patrick Wright, Clemson University.

## Charles Townes, 1915-2015

The optics and photonics world is mourning and paying tribute to Nobel Laureate and laser pioneer Charles Townes at Photonics West this week. Townes, who solved the theoretical problem of creating a pure beam of short-wavelength, high-frequency light, died 27 January. He was 99.

SPIE CEO Eugene Arthurs will pay tribute to the co-inventor of the maser at the LASE plenary session on Wednesday. In addition, all of Townes' research papers in the SPIE Digital Library are being made freely available through March. See <http://ow.ly/ILUtF>.

"We were blessed by having him for so many years," said Arthurs, who called Townes a technical genius who enthusiastically and with great humility and joy gave his time to encourage students. In just one example of his great sense of joy in life, Arthurs noted that Townes joined in the ceilidh dancing at the SPIE Astronomical Telescopes and Instrumentation symposium in Glasgow in 2004. "Charles, then aged 88, was first on the floor and last off. He certainly gave a wonderful image for a brilliant scientist and one I only wish more young people could have seen. May he dance on in a better place."

### Other remembrances of Charles Townes

- "He gave so much to humanity through his intellect, his curiosity, his generosity, and especially his time. He was an inspiration to so many generations of students and will be for generations to come." **M.J. Soileau**, University of Central Florida.
- "Long after the Nobel laurels had been bestowed, he continued to pursue the answers to current questions and to train younger researchers. He certainly did not rest on his laurels." **Don O'Shea**, Georgia Institute of Technology, retired.
- "Charlie was a cornerstone of the Space Sciences Laboratory for almost 50 years. He trained a great number of excellent students in experimental astrophysics and pioneered a program to develop interferometry at short wavelengths. He was a truly inspiring man and a nice guy. We'll miss him." **Stuart Bale**, University of California, Berkeley.
- "Charles Townes was a giant and an inspiration!" **John Dudley**, European Physical Society.
- "Charlie Townes had an enormous impact on physics and society in general. Our department and all of UC Berkeley benefited from his wisdom and vision for nearly half a century. His overwhelming dedication to science and personal commitment to remaining active in research was inspirational to all of us. He was able to carry on innovative new research until he was 99 years old. I don't know how you could be more impressive than that. Berkeley physics has lost a true icon." **Steven Boggs**, UC Berkeley.
- "Charles Townes' scientific explorations and path-breaking discoveries changed our world in wondrous ways, and new uses of the technology are unfolding even today." **Elizabeth Davis**, Furman University.

mains to be seen — going on previous form, he reckons he only has a couple more years to devote to microscopy before changing tack again.

Asked where the technology will have a real-world impact in the near future, Moerner was unequivocal. The obvious answer was in cell biology, he said. "We can see so many things that we couldn't see before." Ultimately, the impact of that on the medical world ought to be profound.

Bringing an unprecedented and downright entertaining BIOS conference session to a close, Tromberg summed up the warmth of feeling in the auditorium when he said: "It's been a remarkable night. All of us here will remember this night for the rest of our lives." Amen.

Scan to follow Photonics West news online.





## Faster and more functional: the microscope-in-a-needle

The microscope-in-a-needle technology that won the SPIE Startup Challenge at last year's Photonics West is now much faster, with the latest advances described as "game-changing" by lead researcher Robert McLaughlin.

McLaughlin, who won last year's contest with a confident and convincing pitch on the radical approach to optical coherence tomography (OCT), presented the latest developments at the BiOS conference earlier this week. The budding University of Western Australia entrepreneur told *Show Daily*:

"It's been such an exciting year since we won the SPIE Startup Challenge. One technical issue we had was that our early prototype probes were very slow. This year we've completely redesigned the scanning mechanism, and increased the speed by a factor of 30. We're now getting towards the speeds that we need to achieve to use this product in surgery."

Another key development in the past year and presented at BiOS was to combine two optical imaging technologies — OCT and fluorescence — into a single needle. "It opens up a lot of new commercial possibilities with fluorescent-labeled disease-specific markers," said McLaughlin. "We worked with biochemists to synthesize a new type of drug that makes cancer cells fluoresce. It's a labelled analog of the breast cancer drug, Tamoxifen. We want to make the cancer glow green, so the surgeon can cut it all out."

Despite those technological advances, McLaughlin is mindful that the needle microscope is still at an early stage of commercialization. He and his team are busy pitching to venture investors and collaborating with design companies to scope out the work that will be required to build a clinical prototype and protect the intellectual property developed.

"The goal for 2015 is to secure our first



Robert McLaughlin (left) and colleague David Sampson from the University of Western Australia. Their "microscope-in-a-needle" was the subject of several papers at this year's BiOS conference. Credit: University of Western Australia.

round of funding," McLaughlin said. "But anyone who has been through this journey knows that it is always more difficult than people expect."

He expects to officially spin the company out from the University of Western Australia this year, and added: "The key development for us has been to define our product roadmap. We've identified neurosurgery as our key initial market, and worked with the neurosurgeons to understand the greatest opportunity. We're currently awaiting ethics approval to try our first in-human tests."

The breast cancer surgery application is expected to provide the firm's second market opportunity — even though it's potentially a much bigger one. "The [breast cancer] product carries more commercial and technical risk," McLaughlin explained. "The larger market is critical in making this investment enticing to venture capitalists, but no one likes risk in their investments. This [past] year we've worked out how we can build on what we are planning to do in neurosurgery to reduce that risk."

Although the focus is now switching to a first round of funding, the scientist sees the main challenge as the transition out of the research lab and into true development mode.

"The curiosity and ingenuity that has driven our research and enabled us to create such unique optical probes is very different to the discipline and focus we need to develop it into a stable, profitable product," he said. "University labs are great at 'research', but usually quite poor at 'development'. That's why we've started talking to engineering firms whose expertise is in product development."

"As a university spin-out, by recognizing the limitations of our organization, we can engage with partners who excel in those areas. Our success won't just be built on our technology — it'll be built on our networks."

Following last year's Startup Challenge success, another accolade came along in the form of the Western Australian Innovator of the Year. "It's a state government program to find the most exciting new companies, and we were competing against all industries," said McLaughlin. "The skills we learned as part of the SPIE Startup Challenge really helped us to explain what we're doing and also the commercial potential of our technology."

• For more on the four previous winners of the SPIE Startup Challenge, and what they have gone on to achieve since, turn to page 9.

MIKE HATCHER



Years of light to continue on Bay Bridge: Now in their final weeks before a hiatus for maintenance, the Bay Lights have been enhancing night-time views of the nearby Bay Bridge for the last two years. The world's largest LED light sculpture, a never-repeating display of 25,000 white LED lights, is 1.8 miles wide and 500 feet high. It was brought into existence by the non-profit Illuminate the Arts group and after a recent fundraising effort, the group announced that the Bay Lights will be reinstalled by January 2016, to hopefully be ready for the next Photonics West. It's an easy trip to the waterfront to see the bridge at night. Take the "F-Market & Wharves" streetcar eastbound on Market Street. Next year, there should be another light-based installation to see: the Light Rail project along Market Street will track the underground movement of BART and Muni trains with light pulses.

Photo by James Ewing.

## IPG raises efficiency benchmark

IPG Photonics is revealing its next generation of kilowatt-class ytterbium fiber lasers on the Moscone Center exhibition floor, with claims of new industry records across a wide range of specifications. Among the highlights are IPG's latest "ECO" and "CUT" industrial laser families, said to set new records for wall-plug efficiency exceeding 45 percent and also for operation time between service interventions.

They are joined by new picosecond and

femtosecond pulsed lasers featuring average powers of up to 100 W. "These families of lasers are expected to significantly increase the use of ultra-short pulse laser micro-machining throughout the industry by eliminating cost barriers to ownership and improving reliability," said the Massachusetts-headquartered firm.

A new addition to IPG's quasi-continuous-wave (QCW) lasers is the YLM-450/4500-QCW, said to provide extra power and temporal pulse shaping in a

compact, low-cost OEM module for applications in micromachining.

IPG's exhibition booth also promises to be a particularly colorful affair this year, with the launch of a broad range of high-power fiber lasers operating in the visible range. Aimed at the entertainment and projection industry, they include a 30 W red laser along with green, yellow, and orange sources.

Other new products include a family of CW, QCW and pulsed Raman lasers spanning the near-infrared range from 1.1 to 1.7 microns, with powers up to 300 W.

Beefing up its offering further into the infrared region, IPG is also showing off "significant improvements" to the hybrid fiber-to-crystal mid-infrared lasers. Including a femtosecond modelocked Cr:ZnSe/S oscillator, they now span the wavelengths all the way to 5.2 microns.

• IPG is set to beat its sales target for the final quarter of 2014. The company just announced that quarterly sales should come in at around \$207 million, up 25 percent on the closing quarter of 2013.

IPG Photonics is at booth 1622.



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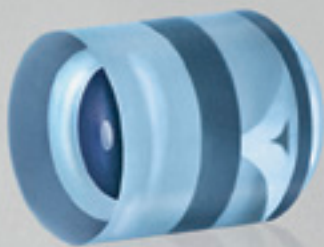
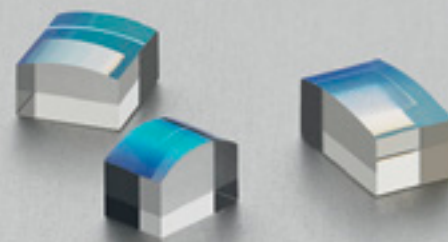
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# Innovation breeds technical revolution

Photonics West's own growth reflects the expansion of a vibrant field as the International Year of Light begins, writes SPIE CEO Eugene Arthurs.

Welcome to Photonics West 2015. I am particularly delighted that this event will set new records in 2015, the year the United Nations has declared the International Year of Light and Light-based Technologies. The expanded exhibit space for Photonics West sold out months ago, the number of technical papers will top 4,700, and all the indicators are for the highest attendance ever. The size and energy of Photonics West reflect the vibrancy of the industry, and are certainly confirmation of the growth in light-based technologies.

Thank you for participating, whether this is your first time or you are returning for yet another year. SPIE works to ensure that this event provides value to all who attend, and your thoughts and concerns are invaluable in our ongoing efforts to enable further development in optics and photonics for the benefit of the world.

Photonics West is home to the latest in biophotonics. We can trace the genesis and emergence of important clinical advances by reviewing past BiOS programs. We continue to nourish the interplay of medicine, science, and technology. As you read this, on Tuesday, you may have missed the packed BiOS Hot Topics session on Saturday night that offered a look at the future. I'd recommend immediately putting it on your calendar for next year.

Light-related business opportunities continue to proliferate — hear more on this in the Industry Events program this week. Some of the growth stems from innovative exploitation of the fundamental nature of light and of light's interactions with matter.

There are also opportunities that result from improvements in computational capability, the ongoing manifestation of "Moore's Law," and declining prices for ever-faster digital control and processing. These capabilities allow development of instruments and processes some of which were conceived of years ago but not implementable at market-acceptable price levels. Now, spectroscopic algorithms, transforms, image manipulation and analysis, etc., are quickly executed by affordable machines that can learn and improve.

Our endlessly inventive photolithography community has played a key role in sustaining Moore's Law. Semiconductor fabrication is an important sector for many companies here at Photonics West.

At this meeting there will be considerable interest in the macro printing revolution which was ignited about 32 years ago by Chuck Hull — who used to hone his curiosity and market sense at our exhibitions — using an ultraviolet laser. There are many approaches to 3D printing, with thermal extrusion perhaps adequate to sate the consumer novelty appetite.

UV and laser-based 3D manufacturing machines have proven their worth in prototyping and have moved onto aerospace factory floors. Integration with 3D optical metrology holds great promise for efficacious advanced manufacturing.

Lasers that laboratories once could not afford are now consumer items with all the concerns that come with power above the eye-safe levels.

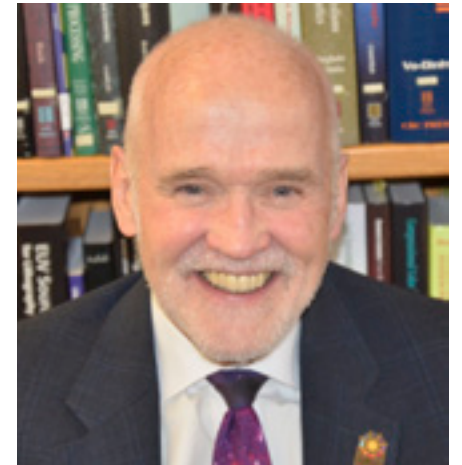
Besides these market opportunities, we

should be thinking about using the technology in our own field. Printing of optics with light sounds a little incestuous perhaps, but a Past President of SPIE threw this out as a BHAG ("big, hairy, audacious goal") when he was co-lead on the 2012 National Academy study, *"Optics and Photonics, Essential Technologies for our Nation."* A few months ago I had the opportunity to see the impressive progress made in this area by LUXeXceL of the Netherlands.

Credit for a lot of the expansion of our markets must go to the industry's relentless progress in product development. Over the years this has reminded me of our understanding of evolution: periods of slowish advances punctuated with quick jumps. I find the interplay of creative ideas, practicality, and financial conditions fascinating.

I have been in the field so long that I know that what seems to some like a new invention can be found in an old paper in the SPIE Digital Library, as one of many ideas before its time. But we are far from done. Factory and clinic-friendly lasers, compact, efficient light sources, "cheap photons" from the Sun and from man-made sources are all contributing to a new light-based technical revolution (I had originally written "industrial revolution" but what we are seeing is not only changing our factories but our homes, laboratories, and clinics).

The 2014 Nobel prizes in physics and in chemistry came as wonderful reminders of progress in our field. The emphasis of the physics prize was strikingly different



SPIE CEO Eugene Arthurs. Credit: SPIE.

to what many have come to expect. Akasaki, Amano, and Nakamura were awarded the prize for "the invention of efficient blue LEDs which has enabled bright and energy-saving white light sources." As one who has sought to bring attention to the challenges facing us all on a vulnerable planet, I welcome this important statement by the Nobel Committee.

The chemistry Nobel for extraordinary advances in microscopy was also an accolade for our community. Betzig, Hell, and Moerner have opened a rich new field of research that already allows us to observe cellular behaviors at what we thought were Abbe-forbidden resolutions. This field continues to see extraordinary innovation, much of which was covered in past BiOS sessions here at Photonics West. It is indeed an excellent example of a quick jump in an area where for a long time the technology seemed plateaued.

Again, thank you for being here with us in San Francisco. I wish you a very productive week. Take a moment to reflect on how our understanding and mastery of light has changed life. Celebrate and advance the dream.

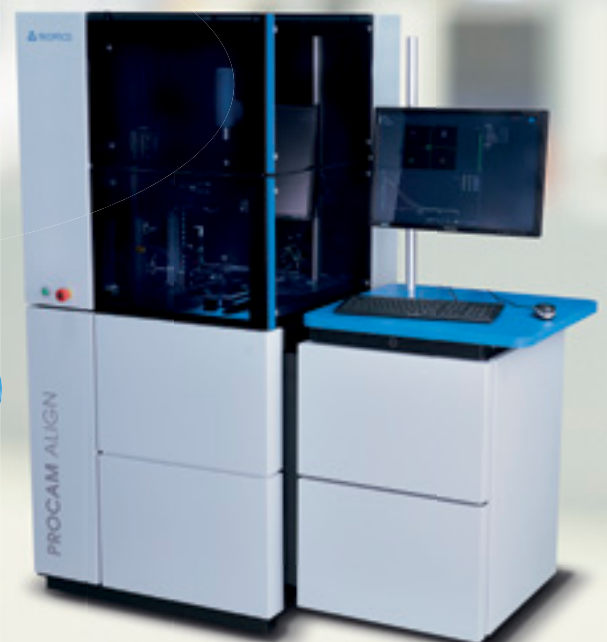
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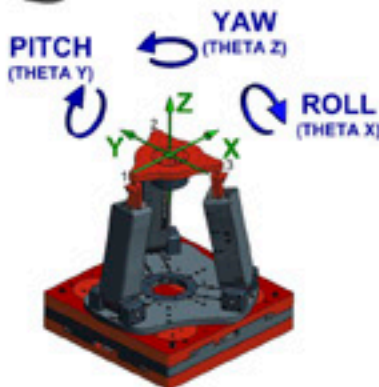
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# Startup Challenge: the winners' stories

Now in its fifth year at Photonics West, the SPIE Startup Challenge is becoming one of the highlights of the conference and has helped several fledgling companies find their way out of the lab and into the commercial world. *Show Daily* caught up with the past winners, who are going from strength to strength.

The SPIE Startup Challenge has come a long way in five years. Originally consigned to a tiny room in the bowels of the Moscone Center with space for barely 50 people, its growing popularity and the quality of pitches has seen the event transfer to a ballroom with ten times that capacity and the addition of a semi-final stage. Sponsorship has grown too, with founding partner Jenoptik now joined by lead sponsor Hamamatsu, plus support from Trumpf, Edmund Optics and Open Photonics.

Dirk Fabian, who looks after student services at SPIE, has organized and hosted the event since its inception. He'd read about a similar competition at Duke University that had been won by Oncoscope, a start-up founded by optics researcher Adam Wax developing an optically guided biopsy technique that promised early detection of cancer.

"The other inspiration for the Startup Challenge was a talk from Professor Andrew Hargadon at the University of California's Systemwide Bioengineering Symposium," Fabian recalls. "It served to destroy the myth of the solo inventor toiling in a workshop, and emphasized that successful entrepreneurs built teams to succeed. This is a difficult process for many, but helping to build teams and make connections is something that SPIE does naturally.



Last year's Startup Challenge winner Robert McLaughlin collects the \$10,000 cash prize. Credit: Matthew Peach.

I thought Photonics West, in the venture capital center of San Francisco, would be a great venue for it."

This year, Wednesday afternoon's grand final will take place from 3.30pm. The winner will depart with \$10,000 in cash, \$5000 in equipment and — maybe more important — the stamp of credibility and a confidence level that could make the difference in future meetings with potential investors, collaborators and commercial partners.

So how have the previous winners of the Startup Challenge been getting along? *Show Daily* caught up with the winning pitchers from recent years to find out.

## Hariharan Subramanian NORTHWESTERN UNIVERSITY 2011 WINNER

Northwestern University research associate Hariharan Subramanian made the very first pitch in the very first

Startup Challenge back in 2011, with a potentially lifesaving new optical method to screen for lung cancer. After a confident presentation highlighting the 92 percent accuracy of a cheek-swab test based on partial-wave spectroscopic (PWS) microscopy, judges including Linda Smith from CeresTech and Sergey Egorov from Tech Coast Angels were sufficiently impressed to hand Subramanian first prize.

With two patents already in the bag, Subramanian said he believed that the market for such a screening method could be worth \$5 billion — similar to the existing market for cervical cancer screening. Back then there was no great cash bonus for the winner, but Subramanian did bag a trip to UC Davis to attend the week-long "boot camp" entrepreneurship course run by Hargadon.

"[It] offered an excellent opportunity to meet with fellow entrepreneurs who were interested in commercializing medical technologies," Subramanian recalls. "[It] also helped me to better understand the process of starting a company, hiring a team, going through fundraising etc."

And very useful that seems to have been. At the following year's Startup Challenge, Subramanian returned with news that he had co-founded a company called NanoCytomics with Northwestern colleague Vadim Backman and Hemant Roy, a colon cancer screening expert from the Boston University School of Medicine, to commercialize the approach. Things appear to be progressing nicely: the company has licensed the technology, and in July 2014 recruited veteran healthcare executive John Hart as its first president.

Offering a completely new way to screen for cancer at an early stage, the key thing about the NanoCytomics technology is that it can be used to determine the risk of a patient having the disease. If that "risk stratification" test comes back positive for cancer, then a follow-up examination using a gold-standard method like a CT or MRI scan can be prioritized and the condition diagnosed at a much earlier stage than would be the case if the same patient waited until symptoms presented.

Subramanian told *Show Daily*: "Since the technology was presented at the Startup Challenge, we have automated the PWS microscope that enables nanocytology, making it possible to complete human-sample processing in about 15 to 20 minutes, compared to the four to five hours in the first-generation system. NanoCytomics has also optimized 'standard operating procedures' for our cell collection at the primary care office, cell transport and preparation such that the samples can be used to pre-screen patients for different types of cancers (e.g., rectal cells to pre-screen colon cancer/adenomas, and buccal cells to pre-screen lung cancer)."

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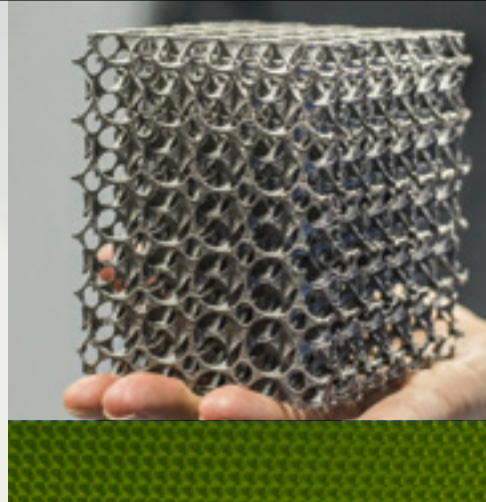
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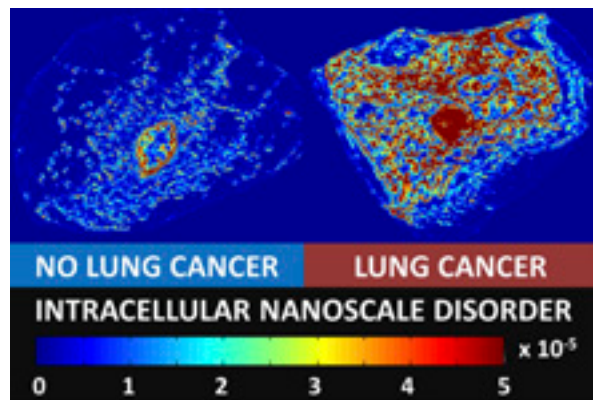
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**Startup Challenge**

continued from page 09

An initial human clinical trial with the improved, high-throughput PWS microscope is under way. “The success of this trial will lead to a large-scale clinical trial, followed by the commercialization of the test, either as a CLIA-based Laboratory Developed Test (LDT), or through an FDA-approved risk-stratification test (similar to a PAP smear test for cervical cancer),” says Subramanian, adding that the next big challenge for the company



Nanocytoomics' cancer-screening technology is based on an optical technique called partial wave spectroscopy. Hariharan Subramanian's pitch on the topic won the inaugural Startup Challenge in 2011. Credit: NanoCytoomics.

is to raise the funds needed to support the clinical trials, and establish a CLIA testing lab. “NanoCytoomics also finds tremendous opportunity in identifying and working with Accountable Care Organizations (ACOs) that incentivize physicians to stress preventative care under the Affordable Care Act.”

In the meantime, Subramanian has also become involved with another start-up that is taking part in this year's SPIE Startup Challenge: Chicago-based Briteseed. This company is working on a technology that can identify blood vessels and improve tactile feedback during laparoscopic surgeries. “[We] have been working on an optical approach to resolve this issue and are already talking to endoscopic manufacturers including Covidien and Ethicon,” he says.

### Carlos Serpa LASERLEAP TECHNOLOGIES 2012 WINNER

In 2012 Carlos Serpa won the Challenge with a pitch on behalf of LaserLeap Technologies, a Portuguese company that had come up with a new laser-based method for drug delivery via the skin. “These are exciting days for LaserLeap,” he told *Show Daily*. “[In] February we will for the first time be present at a trade show in Spain, with our fully developed and certified product.”

Initial market entry will be in the area of skincare cosmetics, aimed at plastic surgeons and dermatologists. This is a segment that Serpa says is highly prone to innovation, and attracted to new non-invasive technologies. “We hope to be *the next big thing* in this market,” he adds. “We are targeting the Iberian Peninsula market in Europe first, and hope to enter the full European market soon.”

Serpa, the company's CEO, says that transforming the new technology into a marketable product has presented numerous challenges. LaserLeap had emerged from a

fundamental research project at the University of Coimbra in Portugal. “We began developing prototypes and testing dermal delivery with target compounds, and then in 2013 the project became a ‘real’ funded start-up, after we signed a financing contract with a venture capital company and a business angel,” he says.

“Throughout 2013 and 2014 we had new challenges, namely the development of a manufacturable design for our first product (called *LL Dermal*) and scale-up of production of the piezophotonic materials and laser-based devices.”

LaserLeap has evolved to become a platform technology that can deliver molecules through the skin using the combination of a laser, an ultrasonic piezophotonic generator and a base dermatological formulation. “This complete system is being tested in two clinics by plastic surgeons, in order to optimize protocols and collect clinical information,” Serpa told *Show Daily*, adding that all installation, manufacturing and human resources recruitment needed to establish the company have now been completed, along with registration of a global trademark and — critically — passing the regulatory process in Europe.

Right now, LaserLeap's main activity comprises the development and commercialization of devices that together produce a broadband, high-intensity photoacoustic wave. When it reaches the skin, that causes a reversible disruption (Serpa describes it as a “skinquake”), enabling the pain-free transdermal passage of molecules that are of cosmetic and medical interest.

“Our pipeline started with cosmetic and dermatological applications,” he says. “In these fields several treatments require that high concentrations of medication reach the epidermis in a few minutes, something that we have already proven possible with our methodology.”

In addition to that, the LaserLeap team is working on promoting its technology for non-invasive and efficient delivery of hyaluronic acid into the skin. That technique could be used for wound healing and wrinkle reduction.

And if the idea of a “skinquake” sounds a little alarming

don't worry: it isn't. “The use of low-power lasers, the fact that the laser is never in contact with the skin and that the process is painless and reversible — skin recovers in a couple of minutes — suggests its use in various important medical, including therapeutic, analgesic and anti-inflammatory procedures that currently use syringes,” Serpa says.

From a business point of view the company's next big challenge is the development and execution of a full sales strategy, in terms of pricing, promotion and distribution. But Serpa already has a very international outlook in mind.

“From the beginning we knew that the LaserLeap products could generate an international impact,” he says. “We have prepared numerous international collaborations, especially in Europe and the US. In particular we

continued on page 13



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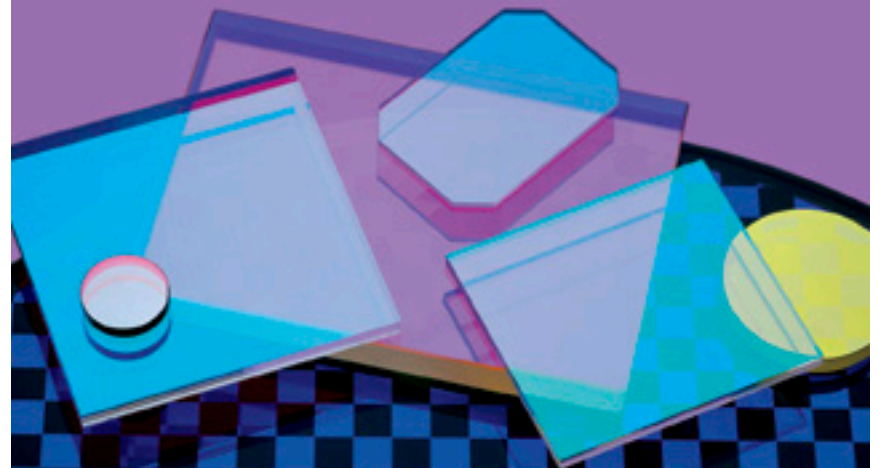
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**Startup Challenge**

continued from page 11

have prepared to enter the US market by applying to the Food & Drug Administration. We will maintain our efforts to become a true multinational company.”

Recalling the 2012 Startup Challenge, Serpa says: “That validation was our first victory. We competed with entrepreneurs from all over the world and the competition came just when we were starting to negotiate funding with venture capital.”

It was a very positive extra point in that negotiation, he adds. National media coverage in Portugal also followed, and although that may have raised the overall profile of LaserLeap technology, Serpa does not believe that it had any direct impact on the company’s business.

**Arun Chhabra****8TREE  
2013 WINNER**

2013 winner Arun Chhabra says that three different types of inspection technology based on optical 3D scanning developed by his company 8tree have been commercialized and that an impressive customer is now on board. “In 2014 we began production shipments of our ‘fastCHECK’ and other products to two different Airbus locations,” he told *Show Daily*. “We are now an official supplier to Airbus.”

After successful field trials, it appears that leading players in the field of aircraft maintenance, repair and overhaul (MRO) are to begin adopting 8tree’s products in the first half of this year. “Alongside that, we are working to get ‘dentCHECK’ included in the Airbus/Boeing repair manuals as an approved tool, which will significantly accelerate customer adoption.”

It isn’t just aerospace. Chhabra and colleagues are now working with a major North American automotive OEM to integrate dentCHECK into their automation environment. “The first orders are expected in the first quarter of 2015, [and] we are in the early stages of addressing similar requests from Japanese auto OEMs.”

On the intellectual property front, Chhabra says that filings have been progressing favorably, with more good news anticipated shortly. There’s even better news on sales, with 2014 revenues doubling year-on-year. “Early bookings in 2015 are on-track to outpace 2014 revenue by mid-year,” he adds. To support all that development, in 2013 8tree welcomed its first two full-time members of staff, before adding an applications engineering manager, and a first advisory board member in 2014. Stay tuned for more expansion in the near future, Chhabra says.

In terms of finance, 8tree continues to be bootstrapped by its founders, albeit with strong interest from investors. The young entrepreneur, who chaired the “startups need more than money” panel session held Monday at this year’s event, says that he will continue to entertain such options to further accelerate the company’s growth.

“As we grow, we continue to encounter healthy challenges that were anticipated at the time of 8tree’s creation,” he told *Show Daily*. “The two primary examples are business development and technology development.”

“[We are] accelerating our expansion into new markets that can benefit significantly from our technology; and in almost all cases, due to traditional offerings in the market, these new industries have a historically poor impression of the “accessibility” (that is, ease of use and affordability) of 3D inspection technology. We invest significant time and resources to help educate, demonstrate and reverse these perceptions.”

On the technical side, the main challenge is developing the in-depth expertise for every new application area that 8tree pursues. “8tree takes a very different approach than traditional scanner companies,” Chhabra points out. Whereas traditional scanners are general purpose systems that require customers to invest significant time in learning and programming to adapt to their individual requirements, 8tree makes application-specific products for 3D inspection.



**Arun Chhabra’s startup 8tree has signed up Airbus as a customer for its “fastCHECK” optical inspection technology.** Credit: 8tree.

“Customers can use them immediately out-of-the-box,” he points out. “To enable this ease-of-use, we shift the burden of learning away from the customer to ourselves, thereby creating a smoother, more enjoyable customer experience. It’s a very different approach than anyone else out there, but one that we believe will create enduring value for customers and 8tree.”

And Chhabra’s recollection of the Startup Challenge? “We are incredibly grateful for all the support from SPIE. The primary benefits have been increased visibility, credibility and access to a broad network of resources and support.”

**Robert McLaughlin  
UNIVERSITY OF WESTERN AUSTRALIA  
2014 WINNER**

Last year, it was another method for cancer diagnosis, in the form of Robert McLaughlin’s “microscope in a needle,” that triumphed. Based on optical coherence tomography, and developed at the University of Western Australia’s Optical and Biomedical Engineering Laboratory in Perth, it helps surgeons to locate the edge of a tumor more accurately. That is critical for reducing the need for repeat surgeries (currently one in four breast cancer patients need to return) and a potential recurrence of the disease. McLaughlin says that a new generation of the needle microscope will be suitable for use in brain surgery.

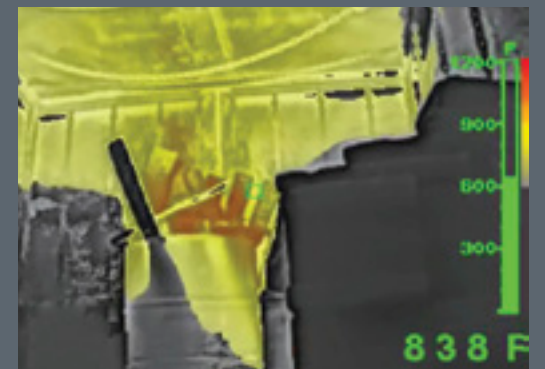
What’s abundantly clear is that each of the Startup Challenge winners has gone from strength to strength, while society in general is set to benefit from some fantastic new photonics technologies in the form of better cancer diagnosis, drug delivery and aircraft maintenance. For anybody seeking the next big thing in photonics, the Startup Challenge is not to be missed.

MIKE HATCHER



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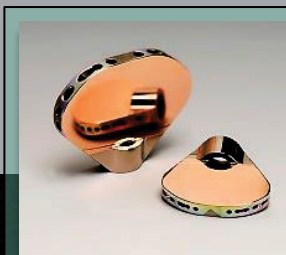
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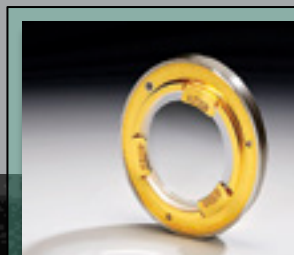




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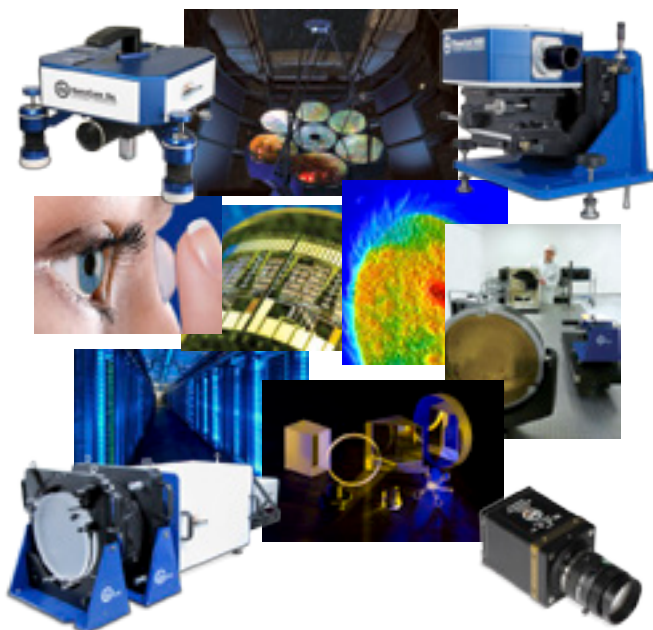
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## Singapore sets its sights on top tier of R&D

Complementary attributes of founders Nanyang Technological University and Southampton's Optoelectronics Research Centre expected to rapidly drive Singapore's new Photonics Institute to international prominence and the launch of diverse spin-offs.

With the aim of establishing Singapore as a center of excellence in photonics research and development, the country's Nanyang Technological University (NTU), in partnership with the University of Southampton's Optoelectronics Research Centre (ORC), last year launched "The Photonics Institute," described by its partners as "one of the most advanced institutes in the field today."

Funded to the tune of SGD\$80 million (USD\$64 million) so far — mainly from the public sector, although there are plans for greater private involvement — facilities include a fiber-optics research and manufacturing unit. Its key backers are the science and technology agency's A\*STAR funding vehicle, and several of the Singapore government's ministries.

The five research units of the Photonics Institute are:

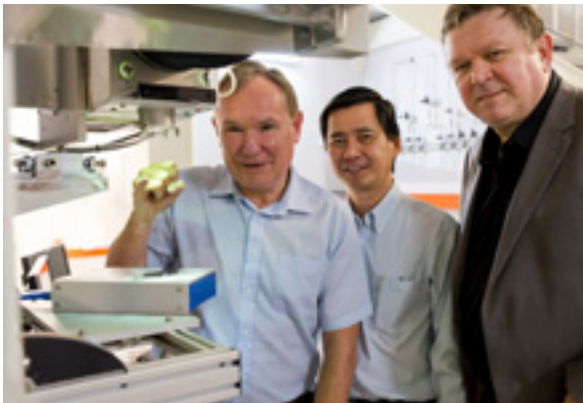
- The Centre for Optical Fiber Technology
- The Centre for Disruptive Photonic Technology
- The LUMINOUS! Centre of Excellence for Semiconductor Lighting and Design
- The Centre for Optical and Laser Engineering
- The OPTIMUS! Photonic Centre of Excellence

The partners are hopeful that the institute will eventually employ more than 120 scientists and staff. *Show Daily* spoke to three co-directors of the operation about their plans for the facility:

### Prof. Sir David Payne ORC DIRECTOR AND CO-DIRECTOR

Philosophically, although Southampton's ORC is the largest such institute in the UK, we had realized that the next generation of research and development needed to be international, something that we are calling research without borders, because other countries have different needs and skill-sets and can complement us.

A number of things are evident to us in the UK. There's a skills shortage of highly trained engineers and scientists here, while Singapore is very good at training scientists so there's an obvious match there. They also have a very clear strategy for the future and it's an easy place to do business.



I-r: David Payne, Tjin Swee Chuan and Nikolay Zheludev, the three co-directors of The Photonics Institute in Singapore. Credit: ORC/NTU.

For many decades, the ORC worked with many Chinese students and we felt that it was time to have a presence in the Far East. So this opportunity with NTU gave us the possibility of a greater critical mass, to double the size of the ORC with a group of people that we know well, respect and like interacting with.

I happened to be with some of them at a conference in Taiwan a few years back and there happened to be a major Singaporean drive to develop a new institute. They asked me to participate and I said to them you don't want me — you want the ORC.

This international model gives us the opportunity to develop start-ups in both countries. I did a start-up some years ago with SPI Lasers. So it's a tremendous opportunity to be able to do it again. It intrigues people to say that we in Southampton could establish a spin-out based in the Far East from day one, which would be supported by two major laboratories. Our plan is to establish new start-ups from the UK but based from the outset in Singapore.

There are a number of possibilities on the stocks for the start-up business model, such as producing short-pulse lasers, or Bragg grating sensors, as are currently being trialed at Singapore's Changi Airport, and which could also possibly be applied in component manufacturing. On the other hand, the start-up could be based on developing fiber itself as we have fiber drawing plants at both the ORC and in NTU.

A good example of the trust that exists between the two partners is that we are happy to discuss openly our latest findings and ideas without fear that the idea will be misappropriated, which could be a problem even within the UK. This trust is based on mutual dependency. We are already pouring out papers and patents. All the metrics are looking good and if we're not careful The Photonics Institute in Singapore will exceed the output of the ORC.

But my policy is that if you want to have a successful collaboration then you

continued on page 16



NTU president Professor Bertil Andersson (l) and University of Southampton Vice-Chancellor Professor Don Nutbeam shake hands on the agreement to set up The Photonics Institute in Singapore in October 2014. Credit: ORC/NTU



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### Singapore R&D

continued from page 15

need to make your partner successful. Benefiting the other side first is the best way to proceed — to create a lock-step together, which results in them trying to help us.

### Prof. Nikolay Zheludev

#### ORC DEPUTY DIRECTOR AND CO-DIRECTOR

The Photonics Institute will be a new model for research and development, which spans both universities in Singapore and the UK, with the aim of developing disruptive ideas in next-generation photonics. It will be a cradle of knowledge and intellectual property, and a focal point for developing ground-breaking applications of light-enabled technologies.

Here [in Singapore], I run the Centre for Disruptive Photonic Technologies, which I set up two years ago, and which represents the most 'blue-sky' thinking here,



The Photonics Institute actually comprises five different centers of excellence and is expected to employ 120 scientists and staff eventually. Credit: NTU.

which I really appreciate. It also encompasses nanophotonics. This site was set up by the Ministry of Education for Singapore, and I also run a laboratory with a similar agenda at the ORC.

My role is that we are helping to set up in Singapore a substantial productivity center that now has a significant critical mass. It is quite politically charged because this is a new collaboration process.

There is also the possibility of further international partnerships, notably with Osaka in Japan, where there is substantial interest and with Technion — the Israel Institute of Technology based at the University of Haifa. We recently received a substantial delegation from Osaka University with about 40 people.

The Centre for Disruptive Photonics Technologies was set up two years ago and our projects have so far raised substantial funding — approximately SGD\$22 million. Our main function is not pilot or prototypes, the focus is developing knowledge and publishing papers, which makes us different from the other four more commercially focused centers.

The main areas of my work in Singapore are looking at photonics meta-materials, quantum plasmonics, photonic materials and nanolasers. I am conducting this work with a 10-15 year outlook in a new 800m<sup>2</sup> laboratory with more than 40 people in a very international team that includes 14 professors and 14 post-docs, among others.

I have taken a lot of inspiration from the recent Royal Society report on the industry which stresses the need for 21st-century research and development to have an international dimension. Here, we could not be more international in our composition and our outlook.

### Prof. Tjin Swee Chuan

#### ASSOCIATE CHAIR OF RESEARCH AT NTU'S SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING AND CO-DIRECTOR

Certainly this new development has been and will be a very interesting activity for me. I have been working in photonics for more than 30 years. This is probably one of the high points of my career so far but there is a lot more work to do to establish the institute at an international level. Because it's important not just to form it properly but to establish The Photonics Institute as a center of high repute in global terms.

Our key objective is to establish a strong critical mass in various aspects of photonics and to become one of the world's key research centers in various branches of photonics. We also have an affiliate research center on silicon photonics — so overall our research and development activities are very broad.

Our idea is to progress some of our upstream work and move it more downstream so that applications can be found and we can create spin-offs to commercialize [products] and develop markets. The aim is to be global and not just focused on southeast Asia. This is where the international collaboration can really be a benefit.

We are constantly talking to a lot of companies already in the market and in Singapore we are also working with the government's Economic Development Board to help coordinate these activities, so that together we can better understand the market needs.

I previously span off a production company that built fiber-optic sensors, and have looked at fiber-optic sensors for various commercial applications. We hope that there will soon be more of such product development from the institute for eventual commercialization. The ORC has a lot of experience in this area, which should be of benefit to us.

We hope that we will develop the first spin-off company within three years — either in sensing or fiber-optics. My own feeling is that sensing is the likely area — sensing is a broad subject and there is always the need for a lot of different types of sensor. Consider the demands of the Internet of Things, which will require many different sorts of sensing technologies.

In Singapore water quality is a very important issue. Singapore does not have enough of its own water, so we have to import it from our neighbors and other sources and control and monitor its quality. I believe another key area of opportunity for our photonics sensing developments will be in food science and security applications. Overall, my feeling is that sensing is a big enough area for developing diverse platform technologies, which can be applied into different markets.

MATTHEW PEACH

Barely three months old, The Photonics Institute's own statement of intent indicates that it is aiming to operate and deliver at the highest level in research and development: "It is significant that 2015 has been declared by the United Nations as the International Year of Light. Indeed, the 21st century belongs to photonics, an enabling technology with applications that span many sectors. Making the most of photonics possibilities will be the key to life-changing technologies — from energy to security, from biotechnologies to low-cost precision manufacturing, from the internet to quantum-level information processing."



## product focus

Welcome to the optics.org Product Focus which we have published specifically for Photonics West 2015 in partnership with SPIE and the Photonics West Show Daily.

Here you will find an effective at-a-glance guide to some of the latest products available on the market with booth numbers if available making it easy for you to check out the products for yourself.

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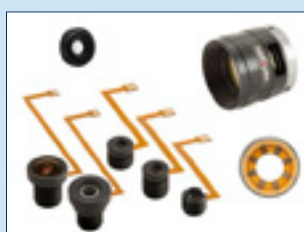
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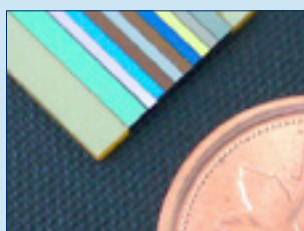
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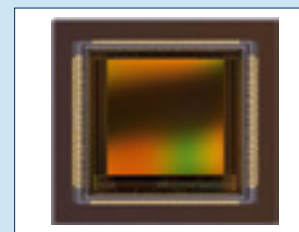
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# Soraa's crystal vision shines

Shuji Nakamura may have just won a Nobel prize for inventing ways of making GaN-based LEDs, but the company he co-founded is profiting from a radically different approach, discovers Andy Extance.

On October 8 last year, the LED lamp manufacturer Soraa held a party for its co-founder Shuji Nakamura at its Fremont, California, headquarters. It was an obvious thing to do: after all, he had been announced as a joint winner of the 2014 Nobel Prize in Physics the day before. But Nakamura says that earning the highest level of acclaim possible in science for jointly inventing the blue LEDs that enable energy-saving white light sources has changed little for him at Soraa. "They were happy about the Nobel Prize, but they were already happy about the GaN-on-GaN technology," he laughs.

Nakamura — who gave the presentation at this year's SPIE Photonics West Fellows Luncheon — is referring to Soraa's unique offering, which has taken one of the industry's furthest steps away from the conventional LED-making approach that he helped devise two decades ago at former employer Nichia. Working with his University of California, Santa Barbara (UCSB) colleagues Steven DenBaars and James Speck, in 2008 Nakamura placed an informed bet on a manufacturing strategy that many considered too expensive. Together they founded Soraa, which in turning their ideas into reality is delivering LED lamps that produce more natural light than previously possible, and powering impressive revenue growth.



**King of the blues:** Shuji Nakamura receives his Nobel prize from King Carl XVI Gustaf of Sweden at the Stockholm Concert Hall in December 2014. © Nobel Media AB Credit: Alexander Mahmoud.

Today, most of the LED industry continues to deposit thin layers of light-emitting gallium nitride (GaN) semiconductor material on sapphire substrate wafers, just as Nakamura did in his pioneering mid-90s work. But Soraa swapped sapphire for wafers cut from large bulk GaN crystals. "GaN-on-GaN is the best technology to make LEDs because we can reduce dislocation densities

dramatically, almost three orders [of magnitude] lower than LEDs on sapphire," Nakamura says. "Crystal quality is much better than LEDs on sapphire, silicon or silicon carbide and that gives much better LEDs."

Mike Krames, Soraa's chief technology officer, joined in 2009 to devise the company's plan to exploit GaN-on-GaN's many benefits. Another central advantage is that

**"GaN-on-GaN is the best technology to make LEDs."**

SHUJI NAKAMURA

these devices can run at power densities ten times higher than existing technologies, Krames reveals. "Lower dislocation density is one necessary, but not sufficient, condition to be able to do that. Other important aspects are distributing power evenly over devices' injecting active regions and spreading heat so there are no thermal gradients."

Thermal gradients cause reliability problems that limit power density, Krames stresses. "Instead of seeing incumbents reduce cost by increasing power density, in fact they go the other way due to limitations of their technology. These days standard high-power chips are bigger than a few years ago in order to eke out little lumens-per-watt [efficacy] gains at the expense of cost and source brightness. Our roadmap is a fundamentally brighter LED source, which means smaller optics, smaller and lower-cost luminaires, and more control over light distribution."

## Out of the hat

GaN substrates also help extract more light than might otherwise remain inside the LED chip, trapped by total internal reflection. To take advantage of this Soraa has rejected conventional square designs and instead made its devices triangular. "In our flip-chip die, you can see the substrate sitting on there like a buccaneer's hat," Krames points out. "It's doing all the work for us. We believe 90 percent of the light generated in the chip gets out — and we believe that's the highest demonstrated by anybody."

But these advantages come with a downside — GaN substrates are difficult to make, putting off almost all LED makers. "Currently, GaN substrates are cut from bulk crystals grown using hydride vapor phase epitaxy (HVPE), but that has lots of problems," Nakamura underlines. "The cost is very high, and HVPE gives hugely strained GaN, which causes problems with substrates bowing. At Soraa we mainly use HVPE, but we are developing a totally new technology called "SCoRA," that will reduce the cost in the future."

SCoRA stands for scalable compact rapid ammonothermal, a novel solution-phase approach. Having recognized the challenge presented by the high cost of GaN substrates immediately, Soraa has been working on SCoRA ever since its inception. It has recently demonstrated production of 2-inch GaN boules, from which the sub-

continued on page 22



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**Soraa** continued from page 21  
strate wafers can then be sliced.

“When that breaks loose not only will the cost be dramatically cheaper than HVPE, but you can also expect the quality to be higher,” says Krames. “[Currently] we have a fundamentally lower-cost platform on a lumen-per-dollar basis, mitigated by a fairly expensive substrate. When the substrate’s no longer expensive, we’ll

be head and shoulders above the rest in terms of capability and control over costs of production.”

### Tight focus

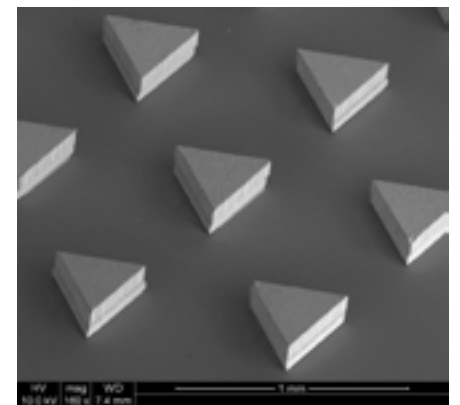
Yet right now, Soraa isn’t pitting its technology directly against rival approaches at the chip level, or in mainstream lighting. “A day doesn’t pass without someone calling and saying ‘Can we buy your LED

chips?’,” Krames says. “Right now, the answer’s no.” Instead, the company is building its GaN-on-GaN products straight into high-quality replacements for directional halogen lights, having started shipping an MR16 replacement in 2012. This vertically integrated model packages violet emitters with blue, green and red phosphors to produce something close to the full spectrum of natural white light.

“You can’t render products properly if you don’t have the entire rainbow of colors,” explains Krames. “You can’t come close to daylight without some short wavelength emission. There are a lot of fluorescent materials in our natural world and they need short wavelengths to look right. Sunlight does it, but most LEDs don’t. Imagine a shop filled with clothing. In the daytime the white clothes look fine, at night-time they look dingy yellow. That’s the reality using standard, blue-based LEDs. We’ve engineered our violet-based, full spectrum LEDs to provide natural light, without heat or UV.”

Concentrating on this kind of product has apparently paid off, notes Stewart Shinkwin, a lighting and LED market analyst at IHS, Inc. In 2013, Soraa’s second year of shipping products, IHS estimates that the firm delivered in the region of \$50-100 million revenues. The company itself is somewhat coy, and says the figure is ‘tens of millions.’

“We expect them to grow significantly, to gain share,” says Shinkwin. “Soraa has stayed away from the general low-cost A lamp market where we’ve seen extreme price competition. They target the commercial space where people care about quality of light. For example, in the retail and hospitality space people want to display products in their shops, food in a restaurant. In these areas price erosion hasn’t been as great — it’s not easy to get the super-high color rendering indexes (CRIs) of 90-plus.”



**Reshaping the industry: Soraa's unusually shaped triangular chips, combined with its GaN-on-GaN material system, let out more light than conventional LED designs.**  
Credit: Soraa.

Shinkwin notes that LED lighting is comparatively widely used in the retail and commercial lighting sectors, where it has 4% penetration, compared to 2% on average across the entire market. Offering a leading product there has been more important to Soraa’s success than its vertically integrated model, he believes.

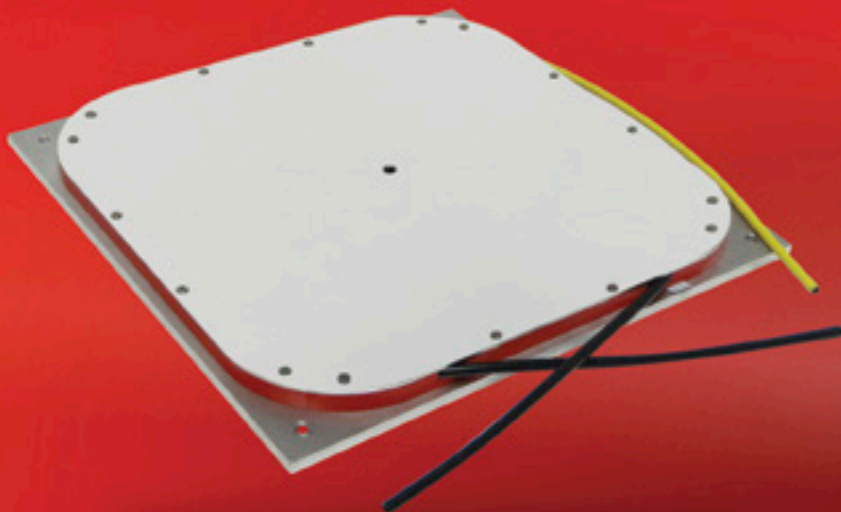
“Just because you’re vertically integrated doesn’t mean the road ahead is easy. Other vertically integrated companies — Samsung being one of the largest LED businesses — have pulled out of the



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**Brilliant achievement: GaN-on-GaN chips paired with three types of phosphor allow Soraa's GU10 MR16 lamps to produce full visible spectrum light.** Credit: Soraa.

LED lamp market in all markets bar Korea. Yet if Samsung wanted to they could go after the market. Similarly Toshiba pulled out of the US about a year ago."

### Solid foundations

To meet that growing demand, Soraa has announced plans for a plant in New York State that Krames says are currently "evolving," with the details to be made public soon. The high power density of Soraa's chips presents another advantage when it comes to these construction plans, in terms of factory size and environmental sustainability. "Factories scale by power density," Krames explains. "So

"My factory can be ten times smaller than a factory from Nichia or Lumileds, for the same amount of lumens shipped."

MIKE KRAMES, SORAA CTO.

if our factories are ten times the power density, my factory can be ten times smaller than a factory from Nichia or Lumileds, for the same amount of lumens shipped."

Soraa is also focussed on delivering a new product generation each year, with the latest generation 30 percent more efficient than the previous one. "That gives you an idea of how much momentum there is behind this platform," says Krames. As well as further improvements in the next generation, Soraa is opening up its vertically integrated business model. "We'll have a new family of light engines and modules that are basically the Soraa LED integrated with optics and heat sinks, but available to be driven and controlled per the customer's desires," Krames says.

This raises the question of whether Soraa should also produce its own fixtures. "The thought is we can move faster if we partner at the fixture level, and of course finding the right partner or partners is a constant discussion within the company. In the future, watch this space, as you can imagine our technology has advantages in other applications where high brightness and high light quality are very nice to have."

As the industry that Nakamura inspired and the

company that he co-founded continue to evolve, the Nobel laureate still finds time to study the fundamental manufacturing processes such as metalorganic chemical vapor deposition (MOCVD) that he used to make his first devices. "I'm actively involved in Soraa work, mainly to determine the direction of the research," he says. "MOCVD is very important for making high-efficiency LEDs, so when we are working on MOCVD growth I'm heavily involved with designing MOCVD tools."

And while it's good to have a Nobel Prize-winner in your ranks, the strength among Soraa's employees runs even deeper, Krames says. He believes their input will keep the company at the industry's leading edge. "We have Shuji, the other founders and a fantastic team of engineers here and they come up with ideas all the time. We have over 300 patents and applications in process. We get together every month and sift through all the ideas, and if we had an unlimited budget we'd have even more. The challenge for Soraa is choosing what not to do."

"Samsung and Toshiba — they're both out of the business and that demonstrates to me that if you don't provide unique and differential value, you're never going to win. We're going to see other would-be LED lamp



**Shuji Nakamura presenting his gift — a white Soraa LED lamp — to the Nobel Museum's collection during the 2014 Nobel laureates' get-together on 6 December.** © Nobel Media AB Photo: Niklas Elmehed.

companies either go out of business or become consolidated over the next few years. Soraa will not be one of those — we will continue to compete, punching well above our weight."

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With the introduction of the new violet SuperK EXTREME EXU series users now have access to diffraction limited laser

sources emitting in the entire 400-2400nm wavelength range. The sources are single-mode over the entire output spectrum and features a maintenance-free lifetime of thousands of hours. The new sources can be paired with variable filters, such as the SuperK SELECT or VARIA, to create a tunable laser with a bandwidth covering the visible and near-infrared part of the optical spectrum and due to the filter quality and superior beam quality of the source, output stability is unrivaled in the industry. Both source and filter are controlled by NKT Photonics new unified software suite, CONTROL, making source and filter work as one integrated system.

The new SuperK EXTREME EXU line of supercontinuum sources are available now and is on display at NKT Photonics booth #811.

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with conductive polymer printing for the use in point-of-care, diagnostics, environmental monitoring and forensic screening applications.

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#### Optical Module Assembly

CDA offers optical module design, prototyping and high volume assembly. These small integrated packages require often high precision alignment between light source and optics as well as proper packaging material for high reliability and maximum performance.

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

CDA additionally provides the integration of microfluidic structures into compact and sensitive devices, (lab-on-a-chip). Such devices



Heads-up display

are becoming increasingly important where chemical, electrical and/or optical properties need to be tested on a small scale. Tried and tested structures and options include:

- channels for separation and mixing
- hydrophobic and hydrophilic surfaces
- combining these with microoptics and printed electronics

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

– design, prototyping, assembly and mass production – are designed to benefit our customers' global strategy."

#### Contact

##### Booth: North Hall 4318

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98529 Suhl, Germany  
eMail: [pia.harju@cda.de](mailto:pia.harju@cda.de)  
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# Choosing a Digital Low Light Camera for Long Range Applications

The ability to observe and record images and scenery undetected are paramount to the safety of both life and infrastructure. Modern warfare techniques, whether static monitoring or mobile surveillance, rely heavily on information gathered via covert long-range surveillance methods such as hidden cameras. The imaging technology is most effective if the camera can produce high quality long range images in both daylight and nighttime conditions. Today, the need to aggregate and share information requires these long range solutions to be digital.

Detection, Recognition and Identification are critical in long range imaging, and each is dependent on proximity. Identification with high probability is a short-range function, as it needs a great level of detail and a high quality image to clearly determine if there is a threat and what it may be. Identification is most difficult under low-light conditions due to poor signal-to-noise ratio and most digital surveillance cameras use supplemental technologies to enhance low light imagery.

The two technologies most often used to supplement CMOS or CCD low light digital imaging are thermal imaging and NIR illumination. Thermal is good for detection and recognition as it relies on differences in adjacent heat signatures. However, thermal technologies do not showcase identifying details, such as cultural signage or facial features, even at short range.

NIR illumination is often used in static surveillance to augment CCD daytime imagery. This is ideal for short range imaging, but the power required to illuminate at long distances is impractical for mobile applications. It can also expose a location to danger, as any reconnaissance with NIR sensitivity can clearly identify a target.

CMOS technology has emerged as a stand-alone digital low light imaging solution. The solid state sensor is impervious to bright light damage, yet can provide superior, high resolution and low noise images from full daylight well into starlight conditions. CMOS sensors can provide high resolution and

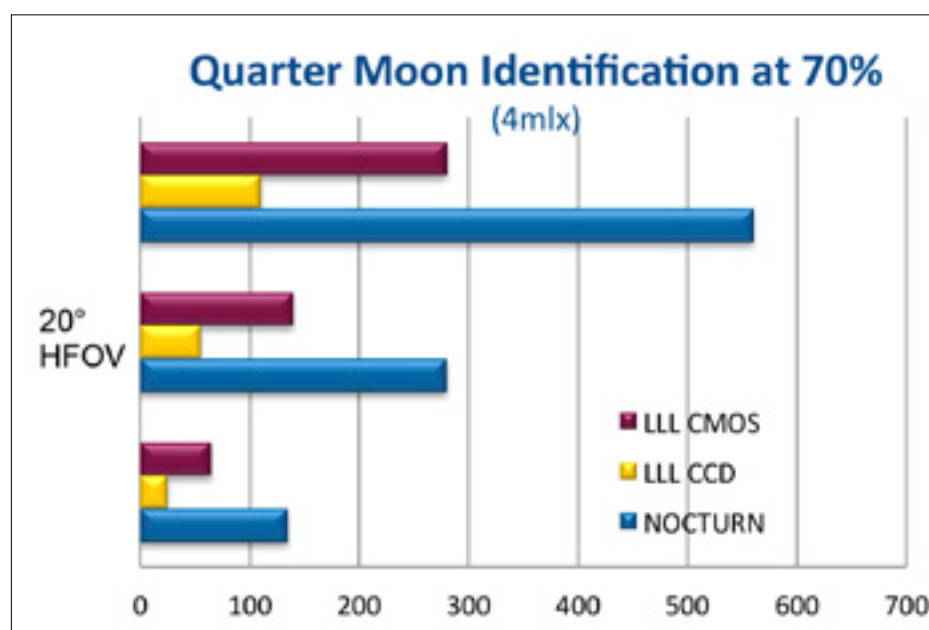


Figure 1: Nocturn camera provides significantly longer identification under quarter moon lighting conditions than competitive digital technologies and without supplemental technologies.

high speed imaging, without supplemental technology and without cooling.

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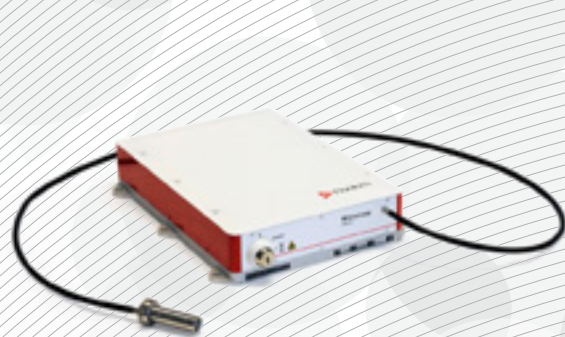
frame rates. Nocturn is offered in a wide range of standard connectivity options, and some models can be ordered in color for added certainty of identification in low light conditions.

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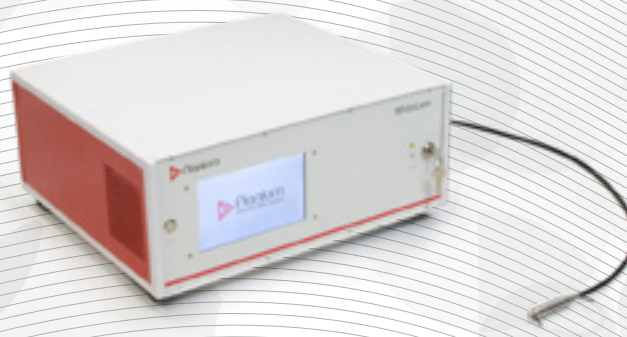
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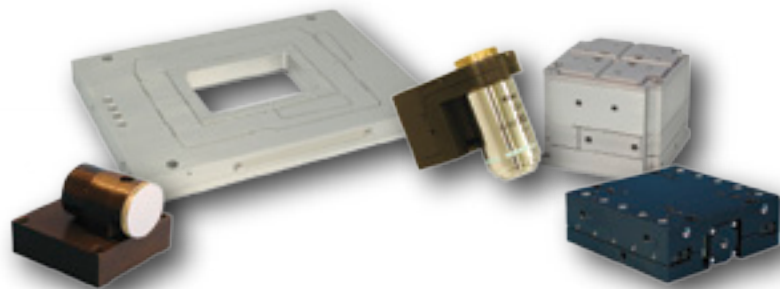
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## A philosophical entrepreneur

Having masterminded more than a decade of solid growth at Thorlabs, Alex Cable wants to “democratize” the mid-infrared spectrum and help generate a wider public appreciation of science and technology — and photonics in particular.

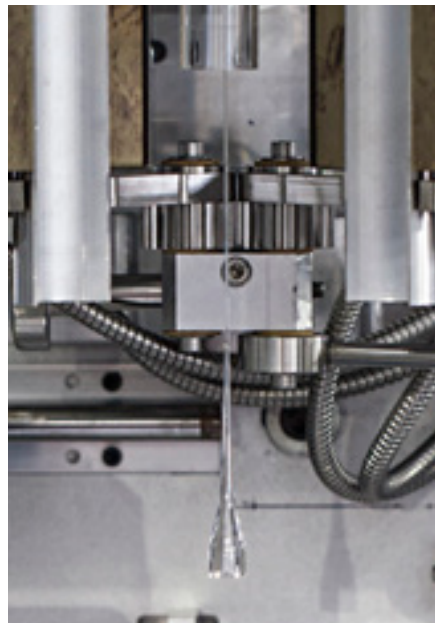
Thorlabs has come a long way since its Photonics West debut. Alex Cable, the man who has overseen the company’s transformation from catalog component distributor to vertically integrated system designer, is not even too sure which year that was, but what he does recall is a 20x30 foot booth. This year, the company will host one of the largest booths in the Moscone (visit #1101 and #1301 in the South Hall), with its now-familiar open-plan design hosting numerous live science experiments using Thorlabs kit.

Anybody wanting to meet Cable should head straight to it. “Booth time is very important,” he says, adding that he makes a point of not scheduling lots of meetings. That inevitably means lots of unprompted, random meetings with existing and potential collaborators — whether it be established customers or new graduate students — but that’s just fine. “Untold opportunities come out of that,” says the Thorlabs chief.

But the main attraction remains the exhibition’s focus on that middle ground, the space between academia and industry. “Photonics West gives us direct contact with the more industry-minded elements of the photonics community,” says Cable. “We see it as a great way to communicate with those translating technology into products. It’s the number-one show for Thorlabs.”

And as the Photonics West event has adapted over the years to reflect the evolution of photonics to a more applied and commercial environment, so the company has evolved too. Cable is keen to emphasize how one-fifth of the company’s annual revenues — which, as of 2014, totalled \$300 million — are consistently generated by products that are less than two years old.

“That represents the rapid rate of in-



Thorlabs has reinvested a large chunk of its profits into manufacturing infrastructure like this fiber drawing facility. Credit: Thorlabs.

novation required in photonics to stay relevant,” he says. “Thorlabs has maintained this ratio for several years.” It’s a strategy that appears to have served the company very well. That \$300 million revenue figure has swelled from only \$50 million a decade ago, representing a compound annual growth rate north of 15 percent.

Cable is confident of another uptick in revenues to maintain the historical growth rate this year. “It’s looking really good,” he says, predicting that Thorlabs’ sales should reach around \$345 million. “The US economy is looking positive, and China also.” Benefiting from its establishment of a substantial design team in China, rather than simply a low-cost manufacturing center, sales there are growing at an even faster rate and, despite worrying macroeconomic news, he feels Europe is doing OK — aided by increased central spending on innovation projects.

“Our satisfaction comes from seeing the business grow, and it becomes a different business every 18-24 months,” says Cable. One of the keys to that has been the re-investment of near enough all the company’s profits, and with a steady earnings before interest, taxes, depreciation and amortization figure of 20 percent, that means a lot of re-investment.

### Reinvestment in manufacturing

Historically, a lot of that re-investment has gone into manufacturing infrastructure. “I love the manufacturing piece,”



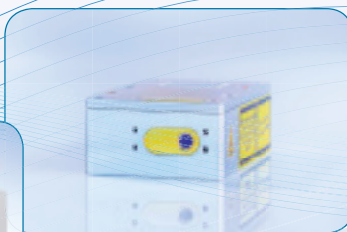
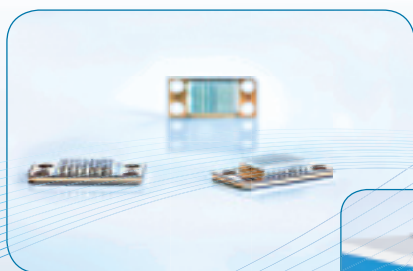
Hands on: Thorlabs chief Alex Cable says that he still spends as much as 30 percent of his time in the laboratory. Credit: Thorlabs.

says Cable, who points out that of the 15,000 products now sold by the firm, more than 93 percent are still made in-house. That includes optical elements in its own glass fab, fabricated from large blocks of fluoride and telluride glass cored at its headquarters facility in Newton. “We want to see photonics technology turned into products that can impact people’s lives. The unusual part is that we’re very driven by the manufacturing side, and we’ve invested heavily in that.”

At the same time, that has enabled a move to vertical integration and the development of products such as high-end optical spectrum analyzers and systems for high-speed optical imaging. “We have gone to the system level, and although we still sell some components for less than a dollar, our most expensive product — a fully-fledged multiphoton imaging system — costs upwards of half a million dollars,” Cable notes.

It’s clear that, despite Thorlabs’ rapid expansion and global footprint, Cable remains very close to the operations of the

continued on page 28



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**Alex Cable**

continued from page 27

business — quite literally in fact. Close to his personal office in Newton is an inventory room housing \$15 million worth of products, while down the corridor is a laboratory focused on optical coherence tomography (OCT). Perhaps uniquely for the owner/executive of a \$300 million photonics company, Cable says that he still spends as much as 30 percent of his time in the lab — and that it gives him a stronger understanding of the customer mindset.

OCT appears something of a pet topic for the CEO. Search through that huge Photonics West conference program and you will find more than half a dozen papers with Cable's name listed among the authors. He has taken a very strong personal interest in the topic over the past 15 years, during which time OCT has emerged from the laboratory to prove itself in a clinical setting and become a billion-dollar industry on its own.

"We have worked with [MIT-based OCT pioneer] Jim Fujimoto for a long time and have a close relationship with the MIT team working on OCT, including a visiting scientist," Cable says. He sees plenty of opportunities for the imaging modality to further grow in importance. Much recent work has focused on cardiovascular imaging applications, but he still sees lots of potential growth in the key area of ophthalmology. One example is the possibility of "whole-eye" imaging that was reported at the Photonics West BIOS Hot Topics event a couple of years ago. That remarkable development was due in no small way to the long-coherence length VCSEL developed by Thorlabs.

"We designed it to be the ideal OCT laser," says Cable, who sees several major application opportunities. One example is in organ transplantation, where OCT



**Semiconductor manufacturing expertise is another string to the Thorlabs bow, and expanded recently with the acquisition of Corning's quantum cascade laser (QCL) business.** Credit: Thorlabs.

could be used to assess a donor organ, and to help monitor the subsequent transplantation process.

**Democratizing the mid-IR**

Another sector that Cable and his team have prioritized is that concerned with the mid-infrared spectrum. Two of the company's key moves have seen the acquisition of significant mid-infrared laser expertise — in the form of Maxion Technologies and, most recently, the quantum cascade laser (QCL) group at glass giant Corning.

"We see mid-infrared technology as an important part of 'real estate,'" Cable told *Show Daily*. "At this stage of my career I can afford to have an ulterior motive, and identify what I see as key technology areas, and have an impact on their adoption."

He also sees some vindication in Thorlabs' mid-IR investments through the recent acquisition of UK firm Cascade Technologies by the industrial processes giant Emerson. "It is very significant, and something that helps to validate Thorlabs' own moves in this segment," he says. "On its own it won't dramatically alter

the landscape but it looks to be a natural consequence of the evolution of the technology, and reinforces the belief that has prompted our own acquisitions."

Existing QC laser designs are, in his words, "ready for prime time," but now begins the hard work of developing instruments for a wider chunk of the technology community. With expertise from QCL chip production through to systems, Thorlabs intends to sell "all of the above" when it comes to QCL technology — a strategy essentially driven by the needs of its customers. And one key requirement is to reduce the cost of mid-IR technology.

"What's needed is a better manufacturing infrastructure," Cable says. "There is a significant premium on the mid-IR at the moment, so it is priced out of many applications. My intention is to 'democratize' the mid-IR, and to fulfil needs of customers beyond simply selling components for 'hero' experiments."

That somewhat philosophical standpoint is reflected in some of Thorlabs' other initiatives. One is its patron spon-

sorship of the International Year of Light (IYL). "It's an effort that allows us to give something back to the photonics community, and to the cities in which Thorlabs operates," says Cable. "We see that as our responsibility." One of the outcomes that he is hoping to witness is a change in the level of appreciation of photonics — a word that was itself shelved by the United Nations as "jargon" before it gave the IYL its stamp of approval.

"A tangible result would be to see a more general comprehension of what photonics is, and the impact that it has had, as well as the potential impact it could have in the future — from medicine to fundamental physics," says Cable.

His feeling, like many, is that we live in a wider culture that, despite its apparently insatiable demand for new hyper-connected gadgets, doesn't fully appreciate the role of scientists and technologists, and photonics as a part of that. The IYL can be a "coming out" showcase for areas where photonics technology has an impact, he adds.

Thorlabs is also involved in the US National Photonics Initiative (NPI), and one of a group of companies to have pledged \$30 million in support for a multidisciplinary effort on neuroscience in partnership with President Obama's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) project. Though they may not be enormous in scope, Cable believes that the various NPI initiatives provide another way to promote the role played by photonics technology to a wider audience. And that prompts another philosophical reflection. "We all want our lives to have a meaning, and for our kids and other people to understand and appreciate what science can do for our society."

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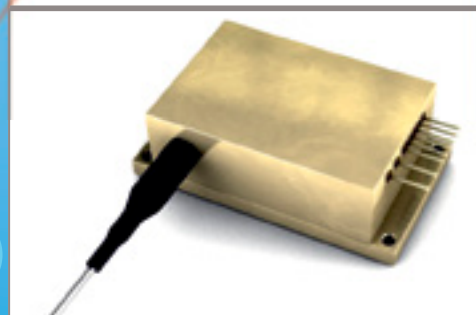
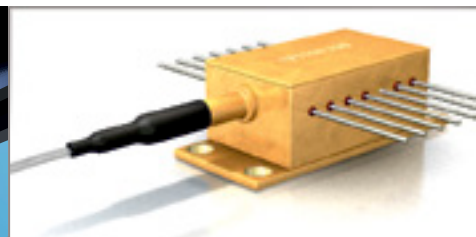
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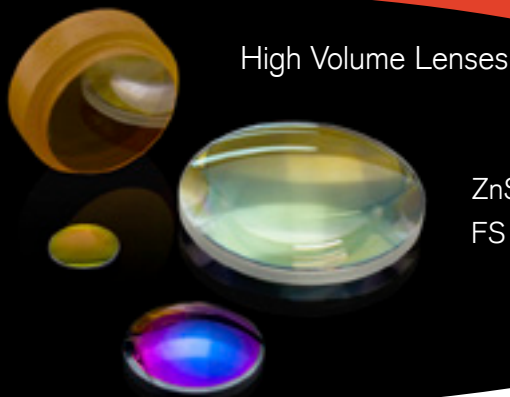
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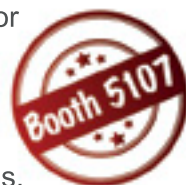
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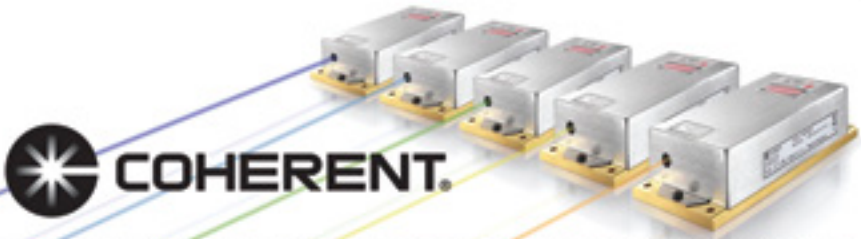
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## Optical MEMS kit will aid crop yields

Egypt-headquartered Photonics West exhibitor Si-Ware Systems has launched an updated generation of its MEMS-based infrared analyzer modules at the show, along with news of an application that is set to help farmers in Africa.

The company won a Prism Award at last year's event for its development of a highly portable Fourier Transform infrared (FT-IR) spectrometer. Now that design has been updated in the first generation of its new — and even smaller — sensor system, branded “NeoSpectra.” Thanks to improved signal-to-noise performance, it is capable of diffuse reflectance as well as transmission measurements.

Though tiny, the MEMS spectrometer offers the same kind of qualitative and quantitative analysis as conventional bench-top FT-IR and Si-Ware is looking to scale up production at its Paris, France, cleanroom later this year to meet expected demand.

Part of that demand will come from

Netherlands-based Dutch Sprouts, for its “SoilCares” initiative. The idea is to use the photonics technology to enable farmers in Africa to directly analyze soil quality *in situ*, and to help improve crop yields in turn. Si-Ware executive VP Scott Smyser told *Show Daily* that the two companies have developed a low-cost soil analyzer about the size of a baseball bat that incorporates the optical MEMS technology.

Farmers simply place the instrument, which has an optical window similar in size to a quarter-dollar coin, on top of their soil to check levels of a number of key variables like fertilizer levels and moisture content. Previous Dutch Sprouts initiatives have used mobile laboratories to provide the same information, but the new tool will put the technolo-

gy into the hands of the farmers directly.

The core design features alignment-free optics, using a lithography process to define the key optical features on the MEMS chip. The analyzer module can be supplied with three different wavelength ranges, one of which extends



Hand-held FT-IR: Si-Ware's tiny spectrometer is set to help farmers improve their crop yields. Credit: Si-Ware Systems.

to 2.6 microns thanks to a separate In-GaAs detector. Key trade-offs such as wavelength precision can be customized according to customer requirements, adds Si-Ware.

Smyser says that the company has plans to extend the wavelength range dramatically in the future, by using different detectors to access molecular fingerprints in the mid-infrared spectral range. In the meantime, the company is working on a next-generation design that will incorporate a light source, with schematic plans on view at its Photonics West exhibit.

Si-Ware is working closely with foundry partners in anticipation of a serious ramp in production in 2016, with customers in the pharmaceuticals, oil and gas, and non-invasive medical sectors evaluating the technology.

*Si-Ware Systems is at booth 4640 in North Hall D.*

## Fiber probes illuminate optogenetics

Capitalizing on the recent surge in demand for optogenetics technologies, Italian start-up Optogenix, spun out of the Istituto Italiano di Tecnologia in Lecce last year, presented its range of light-delivery probes for neurophotonics at the BIOS Expo.

In essence, these are adapted optical fibers, tapered to minimize tissue damage for *in vivo* applications. Some are masked with gold, to precisely deliver

narrow beams of light to specific tissues including neurons.

The company is selling two distinct types of probe. The first, called Lambda-B fibers, are designed for single- and multi-wavelength illumination of large brain volumes “with enhanced homogeneity in comparison to standard fibers.” The second type are side-emitting Sigma fibers, allowing lateral illumination of localized sub-regions.

Ferruccio Pisanello, CTO and co-founder, told *Show Daily*, “We have developed devices for delivering light into the living brain with low-invasive tapered fibers. The tapered fiber allows for uniform light delivery onto an area less than 1 mm<sup>2</sup>. Certain optogenetics applications require a very fine point of light for cell activation.

“We also coat the tip with a mask, such as gold of a few hundred nanometers

thickness, which enables us to create a small hole to limit the light output to a fine point. This also allows us to control the output angle by changing the coupling angle from the fiber into the tapered probe.”

These probes have already been used in neurophotonics experiments on mice, to analyze and control behaviors including panic attacks, epilepsy and dopamine release. Pisanello said he believes that human testing with such systems is probably at least five years away.



UK firm Laser Quantum showed off its octave-spanning, sub-5 femtosecond Vanteon “ultra” laser at the weekend's BIOS Expo. Visit the company at booth 417. Credit: Trish Tunney.

## How to map and fix the brain

Neuroscientist Ed Boyden from the Massachusetts Institute of Technology (MIT) Media Lab used his Saturday afternoon BIOS keynote on the subject of optogenetics to distill the subject down to one simple tag line: “mapping and fixing the brain.”

He told the conference: “At MIT, we are developing technologies that enable the systematic mapping and engineering of the brain and the computations that it performs. We are using optogenetic techniques to enable the analysis of the molecular and anatomical components of the brain, the measurement and control of its high-speed dynamics, and working to understand the mechanisms of repair and rebuilding brain structure and function.”

Boyden described the benefits and functioning of an important group of proteins, called channelrhodopsins, which enable light of certain wavelengths to control various cellular processes. That

phenomenon could potentially be used to treat a wide range of human medical conditions, including blindness and Alzheimer's disease. Channelrhodopsin proteins have been cloned from algae.

He added, “Ultimately we are hoping to create neurotechnologies that enable the correction of brain disorders that affect over a billion people worldwide, and to provide insights into how the brain generates thoughts and feelings, essential to understanding the human condition.”

Although key projects have so far been developed and trialed with rodents and, in some cases, primates, human trials and applications are expected in the medium term. Asked which branches of medicine presented the most likely application, Boyden said that he knew of at least three companies already looking at treating blindness.

MATTHEW PEACH



# OPTO plenary speakers highlight materials science advances

Advances in silicon photonics, ultrafast coherent charge transfers, and tunable metamaterials are paving the way for new commercial applications, from organic solar cells and artificial light-harvesting systems to telecom/datacom and sensing, according to Monday morning's OPTO plenary speakers.

One of the hottest topics at this year's Photonics West is silicon photonics, and the OPTO plenary session featured a pioneer in this field: Yuri Vlasov, manager of the Silicon Nanophotonics Project at IBM



**Yuri Vlasov.** Credit: Adam Resnick

Watson Research Center. For more than a decade, IBM has been developing silicon nanophotonics designed to yield smaller, less expensive chips for short- and long-haul networks that overcome emerging bottleneck issues in big data centers.

"Why is silicon photonics so popular?" Vlasov said. "There is not only interest from academia, but industry as well. Some \$1.5 billion has been invested in the development of silicon photonics in the last decade, in large part because consumer electronics are all going to the cloud, and data centers are forming the backbone of our society today."

But there are limits to how much longer current computing technologies — namely, copper interconnects — can support these mounting data demands, especially in terms of energy efficiency, bandwidth, and transmission speeds.

This is where silicon photonics comes in. These devices integrate photonic and electronic components — including transistors, waveguides, optical couplers, modulators, photodetectors, and CMOS circuits — on a silicon-based platform. This yields a low-cost optical component with nearly infinite bandwidth, reduced power consumption, more embedded functionalities, and better reliability and scalability.

In 2010, IBM unveiled its CMOS-integrated silicon nanophotonics technology, and in 2012 introduced its first device: a 90-nm 25 Gbps silicon nanophotonics module seen as a building block for a new

generation of fiber systems initially transmitting 100 Gbps (25 Gbps/channel) over single-mode fiber.

"What we are working on, as are most companies coming into this market now, is optical communications in the data center, either optical cables or transceivers," Vlasov said. "What is important is a small form factor, low power operation, and, most important, cost. The volumes are small, the cost is large, but the premium is high enough that you can survive and build a good business."

## Coherent charge transfers

Just as silicon photonics is poised to help satisfy our growing data demands, optical technologies are shedding new light on renewable energy sources that can help meet the world's energy needs.

The efficient conversion of light and sunlight into energy is a fundamental challenge in current energy research. Building artificial molecular or nanostructured devices that can harvest and exploit light requires an in-depth understanding of the microscopic principles of the underlying light conversion process, according to Christoph Lienau of University of Oldenburg in his talk on ultrafast coherent femtosecond spectroscopy and first-principles quantum dynamics simulations to explore the primary photo-induced electronic charge transfer in two structures: a carotene-porphyrin-fullerene triad (an elementary component of an artificial light harvesting system) and a polymer/fullerene blend as a model for an organic solar cell.



**Harry Atwater.** Credit: Adam Resnick

"Such ultrafast spectroscopic studies provide direct insight into the fundamental phenomena that initiate the organic photovoltaic process," Lienau said. "They turn out to be very similar to the strategies developed by nature in photosynthesis."

Recent studies indicate that quantum coherence plays an important role in this, he added. For example, he and colleagues demonstrated that the quantum-mechanical, wavelike nature of electrons and their

coupling to the nuclei is key to the charge transfer in an organic photovoltaic device.

"When we used extremely short, femtosecond light pulses to illuminate the polymer layer in an organic cell, we found that the light pulses induced oscillatory, vibrational motion of the polymer molecules," Lienau said. "Unexpectedly, we saw that also the fullerene molecules all started to vibrate synchronously. We could not understand this without assuming that the electronic wave packets excited by the light pulses would coherently oscillate back and forth between the polymer and the fullerene."

A series of quantum dynamics simulations revealed that the evolution of the electronic cloud and the atomic nuclei in this system were responsible for the oscillations. These results provide evidence for similar phenomena in functional artificial photovoltaic devices — a conceptual advancement that could be used to guide the design of future artificial light-harvesting systems.

## Metamaterials and metasurfaces

Progress in understanding resonant sub-wavelength structures has fueled interest in nanophotonic devices, according to the third OPTO plenary speaker: Harry Atwater, a pioneer in surface plasmon photonics credited with coining the term "plasmonics."

Atwater, a professor of applied physics at California Institute of Technology (CalTech), and his team have made great strides in understanding plasmonic metamaterials — assemblies that contain features, patterns, or elements that enable an unprecedented control of light — and the fundamental physics behind them.

"We have demonstrated the possibility of making active, tunable metamaterials that are taking an interesting new direction in the form of metasurfaces (extremely thin films of metamaterials)," Atwater said.

Metamaterials are artificial materials designed with specific unit cell configurations and/or geometric structures. They can be engineered to achieve new properties, such as special values of permittivity and permeability. Metasurfaces have recently attracted attention because of their easy fabrication, relatively low effective surface refractive index loss, and compact size of traditional bulk metamaterials.

"Over the last five years, there has been a ferocious initiative by the optics community to develop metamaterials consisting of resonant subwavelength objects that allow



**Christoph Lienau.** Credit: Adam Resnick

one to achieve materials that have effective permittivity unlike those of natural materials," Atwater said. "It's an exciting enterprise, and one of the features that has surfaced was the challenge of making truly 3D materials that have these embedded resonant sub-wavelength objects."

"But we are seeing opportunities to employ many of the same ideas about these objects in 2D structures — metasurfaces that can be fabricated using nanolithographic machines. And this has manifested itself in an explosion of effort to make arrays of subwavelength antennas using nanophotonic structures."

Flat planar lithographically patterned structures that incorporate sensors and phased-array elements may be usable in a variety of structures where optics and electronics intersect, he added. Potential applications for metamaterials include advanced solar cells, computers, telecommunications, sensors, and microscopes.

KATHY KINCADE

## PHOTONICS WEST SHOW DAILY

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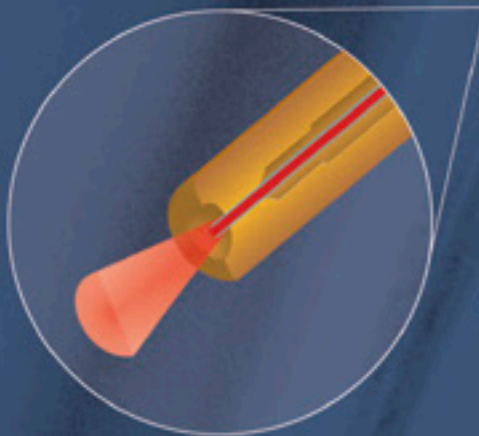
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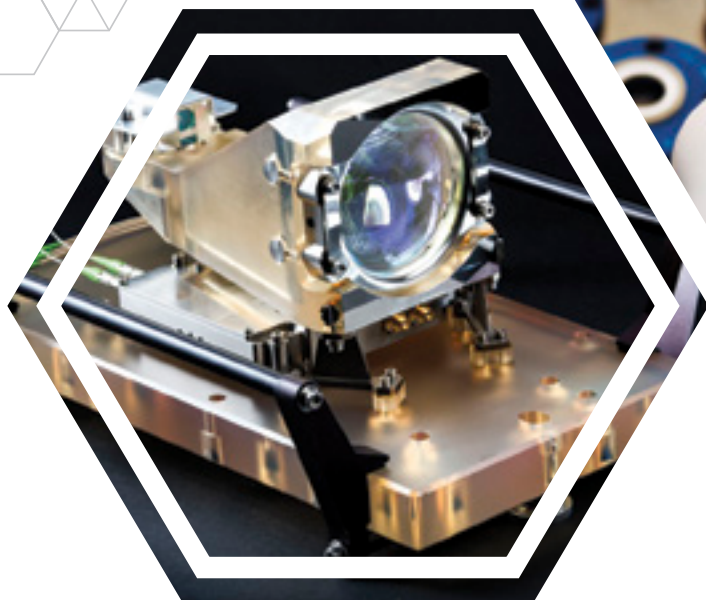
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