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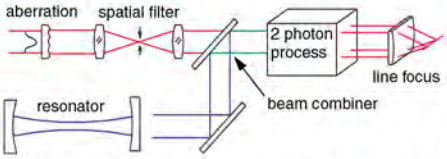

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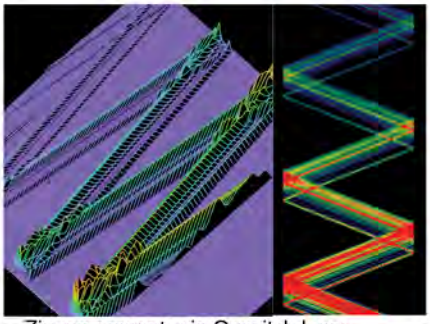
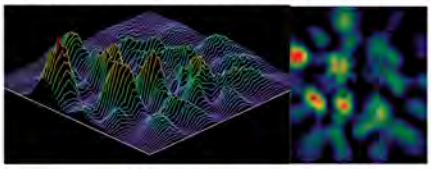
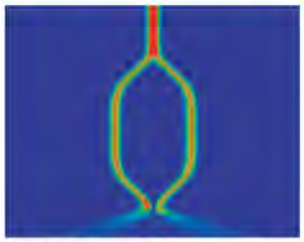


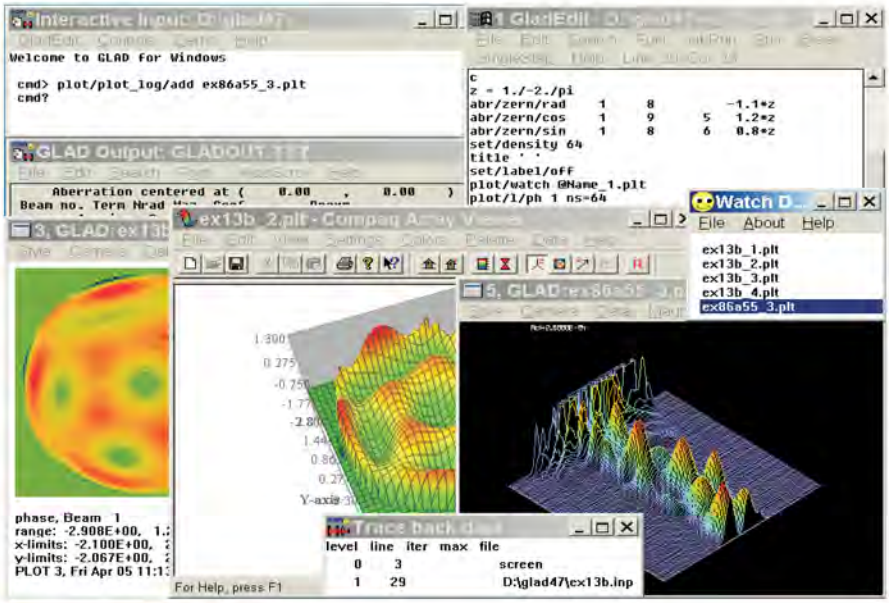
Zigzag resonator in Q-switch laser showing amplification from top to bottom and self-interference at side mirrors.



Transient Q-switch laser mode at 2ns



Photonic switch in the *off* position



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SPIE Professional
Volume 10, Number 3 (ISSN 1817-4035)

Features

Send returns and materials to SPIE Professional,
P.O. Box 10, Bellingham, WA 98227-0010 USA.

SPIE. Professional

The Member Magazine of SPIE
spie.org/spieprofessional

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Volume 10, Number 3 SPIE Professional (ISSN 1817-4035) is published quarterly by SPIE, 1000 20th St., Bellingham, WA 98225-6705 USA.

SPIE.

Send returns and materials to SPIE Professional, P.O. Box 10, Bellingham, WA 98227-0010 USA.

Celebrating international collaboration for optics and photonics technologies

Scientific societies such as SPIE play an important role in bringing together international collaborators from academia, government labs, and industry to advance science, improve people's lives, impact policy and funding, and drive healthy economies. Examples abound in telecommunications, healthcare, security, manufacturing, education, energy, and sustainable development.

Beyond our own technical and business community, professional societies also have a role in communicating with political leaders, educators, and the general public about the impact of the technologies being developed by our constituents.

As a founding partner of the UN-decreed International Year of Light and Light-based Technologies (IYL), SPIE is delighted play a key role in ongoing celebrations that are providing wonderful visibility of the impact of optics and photonics technologies in the daily lives of millions of people around the world.

As SPIE's president, I have had the pleasure of speaking at many IYL events and I hope you have been able to participate in some way too, perhaps even voting in the People's Choice Award in the SPIE IYL photo contest. I congratulate the winners and all the finalists who submitted captivating images to the contest.

Throughout the remainder of the year, SPIE will continue to support the IYL with information and resources, and celebrations at our meetings.

In addition to such global initiatives, SPIE is committed to providing exceptional value to our members. Our publishing services provide the community with the most current technical information; our conferences and other events are opportunities for creating visibility for your work and for networking; and members receive business-relevant data through our industry activities.

VOLUNTEERS ARE KEY TO SUCCESS

SPIE serves the global community, and our volunteer leaders are a key factor in our ability to do this at a world-class level.

This year SPIE is celebrating its 60th anniversary. Over the last six decades, thousands of SPIE members have contributed to the Society, helping create the internationally recognized organization that we are today.

Volunteers are critical to the success of any professional society, and I extend my sincere appreciation to those who have contributed their time, energy, and enthusiasm to SPIE.

Many now in leadership positions got their start by giving a talk, writing a journal paper, or by participating in an exhibition. Later, they may have served on a conference committee, chaired a conference session, or volunteered on an SPIE policy or leadership committee.

The public policy and advocacy work that SPIE does on behalf of the optics and photonics industry has clearly made a difference in increasing public awareness of photonics and the funding that comes along with that visibility. The activities of our members involved with the National Photonics Initiative in the US and Photonics21 in the European Union is a good example of how volunteers can make those efforts effective. Other countries like Japan take note of how these public policy activities are expanding the influence of such efforts.

There are many opportunities available to SPIE members to help advance the society and our industry. These opportunities can offer valuable professional development experience at the same time, contributing to career advancement.

As Christopher Wilcox explains on page 18, there are numerous benefits to becoming more involved with SPIE, even — or maybe especially — as an early career professional. Chairing a conference session and other volunteer activities build knowledge about the Society and can position individuals for future leadership opportunities such as serving on the Board of Directors and even being president.

CHOOSING OUR FUTURE LEADERS

As for my own path to becoming president, I joined SPIE in 1983 and served in various roles including being a member of the SPIE Nominating and Awards Committees prior to being elected to the board of directors.

After I was elected to the position of vice president in 2013, I joined the presidential succession chain by becoming president-elect in 2014 and president in January 2015.

My thanks to all of you who voted for me in that election.

Now I encourage you to vote for our future president. A list of candidates for election to the SPIE Board of Directors is on page 9. I encourage each of you to take a few minutes and vote to choose the future leaders of the Society.

Voting is both a privilege and a right of membership, and I encourage you to use your vote.

I will announce the election results on 11 August at the SPIE Annual Meeting during Optics+Photonics in San Diego. ■

Toyohiko Yatagai
2015 SPIE President

Volunteer with SPIE

You can help positively transform the world by partnering with SPIE in a volunteer role.

As a membership society, SPIE relies on volunteers who ultimately support researchers and engineers in developing solutions for the world's challenges.

Hundreds of individuals volunteer their time and talents in a variety of roles, influencing and shaping the Society to meet the needs of its members and constituents.

Volunteering opportunities exist in all areas including leadership and governance, meetings, publications, committees, education, student-related activities, and awards.

Consider SPIE volunteerism as an avenue to enhance your professional experience. It's a rewarding way to give back to your community. Find out how volunteering with SPIE can advance your career at SPIE Optics+Photonics. A special session on this topic will be held at 1 pm Tuesday, 11 August.

Measuring photonics' impact: It matters

HOW ONE INDUSTRY ASSOCIATION PUT NEW MEXICO ON THE MAP

By **Lynore Abbott**

There is a truism in politics and business: You get what you measure. Universities measure published papers. Businesses measure sales revenues and profits. Politicians measure voter sentiments, jobs, and tax revenues.

Herein lies the problem: *You get what you measure.*

Without a more exacting definition of what one measures, then by human nature, we create more of what we are being measured against, often degrading quality of the product. More papers will be published, but they may not be all high quality or scientifically relevant. More revenues may be collected, but they may result in more environmental waste. More jobs may be created but they may not be high paying.

Herein lies the opportunity: As an industry, we can determine definitions of quality, of "goodness," and future economic impact and add that definition to the simple metric of jobs, revenues, and intellectual property. As an industry, we can help politicians see the significant impact of photonics – which creates life-saving technologies, cleaner products and manufacturing methods, and higher-paying jobs.

If you feel your government representatives do not care about your industry, it is because you have not yet made them care.

Your opportunity is to lead locally and make them care.

GETTING POLICY MAKERS TO CARE

Photonics21 in Europe is a good example. The European photonics technology platform was founded in 2005 and quickly began representing the interests of the photonics community by publishing its research agendas and documenting the growth of the industry's revenues, jobs, and impact on society.

Within four years, the European Commission had identified photonics as one of only six Key Enabling Technologies that play a major role in Europe's economic growth and employment. Now, 10 years later, a photonics public-private partnership is set to invest 3.5 billion euros through the Horizon 2020 program to increase Europe's share of the global photonics market.

The Colorado Photonics Industry Association (CPIA) in the United States measured the photonics impact on the state of Colorado in 1997 and in 2007. CPIA demonstrated company growth, job growth, and salary growth in just 10 years.

SPIE, on behalf of its membership, has launched a worldwide study of the photonics industry, with regular updates at photonics industry events. This data, along with support for the National Photonics Initiative, contributed to the November 2014 announcement that the US will create a public-private partnership for an Integrated Photonics Institute for Manufacturing Innovation (IP-IMI).

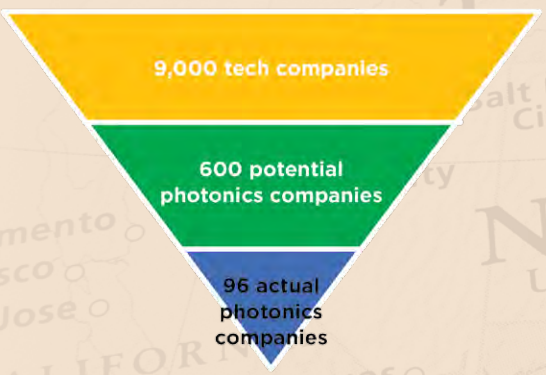
Measurement of specific jobs and specific economic benefits has led to incremental policy, taxation, and curriculum changes. We get what we measure.

What more could we get if we measured more carefully, more specifically, or more locally?

PUTTING NEW MEXICO ON THE MAP

We took on the challenge in New Mexico, a US state made famous simply because many people did not know where it was. Selected to provide critical research and testing sites for the Manhattan Project during World War II because it seemed the best place to conceal the work of the most well-known physicists in the world, its reputation of being largely unknown continues to haunt the work of many a New Mexican technologist.

Due in part to the historical secrecy of the work conducted in the state and the technological complexity of the work, even the average New Mexican does not understand what is developed, built, or discovered at the state's various research facilities, companies, universities, and laboratories.



A study in New Mexico found that 96 of the 9000 technology companies in the state make optics and photonics products, technologies, or services.

Facts about photonics

SPIE formed a team in 2012 to analyze and quantify the impact of photonics in the global market.

In the April 2015 issue of *SPIE Professional*, Stephen G. Anderson, industry and market strategist for SPIE, explained the methodology used to provide periodic reports on the photonics industry.

The SPIE team has created sales, production, and employment profiles of various sectors and will release more information at SPIE Optics+Photonics in August. Thus far, the team has found:

- The 2750 companies producing core photonics components generate $156 billion in annual revenues and employ 700,000 people.
- The 1008 component manufacturing companies exhibiting at SPIE Photonics West in 2012 generated global sales of $84 billion and employed 335,000 individuals.
- The 570 defense and security companies that produce optics and photonics goods and services around the globe generated $216 billion in sales in 2014 and provided 560,000 jobs.
- The biophotonics-enabled marketplace accounted for $91 billion in annual revenues in 2012 and employed 281,000 people at 269 companies.

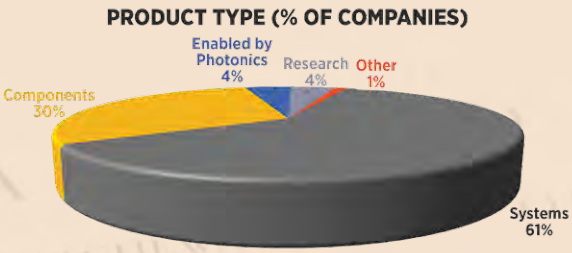
For more information, go to **spie.org/industry**

In February 2015, the New Mexico Optics Industry Association (nmOptics) completed its efforts to identify potential photonics companies, survey the companies to increase the accuracy of the data, provide insights on increasing growth, and analyze the patent database for intellectual property segmentation.

This study, which you can download at nmoptics.org, found:

- 96 firms with optics and photonics products, technologies, or services comprise 6% of all manufacturing companies, produce 8% of the state's manufacturing revenues, and employ 21% of the manufacturing workforce
- 33% of the 1596 US patents assigned to entities in the state are photonics related
- 61% of the optics and photonics firms develop or manufacture complete systems (versus component suppliers)

PHOTONICS DATA DRIVES INVESTMENT



Nearly one third of the photonics companies in New Mexico are component suppliers, while 61% develop or manufacture systems.

Armed with this concrete data, the photonics community within the state has been able to garner support at the highest levels.

The state's pledge of funding support for an IP-IMI facility, for instance, was helpful in the University of New Mexico and University of Southern California consortium being listed as one of three finalists.

Gov. Susana Martinez, in her letter of support for the IP-IMI, stated: "Accelerating the development of a robust photonics capability in New Mexico in the face of a photonics technology revolution is of great importance to New Mexico's economic future. ... New Mexico already boasts significant technological, physical, capital, and human resources, and we believe further public and private investment in the strategies presented in this proposal will yield a high return on investments in job growth and global economic competitiveness."

"Accelerating the development of a robust photonics capability in New Mexico in the face of a photonics technology revolution is of great importance to New Mexico's economic future."

Photonics also has been incorporated into the NM Science and Technology Plan with funding to accelerate the growth of photonics technologies within the state.

Patricia Knighten, manager of the Office of Science and Technology at the NM Economic Development Department, said her office has embraced photonics/optics as a priority focus in the state Science and Technology Plan. "The department has already secured funds for an innovation and commercialization pilot program focused on New Mexico photonics companies," she said.

In addition, Knighten notes that nmOptics and the Office of Science and Technology will develop strategies to build on this program and "to fast track the development of a vibrant statewide photonics industry cluster." Already:

- State officials are promoting photonics during international trade missions.
- Cooperative funding is helping companies exhibit at international trade shows.
- Photonics-related firms and technologies are being recruited to locate subsidiaries or manufacturing facilities within New Mexico.

Exciting developments happen when there is credible data to support a thesis. Our industrial and political leaders are determined to put New Mexico and its photonics industry on the map, at home and abroad.

PHOTONICS LEARNING CURVE

The full report, *Photonics in New Mexico: Diverse Industry Poised for Growth*, was made possible by sponsorship from SPIE, the NM Manufacturing Extension Partnership (MEP), the city of Albuquerque, and nmOptics. Many people helped nmOptics with the research and analysis by working with us to develop a statistically significant and rigorous process, connecting the researchers to corporate leaders willing to answer proprietary questions, and offering guidance from prior experience.

What we learned developing these datasets, networks, and processes can be shared with other industry associations. In fact, as we were finalizing the report, other associations began calling us to learn how we did it, how much time it took, how much it cost, and other items "good to know" before starting their own analysis.

Here are some important things we learned.

Continued on page 7 ▶

Purpose of the NM study

The primary purpose of the New Mexico study was to quantify the economic impact of photonics activity in the state and give policy makers and industry leaders insights into how the industry might grow.

This included collecting information on 9000 technology companies, six universities and colleges, federal labs in the state, and more than 1500 patents assigned to entities in New Mexico. The data were then analyzed to answer several questions, including:

- **Who are the companies in New Mexico that manufacture photonics, incorporate photonics in their products, or utilize photonics in the production of their own products?**
- **Where are these companies located?**
- **What product and market expertise do these companies have?**
- **Which companies are the revenue drivers?**
- **Which photonics companies are the major employers?**

Get updated *SPIE Professional* content online

Although *SPIE Professional* is only printed quarterly, we often create, supplement, and update article content online in between issues.

The full interview with Wolfgang Boch, for instance, was published as a web-only article in the April 2015 online edition of *SPIE Professional*.

Read *SPIE Professional* online at **spie.org/SPIEProfessional**.

European photonics in good shape

Interview with Wolfgang Boch, head of the EC Photonics Unit

Wolfgang Boch, head of the European Commission's (EC) Photonics Unit, is optimistic that the photonics industry in Europe, focused on industrial needs, jobs, and societal challenges, will remain vibrant and vital to Europe's competitiveness.

With the significant investment in photonics via a new public-private partnership (PPP) initiative, part of Europe's seven-year Horizon 2020 innovation effort, and new leadership at the EC since November 2014, Boch says he sees a reinvigoration of support for the photonics community in Europe.

The EC has committed €700 million to meet the photonics PPP objectives, with the private sector pledging four times that amount to make a total investment of €3.5 billion. The purpose of the PPP is to use photonics to create economic growth and jobs in Europe and to create innovative solutions for some the key societal challenges.

"Horizon 2020 places a lot of emphasis on innovation, which means that research and development actions need to be complemented by innovation actions which target activities closer to the market and higher technology readiness levels," Boch says. "Our toolkit of funding instruments has been extended to support these innovation activities."

For instance, the EC is demanding that industry partners put more substantiated business cases forward when applying for funding, Boch says. Firms looking for funding must establish the market opportunities and the path to commercialization of new products and services. Only where the mission is clear will the EC support those activities with appropriate funding.

Overall, the photonics industry is currently in "a good state," Boch says, but needs special attention and further support.

"This is not a contradiction," he says. "It is about investing public money in a vibrant and vital sector, which has a high potential for creating growth and jobs."

PHOTONICS COORDINATION

After being on the job for more than a year, Boch says he feels that a good level of coordination and network of companies and organizations has been established, helping new business ecosystems form across the continent. "This enables coordinated working together on jointly agreed research projects in ways that are more efficient and more effective," he said.

"This is good for all the [players] in this sector, which has been previously rather fragmented, from SMEs to large industry and from universities to research organizations. Photonics21 has played a key role in this and now the photonics PPP will bring this collaboration of the public and private sector to the next level."

> In Europe, the photonics sector is considered to be agile and successful at discovering new opportunities across a vast range of applications and markets.

In Europe, the photonics sector is considered to be agile and successful at discovering new opportunities across a vast range of applications and markets. A good example is laser-based manufacturing. Europe has about half the global market, but this area still requires continuous development to keep pace with the new concepts of highly networked manufacturing processes and ever-increasing digitization.

Boch also sees major opportunities in the medical sector. "Other strong European photonics areas are in optical communications and in biophotonics," he said.

"Exploiting biophotonics offers huge opportunities, for example in terms of early detection of diseases such as cancer or performing blood-sample analysis with lab-on-chip solutions at the patient's bedside with instant results. So there are still major market opportunities ahead of us."

Boch, who replaced Thomas Skordas as head of the Photonics Unit, gave a wide-ranging interview to the Show Daily, an SPIE publication distributed at SPIE Photonics West in February.

To read more about what Boch has to say about photonics in Europe, see the full interview, reprinted in *SPIE Professional* at **spie.org/ECboch**. ■

MEASURING PHOTONICS' IMPACT

◀ *Continued from page 5*

FINANCIAL SUPPORT IS CRITICAL

Our discovery and negotiation period, from the initial inquiries to "explain" photonics to our actual kickoff date, took nine months. This time was well spent as we were able to garner attention for the study, interest in the final results, and participation from economic leadership.

The economic development leadership helped connect us to NM's Bureau of Business and Economic Research, company management willing to share proprietary data, and to site leaders at the larger companies.

INCOMPLETE DATA IS OK

We had to accept that the data would not be perfect or complete.

For example, photonics is not part of a single economic indicator code, including the North American Industry Classification System (NAICS) of codes. The lack of reliable data and the difficulty of investigating companies will drive an engineer crazy. Act as if you are in marketing instead.

Our initial dataset of potential companies to investigate suffered from a number of concerns that you will no doubt face as well:

- Over sampling will consume time (and money) to filter out the non-photonic companies.
- Under sampling will compromise the credibility of your study.
- Companies evolve but do not update their "codes."
- Companies can choose to be unlisted in marketing databases such as Hoover's, a subsidiary of Dun and Bradstreet.
- Marketing databases take time to catch up to actual listings of new companies and defunct companies.
- Individuals will choose to not participate (protecting corporate decision makers from your research team).
- Companies who do not see immediate value in the study will choose not to participate and "wait and see" what is done with the data.

As the data gets better, the results are published, and the impact is made more broadly known, the data will get better and even the old data can be corrected.

Marketing types like to call this "directionally correct." Follow their lead on this.

BUILD CREDIBILITY AND TRUST

nmOptics created a website for the project. As more people participated, they improved the quality of the dataset, added companies we had not been able to find, and created connections to decision makers we did not yet have.

The website enabled potential participants to see how we were managing the proprietary data. They could see how the project was shaping up and provided information so we all could get better data.

COMMUNICATE THE RESULTS

Getting the data is only half the battle. Getting the data in front of the right decision makers is the other half.

nmOptics provided the report, key personnel, and interview time to the local business press, congressional delegations, and state and county legislators.

We have also been promoting our study in trade journals, SPIE cluster events, and other technology networking affairs.

BENEFITS TO NEW MEXICO

The leveraging power of this data is that it can lead to changes in school curriculum, encourage business leaders to learn about local resources, and raise the awareness of legislators before they establish policies and regulations.

Since the publication of our report, New Mexico's economic development leadership has incorporated photonics into the state's Science and Technology Plan, added photonics to its list of trade-mission technologies, and is actively seeking to recruit more photonics companies to the state.

Companies involved in photonics within the state of New Mexico have been excited to learn how large the industry is. They are keen to expand their networks and find new collaborations and new ways of working together. There are also discussions on how to pool resources.

These are all benefits of knowing who else is working in their technology area in the state.

BOTTOM LINE FOR PHOTONICS

The end result for you and the photonics companies in your region?

You get more of what you measure. Data drives development, investment, and change.

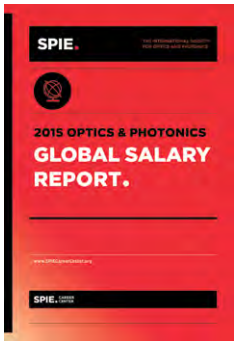
Get the data that supports where you and your region need to go. Shine the light on photonics.

For more information on measuring the impact of photonics and links to references used in this article, read *SPIE Professional* online: **spie.org/SPIEPro**. ■

–SPIE member Lynore M. Abbott is founder of Logical Marketing and vice president of the New Mexico Optics Industry Association (nmOptics). She has more than 20 years' experience developing and launching new products for companies such as CVI Laser, Southampton Photonics, and Polaroid. Abbott has an SB in material science and engineering from Massachusetts Institute of Technology; an executive MBA from University of New Mexico; and an MS in polymer science and engineering from University of Massachusetts, Amherst. She is an active member of the SPIE Corporate and Exhibitor Committee and the SPIE team conducting an ongoing analysis of the photonics business.

Global salary survey shows gender, regional disparities

Salaries in optics and photonics are rising fastest in China, and while median salaries for women overall continue to lag those of men, the gap is closing for those with 15 or fewer years of employment, according to findings in the latest *SPIE Optics & Photonics Global Salary Report*.



The report, which is being mailed to SPIE members with this issue of *SPIE Professional*, also found that workers in all sectors of the industry report high levels of satisfaction with their jobs. For-profit respondents rate team success as their priority, while academic and government respondents say scientific discovery gives them the most satisfaction.

Results from the 2015 survey are based on nearly 6000 validated responses from 100 countries. Women make up 16% of the respondents, roughly mirroring their representation in SPIE membership and at SPIE meetings.

Among key findings:

- The median salary reported by survey respondents is US$64,000, down from last year's US$73,000, primarily reflecting large declines of the euro and yen against the dollar. Salary levels vary widely and are mostly driven by country income level and employer type.
- Salaries paid in Chinese yuan have risen by 33% since 2012 versus 5% increases in euro, dollar, and yen earnings.
- The highest-paid discipline continues to be aerospace, with a median income of US$105,433. Workers in the semiconductor industry were the next highest paid, with a median salary of $88,838.
- Some 55% of workers in lower-income Asian countries expect a raise of 10% or greater in 2015. Only 10% of higher-income Europeans and 11% of North Americans expect raises of that size.
- Workers in industry report higher salaries than those in government or academia.
- Median salaries are highest in the United States ($113,000), followed closely by Switzerland ($104,523).
- Median salaries are 41% higher overall for men than for women, with the largest wage gap attributable to those with more than 15 years of employment. For those with fewer than five years, the wage gap is 8%. In some positions such as academic deans or provosts and directors, women's salaries exceed those of men.
- Women respondents to the survey are younger, with 40% of female respondents under 36 years of age versus 27% of men, suggesting an increase in the number of women entering careers in optics and photonics than in past years.
- Survey respondents are highly satisfied with their jobs overall: 85% enjoy their work, 86% find their work meaningful, and 90% respect the work of their peers.

SPIE CEO Eugene Arthurs said he was encouraged to see so many in the optics and photonics industry anticipate salary jumps in 2015. "I hope these expectations come to pass and that we see better remuneration for the scientists, engineers, and manufacturing professionals who are changing our world," he said.

> Finding solutions to future challenges requires attracting the best and brightest of the next generation to careers in optics and photonics.

REMEDYING GENDER DISPARITY

"While the overall disparity between median salaries for women and men remains discouraging, SPIE is heartened by the narrowing of this disparity among younger professionals and by the continued growth of the percentage of women among our membership and conference participants," Arthurs said.

"SPIE is committed to providing the crucial exposure and networking opportunities that conferences offer for the many brilliant women in our community. Visibility is invaluable, particularly in the early stages of one's career."

Arthurs commended other efforts to help remedy the disparity, such as new European Commission rules about female representation at Digital Agenda (DG Connect) events. (see pages 36.)

Arthurs, who has worked in both academia and industry, echoed the sense of job satisfaction reflected by the survey and encouraged optics and photonics professionals to share that with students, teachers, and parents they meet.

"Members of our community know the rewards of a career that enables one to participate in unlocking the secrets of the brain through work in optogenetics," for example, or discovering a touch-sensitive technology that allows unsighted people to use cellphones.

Finding solutions to future challenges requires attracting the best and brightest of the next generation to careers in optics and photonics, Arthurs said. ■

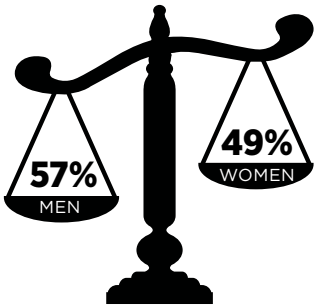
Work week is long for some

Many in optics and photonics work long hours.

According to the SPIE Optics & Photonics Global Salary Report, 37% of workers in higher-income Asian countries reported they work 50 or more hours per week.

Romania had the largest percentage of employees who reported working 55 or more hours per week: 28% said they did.

Job satisfaction



Women and men report similar levels of job satisfaction in all but one area — 57% of men feel that they are paid fairly versus 49% of women.

SPIE 2015 ELECTION.

The following SPIE members are on the ballot for the Society's 2015 election, which is conducted online through 3 August.

SPIE members eligible to vote will select a vice president, a secretary/treasurer, and four new directors for terms beginning 1 January 2016. Officers serve for one year, and directors are elected for three-year terms.

Voting members who have not yet received their ballot instructions should contact staceyC@spie.org.

The candidates for vice president are:

- **Maryellen Giger,** University of Chicago (USA)
- **John Greivenkamp,** University of Arizona (USA)

Videos and more information about the vice-president candidates are available at **spie.org/2015VP**.

The candidate for secretary/treasurer is **Gary Spiegel**, retired, Newport Corp. (USA)

Director candidates are:

- **David Andrews,** University of East Anglia (UK)
- **Jennifer Barton,** University of Arizona (USA)
- **Steve Eglash,** Stanford University (USA)
- **James Fujimoto,** Massachusetts Institute of Technology (USA)
- **Joseph Howard,** NASA, Goddard Space Flight Center (USA)
- **Jay Kumler,** JENOPTIK Optical Systems (USA)
- **Din Ping Tsai,** Academia Sinica (Taiwan)
- **Vasudevan (Vengu) Lakshminarayanan,** University of Waterloo (Canada)

Other officers, previously elected, are SPIE President-Elect Robert Lieberman of Lumoptix (USA), who will become SPIE president in January 2016, and SPIE Vice President Glenn Boreman of University of North Carolina at Charlotte and Plasmonics Inc. (USA), who becomes president-elect next year.

SPIE President Toyohiko Yatagai (Japan), who will become immediate past president in January, will announce the results of the election at the SPIE annual general meeting during SPIE Optics+Photonics in San Diego (USA) 11 August. ■


Giger


Greivenkamp


Spiegel


Andrews


Barton


Eglash


Fujimoto


Howard


Kumler


Tsai


Lakshminarayanan


Lieberman


Boreman


Yatagai

SPIE annual meeting

The annual meeting of the SPIE corporation will be held at 6 pm Tuesday 11 August at the San Diego Marriott Hotel and Marina during SPIE Optics+Photonics.

A members-only reception will follow at 7 pm.

SPIE Gold Medal winner explores world of waves

Nader Engheta receives 2015 SPIE Gold Medal Award

"I am very passionate about the science of light, and I enjoy the thrill of discovery in scientific research," says SPIE Fellow Nader Engheta, recipient of the 2015 SPIE Gold Medal.

The N. Nedwill Ramsey professor of electrical and systems engineering at University of Pennsylvania (USA), Engheta is being recognized as one of the founders of modern electromagnetic metamaterials and a pioneer in the fields of optical metatronics and nanoscale plasmonics.

He has been interested in electrical engineering since he was a boy. Growing up in Tehran, Engheta was fascinated by a battery-operated transistor radio and wondered how it was possible to hear music when the radio was not connected to anything. How could the signal travel from the radio station to the radio without an obvious connection?

This curiosity led him to study electrical engineering at University of Tehran where he pursued his interest in the world of waves through topics such as wave propagation, electromagnetic theory, and solid states.

Engheta attended California Institute of Technology (Caltech) for MS and PhD degrees in electrical engineering. At Caltech, his mentor and advisor was Charles H. Papas, a world-renowned scholar in electromagnetic theory, whose influence led Engheta to study optics and electromagnetics.

Today, fueled by his creativity and passion for science, Engheta and his research group delve into diverse topics at the forefront of optics and microwaves, including nanophotonics; metamaterials; bio-inspired imaging, and microwave and optical antennas.

"Engheta's work has been pushing, and continues to push, the boundaries and frontiers of optical sciences," says Victor G. Veselago of the Russian Academy of Sciences. Engheta has also "truly advanced the optical engineering aspects and the future of optical technology."

METAMATERIALS: BEYOND THE ORDINARY

Metamaterials are structures that have unusual, beyond-the-ordinary effects on waves. (The Greek prefix "meta" means "beyond.") Scientists in this discipline combine physics, engineering, and nanotechnology to develop technologies that can bend and manipulate waves in ways that nature cannot.

Metamaterials are composites of natural materials but are designed to manipulate electromagnetic waves in more complex ways. As multiple manipulations are combined or performed in sequence, metamaterial researchers can change the shape of waves in complex ways.

The shape of objects that a wave interacts with can influence the properties of the wave. Engheta and other metamaterials researchers are designing shapes with features that are smaller than a given wavelength. This has led to the development of super lenses with unprecedented magnification abilities and

cloaking devices that bend waves around an object, making it invisible.

"Nature has given us a lot of materials," Engheta says. "The whole periodic table and all of the combinations of its elements are all made out of atoms and molecules. Natural materials have chemical, electromagnetic, and optical properties that are formed by the arrangement of those atoms and molecules."

In contrast, the properties of metamaterials are formed by man-made structural features. These so-called inclusions are much larger than atoms but smaller than the wavelengths researchers want them to interact with.

"Because they're man made, we can control the properties of those interactions," he says.

OPTICAL METATRONICS DEVELOPED

Engheta has taken metamaterials research to another level by establishing a new discipline that he considers even more transformative and impactful. Developed in 2005, "optical metatronics" is a circuit paradigm made of collections of nanostructures with proper materials, shapes, and sizes that process information at the nanometer scale. These tiny circuits with light could lead to the miniaturization of systems, with possibilities for nanoscale computers and processors.

Engheta points out that a collection of nanostructures properly designed and judiciously arranged next to one another can create optical circuits, in which the nanostructures function as "lumped circuit elements" such as optical nanocapacitors, optical nanoinductors, and optical nanoresistors. These optical-lumped nanocircuit elements create a unifying set of "circuit alphabets" for electrons and photons, linking and merging nanoelectronics and nanophotonics. Scientific ideas and engineering designs can now be transferred between these two fields.

At his university lab in 2010, Engheta and his team built the first physical optical metatronic circuit, which manipulates light waves similar to the way an electrical circuit in a computer or phone manipulates electrons. Optical metatronics may one day be used to create objects that do math when light is shined on them.

"What if we could make a material where we put a function in on one end and get its derivative or integral out on the other? We're working on that," Engheta says.

RESEARCH ON POLARIZED VISION

When Engheta came to University of Pennsylvania in 1987, he built his research group around the idea of electromagnetic wave interaction with chiral structures.

"Chiral structures have handedness, like how your right and your left hand are different from one another," Engheta explained in a 2012 interview with *Penn Current*. "Helical structures — DNA, for example — have chiral properties. My group and I were interested in how we could learn from these kinds of helical structures in nature and translate it to the microwave frequency. We wanted to see how man-made chiral structures, things like springs, interacted with microwave signals."

Finding the answers to these questions was the precursor to Engheta's interest in metamaterials, but it also led to his interest in a completely different field — biologically inspired optical imaging.

Some animals, such as cuttlefish and bees, have polarized vision, which allows them to see aspects of light invisible to humans. Animals with this ability can use it for several behaviors including orientation, navigation, object recognition, and signal detection.

Like the young boy who questioned how sound could come from a "disconnected" radio, Engheta was intrigued by this phenomenon.

"Species with polarized vision can detect the characteristic of image-forming light and extract its information," Engheta says. "We asked ourselves what we could learn from this interesting ability that has evolved in certain biological visual systems."

> "Let yourself be driven by curiosity and follow your passion for discovery."

This has led to various applications such as improved detection, enhanced visibility in low-contrast conditions, longer detection range in scattering media, polarization-sensitive adaptation based on changing environments, surface deformation-variation detection, and "seeing" objects in shadows.

ACTIVE INVOLVEMENT WITH SPIE

An active SPIE member since 2007 and an SPIE Fellow since 2011, Engheta has been a cochair of a metamaterials conference at SPIE Optics+Photonics for several years. This year the conference is expanding from fundamental and applications research to include metadevices and metasystems.

"SPIE is a fantastic organization, promoting scientific and technological interaction among scientists and engineers both from academics and industry, working in all aspects of optics," says Engheta, who "feels fortunate" to be a part of the Society.

Engheta is also an inspiring educator who tells his students, "Let yourself be driven by curiosity and follow your passion for discovery."

The SPIE Gold Medal, the highest honor the Society bestows, recognizes Engheta's transformative and groundbreaking contributions to optical engineering of metamaterials and nanoscale plasmonics, metamaterial-based optical nanocircuits, and biologically inspired optical imaging. Engheta will formally accept the award 12 August at SPIE Optics + Photonics. ■

–Karen Thomas, SPIE editor.

Nominate a colleague for SPIE awards

SPIE presents several annual awards that recognize individual and team technical accomplishments in optics and photonics and service to the Society.

Nominations may be submitted to SPIE through 1 July for the Britton Chance Biomedical Optics Award and the Biophotonics Technology Innovator Award and by 1 October for all other SPIE awards.

Nominations remain active for three years from the submission date, except for the SPIE Early Career Achievement Award and the Joseph W. Goodman Book Writing Award.

Nominations must be accompanied by:

- Nomination form
- Citation stating the accomplishments of nominee
- Description of the significant aspects of nominee's career
- Candidate's curriculum vitae listing educational background, positions held, publications, awards, honors, activities, and offices held within SPIE
- At least two letters of reference, not from the nominator

More information: **spie.org/awards**.

STEM advocate is new Guenther Congressional Fellow

Jennifer Brookes, a PhD candidate at University of Washington (USA), will be the 2015-2016 SPIE/OSA Arthur H. Guenther Congressional Fellow.

Brookes, who volunteers with the Science Explorers, a university outreach group facilitating activities at an afterschool program for elementary students, was selected for a one-year term working as a special legislative assistant on the staff of a US congressional office or committee in Washington, DC.

The Congressional Science and Technology Policy Fellows program aims to bring technical and scientific backgrounds and perspectives to the decision-making process in Congress. It also provides scientists and engineers with insight into the inner workings of the federal government. Brookes will begin her term in September.

Brookes is pursuing her degree in physical chemistry and is a member of Professor Munira Khalil's research group. She is interested in issues regarding energy, natural resources, and the advancement of underrepresented demographics in science, technology, engineering, and mathematics (STEM) fields.

Her doctoral research focuses on understanding the local solvent environment of biologically relevant iron-nitrosyl systems using 2D infrared spectroscopy.

Kazuyoshi Itoh

DENNIS GABOR AWARD

SPIE Fellow Kazuyoshi Itoh, a prominent researcher and educator in holography, optical signal processing, and nonlinear optical microscopy, is the recipient of the 2015 Dennis Gabor award.

Itoh, a professor at Osaka University (Japan), is recognized for his 30 years of contributions to the development of incoherent holography and nonlinear optical microscopy and for his pioneering work on coherence-based multispectral and 3D imaging, nonlinear optical imaging, and manipulations of biological and inorganic industrial materials.

SPIE presents the Dennis Gabor Award every year to recognize outstanding accomplishments in diffractive wavefront technologies, especially those that further the development of holography and metrology applications.

In the early 1980s, Itoh pioneered research on coherence-based multispectral imaging and 3D imaging. He developed a wavefront-folding interferometer that can measure the complex coherence function by averaging out the phase noise caused by the air turbulence.

His technique was the first successful application of incoherent holography for imaging through air turbulence.

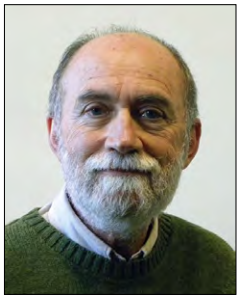
Itoh discovered the importance of performing phase unwrapping before averaging and proposed an algorithm for efficient phase unwrapping, known as the Itoh Algorithm. This algorithm forms one of the bases of today's phase unwrapping techniques and is cited widely in interferometry, side-looking radar, and magnetic resonance imaging.

His other developments include a novel four-wave-mixing microscopy technique, called stimulated parametric emission microscopy, and a nonlinear optical microscopy technique called stimulated Raman scattering microscopy (SRS). This innovative technique is capable of highly sensitive, high-contrast, 3D, live imaging of cells and tissues without staining or labeling.

Itoh, who has presented numerous invited papers at SPIE conferences, served on the executive committee of the former SPIE Japan Chapter and was the president of the Optical Society of Japan from 2006 to 2008. He is currently a member of the Science Council of Japan. ■

Guillermo Kaufmann

CHANDRA VIKRAM AWARD IN OPTICAL METROLOGY



SPIE Fellow Guillermo Kaufmann, head of the Optical Metrology Lab at Instituto de Física Rosario (Argentina) is the 2015 recipient of the Chandra S. Vikram Award. The award recognizes Kaufmann's contributions to speckle metrology; its applications in material science, experimental mechanics, and nondestructive testing; and his development of novel fringe-analysis methods.

The Chandra S. Vikram Award is given annually for achievements, developments, or inventions of significant importance to optical metrology.

In addition to speckle metrology, Kaufmann has made outstanding contributions in holographic interferometry, fringe analysis, phase-shifting interferometry, phase unwrapping, speckle noise reduction, and digital image processing. He has also developed optical-metrology methods in experimental mechanics and material science, and coherent-optics techniques for strain analysis and nondestructive testing.

Kaufmann's novel speckle interferometry techniques and their application in experimental mechanics, materials technology, and nondestructive testing are well-known to the scientific community, notes SPIE Fellow and 2012 SPIE Gold Medal recipient Daniel Malacara Hernández, professor emeritus at Centro de Investigaciones en Optica (CIO) in Mexico.

"His most important contributions in the field of speckle metrology began in 1978-79 as a research fellow of the National Physical Laboratory (UK) under the supervision of J.M. Burch and A.E. Ennos, who created these techniques," says Malacara Hernández.

During this time, Kaufmann developed the first automatic readout system to analyze the Young's fringes produced in speckle photography, a simple technique used for deformation and strain measurement in solid mechanics and velocity measurement in fluid mechanics.

Kaufmann has served on the SPIE Board of Directors and several SPIE committees, including the Symposia, Education, and Fellows committees. He was the honorary chair and proceedings co-editor for the Speckle 2010 conference in Brazil and has authored several articles in the SPIE journal *Optical Engineering*. ■

Richard Juergens

A.E. CONRADY AWARD

SPIE member Richard Juergens, a senior engineering fellow at Raytheon Missile Systems (USA) and a leading authority in optical system design and optical component fabrication and testing, is the 2015 recipient of the A.E. Conrady Award. The award recognizes him for developing optimization techniques and tolerancing methods for optical designs and for training and mentoring optical engineers.

The A.E. Conrady Award is given annually in recognition of exceptional contributions in design, construction, and testing of optical and illumination systems and instrumentation. The award recognizes developments of new equipment, techniques, and applications for designing, testing, analyzing, and/or evaluating optical and illumination systems, components, and theories.

During his 45-year career, which includes working at six companies, Juergens developed optical engineering algorithms and methodologies for the design and engineering of optical systems. These were used to design and build visible and infrared optical systems, including all-refractive, all-reflective, catadioptric, multi-FOV, and zoom systems. During this process, he codified his algorithms and methodologies into a suite of optical software tools, mainly in the form of software macros to be run from within the CODE V optical design program. These macros make the performance metrics more flexible and useable for lens design.

Juergens is also well-known for sharing his knowledge. A significant part of his career has been spent mentoring and developing junior optical designers and engineers. He has traveled to companies throughout the US, Europe, Japan, Korea, and India giving training and technical support as well as teaching seminars on optical design techniques.

"Rick has given innumerable lectures on optical design, optical design software, and other topics in optical engineering, and his material has been incorporated into the instruction of several of our classes," says SPIE Fellow John Greivenkamp of University of Arizona (USA).

"We are only one of the many groups that Rick has supported. He has impacted the careers of hundreds and hundreds of optical engineers," Greivenkamp adds. ■

Tuell family with SPIE President-Elect Robert Lieberman.

Grady Tuell

GEORGE W. GODDARD AWARD

SPIE Senior Member Grady Tuell, associate director of the Electro-Optical Systems Lab (EOSL) at Georgia Tech Research Institute (GTRI), was presented with the 2015 SPIE George W. Goddard Award at SPIE DSS in April.

SPIE presents the George W. Goddard Award annually in recognition of exceptional achievement in optical or photonic instrumentation for aerospace, atmospheric science, or astronomy.

The award recognizes Tuell's foundational research and development in bathymetric lidar and data fusion, and his work in further advancing airborne lidar remote sensing in other ways, including real-time calculation of total propagated positioning error. His contributions span from algorithms to commercial airborne systems.

Before coming to Georgia Tech, Tuell cofounded Optech International, a subsidiary of Toronto-based Optech Inc., and oversaw the evolution of Optech's bathymetric lidar technologies. At Optech, he transformed airborne bathymetric lidar from a depth-measuring technique to true environmental mapping and imaging of the sea floor.

In the course of that work, he pioneered the technique of fusing hyperspectral-image data with lidar data to yield a whole new suite of data products. His visionary work resulted in a commercial instrument, the Coastal Zone Mapping and Imaging Lidar, which is now being manufactured and flown.

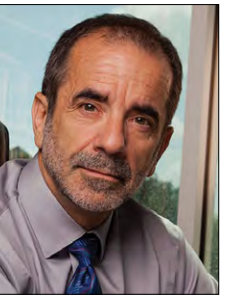
Tuell previously served 20 years as a commissioned officer with the National Oceanic and Atmospheric Administration (NOAA) where he managed all R&D efforts associated with the adoption of new technologies into NOAA's coastal-mapping efforts.

He was recognized with the US Department of Commerce Gold Medal for introducing imaging spectroscopy, lidar, and synthetic aperture radar into NOAA's nautical charting program.

Tuell has served on the organizing committee for the SPIE conference on algorithms and technologies for multispectral, hyperspectral, and ultraspectral imagery. ■

Aristide Dogariu

G.G. STOKES AWARD



SPIE member Aristide Dogariu, professor of optics at CREOL, University of Central Florida (USA), is the 2015 recipient of the G.G. Stokes Award. Dogariu is recognized for his development of new theoretical concepts and innovative methods and techniques for understanding and measuring polarization properties of light-matter interaction.

SPIE gives the G.G. Stokes Award annually for exceptional contribution to the field of optical polarization.

"Professor Dogariu is undoubtedly one of the leading authorities in the field of polarization optics," notes Emil Wolf of University of Rochester (USA), who received the Stokes Award in 2010.

Dogariu's work on stochastic scattering polarimetry, on the degree of mutual polarization, and the polarimetric description of random electromagnetic fields with different spectral composition is of particular importance, Wolf says.

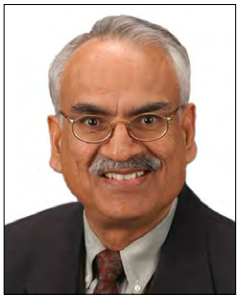
Dogariu's most significant contributions to the field of optical polarization include the use of statistical analysis based on higher-order field correlations to analyze the polarization properties of random fields and the use of polarization characteristics of light for describing its interaction with complex media.

These analysis and measurement tools have direct implications for a number of remote sensing and biophotonics applications. In addition, he has developed a new class of polarimetric techniques that rely on stochastic measurements.

This pioneering approach, based on statistical analysis of measured intensities, permits circumventing a number of limitations of classical polarimetry including the need for controlling the excitation fields and the measurement geometries.

Dogariu has served on several SPIE conference program committees including ones on polarization science and remote sensing; reflection, scattering, and diffraction from surfaces; and active polarimeter systems. ■

Virendra Mahajan
SPIE EDUCATOR AWARD



SPIE Fellow Virendra Mahajan has been selected as recipient of the 2015 SPIE Educator Award for sharing knowledge in the area of optical imaging, aberrations, and wavefront analysis through his voluntary teaching of students and professionals and the writing of five books. The award will be presented at SPIE Optics+Photonics in August.

The annual SPIE Educator Award recognizes outstanding contributions to optics education by an SPIE instructor or an educator in the field.

Mahajan has been an adjunct professor in the College of Optical Sciences at University of Arizona (USA) since 2004. During his first three years of teaching there, he would fly from Los Angeles to Tucson to teach a three-hour class and then fly back to California.

Mahajan's unique talent and knowledge in the area of optical aberrations is reflected in authorship of five books on optical imaging and aberrations, all published by SPIE. Widely used by students and professionals, his book, *Aberration Theory Made Simple*, has been translated into Spanish and Russian and will be translated into Chinese.

Inspired by Mahajan's lectures, SPIE Senior Member José Antonio Díaz Navas, of University of Granada, (Spain) did the Spanish translation of the second edition.

"Dr. Mahajan has educated hundreds of professionals and students through teaching short courses," said Navas. "This for me is what a true educator does: disseminate, discuss, and share with anyone anywhere what he or she has learned."

Mahajan, a retired Distinguished Scientist/Engineer at the Aerospace Corp., has also been an adjunct or visiting professor at National Central University in Taiwan; National Institute for Astrophysics, Optics, and Electronics in Mexico; the College of Optics and Photonics at University of Central Florida; and University of Southern California.

Mahajan serves as a conference chair, teaches courses at SPIE events, and volunteers in the Society's visiting lecturer program. He has served on several committees and was the 2006 recipient of the SPIE A.E. Conrady Award. ■

Two receive SPIE Early Career Achievement Awards

Miriam Serena Vitiello and Alan Lee awarded inaugural prizes

Two SPIE members whose work with terahertz quantum cascade lasers (QCLs) has advanced the field of THz photonics have received the inaugural SPIE Early Career Achievement Awards, one for an academic focus and the other for an industry focus.

Miriam Serena Vitiello, a staff research scientist at the National Research Council (CNR) of Italy and an assistant professor at Scuola Normale Superiore, is the recipient of the award in the academic category.

Alan Lee, founder of LongWave Photonics (USA), is the award recipient in the industry category.

SPIE established the Early Career Achievement Award in 2007, and the SPIE Awards Committee created separate categories for it in 2014, to honor SPIE members of distinction whose highest earned degree has been awarded within the previous 10 years.

Seongsin Margaret Kim, associate professor at University of Alabama (USA) and chair of the subcommittee for the SPIE award, noted it is a coincidence that the two award recipients work in similar areas of photonics.

Miriam Vitiello (left) accepts the award from SPIE President-Elect Robert Lieberman.

"Both Miriam Vitiello and Alan Lee have deeply impacted the field of terahertz photonics and the terahertz community despite their relatively short professional careers," Kim said. "Their selection for the SPIE Early Career Achievement Award is highly deserving and an indication of the upward trajectories of their careers, both in academia and industry."

Each award comes with a $2,000 honorarium.

VITIELLO WELCOMES JOINT RESEARCH

Vitiello is being honored for her pioneering research on semiconductor-laser sources and electronic high-frequency nanodetectors, which have opened new frontiers in the terahertz photonics and optoelectronics fields. Among her achievements are:

- Development of the first micro-probe photoluminescence/micro Raman technique to measure individual sub-band electronic temperatures, lattice temperature, optical phonon distributions, and quantum efficiency in QCLs with ultrahigh spatial resolution
- Invention of nanowire field-effect-transistor (FET) THz detectors
- Invention of graphene-based THz plasma-wave detectors

In recommending her for the award, SPIE Fellow Federico Capasso, a co-inventor of the QCL, noted that Vitiello pioneered the use of nanomaterials in the realization of THz devices.

"Using plasma waves in the channel of field-effect transistors, she developed the first FET detectors based on InAs nanowires and the first THz detectors made of graphene," Capasso said. "Both these works initiated important new research directions. These devices can now operate at room temperature, up to frequencies above 3 THz, and have noise comparable with commercial technologies.

"They hold major promise for commercialization in many applications, including future fast multi-pixel terahertz cameras," Capasso said.

Applications for her cutting-edge technological advances in THz detectors and devices that generate THz radiation include metrology, sensing, and security.

Vitiello received her PhD at University of Bari (Italy) in 2006 and currently leads her own research group at CNR. She also coordinates the THz research line among three different CNR institutes in Italy and collaborates with other researchers in Europe and around the globe. A joint research project with Rutgers University in the USA, for instance, involves the transmission of THz radiation through hollow waveguides.

Vitiello is a member of the program committees for SPIE conferences on quantum sensing and nanophotonic devices (Photonics West) and THz emitters, receivers, and applications (Optics+Photonics) and has authored or co-authored some 70 peer-reviewed journal articles in nine years, including in *Optical Engineering* and the *Journal of Nanophotonics*.

She received her award at SPIE Optics+Optoelectronics in Prague in April.

LEE COMMERCIALIZES THZ TECHNOLOGY

Lee

Lee, who received his PhD in electrical engineering from Massachusetts Institute of Technology (USA) in 2010, founded the first company to commercialize a "turnkey" terahertz QCL system. LongWave, based in California, has developed product lines of QCL based systems for nondestructive testing; precision local oscillators for the remote-sensing and astronomy community; and laser spectroscopy.

In addition to commercial developments, LongWave has received funding from NASA and the National Science Foundation for work on non-destructive imaging using terahertz radiation, frequency-agile QCL sources, and local oscillator sources for astronomy.

He is being recognized for his early-career achievements on standoff-distance real-time THz imaging. The differential imaging technique proposed in his work formed the basic working principle of several commercial THz imagers/cameras.

Lee first demonstrated real-time terahertz imaging with terahertz QCLs and microbolometer cameras while working on his doctorate. Prior to this, nearly all THz imaging was performed using expensive Ti:Sapphire lasers, where the image was collected by scanning the

Continued on page 39 ▶

Keith Doyle

SPIE TECHNOLOGY ACHIEVEMENT AWARD

SPIE Fellow Keith Doyle, a leading authority in integrated optomechanical performance analysis who leads the Structural and Thermal-Fluids Engineering Group at MIT Lincoln Laboratory (USA), is the recipient of the 2015 SPIE Technology Achievement Award.

Doyle is honored for his achievements in incorporating elements of optical, thermal, and structural engineering into the analysis of optical systems used in ground, aerial and spaceborne optics for astronomical, remote sensing, laser communications, and military applications. The optical systems are also used in microlithography, telecommunications, and consumer optics.

Doyle is author or coauthor of more than 30 technical articles and is the lead author of a SPIE Tutorial Text, *Integrated Optomechanical Analysis*, now in its second edition. (**spie.org/Publications/Book/974624**)

At MIT Lincoln Labs, Doyle oversees development of advanced engineering technologies and multidisciplinary engineering solutions that enable prototype systems. These developments include optimal structures, high-efficiency thermal-fluid heat exchangers, and aerodynamic platforms created using novel materials and state-of-the-art integrated analysis and environmental test capabilities.

Along with efforts to improve software tools and analysis methods for aero-optical effects and to use smart materials for optical metering structures, Doyle is active in the training and educating of the next generation of optomechanical engineers. He is an SPIE course instructor and serves on the program committees for several SPIE conferences.

Doyle has a PhD in engineering mechanics and optical sciences from University of Arizona and has worked at the federally funded R&D center at MIT; Optical Research Associates (ORA), now a division of Synopsys; and Sigmadyne.

At Sigmadyne, he led the development team for the SigFit engineering software, which is used for modeling rigid-body and elastic optical-surface errors, line-of-sight jitter, system-wavefront error, thermo-optic effects, stress birefringence, structural dynamic responses, and mechanical optimization.

At ORA, SPIE Fellow Kevin P. Thompson said Doyle advanced the communications between a team of mechanical designers and optical designers while working on new optical system designs.

"He represents one of only a few individuals with the background in integrated modeling," Thompson said, as well as a simultaneous "understanding of optical design and more significantly optical designers and the software environment they work in." ■

ADVENTURES OF A CONFERENCE SESSION CHAIR

By **Christopher C. Wilcox** and **Matthew E.L. Jungwirth**

One of the core roles of SPIE, along with its vast history of publishing, is assisting its members in organizing, attending, and participating in its symposia.

SPIE also works very hard to incorporate involvement of its younger members and students. When SPIE Fellow David V. Wick asked me (Christopher) to replace him as chair of his session at SPIE DSS in 2012, I quickly took the opportunity to help and organized a session on adaptive optics and MEMS technology. At the time, I was an early career member with SPIE and had already published several articles in adaptive optics and atmospheric optics.

Wick, on the other hand, was a long time SPIE member who has served on numerous SPIE committees and the SPIE Board of Directors. Wick and I had worked together for several years at a joint Sandia National Laboratories/Naval Research Laboratory program in adaptive optics and lightweight adaptive mirrors and telescopes. He has always been involved with SPIE, especially in reaching out to its younger members. I felt honored to be asked to take over the session he built.

After two years of running the session myself, I asked a colleague, Matthew Jungwirth, to cochair the session with me. We had worked together for several years under the same program while he was at Sandia National Labs working on his PhD dissertation project. I knew that Jungwirth, an early career SPIE member and now an optical scientist at Honeywell International, was interested in becoming more involved in SPIE, and he seized the opportunity to become a session co-chair.

Here are some of our observations on getting involved with a conference.

RECOGNIZING AND SEIZING OPPORTUNITIES

Being invited to chair a conference session by a more senior member like Wick is one of two ways that young SPIE members can become involved in conferences.

Wick ensured that a highly successful conference session would remain active by passing his duties over to us, and we decided not to let this opportunity pass. However, young SPIE members don't have to wait for opportunity to come to them.

We encourage all SPIE members who are interested in playing a bigger role at conferences to create that opportunity themselves by engaging conference and session chairs. Introduce yourself to them, hand out your business card, and ask how you can help or aid the conference. We can assure you that help is always welcome.

BUILDING A CONFERENCE SESSION

Setting up a conference for an SPIE symposium can take a considerable amount of organization and planning. Within each conference, there are sessions that can contain several presentations. Many session chairs are open to having papers submitted for review.

Some sessions, such as ours, contain only invited presentations. In other words, only those authors who have been personally invited by us, the chairs, will present at the session. Therefore, our main job is creating an interesting and engaging session that is technically relevant and cohesive.

Left to right: Former SPIE President Eustace Dereniak, Christopher Wilcox, Matthew Jungwirth, and SPIE Senior Director Andrew Brown at SPIE DSS in 2014.

Typically, it can take nearly a year to set up a proper conference session — time that is spent deciding upon a session topic, inviting prospective authors, reading and approving abstracts and papers, and, lastly, moderating the session itself.

The result of our joint efforts was a session held 24 April at this year's SPIE DSS on novel beam-control applications and techniques at the Micro-Nanotechnology Sensors, Systems, and Applications conference. Here, the goal of our efforts was finally realized, enabling presentation to the scientific community of five scientists' and engineers' latest and greatest research.

Topics covered included a hybrid system of software and hardware processing, an adaptive optical system, ultraspectral imaging, lidar systems, and a novel deformable liquid lens to mimic the human eye.

All the presentations were engaging, incredibly interesting, and very successful. ■

–SPIE member Christopher Wilcox is an electrical engineer at the US Naval Research Lab in New Mexico. He has a PhD in engineering from University of New Mexico and has developed several Android apps, including the SPIE Field Guide and SPIE conferences apps.

–Matthew Jungwirth, also an SPIE member, is an optical scientist at Honeywell International. He has a PhD in optical sciences from University of Arizona.

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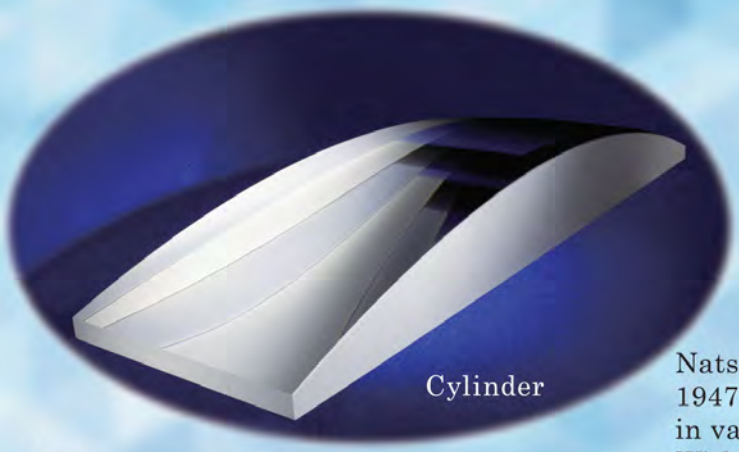

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SPIE INTERNATIONAL YEAR OF LIGHT PHOTO CONTEST

LEDs paint prize-winning photo

Ian Bell used a Nikon D7000 camera to capture this award-winning photo. The photo was shot with 17-55mm f/2.8 lens, Manfrotto tripod, Bowens moonlight triggered with a PocketWizard, and a homemade RGB LED rig.

The image receiving the third-place prize in the SPIE International Year of Light Photo Contest shows an athlete on a stand-up paddle board using LED lights to "paint" across a calm bay in the US Pacific Northwest.

The light painting by Ian Bell of Bozeman, MT (USA), is a long-exposure photograph enabled by a variety of photons, light-based technologies, and optical devices that are being celebrated during the International Year of Light and Light-based Technologies in 2015 (IYL2015).

Bell graduated with honors from Montana State University this spring with degrees in photography and business management. He says he plans to continue pushing the boundaries of what is technically and creatively possible with his sports, lifestyle, and landscape photography business.

His prize-winning image is part of a series of light-painted photographs he calls "Lumen." The photo project was shot in various locations, mostly at night or twilight and shows athletes painting with light while on horseback, skis, bikes, and ice skates as well as the stand-up paddle (SUP) board. Bell's paddleboarder, with a LED rig mounted to his paddle, was shot in Fisherman Bay on Lopez Island, WA, after sunset on 3 August 2014.

"The LEDs mixed with a long exposure allow us to study the movements of the athlete over time," Bell says. "A quicker, more traditional exposure would not have allowed us to see" the athlete or the ribbon of light from the LEDs that are reflected on the still water.

Light painting is a photographic technique in which either a light source or a camera moves while the photo is being taken. The camera records, over several seconds, minutes, or more time, a subject or scene in a single frame.

SPIE member John Dudley, chair of the IYL2015 Steering Committee, has called light painting a "perfect example of how the science of illumination technology can combine with artistic design to create works of beauty and inspiration — and raise awareness of the International Year of Light and its goals."

IYL2015 is a global initiative adopted by the United Nations to raise awareness of how optical technologies promote sustainable development and provide solutions to worldwide challenges in energy, education, agriculture, communications, and health. SPIE is one of 12 founding partners.

CHOSEN FROM 800+ PHOTOS

SPIE is providing prizes of US $4,500 in the photo contest, including $500 for Bell's third-place award and another $500 for the People's Choice Award, which is being decided in a public vote.

A panel of 40 graduate students in art and science programs screened more than 800 photos submitted to SPIE in 2014, rating each photo on how well it depicted the contest theme of light and light-based technologies in daily life, artistry, scientific interest, and other criteria.

From the top-rated 35 images, an executive panel then selected the top three photos.

The People's Choice competition in the photo contest is to decide which of the remaining 32 images will receive the People's Choice Award and appear on the cover of the October issue of *SPIE Professional*.

Bell and the first- and second-place winners are not eligible for the People's Choice Award.

Anyone can vote in this phase of the contest by going to spie.org/IYLphoto before 15 August. Voters who provide their email address will be entered in a drawing for a GoPro camera. (Some restrictions apply.)

For more information on the People's Choice Award, go to page 22.

More photos from Bell's Lumen project can be found at **http://ianbellphotography.com/lumen**.

LEDS A PHOTO FAVORITE

LEDs, created with optics and photonics technologies, were a popular photographic subject in the contest.

The bright, low-cost, energy-efficient diodes that have brought social, environmental, health, educational, and economic gains to society are shown in all three prize-winning photos and numerous others submitted.

British photographer Paul Reiffer won the first-place prize with a long-exposure photograph of the vehicle, road, and other city lights on and around Shanghai's Nanpu Bridge on New Year's Eve 2013. The professional photographer from Weymouth, England, planned his shot so he could capture the "rainbow" display of the three-layered ramp to the bridge that links Puxi to Pudong.

"Every weekend and public holiday, Shanghai's road network transforms into a multicolor LED light show throughout the city," Reiffer said.

Both Bell's and Reiffer's photos show LEDs creating a flowing motion.

Bell says he rigged a homemade LED array on the paddle for his contest photo, illustrating the ubiquity of this revolutionary lighting technology.

Susanta Mukherjee of India won the second-place prize for his photo of Indian children showing off their new solar-powered LED study lights.

The rechargeable lights were provided by the One Child One Light (OCOL) Foundation and distributed by a non-governmental organization called ARCHI at a school in the electricity-scarce Sundarbans region of West Bengal in March 2014. OCOL makes the portable LED lights available to non-profit organizations for $2-$3 so that children studying at home don't have to depend on kerosene or oil-based lamps that emit smoke, toxic fumes, and very low light. ■

IYL blog

Stay up to date with all the resources, events, and discussions associated with the International Year of Light (IYL) on the IYL blog.

The IYL blog (light2015blog.org) has a wealth of information on light in nature, culture, education, health, efficient lighting, and quantum mechanics. Several posts so far this year have celebrated the pioneers in optics and photonics such as Ibn Al Haytham, Albert Einstein and Augustine Fresnel, and others are informative reads about lasers in astronomy, nanolithography, light-speed computing, and more.

You can also receive email notifications of weekly events and new posts by signing up on the site.

The International Year of Light is supported by SPIE and 100 international partners. The European Physical Society is coordinating the year-long celebration under the auspices of UNESCO.

Contest judges

Executive judges in the SPIE International Year of Light Photo Contest included SPIE member Joe Niemela of the International Centre for Theoretical Physics (ICTP) in Italy, which is serving as the global secretariat for IYL2015; Deborah Klochko, director of the Museum of Photographic Arts in California (USA); and award-winning American photographer Mathieu Young.

JOSEPH NIEMELA

DEBORAH KLOCHKO

MATHIEU YOUNG

INTERNATIONAL YEAR OF LIGHT 2015

SPIE INTERNATIONAL YEAR OF LIGHT PHOTO CONTEST

Images in SPIE IYL Photo Contest serve as ambassadors of light

Photo and photon enthusiasts will decide which image wins the People's Choice Award.

The 32 photos eligible for the People's Choice Award in the SPIE International Year of Light (IYL) Photo Contest portray light and light-based technologies in daily life, depicting the problem-solving potential of optics and photonics technologies as well as society's enjoyment of light in art, culture, recreation, and the natural world.

Photo and photon aficionados everywhere have until 15 August to vote online for their favorite image illustrating the theme of light in daily life.

Eight of the 32 photos in the People's Choice Award competition show LEDs, solar panels, lasers, and/or mobile-communication devices developed by optical engineers. Two of the images are micrographs that resemble colorful abstract paintings, while others portray various types of light and light technologies used for health, education, sustainable energy, and sustainable development.

Two photos show lighting at places of worship; two images were photographed inside caves; and there are several inspiring photos showing the Milky Way, aurora borealis, and other nightscapes.

There's even a selfie among the group.

SPIE is providing a prize of US $500 for the People's Choice Award and will announce the winner in September. The winning photo will also appear on the cover of the October issue of *SPIE Professional*.

SHOWING THE WORLD OUR OPTICS, PHOTONICS

IYL2015 is a year-long celebration of the crosscutting discipline of science that has revolutionized medicine, astronomy, and clean energy; opened up international communication via the Internet; and continues to be central to linking cultural, economic, and political aspects of the global society.

"While the SPIE International Year of Light Photo Contest has been extremely successful in engaging people within the photonics community, it has been even more successful in engaging people outside the community," said SPIE CEO Eugene Arthurs

"The photos themselves have served as ambassadors of the IYL observance, raising awareness of the inspiring beauty of light in nature, art, and even technology as well as of the power of light-based technologies to provide benefit in lives around the world," Arthurs said.

More than 800 images were originally entered into the competition, with two panels of judges selecting the top 35 photos based on scientific interest, creativity, and how well the photo communicated the contest theme. The top three photos were announced in January and are not eligible for the People's Choice Award.

"SPIE is very grateful for the response from the photographers, the judges, and others who have seen the photos to date," Arthurs said.

"We hope that the People's Choice Awards' voting will connect many more people who may enjoy the images and thereby appreciate how vitally important light is to each of us."

SPIE, an IYL founding partner, has posted the 32 images online in various social media channels and will display them at SPIE Optics+Photonics in August. Some of the photos have also been included in IYL displays at SPIE conferences and IYL events and in the book SPIE produced for the IYL, *Celebrating Light: 50 Ways Light-based Technologies Enrich Our World*.

More information on the contest and how to vote: **spie.org/IYLphoto**. ■

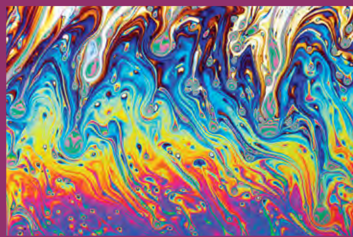
IYL voters could win GoPro camera

People who cast a vote for the People's Choice Award in the SPIE International Year of Light Photo Contest may be eligible to win a GoPro camera.

Voters who provide an email address are being entered in a drawing for a GoPro. SPIE will have a random drawing in September to choose one voter for the compact, point-of-view, digital video camera. Only one vote and one entry per person.

More information: spie.org/IYLphoto

VOTE FOR YOUR FAVORITE — spie.org/IYLphoto

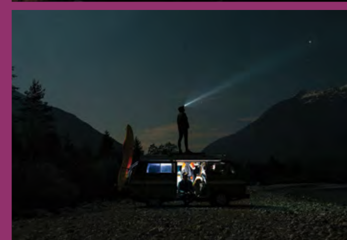









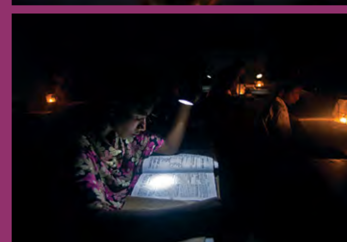















SPOTLIGHTS

New publishing venue for short tutorials on optics

By **Robert Fiete**

What is the best publishing venue for authors who would like to publish a 20- to 50-page tutorial that summarizes a broad topic or highlights a specific niche in optical science and technology? SPIE Press manager Tim Lamkins was struggling with this question when I approached him in 2013 with an idea for a book tutorial.

I thought about writing a tutorial about image resolution after I realized how often I was breaking the bad news to people that the incredible imaging technologies portrayed in Hollywood productions are simply the product of imaginative writers. Of particular note is the "zoom and enhance" capability seen in TV shows and movies that allows a crime lab technician to magnify a digital image on a computer to an incredible level of detail necessary to break the case.

When I proposed the tutorial on imaging resolution to Tim, we both understood that this specific topic would be only approximately 50 pages; hence it would be too short for the *SPIE Tutorial Text* series, whose length is typically approximately 200 pages. We also agreed that this niche subject really wasn't appropriate for inclusion in an SPIE journal, so we were stymied.

Shortly afterward, Ken Barat, a laser safety consultant, proposed writing a tutorial on setting up a laser lab. So now, Tim had proposals from two authors who wished to publish short tutorials on concise topics.

As Tim saw it, the only solution was to create a new e-book series for short, concise, instructional tutorials.

With the smaller size of these tutorials, releasing them electronically as e-books seemed to make the most sense, and the *SPIE Spotlight* series was born.

It was hard for me to contain my excitement over this idea, and I jumped at the chance to be the series editor.

SIX TOPICAL AREAS

Our first task was to create topical areas and recruit editorial board members with expertise in those subject areas. The six topics we arrived at cover everything from biomedical optics to signal processing to semiconductor, energy, and imaging technologies.

These editorial board members will periodically put out a call for e-book proposals on specific subject matters within their topical areas. The board members and their subject areas are:

- Rick Kendrick of Lockheed Martin for aerospace and defense technologies
- SPIE Fellow Paul Lane of the US Naval Research Lab on energy and the environment
- SPIE Member Stefan Preble of Rochester Institute of Technology for semiconductor technology
- SPIE Fellow Majid Rabbani of Kodak for electronic imaging and signal processing
- SPIE Senior Member Brian Sorg from the US National Cancer Institute for biomedical optics and medical imaging
- SPIE Fellow Rich Youngworth of Riyo for optical design and engineering

The SPIE Spotlights series covers aerospace technologies, medical imaging, optical design, and several other technical areas.

We have already published three of these e-books: an overview on optical fiber sensing; the "how-to" e-book on laser lab logistics; and my *Spotlight* on the true capabilities of the "zoom and enhance" technology portrayed in films and TV. Also, calls went out this spring for potential authors to submit proposals for *Spotlight* e-books on orbital debris, quantum integrated photonics for semiconductors, digital photography, and optical design and engineering of digital systems.

All *Spotlights* are peer reviewed before publication and the authors receive royalties, just as they would for any other book SPIE publishes. E-books in the Spotlight series are available for mobile devices and as downloadable PDFs. They are also accessible to institutional users via the SPIE Digital Library.

We encourage interested authors to visit **spie.org/Spotlights** to learn more about submitting ideas for publication in the *SPIE Spotlight* series. ■

–SPIE Fellow Robert Fiete is editor of the SPIE Spotlights series. He is a chief technologist and director of R&D at Harris Corp. (USA).

R&D Highlights

Neurophotonics honors Larry Cohen

The April-June issue of the SPIE journal *Neurophotonics* features a tribute to the brilliance and originality of Lawrence B. (Larry) Cohen as well as reports on the latest advances in voltage-sensitive dyes and multiple-site optical recording methods enabled by the work of Cohen and his team. Journal editors say Cohen's research has paved the way for advances in functional imaging of the electrical activity of live tissue in real time.

In an editorial in the special section, guest editors Brian Salzberg of the University of Pennsylvania (USA) and Dejan Zecevic of Yale University School of Medicine (USA), where Cohen has been a professor for 35 years, laud Cohen's dominant role in developing and applying optical methods in cell physiology, biophysics, and neuroscience.

Advances in functional imaging of the nervous system and other physiological systems — barely conceivable without optical mapping using potentiometric probes and, more recently, genetically encoded voltage-sensitive proteins pioneered by Cohen and his colleagues — are only the beginning, Salzberg and Zecevic noted.

The era in which optical methods, especially fluorescence, but also absorbance, birefringence, and light scattering, are applied to an extremely large range of biological preparations could not have occurred without Cohen's pioneering and extremely fruitful work, they said.

More than a dozen papers demonstrate the legacy of Cohen's research, beginning in the late 1960s.

John Nicholls of the International School for Advanced Studies (Italy) writes that at that time, Cohen devoted himself to two key problems: finding the dyes that would best light up during activity and developing the best methods for recording optical signals.

"He moved up from single axons, to groups of nerve cells in invertebrates, and then to an important biological problem: the organization of olfactory processing that gives rise to the sense of smell," Nicholls says. "This progression took many years, but Larry never swerved from his aim: to observe how tens, or hundreds, or thousands of nerve cells process information in real time."

Kohtaro Kamino of Tokyo Medical and Dental University worked in Cohen's lab at Yale and witnessed the birth of this frontier field. In the 1970s, when large photodiode arrays were not yet available, Cohen, together with Salzberg and then Amiram Grinvald, used individual light guide modules to introduce multiple-site optical recording methods into neurobiology.

With colleagues including Kamino, Cohen began using 5x5-element photodiode arrays, and by the early 1990s had built systems incorporating 464-element arrays. Kamino's article in the special section details how this early work influenced his research centering on capturing development of cardiac and neural systems in early-stage chick and rat embryos.

Photo courtesy Kohtaro Kamino.

From left, Amiram Grinvald, Larry Cohen, Kohtaro Kamino, Brian Salzberg, and William Ross at a gathering in Tokyo in 2000.

Among other articles in the special section, "Linker length and fusion site composition improve the optical signal of genetically encoded fluorescent voltage sensors," by Arong Jung of the Korea Institute of Science and Technology (KIST) et al., describes how the linker-length sequence affects the optical signal of the fast fluorescent probes first developed in Cohen's lab. Cohen later went on to be a senior researcher at KIST.

Another article, "Branch specific and spike-order specific action potential invasion in basal, oblique, and apical dendrites of cortical pyramidal neurons," coauthored by Wen-Liang Zhou of the University of Connecticut Stem Cell Institute, uses the principles of optical imaging developed by Cohen to investigate action potential invasion into thin dendritic branches of prefrontal cortical L5 pyramidal neurons.

These and all other articles in the *Neurophotonics* are freely available on the SPIE Digital Library through the end of 2015 at **neurophotonics.spiedigitallibrary.org.** ■

Sensing and imaging take lead role at SPIE DSS 2015

Biometric and surveillance technology, thermal imaging for oil and gas exploration and monitoring, robotics, and numerous photonic sensors will provide crucial research and engineering capabilities needed for the defense, security, and sensing community.

These were some of the takeaways at SPIE DSS in April, the largest annual optics and photonics conference and exhibition on the US East Coast. More than 5100 people participated in 55 conferences, the 382-company exhibition, multiple industry programs, and 30-plus professional development courses in Baltimore, MD (USA).

Technologies included infrared, hyper- and multispectral imaging, quantum cascade lasers, fiber-optic sensors, data analysis for cyber-threat detection, and more — all exploring new research frontiers.

A commercial and scientific sensing emphasis launched at the event in 2014 gained momentum in 2015 with 23 conferences, increased industry involvement, and expanded topic areas such as smartphone spectroscopy, high-resolution night-vision and thermal-imaging systems, food safety, and healthcare.

"A lot of technology exists within the military and defense environment that is capable of being rolled out into the commercial world," said David Bannon, CEO of Headwall Photonics, an SPIE corporate member and frequent exhibitor.

New this year, FLIR Systems displayed its innovative culture with the help of documentary maker Louis Psihoyos and nature-show host Casey Anderson — not in a booth at the exhibition floor, but on its Center Stage.

Psihoyos described how he used FLIR cameras in his Academy-Award-winning documentary "The Cove."

FLIR's technology enabled underwater, surveillance, and other capabilities in that film and in his soon-to-be-released documentary "Racing Extinction," a film aiming to expose the hidden world of endangered species and the race to protect them against mass extinction. Psihoyos used filters developed by FLIR that make gases such as methane and CO_2 visible in the latter film.

Anderson, a television host and producer of National Geographic's "America the Wild" and "Expedition Wild" discussed his documentary, "Wild Nights, The Dark Planet Revealed." He demonstrated how FLIR thermal cameras have enabled him to see previously unseen frontier and wildlife in the night. "FLIR technology has opened up a new world for me," Anderson said.

NATURE OF CONFLICT HAS CHANGED

In his plenary talk, C. David Brown, the US Deputy Assistant Secretary of Defense for developmental test and evaluation and a retired US Army Reserve colonel, noted that the nature of conflict has changed in significant ways. Instead of on a battlefield, for instance, conflicts of the future will occur in the commons — areas that have no domain owners — and will involve state actors as well as non-state actors, Brown said.

Technology advancements, known as "offsets" in the military, will continue to be important, Brown said, but they will be different from the asymmetric capabilities the US built in the late 1950s or the "own-the-night" emphasis of the 1980s.

Challenges in this era of "the rise of the commons" include modern electronic warfare, ballistic- and cruise-missile defense, precision navigation and timing, communications, intelligence surveillance and reconnaissance, integrated air defense, cyber threats, and weapons of mass destruction, Brown said.

At the same time, the US Department of Defense is concerned that a return to budget sequestration would cause delays or cancellation of capabilities under development, Brown said. He listed programs such as the Aerospace Innovation Initiative, next-generation adaptive engine, ground-based interceptor missile-defense system, and space control efforts.

To help mitigate threats, develop affordable new and extended capabilities in existing systems, and create "technology surprise" through science and engineering, the US will work toward a smaller, leaner, technologically advanced military, said Brown, who has a PhD in electrical engineering and teaches graduate courses at Johns Hopkins University. The aim, he said, will be to confront and defeat aggression by protecting and prioritizing existing investments, rebalancing the nation's global posture, building partnerships, and strengthening alliances.

Photonics technologies, particularly highly sophisticated electro-optical, infrared, acoustic, seismic, and magnetic sensors are essential, he said.

NICHE MANUFACTURING MARKET

In a separate talk, William Chappell, deputy director of the Microsystems Technology Office at the US Defense Advanced Research Projects Agency (DARPA), discussed the next generation of microsystem technology. He said it will involve heterogeneous integration of blended electronic and optical designs to facilitate requirements including personalization, rapid design and portability, and security.

"Light will become the next frequency," he said, with important enabling technologies including lasers, detectors, nonlinear optics, and silicon chips.

Underscoring the overlap in opportunities for both military and commercial markets, one of the biggest conferences at SPIE DSS covers fiber-optic sensors and applications. It is the largest annual gathering of scientists and engineers in the field of optical

SPIE sizes market for defense

Industry programs at SPIE DSS included a panel discussion on the potential of industry and government collaboration, an update from the SPIE team on its analysis of the size of the photonics market, and an overview of US programs with the potential of changing several technology landscapes.

The SPIE team found that the photonics-enabled global market in defense and security logged $216 billion in sales last year.

SPIE Industry and Market Analyst Stephen G. Anderson also said the defense and security sector includes 570 companies that are responsible for 560,000 jobs.

The three largest segments, which account for the lion's share of the market, are the aerospace and defense industry, anti-counterfeiting, and video surveillance, Anderson said.

The industry program also included discussion on proposed changes to US export regulations controlling and limiting non-US sales of key photonics technologies such as lasers and sensors. (See page 35.)

C. David Brown gave the plenary talk at SPIE DSS 2015.

sensing for commercial, scientific, industrial, and environmental applications.

At one session, Peter Kiesel of PARC, a Xerox company, reported on new fiber-optic sensing technology that can be embedded within next-generation batteries and other objects to understand a variety of parameters including temperature, pressure, and chemical composition.

Researchers at PARC invented this high-resolution, wavelength shift detection (WSD) and interrogator technology and are in the process of identifying market-facing partners interested in licensing and further commercializing the technology.

SPIE corporate member Open Photonics is partnering with PARC on the next phase of commercialization of the technology, which can be used for structural-health monitoring and to monitor the internal condition of batteries, wind turbines, generators, or engines.

These sensors have been developed with support from the Advanced Research Projects Agency-Energy (ARPA-E) and are being eyed by the growing market for battery management because they can, for example, better predict miles-to-empty in an electric vehicle, give better state-of-charge estimates, or reveal internal damage.

Tiny optical wavelength shifts, at the picometer and even femtometer scale, provide immediate feedback via smart embedded sensors. These optical sensors provide better information about what is going on inside a battery than can be inferred by external measurement of voltage, current, and temperature.

AWARD HONORS 3D PIONEER

Among the awards given at SPIE DSS for exceptional papers was the inaugural "Fumio Okano Best Paper Award" in the 3D Imaging, Visualization, and Display conference.

Conference Chairs and SPIE Fellows Bahram Javidi of University of Connecticut (USA) and Jung-Young Son of Konyang University (Korea) presented awards to three winners and coauthors:

- SPIE Fellow Hong Hua of University of Arizona (USA), for the paper, "An integral imaging augmented reality display"
- Kenji Yamamoto of National Institute of Information and Communications Technology (Japan), for the paper, "Reconstruct holographic 3D objects by double phase hologram"
- SPIE Fellow Manuel Martínez-Corral of University of València (Spain), for the paper "Three-dimensional microscopy through liquid-lens axial scanning"

The new award is sponsored by NHK, the Japan Broadcasting Corp., where Okano worked with his colleagues to rejuvenate the potential of integral photography as a viable approach for 3D displays. Okano, a longtime chair at the 3D conference who died in 2013, made numerous innovations and refinements of integral photography 3D display systems.

For more news and photos from SPIE DSS, visit **spie.org/DSSnews**. ■

RECOMMENDED READING

Optimizing OPV performance

The field of organic photovoltaics (OPVs) was launched with the promise of the development of low-fabrication-cost solar cells and modules. Thirty years later, OPVs have still not fulfilled this expectation.

In spite of great advances achieved in research and development throughout the last decades, especially in terms of their reported power-conversion efficiencies (PCEs), there remain fundamental scientific issues and technological challenges that must be addressed before OPVs can be seriously considered and implemented in reliable and long-lasting applications.

The synthesis of highly soluble organic semiconductors was initially considered as an important breakthrough that would definitely change the fabrication of photovoltaics once for all. Nowadays, the promise of printing solar cells using low-cost and high-throughput mass production techniques still stands. The possibility of printing solar modules at production speeds up to several meters per second using inkjet, slot die, screen, or gravure printing would allow the coating of the same photoactive area in a single day as that of a traditional silicon foundry in a year!

Hence OPV remains to be a technology subject to further study for on and off-grid applications for which energy production is still the leitmotif.

A recent article in the *Journal of Photonics for Energy* gives a brief review of the recent development of a class of organic solar cells based on a bulk heterojunction consisting of a polymer electron donor/hole transporter and a fullerene electron acceptor/transporter.

The article, "Polymer:fullerene solar cells: materials, processing issues, and cell layouts to reach power conversion efficiency over 10%, a review," provides a discussion of new materials synthesis and processing and device fabrication and optimization.

In terms of new materials, authors Ikerne Etxebarria, Jon Ajuria, and Roberto Pacios of IK4-IKERLAN (Spain) report on a new class of light-harvesting polymers based on benzodithiophene and dithienopyran-difluorobenzothiadiazole derivatives, which led to OPVs with 9% PCE. Incorporating deterministic aperiodic nanostructures (DANs) for broad angle light manipulation resulted in 10% PCE for an OPV based on benzodithiophene.

They also point out the importance of adopting smart processing strategies for a large variety of polymer families using additives, solvent mixtures, and post-processing treatments. These are crucial for controlling the bulk morphology of the light-harvesting active layer(s) that results in improved device efficiencies.

They then discuss various device layouts and architectures to optimize the OPV performance. Examples include alternative interlayers of polymeric films and/or inorganic semiconducting metal oxides; inverted device configuration for different polymeric donors; and tandem cell structures. For instance, three complementary absorbers implemented in a triple-junction solar cell led to a record OPV efficiency close to 12%.

The open-access article appears in a special section on solution-processable organic solar cells.

Source: **dx.doi.org/10.1117/1.JPE.5.057214**

New plasmonic transparent electrodes for OPVs

A proposed new design could increase photon absorption 200%

Researchers from Lehigh University (USA) have proposed a new transparent conducting electrode (TCE) design for organic photovoltaics (OPVs) that could result in a doubling of power-conversion efficiency, to 24% from the 12% achieved with today's state-of-the-art OPVs.

Their approach employs a light-trapping strategy using plasmonic nanostructures to enhance photon absorption, i.e. increasing the optical but not the physical thickness of the light-harvesting layers.

Limits on the thickness of these organic active layers have been one of the major challenges to improving the OPVs' efficiency in converting solar energy into electricity. This is primarily due to the low-charge-carrier mobility and small exciton-diffusion length (~1-10nm) in most organic semiconductors.

Their research article is published in a special section on nanophotonics and plasmonics for solar-energy harvesting and conversion in the current issue of the *Journal of Photonics for Energy*. In "Transparent electrodes based on two-dimensional Ag nanogrids and double one-dimensional Ag nanogratings for organic photovoltaics," SPIE member Beibei Zeng and coauthors systematically studied the optical and electrical properties of ultrathin one- and two-dimensional silver (Ag) nanogratings and nanogrids, respectively.

They report a sheet resistance <10 Ω/sq, better than that of a typical commercial electrode material such as indium tin oxide. They show that 2D Ag nanogrids can provide polarization-independent light-trapping effects for OPVs, which lead to a large photon absorption enhancement (150%) in the organic light-harvesting layers.

Taking the design one step further, they propose an OPV structure sandwiched between one top and one bottom 1D Ag nanogratings, which are perpendicular to each other. This leads to additional excitation of the surface-plasmon resonances (SPRs) in the central part under both transverse magnetic (TM) and transverse electric (TE) polarizations and a photon-absorption enhancement of 200%.

"These design principles are quite general and can be extended to other organic, inorganic, and organic/inorganic hybrid optoelectronic devices with thin active layers," the researchers conclude. They add that since SPRs are sensitive to the geometric parameters of metallic nanostructures and the dielectric constants of surrounding materials, however, "careful consideration is required for each specific design and material used."

Coauthors on the paper are SPIE Fellow Zakya Kafafi, founding editor-in-chief of the journal who chairs the Organic Photonics+Electronics symposium and the OPV conference at SPIE Optics+Photonics, and Filbert Bartoli, chair of the Electrical and Computer Engineering Department at Lehigh.

Source: **http://dx.doi.org/10.1117/1.JPE.5.057005** ■

SPIE grants 4 prizes at Intel Science Fair

Teenagers with photonics projects on spectroscopy for disease diagnosis, light-based vision therapy for brain-injured patients, 3D object tracking in liquids, and 3D mapping and analysis of complex structures won special prizes from SPIE at this year's Intel International Science and Engineering Fair (ISEF).

The prize-winning students were among more than 1700 finalists from 75 countries who qualified for the world's largest high-school science research competition by participating in regional, state, or national fairs associated with the Society for Science and the Public.

SPIE member Haiyin Sun, senior optical engineer with ChemImage Corp., and SPIE Science and Technology Strategist Bob Hainsey selected recipients for the SPIE awards.

Both judges commented that several projects the students presented at the weeklong fair in May were well beyond high-school-level optics and could lead to valuable engineering progress or scientific discovery.

The first-place SPIE award went to John L. Dean, 17, of Scotia, NY (USA) for "Three-dimensional object tracking using a rapid scanning double droplet system microscope." Dean built a piezo-vibrating liquid lens system that can change the focal length in real time.

"Think of life-science applications in aqueous solutions where you want to track cell motion," Hainsey said of the possible uses for the system. "John demonstrated a full-system approach with both hardware and software — and a deep understanding of optics."

The second-place SPIE prize was awarded to Natasha Goenawan and Ziyan Mo, both 16, of Kalamazoo, MI (USA) for "Two-photon spectroscopy for the early diagnosis of ALS: folding and aggregation of SOD1." Their research centered on the activation of proteins tied to ALS (amyotrophic lateral sclerosis, also known as Lou Gehrig's disease).

Courtesy Intel

Intel ISEF winners and judges. Left to right in front row are Mo, Goenawan, and Floyd. Back row: Sun, Dean, Zvara, and Hainsey.

Savannah Floyd, 15, of Choudrant, LA, (USA) won third place for "TBI: light more than meets the eye." Her project dealt with laser light therapy to restore peripheral vision in traumatic brain injury (TBI) patients.

Fourth place went to Daniel Zvara, 18, of Lietava, Slovakia, for "Computer vision: mapping and orientation in 3D space."

The students received a combined total of $5,000 US for the four SPIE awards. ■

JOURNAL OF BIOMEDICAL OPTICS

Section on light for life

The *Journal of Biomedical Optics* is celebrating the International Year of Light and Light-based Technologies (IYL) with a special section on "Light for Life."

Papers in the June issue of the journal give an overview as well as specific insights into the revolutionary impact of light technologies on medicine and biology, highlighting the ways that biophotonics has improved both medical diagnostics and treatments.

Guest editors of the special section are SPIE Fellows Katarina Svanberg (Sweden), a former SPIE president; Rainer Leitgeb (Austria); Nirmala Ramanujam (USA); and Jürgen Popp (Germany) along with SPIE Senior Member Peter Andersen (Denmark).

"Our armory to fight life-threatening diseases has been significantly enhanced by light-based technologies, either by improved diagnostics or by providing efficient image guidance during surgery, or for treatment itself," the guest editors say in an editorial.

The collection of papers highlights the rapidly growing interdisciplinary field of biomedical research that has produced new methods for noninvasive disease screening, diagnosis, and treatment monitoring and enabled novel approaches for disease detection, optical biopsy, and surgical guidance such as laser immunology and photodynamic therapy.

The editors say they hope the special section is a valuable resource, even for people outside the biomedical optics community. "They might get a glimpse of how light technologies have impacted biology and medicine today and how they reshaped our understanding in biomedical research," they write.

Citing advances in laser applications, photodynamic therapy, and microscopy techniques, the editors note that the 2014 Nobel Prize in Chemistry was awarded for "opening the door to optical in-vivo nanometer imaging."

"Modern light technologies play a vital role in our daily lives," they write. "We live in exciting times."

IMAGING TECHNIQUES GO DEEP

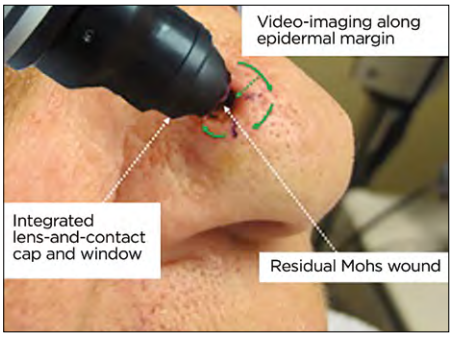
Among the papers in the special section is an open-access article on multiphoton microscopy (MPM) by a team at Massachusetts Institute of Technology. MPM allows for deep tissue imaging with molecular contrast and high resolution and is the key imaging technique for studying the brain in vivo.

Recently introduced temporal focusing techniques allow parallel acquisition of multiphoton signatures over the full focal plane, thereby speeding up volumetric tissue imaging.

In "Objective, comparative assessment of the penetration depth of temporal-focusing microscopy for imaging various organs," Christopher J. Rowlands and coauthors discuss the penetration depth of both techniques for different murine tissue and introduce an original method for quantitative assessment of the image quality over tissue depth.

Their results indicate that spot-scanning MPM outperforms temporal focusing but is still slower in acquisition time.

Eileen S. Flores and colleagues at Memorial Sloan Kettering Cancer Center (USA) contributed another open-access article. In "Intraoperative imaging during Mohs surgery with reflectance confocal microscopy: initial clinical experience," they report on a new model for the micrographic surgery that has become standard



Courtesy J. Biomed. Opt. 20(6)

Reflectance confocal microscopy (RCM) imaging of the residual wound after a Mohs stage 1 excision.

procedure for treating non-melanoma skin cancer, a disease that is dramatically increasing worldwide.

Flores' paper provides evidence that combining Mohs surgery with intraoperative optical imaging to outline tumor margins helps significantly ease the currently tedious and inefficient procedure of removing the malignant tissue. Although their work has been tried on only 25 patients with skin cancer, they propose that the technique may also be used in other types of surgery.

MICROSCOPY AND MEDICAL LASERS

Two other articles of note discuss how biomedical optics is used in the study of brain function and show the process of laser technologies making their way out of the lab and into clinical practice.

Anna L.A. Mascaro and colleagues at University of Florence (Italy) review various neurophotonics techniques in "Towards a comprehensive understanding of brain machinery by correlative microscopy." The researchers discuss hybrid techniques that correlate information from different imaging technologies such as magnetic resonance to light and electron microscopy to help bridge the gap between temporal and spatial scales of brain function.

In "Medical laser application – translation into the clinics," an international team of researchers discusses the path from successful demonstration of new technologies to prototype systems and their actual translation into medical practice. Usually this long and cumbersome process requires patience, persistence, and financial support.

Lead author Ronald Sroka of Hospital of Munich University gives several examples of promising medical laser technologies that have overcome various barriers before finally achieving acceptance in the medical community.

PARALLEL TALKS IN MUNICH

Publication of the IYL-themed scientific articles and reviews was timed to coincide with a "Hot Topics" session with the same "Light for Life" focus at the June 2015 SPIE/OSA European Conferences on Biomedical Optics (ECBO) in Munich, Germany.

Svanberg, moderator of the event, organized an internationally renowned group of experts to discuss emerging developments in biophotonics for the life sciences and show how these technologies are poised to improve the human condition.

In separate plenary sessions at ECBO, 2014 Nobel Laureates Stefan Hell and Eric Betzig were scheduled to discuss how their breakthroughs allowed scientists to visualize the pathways of individual molecules inside living cells. SPIE Fellows Sune Svanberg and Federico Capasso and SPIE member Ernst H. K. Stelzer were also announced as plenary speakers.

The special section in the *Journal of Biomedical Optics* can be found in the SPIE Digital Library at: **biomedicaloptics.spiedigitallibrary.org.** ■

FINDER rescues Nepal victims

A search-and-rescue technology called FINDER, for Finding Individuals for Disaster and Emergency Response, located four men trapped under some 10 feet of rubble in Nepal this spring.

Under development by the US Department of Homeland Security Science and Technology Directorate and NASA JPL, FINDER uses low-power microwave radar to detect small movements from the breathing and heartbeats of buried victims.

Unwanted data that comes into the suitcase-sized device is eliminated with sophisticated signal-processing tools, and algorithms are used to detect the variation in the instantaneous heart rate due to respiration.

People who are buried under shallow rubble are usually rescued first, according to FINDER task manager Jim Lux. "So we're looking for people who are deeper. We've recently added functions to the tool, so you can detect victims that are, say, more than five but less than 15 meters away."

Photonics for a Better World

1ST RESPONDERS IN NEPAL EARTHQUAKE USE MANY PHOTONICS TECHNOLOGIES

By **Rebecca Pool**

Within minutes of the first of two deadly earthquakes that devastated Nepal this spring, photonics technologies from satellites to smartphones focused on the destruction to provide life-saving data to disaster response teams.

The two massive earthquakes, a magnitude-7.8 quake on 25 April followed by a magnitude-7.3 on 12 May, combined with tremors and aftershocks, killed more than 8500 people and injured at least 21,000.

High-resolution satellite images are crucial to relief efforts following any natural disaster, with key organizations ensuring information reaches the hundreds of emergency services groups involved in recovery operations.

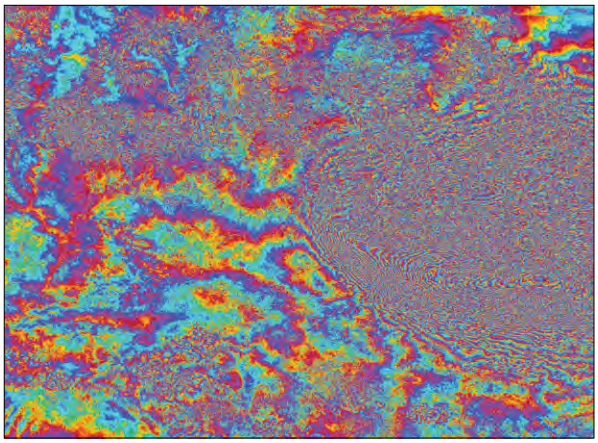
Immediately after the first earthquake, the Global Disaster Alert and Coordination System, a joint UN and European Commission initiative, instructed the UN satellite imagery program, UNOSAT, and its partners to start mapping the region.

Under the International Charter on Space and Major Disasters, myriad satellite-related organizations acquired images of priority regions that UNOSAT swiftly integrated into a web map. US-based commercial satellite operator DigitalGlobe played a key role in the rapid-mapping effort and released its own imagery of affected areas to all response and recovery efforts.

"The morning after the earthquake struck, we were able to capture imagery across the devastated regions using [several] of our satellites," said Georgios Ouzounis, a DigitalGlobe scientist who designs and develops advanced algorithms and methods for satellite and aerial image processing.

"The areas of Nepal affected by the earthquake were within our most recently launched WorldView-3 satellite's field of view, during one of its 15 orbits around Earth," Ouzounis said.

Static imagery of this region, some 13km by 13km in area, was collected and pieced together to produce longer strips as the satellite moved along its orbit, he explained. DigitalGlobe's satellite can collect imagery over 680,000 sq km every day, producing images with a resolution as high as 30cm.



Copyright ESA, DLR Microwaves and Radar Institute, GFZ, e-GEOS, INGV-ESA SEOM INSARAP study

Two Sentinel-1A scans over Kathmandu, Nepal, before and after the 25 April earthquake, generated an interferogram that reveals ground movement. Each fringe of color represents about 3 cm of deformation. The large amount of fringes indicates a large deformation pattern with ground motions of 1 m or more.

GROUND MOVEMENT AND FUTURE RISK

Satellite imagery from around the world is also being used to pinpoint areas at greatest risk from future earthquakes. The European Space Agency, for one, has produced interferograms from data captured by its radar satellite, Sentinel-1A, that reveal ground movement across Nepal and will assist in future disaster planning.

The imagery acquired before and after the earthquake has been combined to produce interference patterns that researchers use to quantify ground movement. These interferograms have already shown that the maximum land deformation following the earthquake was only 17km from Nepal's capital, Kathmandu, explaining the extensive damage in this area.

Sentinel and other radar satellites are being used for continuous mapping, said Tim Wright, a professor at Leeds University (UK) who works with ESA as part of the Earthquakes without Frontiers project.

"We can relate this information to what happened in the earthquake and work out which bits of fault slipped and, equally importantly, which bits didn't slip and have the potential to fail in future earthquakes," Wright said.

RADAR MEASUREMENTS PLUS GPS

While satellite imagery is critical in relief efforts, other sources of data are becoming increasingly important as well. As part of his ESA efforts, Wright has been working with Jean-Philippe Avouac, a

professor at University of Cambridge's Earth Systems Sciences doctoral training program (UK), to combine radar satellite measurements with GPS data as well as general seismic observations.

With the combined data, the researchers can better understand the physics of Nepal's earthquakes and model what's happened below the Earth's surface to assess future potential earthquakes.

"GPS [data] provides a time history of events. So you can, in principle, track measurements every second or even more frequently," Wright said. "This really helps us to nail down the temporal evolution [of post-seismic motion] particularly in the first few days between the earthquake and first radar acquisition."

Similarly, researchers from California Institute of Technology (Caltech) and NASA Jet Propulsion Laboratory (JPL) have combined satellite radar imaging data with GPS data and worldwide seismic observations to estimate the slippage of the geologic fault beneath Nepal. The research forms part of the Advanced Rapid Imaging and Analysis (ARIA) project and will provide tools and data for relief groups.

Mark Simons, a professor of Geophysics at Caltech, predicted that within five years, this type of information "will be available within hours of a disaster, resulting in an ability to save more lives."

UAVS HELP MAP DESTRUCTION

Drone footage has also proven critical to relief efforts in Nepal. Images from these unmanned aerial vehicles (UAVs) were among the first to reveal the post-earthquake devastation and have helped responders pinpoint where aid is needed.

Courtesy GlobalMedic

Aeryon Lab's UAVs mapped regions of devastation to help GlobalMedic relief workers.

Aeryon Labs (Waterloo, Canada) has supported Canada-based GlobalMedic by supplying three small, unmanned aerial systems and a flight engineer to capture aerial photography and live videography for detailed mapping of disaster zones. According to Aeryon, infrared cameras capture images close to the ground, enabling operators to locate a human face some 300m into the distance.

CROWDSOURCING BIG DATA

But while satellite images, GPS data, aerial imagery, and other tools have helped to save lives across Nepal, crowdsourcing has played a massive part in recovery and rescue missions. Soon after the quake, DigitalGlobe activated Tomnod, a crowdsourcing platform that allows online volunteers to pore over satellite images, compare new images with old, and tag damaged infrastructure.

More than 30,000 volunteers used the platform within the first month, according to Ouzounis of DigitalGlobe, resulting in the cataloguing of thousands of damaged roads, buildings, and areas of major destruction.

Because the volumes of crowdsourced data from Tomnod are so vast, it must be plugged into an algorithm that identifies frequent tag agreements to discover which areas are in need of the most help.

UNOSAT'S free smartphone app called UN-ASIGN has also been used to automatically upload to the organization's web maps photos that have been taken by volunteers in disaster regions. These volunteer images have validated satellite imagery from Nepal as well as provided accurate details on damage in specific locations.

For its web maps, the organization has also drawn on information pouring out of the OpenStreetMap community. Thousands of OpenStreetMap volunteers worldwide have been rapidly editing satellite imagery to provide such information as the location of open spaces that could be used for helicopter landing.

For more information, including images and video, go to **spie.org/Nepal15**. ■

–Rebecca Pool is a UK-based freelance writer.

SPIE.

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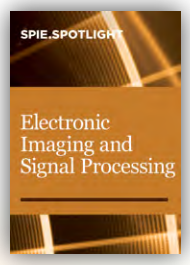

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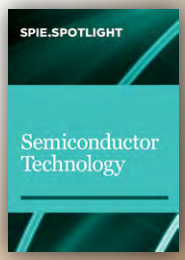

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Proposed changes to US export rules to impact global photonics industry

By **Jennifer Douris**
Government Affairs Director for SPIE

The stakes are high for the global optics and photonics industry as the US considers new regulations on the export of technologies and commodities covered by the International Traffic in Arms Regulations (ITAR).

A 60-day public comment period on proposed changes to Category XII of the US Munitions List (USML), which could affect non-military uses of photonics products and technologies everywhere, is scheduled to end 6 July.

It is important that all businesses review the proposed changes carefully because they contain many provisions that could hamper global competitiveness of US industry now and in the years to come. The proposal could also impact imports by non-military suppliers outside the US.

The proposed regulations govern certain cameras, range-finder systems, detectors, and other optical components and software and have broad implications for manufacturers, exporters, and research universities both inside and outside the US.

The rewrite of Category XII is part of a general overhaul of the US export control system, called Export Control Reform (ECR), that the Obama administration initiated in 2009. Most of the other export control categories have already been addressed. The administration saved Category XII for last due to its complexity and importance to both industry and the military.

The ECR initiative was launched with the express purpose of focusing government enforcement resources on protecting the most significant military technologies and reducing controls on less significant technologies; i.e., building "higher walls" around fewer items. The ECR was also aimed at strengthening the US industrial base by reducing incentives for non-US companies to avoid using US products that come with ITAR restrictions. Furthermore, ECR was meant to clarify and simplify export control regulations, reducing redundancies and ambiguity.

ECONOMIC DETERRENTS FOR INDUSTRY

The proposed changes for Category XII deviate greatly from these core principles. The proposal, published in the Federal Register 5 May, is far more complex and expansive than the commodities controlled under the current Category XII. More importantly, the proposal does not properly recognize the non-US availability of many of the commodities that it proposes to control.

Commercial markets dominate sales of many technologies described in the Category XII proposal. For example, there are at least nine companies located in seven countries outside the US that manufacture uncooled infrared detectors. The governments of all of those countries control those items as commercial/dual-use.

By controlling these items as ITAR, the US government ensures that foreign industry will continue to grow while US industry is effectively hampered from competing in the global marketplace. Ultimately, a reduction of the industrial base in the US is a national security issue.

Companies everywhere that make dual-use products deemed to fall under the proposed Category XII could find themselves at a disadvantage in the global marketplace. For example, manufacturers of medical equipment that includes advanced focal-plane-array detectors may encounter export or import problems.

Companies outside the US who sell primarily in their "local" markets may think they won't be affected by the proposed rules. However, in today's world, all markets are global; exclusion from the US market or added overhead to participate in a major part of the market will act as an economic deterrent for these and other companies to use some advanced technologies.

ENCROACHING ON COMMERCIAL MARKET

Moreover, the Category XII proposal defines performance parameters for items on the list that are not unique to military applications. Instead, the performance parameters listed are either at the edge of or intruding on today's commercial market.

Performance parameters that specify wavelengths, pixel counts, and maximum radiant sensitivity, for instance, will be used to determine whether the technologies or goods are included on the USML.

This approach is troublesome, given rapid advances in technology and performance improvements of the items covered by Category XII and the extremely slow and difficult process of changing US regulations.

In addition, placing limitations on the performance of goods and technologies that might have a dual use is a disincentive for US companies to invest in emerging technologies that might require exceeding those parameters.

POTENTIAL PATH FORWARD

A solution to many of the problems in the proposal for Category XII is to fully apply the "specially designed" criteria (defined in section 120.41 of the USML) to the commodities and components listed, and to align that list with the Wassenaar Arrangement to ensure equal footing with US allies. The US and 40 other countries are signatories to the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-use Goods and Technologies, which has its own munitions list.

One goal of the ECR was to create a regulatory definition of "specially designed" under both the USML and the Department of Commerce Control List (CCL) to streamline the decision on whether an item is "specially designed" for the military and thus subject to ITAR controls. The US departments of Defense and Commerce agreed on a common definition in October 2013. The definition, when applied, would release commodities that are in commercial use

Continued on page 37 ▶

Government division in Europe takes pledge for women in science

Simply "trying" to ensure appropriate female representation among conference speakers and on panels is not enough, the European Commission's Digital Agenda has decided.

Robert Madelin, the director general of DG Connect, the EC division for Communications Networks, Content, and Technology, has taken a new position in an effort to ensure that women's voices are heard more widely at technology events in Europe.

Earlier this year, Madelin announced a pledge to include at least two women speakers at all events organized by DG Connect. In a blog post titled "All-male panels in tech: we say no," Madelin said "trying our hardest" is no longer sufficient.

DG Connect staff speaking at conferences organized outside the EU will continue to try to ensure better representation for women at those conferences because "we obviously can't guarantee it," Madelin said. However, they will refuse invitations to speak on all-male panels and at all-male conferences organized by outside stakeholders.

The three-point pledge to promote diversity was immediately lauded by photonics community leaders, including SPIE members actively promoting personal and professional growth for women in optics and photonics.

"These decisions are very important in making visible the work done by female scientists in science and technology," said María Yzuel of Universitat Autònoma de Barcelona, the SPIE president for 2009. "Role models are important for female students to see that there are high-level women in these fields."

Yzuel noted that in general, science and engineering are seen as fields for men at secondary schools, and that many young women choose not to pursue a profession or career as a scientist after earning a bachelor's or even master's degree.

"Government agencies and companies are talking much about the attraction of talent," she said. "Decisions like the one taken by DG Connect should encourage women to take scientific or technical degrees and for PhD students and early-career professionals to stay in the field."

Serving on program organizing committees and giving talks in conferences are very important in developing one's CV, Yzuel said.

CHANGING ATTITUDES ABOUT WOMEN

Another former SPIE president, Katarina Svanberg, a professor of oncology at Lund University, said she was encouraged by DG Connect's pledge.

Although women and men should have the same opportunities in science as well as in higher academic positions, Svanberg said that in reality, "tradition, especially regarding family matters, puts women at a disadvantage due to an offset in active professional time."

Changing attitudes both on the personal and the societal level are needed, she said. "Equal opportunities mean equal available time. It is really a question of creating equal time for women as is available for men to pursue advanced professional and scientific activity — in which they of course are equally capable — and of organizing work to provide equal possibilities.

"When men and women truly equally share in daily life matters, which is the trend in many countries, the situation will improve immensely, and women can have time to flourish with their full competence and brain force. Eventually, there will be as many females in high positions as men as well as numerous female Nobel laureates in science," Svanberg said.

SPIE CEO Eugene Arthurs congratulated DG Connect for its pledge. "The world's needs for technology advances in communications, health care, energy, and other areas are continually growing," Arthurs said. "To meet future needs, we will need the benefit of perspectives, insights, and intellect of the entire workforce, and we cannot afford to discourage the 51% who are women from providing their contributions."

In making the announcement in March, Madelin has asked DG Connect stakeholders for support, including adding to a list of outstanding women in technology who could potentially serve as speakers and panelists. He asked everyone who organizes or speaks at conferences to spread the word and act accordingly.

"The more we apply it, the quicker we will make this change happen," Madelin said.

SPIE HAS BEEN PROACTIVE

Arthurs noted that SPIE has already been working in this direction, through its Women in Optics program, conference organization, and other areas. Female representation among SPIE members has increased 25% within the last five years, and participation in SPIE conferences has grown as well, he said.

"We continue to work toward greater equity and are encouraged by this strong action on the part of DG Connect," Arthurs said.

DG Connect is charged with the development and use of information

and communication technologies (ICTs) throughout European Member States to promote economic growth by. The directorate coordinates funding of ICT research and innovation under Horizon 2020, the biggest research and innovation program ever in Europe, with nearly €80 billion of funding available through 2020.

SPIE Senior Member Eva M Campo, of Bangor University (UK) and University of Texas at San Antonio (USA), pointed to Madelin's acknowledgement that former approaches at DG Connect, where diversity was either recommended or encouraged, have had little influence on panel composition.

Even with the promise of two women on future panels organized by DG Connect, Campo said, women "also have to be heard and their opinions adequately considered and projected."

Campo said she hoped women's voices will be heard more widely as a result of the new proactive measure and that DG Connect's pledge will be extended to other EC-funded programs or possibly lead to Parliament-approved legislation. "It would certainly be consistent with the direction of the DG Directorate and the European Union at large," she said. ■

US EXPORT RULES

◀ *Continued from page 35*

from Category XII and place them on the CCL where they would be treated as dual-use items.

This approach would also eliminate the need to establish specific performance parameters on these items.

Many of the commodities and components the USML proposes to control would more appropriately be placed on the CCL. Though still controlled under Commerce, the CCL allows for more flexibility on how export controls are applied and can adjust to conditions more quickly than the USML.

TIME TO GET INVOLVED IS NOW

It is likely that an interim proposed rule will be published before the rules for Category XII are finalized. That would allow for a second chance for companies to comment on the changes.

Nonetheless, the real opportunity for photonics companies to express their opinions on the proposed changes is now.

Companies interested in getting involved with or learning more about export controls can find resources at **spie.org/cat12**.

–Jennifer Douris is government affairs director at SPIE and a member of the Sensors and Instrumentation Technical Advisory Committee (SITAC) within the US Department of Commerce. ■

SPIE CEO Eugene Arthurs (at center holding "are" sign) and participants of the Lighting up Africa with Lasers, Optics, and Fibers event in March.

Promoting optics in Africa

SPIE member Rim Cherif, associate professor at ISET'Com/Sup'Com, the Engineering School of Communications at University of Carthage (Tunisia), wants to ensure that her students get the same opportunities to pursue research as she did. She voiced this aspiration after receiving the 2015 ICO/ICTP Gallieno Denardo Award for young researchers from developing countries.


Cherif

"In my country, there is little money to buy equipment for research and not many experimental facilities," Cherif says. "You cannot only do theory and modeling in optics research; you have to somehow validate your work experimentally."

One way Cherif works toward increasing opportunities for optics and photonics students and professionals is through collaboration with student organizations in Africa and the Optical Society of Tunisia (OST).

In 2009, Cherif spent three months with the Sandwich Training Educational Program (STEP), a fellowship program for PhD students from developing countries that is sponsored by the International Centre for Theoretical Physics (ICTP) and the International Atomic Energy Agency (IAEA). While participating in STEP, she observed activities of a few SPIE Student Chapters.

Once back home in Tunisia, Cherif conferred with SPIE Fellow Mourad Zghal (also of University of Carthage) about creating a student chapter devoted to optics and photonics. With help and advice from SPIE Fellow and past SPIE President María Yzuel, the SPIE Tunisia Student Chapter began.

It took about a year to convince students at Sup'Com of the benefits they would derive from volunteering with a chapter, she said. But by 2010, there were enough grad students to begin holding regular seminars with optics and photonics pioneers and bringing hands-on demonstrations of optical technologies to rural and underprivileged communities and schools.

Cherif and Zghal, who is cofounder and president of OST, now serve as advisors to the SPIE Optics & Photonics Tunisia Student Chapter, one of three SPIE Student Chapters in Africa. The others are the Council for Scientific and Industrial Research Chapter and Stellenbosch University Chapter, both in South Africa.

ACTIVITIES THROUGHOUT AFRICA

Cherif described the growth of optics education outreach activities by students in Africa in a paper for the 2014 Education and Training in Optics and Photonics (ETOP) conference.

"Expansion of student activities in Africa: from south to north," coauthored with Sub'Com colleagues and participants in the other Student Chapters in Africa, discusses how chapter members developed technical and leadership skills while bringing optics education workshops to primary and secondary schools and through networking with peers.

Some of the students have traveled thousands of kilometers through South Africa and Namibia to bring interactive science lessons to rural schools, all with the goal of attracting more young people to a career in optics and photonics.

Some of the students have traveled thousands of kilometers through South Africa and Namibia to bring interactive science lessons on liquid crystals, lasers, and other topics to rural schools, all with the goal of attracting more young people to a career in optics and photonics.

The Tunisian students presented some of the most successful outreach projects in 2014, she said, bringing demonstrations on reflection, refraction, and other optical phenomena to more than 200 secondary students.

CONNECTING SCIENTISTS AND STUDENTS

Members of the optics and photonics community are increasing the visibility of optics and photonics in Africa in other ways, too.

The first African Summer School on Optics and Applications to Sustainable Development was a weeklong training program in 2013 that brought graduate and post-doctoral students together with scientists from around the world. It was organized by OST and supported by SPIE, ICTP, and several other organizations.

The OST has continued to develop workshops in Africa, such as "Shedding Light on the Contributions of Muslim Scholars to Science and Technology" in December 2014. Supported by SPIE and UNESCO, this workshop brought attention to significant optical innovations from the Golden Age of Islamic Sciences.

And earlier this year, the OST and the African Laser Center (South Africa) held the workshop, "Lighting up Africa with Lasers, Optics, and Fibers" in Carthage. Along with promoting optics and photonics education, this workshop addressed how light technology will be a key driver of innovation in the 21st century.

In September, the ICTP will sponsor the Advanced School and Workshop on Fibre Optics in Alice, South Africa. Zghal, one of the program directors, says the five-day workshop will connect scientists and students from across Africa on a topic that will have a great impact on scientific and economic development for the continent. Topics to be covered from 28 September to 1 October include material design, multiplexing, light transport, and the applications of fiber optics in communication and sensors.

IMPROVING SCIENCE EDUCATION

Promoting optics and photonics in Africa is particularly important because the number of students selecting physics as a discipline is gradually dwindling in developing countries, and even in some developed countries, Zghal notes.

"African countries definitely need better-prepared researchers and teachers in optics and photonics to pass on their skills to younger generations," Zghal says.

To meet this challenge, organizations such as the OST and the SPIE Tunisia Student Chapter are working with secondary schools to improve physics and math education in their country and interact with students to show the benefits and possibilities of careers in physics – with an emphasis on optics.

Zghal says it is "vital that the brightest young minds from all areas of the world continue to be attracted to careers in this field."

–Karen Thomas, SPIE editor. ■

SPIE EARLY CAREER ACHIEVEMENT AWARDS

◀ *Continued from page 16*

sample to collect pixel-by-pixel data.

"The high power newly available from a THz QC-laser illumination source led to his clever new approach, where the laser output was modulated in sync with the camera frame rate, allowing THz images to be collected even with a large thermal IR background," said Benjamin S. Williams, an associate professor at University of California, Los Angeles (UCLA) who worked closely with Lee when Lee was working on his MS at UCLA.

"Various imaging configurations were demonstrated, including stand-off imaging over 25 m, a non-trivial task considering the strong atmospheric absorption in the THz range. Along the way, his contributions have taken the THz QC laser from a not-particularly-useful device, to a viable component," Williams added.

Both Williams and Qing Hu, Lee's doctoral adviser at MIT, said Lee has excelled in both the technical and commercial realms. Hu noted that Lee has succeeded as a startup entrepreneur because of "his well-rounded skills in system-level engineering, integration of diverse technologies, identifying and securing potential customers and sponsors, and knowledge of intellectual properties." ■

SPIE. OPTICS+ PHOTONICS 2015

Celebrating optics and photonics in the International Year of Light

The celebration for the International Year of Light and Light-based Technologies (IYL) continues at SPIE Optics+Photonics 9-13 August in San Diego, CA (USA). IYL-related presentations and workshops will be available along with a display of the 32 images vying for the People's Choice Award in the SPIE IYL Photo Contest. (See page 22).

More than 4300 attendees are expected at this annual event featuring 3300 papers on the latest research in emerging optics and photonics technologies. Also on the program: numerous technical and networking events, a three-day industry exhibition, job fair, and professional development activities for students.

The Women in Optics presentation 10 August will feature reports on IYL activities from around the world. Panelists include SPIE student members Laura Tobin of University College Dublin (Ireland), who was a judge in the photo contest; Anne-Sophie Poulin-Girard of Université Laval (Canada); and Sona Hosseini of University of California, Davis (USA).

A workshop for optics educators will demonstrate how to introduce light and optics to young students with the Light Blox kit, the official educational kit for the IYL.

There also will be several award presentations at SPIE Optics+Photonics, including the 2015 Early Career Achievement Award, SPIE Educator Award, and the SPIE Gold Medal.

PLENARY SPEAKERS

SPIE Optics+Photonics will open with two symposium-wide plenary speakers contributing their insights into comet chasing and optical wave sculpting.

Chmielewski

Engheta

The Rosetta Mission, the third cornerstone mission of the European Space Agency's comprehensive Horizon 2000 plan, made history 12 November 2014 when the lander module Philae soft-landed on a comet. US Rosetta project manager **Artur B. Chmielewski** of NASA's Jet Propulsion Lab (USA) will review the landing and tell how Philae became a comet chaser, lander, and hopper in the same mission.

"At the time of this conference, a planned dive into the comet plume may have already yielded important results," Chmielewski notes.

SPIE Fellow and 2015 SPIE Gold Medal Award recipient **Nader Engheta** of University of Pennsylvania (USA) will discuss some of the technologies made possible by controlling photons and optical waves.

"Materials control waves, and they can tailor, manipulate, redirect, and scatter electromagnetic waves and photons at will," Engheta says. "Recent developments in condensed matter physics, nanoscience, and nanotechnology have made it possible to tailor materials with unusual parameters and extreme characteristics, providing fertile ground for innovation and discovery."

Five more plenary sessions will have experts discussing topics covered by the four symposia: NanoScience+Engineering; Optics+Photonics for Sustainable Energy; Organic Photonics+Electronics; and Optical Engineering+Applications.

Open to all technical attendees, these sessions address breakthroughs in nano-bio-optomechanics, solar-cell technologies, organic electronics, signal processing, and wearable technologies.

Plenary speakers include:

NANOSCIENCE+ENGINEERING

- SPIE member **Keisuke Goda** of University of Tokyo (Japan), "Extreme Imaging and Beyond"
- SPIE member **Reuven Gordon** of University of Victoria (Canada), "Nano-Bio-Optomechanics: Nanoaperture Tweezers Probe Single Nanoparticles, Proteins, and their Interactions"
- SPIE Fellow **Mark Brongersma** of Geballe Laboratory for Advanced Materials (GLAM) (USA), "Device Applications of Semiconductor Nanoantennas and Metafilms"

OPTICS+PHOTONICS FOR SUSTAINABLE ENERGY

- **Wyatt Metzger** of the National Renewable Energy Laboratory (USA), "Status and Challenges of CdTe Photovoltaics"

Student events at Optics+Photonics

The SPIE Student Chapter Leadership Workshop 8 August is a full-day program on effective career and chapter development practices along with presentations on career skills, optics entrepreneurship, and publishing.

Workshop leaders include SPIE Student Services staff, Student Chapter alumni, and professional development instructor Jean-luc Doumont of Principiae (Belgium).

Doumont will also lead a workshop on how to persuade others using tactics such as personal/organizational power and social influences.

New to this year's schedule is the Student Chapter Bootcamp. Open to members of SPIE student chapters formed within the last year, this session offers tips on chapter benefits and management.

Other student events include:

- The Optics Outreach Games
- Lunch with the Experts
- A career choices panel discussion
- A professional skills development workshop
- Student chapter poster exhibits

- **Timothy Schmidt** of University of New South Wales (Australia), "Photochemical Upconversion of Light for Renewable Energy and More"
- **Rebecca Jones-Albertus** of the US Department of Energy's Solar Energy Technologies Office (USA), "The Importance of Reliability to the SunShot Initiative"
- **Liejin Guo** of Xi'an Jiaotong University (China), "Solar Hydrogen: Harvesting Light and Heat from the Sun"

ORGANIC PHOTONICS+ELECTRONICS

- SPIE member **Chihaya Adachi** of Kyushu University (Japan), "Current Status of High Efficiency OLEDs Based on Delayed Fluorescence"
- **George G. Malliaras** of Ecole Nationale Supérieure des Mines de Saint-Étienne (France), "Interfacing with the Brain using Organic Electronics"
- **Takao Someya** from University of Tokyo (Japan), "Ultraflexible Organic Thin-Film Devices for Wearable and Implantable Electronics"
- SPIE Fellow **Yang Yang** of University of California, Los Angeles (USA), "Recent Progress on Hybrid Organic-Inorganic and Perovskite-based Solar Cells"

SIGNAL, IMAGE, AND DATA PROCESSING

- SPIE Fellow **Thrasyvoulos N. Pappas** from Northwestern University (USA), "Visual Signal Analysis: Focus on Texture Similarity"
- SPIE Fellow **Aydogan Ozcan** of University of California, Los Angeles (USA) and California NanoSystems Institute (USA), "Democratization of Next-Generation Imaging, Sensing, and Diagnostics Tools Through Computational Photonics"
- SPIE Fellow **Bernard C. Kress** of Google (USA), "Restocking the Optical Designer's Toolbox for Next-Generation Wearable Displays"

CAREER AND INDUSTRY DISCUSSIONS

According to the 2015 SPIE Optics & Photonics Global Salary Report, included with mailed copies of this magazine, women's salaries continue to lag behind men's in most areas of the world. (See page 8.) Women in the optics workplace will be one of the topics covered in a panel discussion sponsored by the SPIE Career Center.

Women scientists and engineers on the panel will share their perspectives and experiences along with insights from the salary survey.

Photonics industry events include:

- Kerry Scarlott and Ian Moss, attorneys for Goulston and Storrs, will lead a discussion on best legal practices for navigating ITAR and other international trade regulations.
- SPIE industry and market strategist Stephen Anderson will profile the global optics and photonics industry at the SPIE Optics+Photonics exhibitor breakfast.
- A panel of professionals in the optics and photonics sector will discuss industry careers outside of academia and cover the process of getting hired at technology-based companies and non-academic facilities.
- A panel of experts in finding and vetting new technology ventures will offer advice on corporate investment programs, crowdfunding, nontraditional venture capital, and other new options for funding that are becoming popular.


Goda


Gordon


Brongersma


Metzger


Schmidt


Jones-Albertus


Guo


Adachi


Malliaras


Someya


Yang


Pappas


Ozcan


Kress

TALKS ON SOLAR, ASTRONOMY, MORE

SPIE member Jake Jacobsen of Synopsys (USA) will chair a technical event on solar energy production 10 August.

"Since we last discussed this topic five years ago, solar energy production in the US has seen substantial growth," Jacobsen notes. This technical session on illumination will cover the current state of solar energy production and insights into the future of this expanding technology.

Moving further out into the cosmos, 2014 SPIE President H. Philip Stahl of NASA Marshall Space Flight Center and Heidi Hammel of the Association of Universities for Research in Astronomy (AURA) will co-chair a presentation on the future of UV/optical/near-IR (UVOIR) space astronomy.

They will discuss information gathered from an AURA-commissioned report on future space-based options for UV and optical astronomy that significantly advance our understanding of the origin and evolution of the cosmos and the life within it.

In the continuing search for life on other planets, SPIE Fellow Richard B. Hoover, an astrobiologist at Athens State University (USA) and the Buckingham Centre for Astrobiology (UK), has led scientific expeditions to search for microbial extremophiles, organisms that can live in extreme conditions. Hoover will lead the 2015 SPIE Life in the Cosmos Panel in a review of recent discoveries in astronomy, microbiology, and astrobiology and discuss their implications.

To cover aspects of light in the natural world and ongoing research involving practical and experimental aspects of optics in nature, SPIE Fellow Rongguang Liang will chair a conference on light in nature.

Other technical events include poster sessions, a workshop on x-ray optics, and a discussion on lens design.

For more information: **spie.org/op**. ■

Photo courtesy Svobodat

CubeSats

Miniaturized satellites, 10-centimeter cubes known as CubeSats, were developed to lower the cost of space missions.

By using commercial, off-the-shelf electrical components, universities and companies can usually build one for about $10,000. Launch costs are approximately $100,000 to $125,000.

CubeSats are often used to study climate by monitoring atmospheric parameters such as water vapor content.

The QB50 project is an international initiative to launch 50 CubeSats in 2016 for in-situ measurements in the lower thermosphere and re-entry research.

Photo of Harrington: Courtesy US National Nuclear Security Administration; Photo of Tuell: Courtesy of Georgia Tech Research Institute

Remote-sensing and security events to be held in Toulouse in September

SPIE Europe to host 23 conferences

Plenary speakers for this year's SPIE Remote Sensing and SPIE Security+Defence in Toulouse, France, include SPIE Senior Member Grady Tuell, the recipient of the 2015 SPIE George W. Goddard Award.

Tuell

Tuell, associate director of the Electro-Optical Systems Lab at Georgia Tech Research Institute (USA) and an expert on bathymetric lidar, will be the plenary speaker at SPIE Remote Sensing, collocated with SPIE Security+Defence 21-24 September.

Harrington

Anne Harrington, deputy administrator for Defense Nuclear Nonproliferation at the US Department of Energy's National Nuclear Security Administration, will be the Security+Defence plenary speaker.

The joint plenary session will also include a panel discussion on CubeSats, the miniature satellites used for Earth observation, reconnaissance, space and climate research, situational awareness, and other applications. Representatives from Surrey Satellite Technology (UK), the QB50 project, and other organizations involved in the design, manufacture, launch, and operation of these small satellites will discuss the instruments and other details about their missions.

The two European symposia are expected to have a combined attendance of 900 scientists and industry representatives from 25 countries.

SPIE. REMOTE SENSING

Ten conferences at SPIE Remote Sensing will cover the optical technologies used on sensors, systems, and satellites and their applications in agriculture, atmospheric science, oceanography, environmental monitoring, and other areas.

Representatives from space agencies in Japan, France, the USA, the Netherlands, and elsewhere will give updates on their ongoing and upcoming missions. Special sessions within the conferences will cover such topics as lidar techniques and hyperspectral remote-sensing modeling and applications.

Symposium chair is SPIE Senior Member Charles R. Bostater of the Marine-Environmental Optics Lab and Remote Sensing Center at Florida Institute of Technology (USA).

More information on SPIE Remote Sensing: **spie.org/ERS**.

SPIE. SECURITY+ DEFENCE

SPIE Security+Defence, in its 12th year, will have 13 conferences with a European focus on fundamental optical and photonics science and their applications in defense and security systems.

Topics to be covered include optronics, hyperspectral imaging, biomimetics, high-power lasers, signal processing, unmanned sensors, free-space optical communication techniques, camouflage design, and infrared systems.

Many of these devices and technologies are considered "dual-use" because they may be used in medicine, manufacturing, and other commercial applications in addition to detection and identification of weapons and illegal items.

A new conference will cover target and background signatures and the algorithmic and experimental approaches for distinguishing the weak signal of a target from a cluttered background of images. Presentations in this conference will cover the tools to distinguish between target and background properties in the visible to the thermal infrared spectral region.

SPIE Fellow David H. Titterton of the UK Defence Academy (UK) is symposium chair, and SPIE member Reinhard Ebert from Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB (Germany) is cochair.

More information on SPIE Security+Defence: **spie.org/ESD**.

Registration at either symposium provides access to all conferences and presentations at both events as well as admittance to the exhibition 22-23 September where the latest in components, devices, and technologies may be found. ■

SPIE. LASER DAMAGE

27-30 September

SPIE Laser Damage will be held 27-30 September at NIST in Boulder, CO (USA).

The 47th annual symposium on optical materials for high-power lasers will focus on four technical areas: thin films; fundamental mechanisms; materials and measurements; and surfaces, mirrors, and contamination.

In addition, there will be a mini symposium on laser-induced damage to multilayers in the femtosecond regime.

More information: spie.org/LD.

SPIE.

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EVENTS AROUND THE WORLD 2015

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Upcoming events and deadlines

Check your monthly SPIE Member E-news for links to these events.

JULY

1: Nominations due for 2016 SPIE Britton Chance Biomedical Optics Award and SPIE Biophotonics Technology Innovator Award

4-6: International Workshop on Thin-films for Electronics, Electro-Optics, Energy and Sensors

6: Comment period ends on proposed changes for US munitions list

6-8: International Conference on Photonics Solutions

AUGUST

3: Abstracts due for SPIE Photonics West 2016

3: Last day to vote in SPIE 2015 election

4-7: International Conference on Optical Angular Momentum

8: SPIE Student Chapter Leadership Workshop

9: Optics Outreach Games

9-13: SPIE Optics+Photonics

11: SPIE Annual General Meeting

15: Last day to vote for the People's Choice Award in the SPIE International Year of Light Photo Contest

17: Abstracts due for SPIE Medical Imaging 2016

24-26: SPECKLE

SEPTEMBER

1-4: Micro- to Nano-Photonics (ROMOPTO)

7-10: SPIE Optical Systems Design

8: Abstracts due for SPIE Smart Structures/ NDE 2016 and SPIE Advanced Lithography 2016

12: Wonders of Light: IYL Family Science Fun

14-18: Correlation Optics

15: Nominations due for SPIE Fellow

21-24: SPIE Remote Sensing and SPIE Security+Defence

24-25: SPIE/NIH Biophotonics from Bench to Bedside

27-30: SPIE Laser Damage

29-1 OCTOBER: SPIE Photomask Technology

29-1 OCTOBER: SPIE Scanning Microscopies

OCTOBER

1: Deadline to nominate a colleague for an SPIE award

2: Applications due for the Prism Awards for Photonics Innovation

4: Abstracts due for SPIE DSS 2016

9: Abstracts due for SPIE Photonics Europe 2016

12-15: SPIE Optifab

27-28: SPIE/OSJ Biophotonics Japan

INTERNATIONAL YEAR OF LIGHT 2015

Read about the International Year of Light at: **spie.org/IYL**

Supported by SPIE and 100 international partners and coordinated by the European Physical Society under the auspices of the UN, the International Year of Light and Light-based Technologies is a global initiative for 2015 to highlight the importance of light and light-based technologies.

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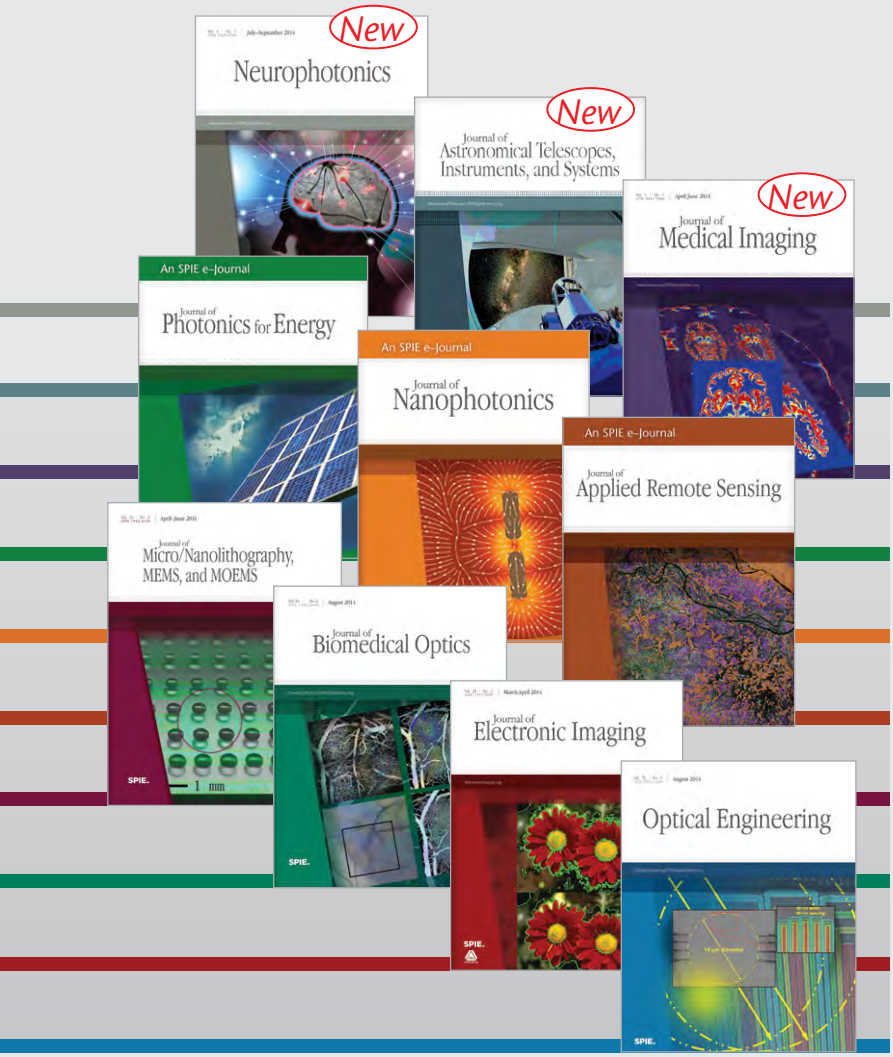

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