# AOS News

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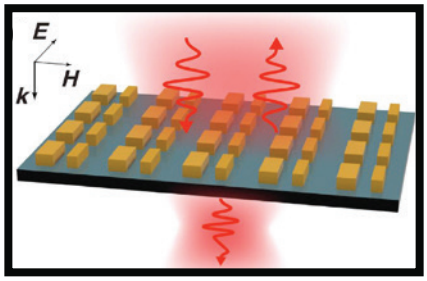
AUSTRALIAN OPTICAL SOCIETY



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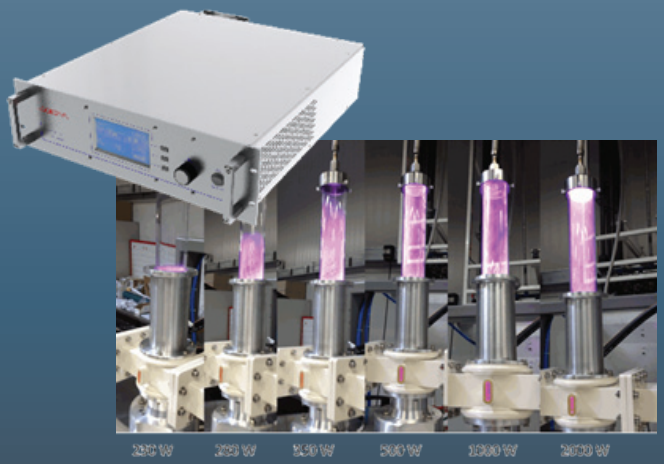

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AOS News is the official news magazine of the Australian Optical Society. Formed in 1983, the Society is a non-profit organisation for the advancement of optics in Australia. Membership is open to all persons contributing to, or interested in, optics in the widest sense. See the back page (or the AOS website) for details on joining the Society.

Submission guidelines

The AOS News is always looking for contributions, especially from AOS members. Here is a short summary of how to make a submission.

**Call for submissions!**

Please consider writing something for the next issue.
We are looking for:

Scientific articles on any aspect of optics

Review articles on work in your lab

Conference reports from meetings you attend

Articles for the Optics in Everday Life section

General interest articles

How can you submit?

► The easiest way is by email. We accept nearly all file formats. (Famous last words!).

► Submitted articles will be imported into an Adobe InDesign file. It is best if the diagrams and other graphics are submitted as separate files. All common graphics formats are acceptable, but the resolution must be in excess of 300d.p.i.. Be aware that all colour diagrams will be rendered in grayscale, so if you do use colours, choose colours that show up well in grayscale.

► When using Greek letters and mathematical symbols, use font sets such as Symbol or MT Extra. Please avoid using symbols that are in Roman fonts, where the Option or Alt key is used; e.g. Opt-m in Times font on the Mac for the Greek letter mu.

► If using TeX, use a style file similar to that for Phys Rev. Letters (one column for the title, author and by-line, and two for the main body). The top and bottom margins must be at least 20mm and the side margins 25mm. Submit a pdf file with the diagrams included (no page numbers), as well as copies of the diagrams in their original format in separate files.

► If using a word processor, use a single column. If you do include the graphics in the main document, they should be placed in-line rather than with anchors, but must be submitted separately as well.

What can you submit?

- Scientific Article: A scientific paper in any area of optics.
- Review Article: Simply give a run down of the work conducted at your laboratory, or some aspect of this work.
- Conference Report
- General Interest Article: Any item of interest to members such as reports on community engagement, science in society, etc.
- Article for Optics in Everyday Life section: An explanation of the optics behind any interesting effect, phenomenon, or device.
- News Item
- Obituary
- Book Review
- Cartoon or drawing
- Crossword or puzzle

Reviewing of papers

On submission of a scientific or review article you may request that the paper be refereed, and if subsequently accepted it will be identified as a refereed paper in the contents page. The refereeing process will be the same as for any of the regular peer reviewed scientific journals. Please bear in mind that refereeing takes time and the article should therefore be submitted well in advance of the publication date.

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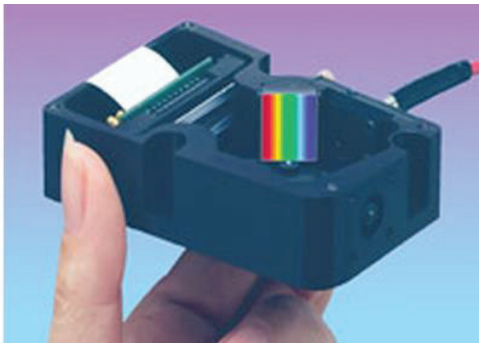

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Contributions on any topic of interest to the Australian optics community are solicited, and should be sent to the editor, or a member of the AOS council. Use of electronic mail is strongly encouraged, although submission of hard copy together with a text file on CD will be considered.

Advertising:
Potential advertisers in AOS News are welcome, and should contact the editor.
Rates: Colour pages $345, Black and White pages $175, with a surchargee for choosing a specific page for the ads (rates excl. GST). 1-2 Black and White pages in the main body of the newsletter are free to corporate members.

Copy Deadline
Articles for the next issue (Oct 2019) should be with the editor no later than 19 Oct 2019, advertising deadline 12 Oct 2019.

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Australian Optical Society website:
http://www.optics.org.au

- News
- Membership
- Optics links
- Prizes/awards
- Conferences
- Jobs/Scholarships
- Affiliated societies
- ...and more

August 2019 Volume 33 Number 2

## Articles



## Departments



Cover Pictures:

- The next winner of the AOS photo competition is Krzysztof Maliszewski. The photo presents a sunrise above Rangitoto Island, New Zealand. You don't need to take ND filter to observe a perfect sunrise or sunset; just remember to take your sunglasses!
- Insets (left to right)
  - Large telescope arrays use aperture synthesis to obtain images using information from many individual telescopes, see page 25. CSIRO's Square Kilometre Array Pathfinder (ASKAP) radio telescope at the Murchison Radio-astronomy Observatory in Western Australia. Image credit: CSIRO.
  - Dielectric metasurfaces with sharp resonances can be used for biosensing applications. Here is a schematic of the scattering of light by an asymmetric metasurface composed of a square lattice of pairs of dielectric bars of different widths, see page 28.

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# President's Report

Since the last AOS news we have had a full council meeting of the Society in Sydney in July, and completed the data collection and analysis for the regional Photonics industry. The results of this survey will be released formally at a launch of the report during the ANZCOP conference in December, but involvement in the process has been fascinating for me. The key has been the "apportionment meetings" where the proportion of a company's production that can fairly be allocated to the sector is decided. Several members of the AOS council were also at the Laser world of Photonics conference in Munich in June, and were able to meet with the author of the survey and discuss details of the methodology used. This will also be the subject of a presentation at ANZCOP which I can recommend to members.

The planning and organisation of our ANZCOP conference has required regular teleconference meetings with SPIE staff. This has itself been a bit of a challenge at times, with key people from time to time in Europe, as well as in Australia and on the East Coast of the US. Nevertheless, the facilities for video conferencing have improved steadily over the last couple of years, to the point where they do now provide a platform for effective meetings between multiple participants. We also used this facility for the Council meeting and will be making more use of it in the future.

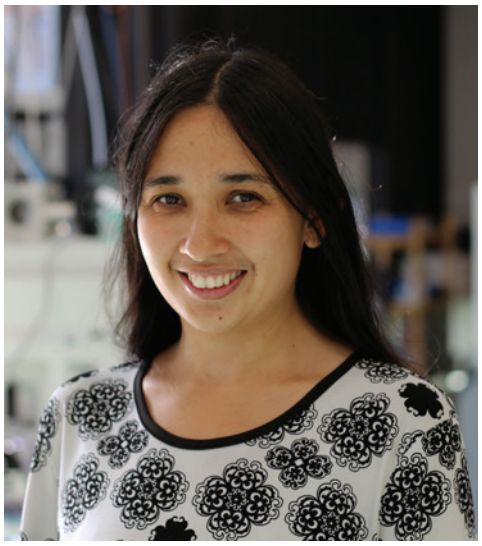
I was also able to attend the annual meeting of the Executive Bureau of the International Commission for Optics (ICO) in Tunisia in August, where the meeting was collocated with a meeting of Commission C17 of the International Union of Pure and Applied Physics (IUPAP) which I also attended. There have been a number of issues raised in recent years concerning the desirability of ICO moving to become a full Union of the International Science Council (ISC). In particular, Commission C17 of IUPAP has expressed concerns about ways in which cooperation can be enhanced, and duplication avoided. To a certain extent, the evolution of ICO to a full union of ISC parallels the development and evolution of the professional Optical Societies around the world, alongside the professional Physics Societies, and reflects the growing economic importance of Optics and Photonics. I apologise for the proliferation of acronyms in this report, but while the higher levels of international scientific cooperation and collaboration may seem of little relevance, there are a number of ways in which they can have an influence on our Society. As an example, ICO, Commission C17, together with Optical Societies around the world, all support the International Day of Light (IDL), while national contacts in our region coordinate our national celebrations of IDL through the AOS.

Another initiative which concerns a number of members of the AOS, is the promotion of the Global Environmental Measurement and Monitoring Network or GEMM Network. The idea for this network was originally developed by the Optical Society of America, as a response to concerns about climate change. It focusses on the ways in which better optical instrumentation can assist with monitoring the environment. The network consists of a growing number of GEMM nodes around the world, and a meeting of all nodes was held recently in Scotland which I was able to attend. Each node concentrates on issues of climate change which are of most immediate concern locally, and the need for instrumentation varies with these concerns. In California for example, the top concern is air quality which is being degraded by increased particulates from forest fires, while in Canada it is the melting of the permafrost. The founding workshop of the New Zealand node is being held on November 15th in Wellington. This will include a wide range of participants from many backgrounds, with the aim of formalising the priorities for New Zealand and the instrumentation development which is needed. It is already abundantly clear however, that the priorities for New Zealand differ significantly from those in Australia, and a wide range of optical instrumentation is needed across the region.

I hope that a report on this workshop can also be presented at ANZCOP 2019 but the schedule is already packed. A draft programme is available on the website and I urge all members to attend what should be a fascinating Conference in Melbourne in December.

*John Harvey*
AOS president

# Editor's Intro



Welcome to another issue of AOS News. We have a selection of articles for you this time including details about biosensing with dielectric metasurfaces and an item about the upcoming IONS-KOALA meeting. There is a look at the history of polaroid cameras, and our 'Optics in Everyday Life' section explores aperture synthesis. We also have the next winner of our photo competition and details on how to enter. Please send in articles or conference reports if you can as we haven't had many new contributions this year and would love to hear from you.

There is a lot of talk about lack of female role models in science and the effect this can have on girls wanting to participate, particularly in subjects like physics. I have never really felt affected by this myself, but it has been shown to be an important issue. Recently I was toying with the idea of writing an article on a historical figure in optics for AOS News and decided that I would prefer to write about a female. This is when I really encountered the lack of information first-hand. There are a few personalities that everyone has heard of, but most people already know about them and they aren't really that related with optics. I have put this project on hold for the moment as the person I wanted to pursue the most was Mary Somerville who was mentioned in an article in the previous issue. It did drive home the fact that even though there were women taking part in science in history, many of their stories remain largely unknown or with little detail provided.

There are people who are trying to do something about this lack of information, starting with contemporary scientists. A Wikipedia Edit-a-thon to add current female scientists' biographies to Wikipedia recently took place in Sydney on 25 July. The group Franklin Women organised the event, held on the birthday of Rosalind Franklin, to increase the visibility of women and their contributions. According to Franklin Women, only 18% of Wiki profiles are about women and less than 20% of contributors to Wikipedia are female. The editing session aimed to address both of these issues. The focus may have been medical science, but specifically adding information about women scientists is an idea that is gaining traction. Dr Melina Georgousakis, founder of Franklin Women was inspired by Dr Jess Wade from Imperial College, London who started adding women in STEM to Wikipedia in 2017, has organised a number of edit-a-thon events and aims for the idea to become global.

Dr Wade wants female scientists to get the recognition they deserve and has personally written over 650 entries. She was motivated by the book, Angela Saini's 'Inferior: The true power of women and the science that shows it', that investigates the stereotypes that have hindered women's contribution to society. She wants people to be inspired by these women's achievements and to change people's perceptions about scientists and the contributions made by women and minorities. Frustration at some of the negative or superficial messages that were attempts to persuade more girls to take up science led Dr Wade to turn to Wikipedia as a way to increase the reach of her efforts. Whenever she came across a female scientist who had made an excellent contribution she wrote a Wikipedia entry for them if they didn't already have a page. Now she looks for people who win awards or fellowships, checks that they are notable enough and then researches them to create a biography for Wikipedia.

There has recently been media attention about Wikipedia's notability standards as a number of pages that have been created about women scientists were deemed not notable enough and subsequently deleted. This happened multiple times for the same person. Dr Wade finds this frustrating as she points out that there are pages for film extras and sports teams that most people have never heard of. It is also concerning that female academic and ethnic minority women in particular are more likely to be nominated for deletion. This was famously the case for 2018 physics Nobel Prize winner Donna Strickland whose page had been rejected prior to her winning the prize. It has been found that female physicists were 19% less likely to have a Wikipedia page than males with the same h-index. Redressing this imbalance will take time but is something Dr Wade is working on.

Dr Wade has worked with Maryam Zaringhalam, a science communicator from the American Association for the Advancement of Science to hold edit-a-thons around the world. They in turn are building on progress made by others such as Emily Temple-Wood, founder of the WikiProject Women Scientists and Rosie Stephenson-Goodknight, co-founder of the WikiProject Women in Red, both of whom are working towards an increase in the number of biographies available on Wikipedia about women. They all want girls to have more role models and inspiration that they can easily find out about using the world's most popular online encyclopaedia.

*Jessica Kvansakul*
Editor

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# IONS KOALA - A Conference by Students for Students

*by Farhan Azeem*

**The Conference on Optics, Atoms and Laser Applications (KOALA) takes place annually. It is organised by students under the platform of International OSA Network of Students (IONS) in Australia and New Zealand.**

In 2018 IONS KOALA was co-organised by the OSA student chapters based in the University of Sydney and Macquarie University. A diverse set of students from all around the world attended the conference. The participants consisted of both undergraduate and postgraduate students and presented their research in the form of posters and oral presentations. The range of topics presented at the conference included quantum optics, biophotonics, optical resonators, spectroscopy, micro and nanofabrication, nonlinear optics, lasers, atomic and molecular physics.

Since KOALA is a conference organised by students for students, it gives the participants a suitable platform to present their work in a friendly environment with their fellow students. Moreover, it provides the students an opportunity to learn about and explore other research fields in physics as well. The conference itself is not limited to talks and presentations but features social events and an industry & innovation evening. The social events allow the participants to liaise and interact with their peers, whereas the industry & innovation evening allows them to learn about new technologies, and discover potential career paths after their studies.

The 12th in the series, IONS KOALA 2019 is being hosted at the University of Otago, in Dunedin, New Zealand. The conference will run from 2nd to 6th December. Registrations are now open. For more information, please see the KOALA website: http://ionskoala.osahost.org/

Farhan Azeem is with the Otago Optics Chapter, University of Otago, Dunedin, New Zealand.


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# News

**Chennupati Jagadish recognised for contribution to science**

AOS member, Distinguished Professor Chennupati Jagadish AC FAA, from Australian National University has been recognised for his outstanding work by the Australian Academy of Science (AAS). Professor Jagadish has been awarded one of the Academy's top honours, the Thomas Ranken Lyle Medal. His pioneering work has included developing semi-conductors used in LED lights and designing some of the world's smallest lasers.

Professor Jagadish has also trained a large number of PhD students and early-career researchers who've gone on to hold leading positions in industry and academia. "I am humbled and grateful to receive the Thomas Ranken Lyle medal," Professor Jagadish said. "This is recognition for my group members and collaborators, past and present. I am delighted the light technologies which we have been developing have been acknowledged by the Academy and the physics community. It's a good example of how investing in basic science leads to technologies which benefit humanity."

Professor Chennupati Jagadish. Image credit: Stuart Hay, ANU.

Source material: https://www.anu.edu.au/news/all-news/anu-researchers-recognised-for-contribution-to-science

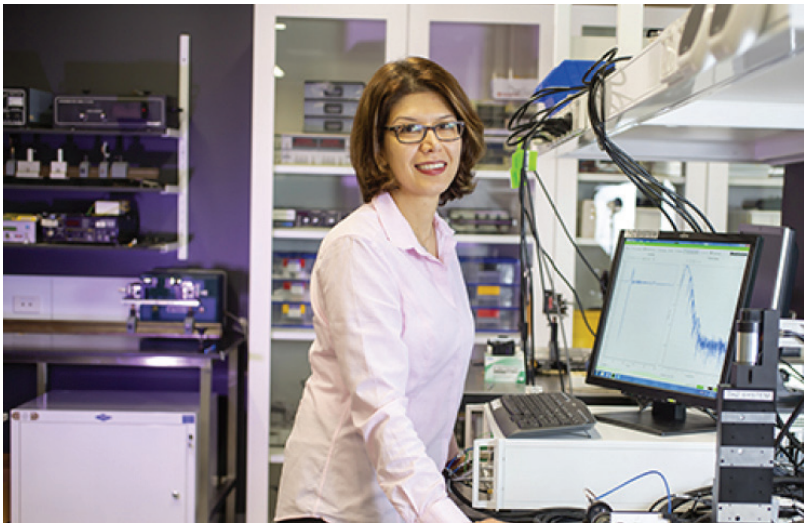
**AOS trio announced as OSA Senior Members**

The Optical Society (OSA) Board of Directors recently announced its 2019 class of new Senior Members, including a number of AOS members. The Senior Member distinction, awarded this year to 219 OSA members, recognises experience and professional accomplishment within the field of optics and photonics. “We are proud to have such a distinguished and diverse group of optical scientists and engineers join the rank of Senior Membership,” said OSA President-Elect Steve Fantone. “Their contributions to their respective fields provide the fuel that powers future advances. On behalf of the OSA, I congratulate each of you.”

The 2019 class joins a distinguished group of scientists, engineers, entrepreneurs and innovators who have demonstrated exemplary professional accomplishments in optics and photonics. To qualify for OSA Senior Membership, individuals must have at least 10 years of significant professional experience in the field, five years of active OSA Membership and two endorsement statements from current OSA Members. AOS members Shaghik Atakaramians, University of New South Wales, David McGloin, University of Technology, Sydney, and Danuta Sampson, University of Surrey were recognised in the 2019 class of new Senior Members.

Professor David McGloin. Image credit: UTS.

Source material: https://www.osa.org/en-us/about_osa/newsroom/news_releases/2019/the_optical_society_announces_2019_class_of_senior/

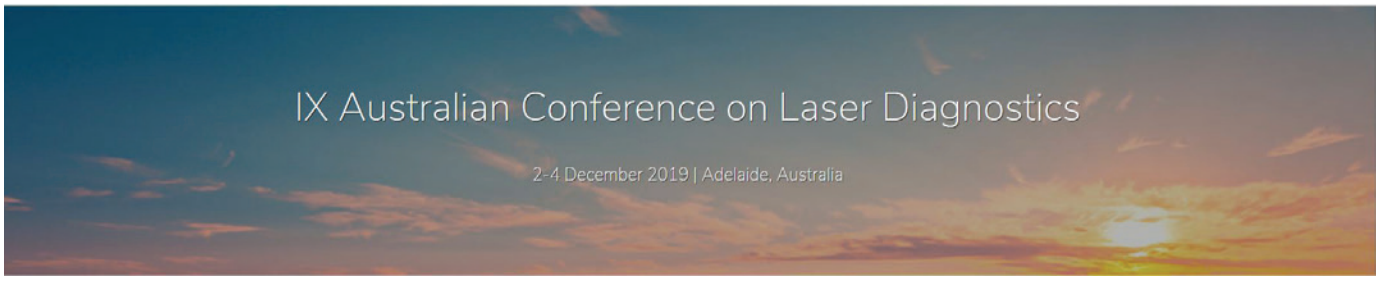


Dr Shaghik Atakaramians. Image credit: UNSW.

Dr Danuta Sampson. Image credit: University of Surrey.

# Conferences

**2-4 December 2019, ACLD**




The 9th Australian Conference on Laser Diagnostics (ACLD) will be held in Glenelg, a vibrant seaside of Adelaide, from 2 to 4 December. The conference builds on a series of successful meetings since the first Sydney conference in 1996. The conference aims to bring together Australian and international researchers to discuss the development and applications of laser diagnostic techniques. www.acld.org.au

**2-6 December 2019, KOALA**


The 12th Konference on Optics, Atoms and Laser Applications (KOALA) will be held at the University of Otago from 2 to 6 December. KOALA, a conference for students, run by students, was founded in 2008 by PhD students at the University of Queensland, Brisbane. They were inspired by the success of the Young Atom Opticians (YAO) meetings in Europe and thought it would be great to start a similar student-run meeting in Australasia. The conference has been held annually ever since, and quickly grew in size and reputation. Previous KOALA conferences have showcased student research in a wide range of areas from astrophotonics to biomedical imaging, quantum optics, solid-state physics and more. We welcome research from these topics and any other related field! ionskoala.osahost.org

**8-12 December 2019, ANZCOP**

The Australian and New Zealand Conferences on Optics and Photonics (ANZCOP) 2019 will be held in Melbourne from 8 to 12 December. This co-locates several SPIE conferences together with the 44th ACOFT, ACOLS and the AOS Conference with a central theme of optics and photonics. The ANZCOP conferences will connect people across all scientific disciplines associated with optics and photonics, incorporating general streams on optical science and technology and focused topical conferences on micro- and nano-materials and devices, biomedical photonics, and astronomical instrumentation. spie.org/conferences-and-exhibitions/anzcop


**2-6 August 2020, CLEO-PR 2020**

The 14th Pacific Rim Conference on Lasers and Electro-Optics (CLEO Pacific Rim, CLEO-PR 2020) will be held at the International Convention Centre, Sydney, Australia from 2 to 6 August 2020. The Conference will cover all major areas in lasers and optoelectronics along with tutorial sessions, invited sessions and workshops in areas of current interest. The organising committee invites you to join us in Sydney in 2020. We look forward to seeing you there. www.cleopr2020.org

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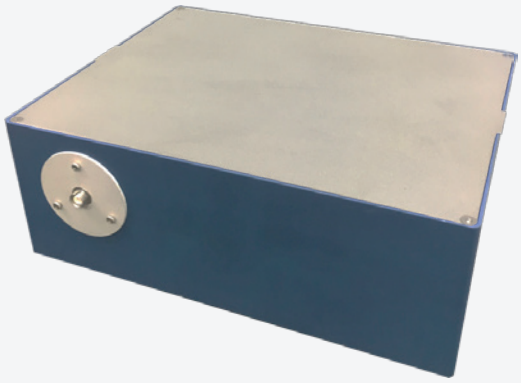

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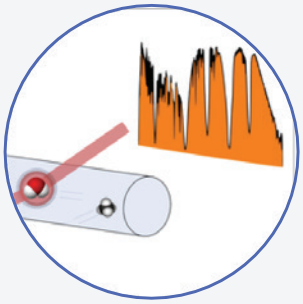

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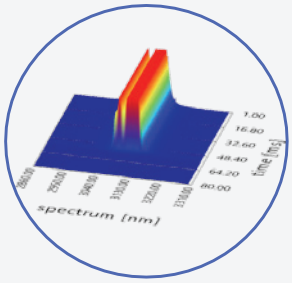


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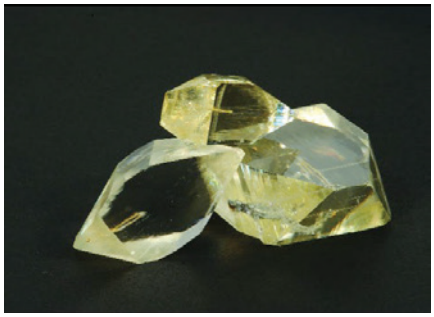
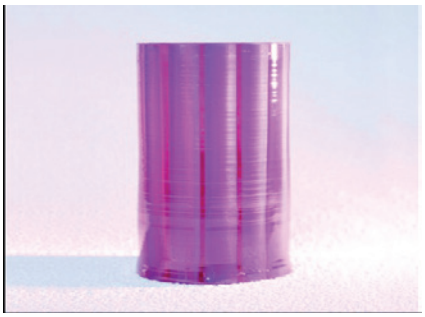
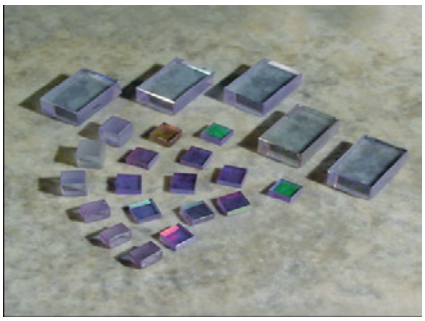
***The clear choice of crystals.***

## We'd like to make something crystal clear.







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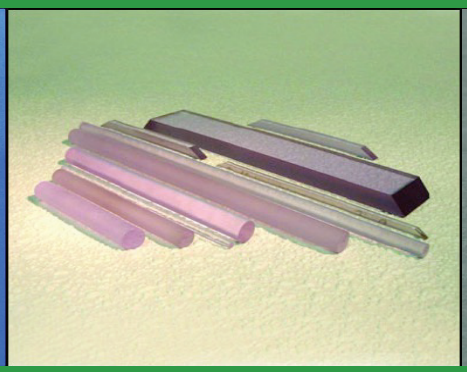

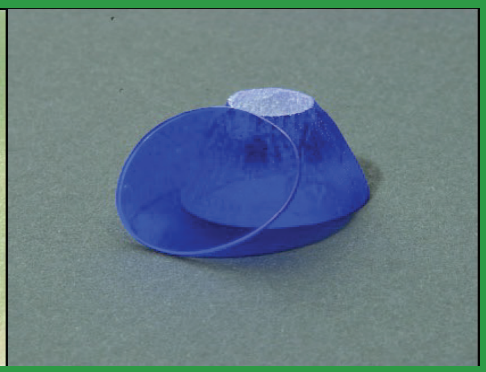

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# AOS Photo Competition

Help us demonstrate the beauty of optics and photonics.

Please submit photographs that capture some aspects of optics and photonics, and are aesthetically pleasing. They can, for instance, be of your research, of optical phenomena, of optical devices.

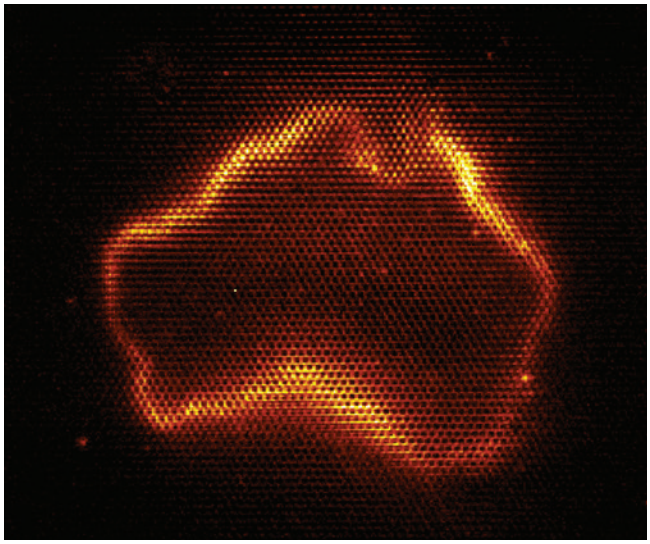
We want your assistance in generating photographs that we can use to promote Australian and New Zealand optics and photonics in print and online. We will publish the best photograph on the front cover of AOS News, and whoever submits this will get a year's membership free.

To enter, you need to send to ausoptsoc@gmail.com:

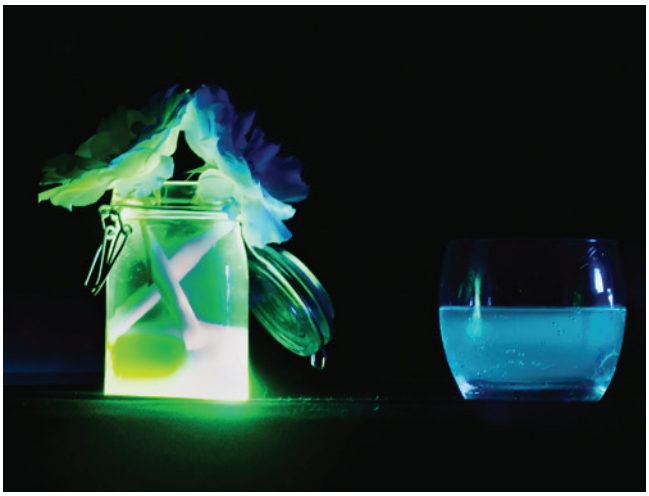
1) The photograph (see required specifications below)
2) Your name and organisation
3) A brief (one or two sentence) description of the photo
4) A covering email, that states "I ____full_name____ took this photograph and own the copyright. I hereby provide a royalty-free, perpetual, non-exclusive license to the Australian Optical Society to reproduce this photograph in print, online or other format."

The photos will be judged by a panel including three AOS Councillors, the Editor of the AOS News and the AOS Webmaster.
The competition will continue on a quarterly basis with judging for each issue of AOS News. AOS reserves the right to carry forward good entries from one quarter to the next, and in any particular quarter to award multiple winners or to award no winner. The competition will initially run until end of 2019. AOS may extend this date or terminate earlier, advising by email, through AOS News, or other reasonable communication.

Queries to ausoptsoc@gmail.com



Our past winners are pictured here. Top: Topological Australia, by Sergey Kruk, Australian National University, shows a photograph of an optical topological state shaped into an Australian continent. Middle: The photo presents a sunrise above Rangitoto Island, New Zealand. You don't need to take ND filter to observe a perfect sunrise or sunset; just remember to take your sunglasses! By Krzysztof Maliszewski. Bottom left: Ice bow by Stephane Coen, University of Auckland, shows a 22-degree halo around the sun, caused by high altitude ice crystals. Bottom right: A phosphorescence effect is especially spectacular in darkness. The picture presents an experiment set created by University of Auckland SPIE Student Chapter for celebrating the International Day of Light. By Krzysztof Maliszewski.



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Coherent SCIENTIFIC

# Australasian Research in the News

**Electronic chip mimics the brain to make memories in a flash**

Engineers have mimicked the human brain with an electronic chip that uses light to create and modify memories. RMIT researchers drew inspiration from an emerging tool in biotechnology – optogenetics – to develop a device that replicates the way the brain stores and loses information. Optogenetics allows scientists to delve into the body's electrical system with incredible precision, using light to manipulate neurons so that they can be turned on or off. The new chip is based on an ultra-thin material that changes electrical resistance in response to different wavelengths of light, enabling it to mimic the way that neurons work to store and delete information in the brain.

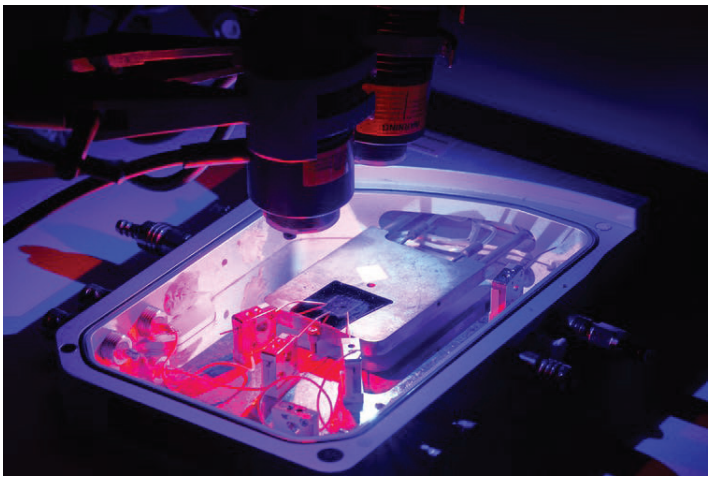
The new type of chip imitates the fundamental biology of nature's best computer. Image credit: RMIT.

Research team leader Dr Sumeet Walia said the technology moves us closer towards artificial intelligence (AI) that can harness the brain's full sophisticated functionality. "Our optogenetically-inspired chip imitates the fundamental biology of nature's best computer - the human brain," Walia said. "Being able to store, delete and process information is critical for computing, and the brain does this extremely efficiently. We're able to simulate the brain's neural approach simply by shining different colours onto our chip. This technology takes us further on the path towards fast, efficient and secure light-based computing. It also brings us an important step closer to the realisation of a bionic brain - a brain-on-a-chip that can learn from its environment just like humans do."

Dr Taimur Ahmed, lead author of the study published in Advanced Functional Materials, said being able to replicate neural behaviour on an artificial chip offered exciting avenues for research across sectors. "This technology creates tremendous opportunities for researchers to better understand the brain and how it's affected by disorders that disrupt neural connections, like Alzheimer's disease and dementia," Ahmed said. The researchers, from the Functional Materials and Microsystems Research Group at RMIT, have also demonstrated the chip can perform logic operations – information processing - ticking another box for brain-like functionality. Developed at the Micro Nano Research Facility, the technology is compatible with existing electronics and has also been demonstrated on a flexible platform, for integration into wearable electronics.

**How the chip works**

Neural connections happen in the brain through electrical impulses. When tiny energy spikes reach a certain threshold of voltage, the neurons bind together - and you've started creating a memory. On the chip, light is used to generate a photocurrent. Switching between colours causes the current to reverse direction from positive to negative. This direction switch, or polarity shift, is equivalent to the binding and breaking of neural connections, a mechanism that enables neurons to connect (and induce learning) or inhibit (and induce forgetting). This is akin to optogenetics, where light-induced modification of neurons causes them to either turn on or off, enabling or inhibiting connections to the next neuron in the chain.



The chip is activated by different wavelengths of light. Image credit: RMIT.

To develop the technology, the researchers used a material called black phosphorus (BP) that can be inherently defective in nature. This is usually a problem for optoelectronics, but with precision engineering the researchers were able to harness the defects to create new functionality. "Defects are usually looked on as something to be avoided, but here we're using them to create something novel and useful," Ahmed said. "It's a creative approach to finding solutions for the technical challenges we face."

The work, with co-authors from RMIT's Sir Ian Potter NanoBiosensing Facility, Colorado State University, Australian National University and Queensland University of Technology, is published in Advanced Functional Materials and Small.

Source material: https://www.rmit.edu.au/news/media-releases-and-expert-comments/2019/jul/electronic-chip-mimics-brain

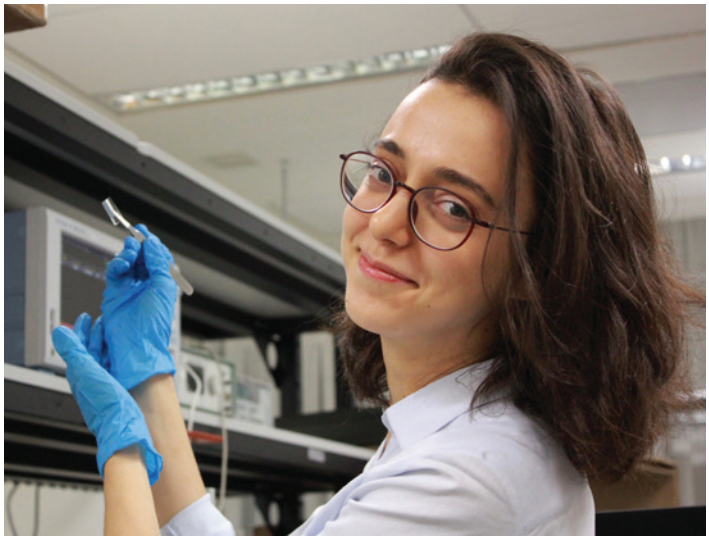
Original articles: T Ahmed, S Kuriakose, S Abbas, MJS Spencer, M Ataur Rahman, M Tahir, Y Lu, P Sonar, V Bansal, M Bhaskaran, S Sriram and S Walia, *Multifunctional Optoelectronics via Harnessing Defects in Layered Black Phosphorus*, Advanced Functional Materials, 1901991, (2019). https://doi.org/10.1002/adfm.201901991

T Ahmed, S Kuriakose, ELH Mayes, R Ramanathan, V Bansal, M Bhaskaran, S Sriram and S Walia, *Optically Stimulated Artificial Synapse Based on Layered Black Phosphorus,* Small, **15** (22), 1900966, (2019). https://doi.org/10.1002/smll.201900966

**'Tsunami' on a silicon chip: a world first for light waves**

A tsunami holds its wave shape over very long distances across the ocean, retaining its power and 'information' far from its source. In communications science, retaining information in an optic fibre that spans continents is vital. Ideally, this requires the manipulation of light in silicon chips at the source and reception end of the fibre without altering the wave shape of the photonic packet of information. Doing so has eluded scientists until now.

A collaboration between the University of Sydney Nano Institute and Singapore University of Technology and Design has for the first time manipulated a light wave on a silicon chip that retains its overall 'shape'. Such waves, whether a tsunami or a photonic packet of information, are known as solitons. The Sydney-Singapore team has for the first time observed soliton dynamics on an ultra-silicon-rich nitride (USRN) device fabricated in Singapore using state-of-the-art optical characterisation tools at Sydney Nano.



Ezgi Sahin, a PhD student at Singapore University of Technology and Design. Image credit: Singapore University of Technology and Design.

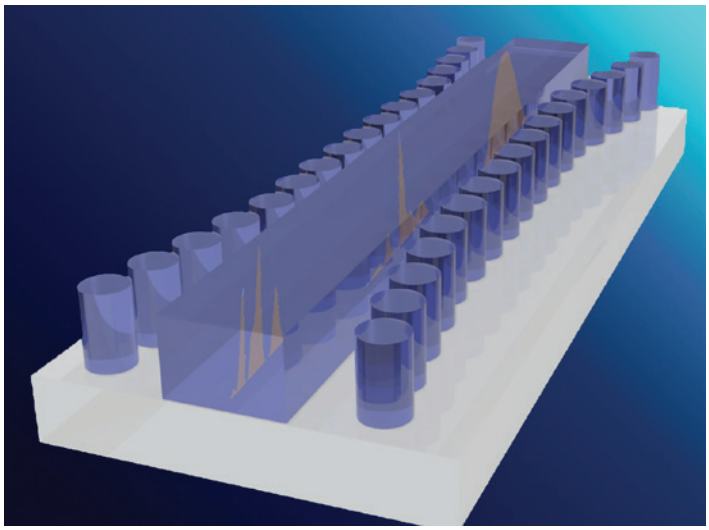
This foundational work, published in Laser & Photonics Reviews, is important because most communications infrastructure still relies on silicon-based devices for propagation and reception of information. Manipulating solitons on-chip could potentially allow for the speed up of photonic communications devices and infrastructure.

Ezgi Sahin, a PhD student at SUTD conducted the experiments with Dr Andrea Blanco Redondo at the University of Sydney. "The observation of complex soliton dynamics paves the way to a wide range of applications, beyond pulse compression, for on-chip optical signal processing," Ms Sahin said. "I'm happy to be a part of this great partnership between the two institutions with deep collaboration across theory, device fabrication and measurement."

Co-author of the study and Director of Sydney Nano, Professor Ben Eggleton, said: "This represents a major breakthrough for the field of soliton physics and is of fundamental technological importance. Solitons of this nature – so-called Bragg solitons – were first observed about 20 years ago in optical fibres but have not been reported on a chip because the standard silicon material upon which chips are based constrains the propagation. This demonstration, which is based on a slightly modified version of silicon that avoids these constraints, opens the field for an entirely new paradigm for manipulating light on a chip."

Professor Dawn Tan, a co-author of the paper at SUTD, said: "We were able to convincingly demonstrate Bragg soliton formation and fission because of the unique Bragg grating design and the ultra-silicon-rich nitride material platform (USRN) we used. This platform prevents loss of information which has compromised previous demonstrations."

Solitons are pulses that propagate without changing shape and can survive collisions and interactions. They were first observed in a Scottish canal 150 years ago and are familiar in the context of tsunami waves, which propagate thousands of kilometres without changing shape. Optical soliton waves have been studied since the 1980s in optical fibres and offer enormous promise for optical communication systems because they allow data to be sent over long distances without distortion. Bragg solitons, which derive their properties from Bragg gratings (periodic structures etched in to the silicon substrate), can be studied at the scale of chip technology where they can be harnessed for advanced signal processing.



Artist's impression of the Bragg gate on a silicon substrate. Image credit: University of Sydney.

They are called Bragg solitons after Australian-born Lawrence Bragg and his father William Henry Bragg, who first discussed the concept of Bragg reflection in 1913 and went on to win the Nobel Prize in Physics. They are the only father and son pair to have won Nobel Prizes. Bragg solitons were first observed in 1996 in Bragg gratings in optical fibres. This was demonstrated by Professor Eggleton while he was working on his PhD at Bell Labs.

The silicon-based nature of the Bragg grating device also ensures compatibility with complementary metal oxide semiconductor (CMOS) processing. The ability to reliably initiate soliton compression and fission allows ultrafast phenomena to be generated with longer pulses than previously required. The chip-scale miniaturisation also advances the speed of optical signal processes in applications necessitating compactness.

Source material: https://sydney.edu.au/news-opinion/news/2019/07/04/tsunami-on-a-silicon-chip-a-world-first-for-light-waves.html

Original article: E Sahin, A Blanco-Redondo, Peng Xing, DKT Ng, CE Png, DTH Tan, BJ Eggleton, *Bragg Soliton Fission: Bragg Soliton Compression and Fission on CMOS-Compatible Ultra-Silicon-Rich Nitride,* Laser Photonics Rev., **13** (8), 2019.
https://doi.org/10.1002/lpor.201970032

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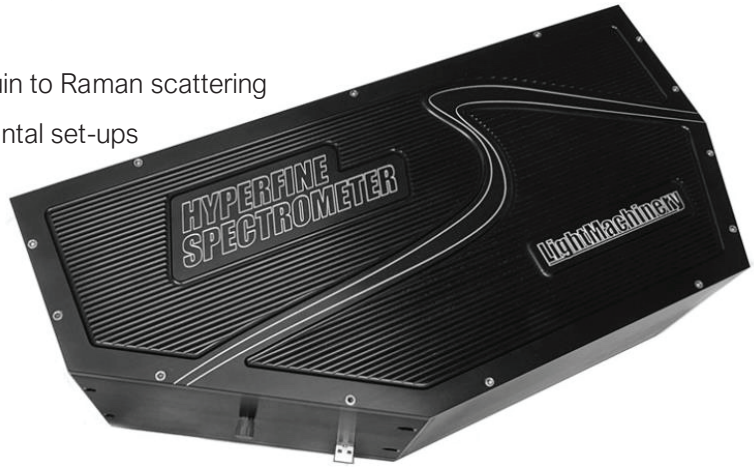
# Setting the new standard for range and resolution

## HYPERFINE SPECTROMETER

- Six models to cover a 400nm to 1600nm range
- Ideal for pulsed laser characterization
- Measure small spectral shifts from Brillouin to Raman scattering
- LabView Drivers for automated experimental set-ups
- Software for review, save and export

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# Product News

## Cobolt 785nm STM laser for Raman

Cobolt AB, a part of HÜBNER Photonics, introduces the addition of a new wavelength of 785 nm single transverse mode (STM) to the Cobolt 08-01 Series of frequency stabilized, narrow linewidth lasers.

With up to 120 mW and a linewidth of <20 pm, the Cobolt 785nm is ideal for Raman spectroscopy and imaging applications with an integrated optical isolator and spectral filter. The Cobolt 785nm STM complements Cobolt's current offering of narrow linewidth laser diodes; 405 nm, 457 nm, 473 nm, 515 nm, 532 nm, 561 nm, 633 nm, 660 nm and 1064 nm.

All Cobolt lasers are manufactured using proprietary HTCure™ technology and the resulting compact hermetically sealed package provides a very high level of immunity to varying environmental conditions along with exceptional reliability. With demonstrated lifetime capability of >60 000 hours and several thousand units installed in the field, Cobolt lasers have proven to deliver unmatched reliability and performance both in laboratory and industrial environments and are offered with market leading warranty terms.


## Highest efficiency high pulse energy pulsed diode laser

Photonics Industries', the pioneer of intracavity solid-state harmonic lasers, has introduced a new line of pulsed diode pumped lasers, the DP Series, for applications that need short pulses (<10ns), high pulse energy with low power consumption, and air cooling. The DP series has several standard lasers available with up to:

- 20mJ at 1053nm
- 18mJ at 527nm
- 4mJ at 351 nm

All with a $TEM_{00}$ mode quality at high repetition rates (up to 200Hz) in a compact, industrial grade, small all-in-one form factor. Also, the high rep rate version, the DP2K Series, fit applications that require high pulse energies at up to 2kHz rep rates with low power consumption. The DP2K Series is available in IR (1064nm), green (532nm) and/or DUV (266nm).

Industrial and research laser based material processing applications include:

- Micromachining/ablation
- Pulsed laser deposition
- Laser cleaning
- Harmonic and parametric pumping
- Laser induced breakdown spectroscopy (LIBS)
- Laser induced fluorescence (LIF)
- THz generation
- PIV
- Nonlinear spectroscopy

## Sprout-H 532nm 18W pump laser

Lighthouse Photonics announce the release of the Sprout-H™, a compact, modular, diode-pumped solid-state (DPSS) laser providing up to 18 Watts continuous-wave (CW) power at 532nm in a near perfect $TEM_{00}$ mode with extremely low optical noise and excellent long-term stability.

Sprout-H is truly a next-generation laser designed and manufactured using many years of experience to provide a sealed, turn-key source of collimated green light with high spectral purity. There are 7 versions available ranging from 5 Watts to 18 Watts. The laser head is a monolithic 3-dimensional design for ruggedness and compactness. The pump diode, integrated inside the laser head, has a typical mean time to failure (MTTF) of more than 50,000 hours to minimize cost-of ownership. The laser head can be disconnected from the control cable for easy integration. The power supply contains an integrated thermo-electrically-cooled (TEC) chiller.

For more information, contact Warsash Scientific at sales@warsash.com.au or 02 9319 0122

## New MiniJewel Laser from Quantum Composers


The new MiniJewel is a compact, conductively cooled, laser with a fundamental output of 1064nm. The rugged resonator design allows for less misalignment than other lasers. This multi-mode laser weighs 1.4kg and with a 165mm x 97mm x 36mm footprint, it is perfect for portable applications or customers with limited space requirements. Included is the MiniJewel software which users can utilise to control energy, firing mode, and frequency.

Laser Features

- Energy Max: 8mJ @1064nm
- Rep Rate: 1 to 30Hz* Rep Rate
- Wavelengths: 1064nm, 532, 355 & 266
- Power supply, 36-50VDC
- Efficient, reliable diode pump
- Remote Interlock, Input Trigger
- Beam Divergence: ≤ 6.0mr
- Beam Divergence (mrad) ≤ 6.0
- Beam Diameter (mm) 1.5 ± 0.5mm
- Pulsewidth: 6.0 ± 2.0 ns

## Ocean Optics new LSM Series LED Light Sources available from Lastek

- UV, Visible, NIR and broadband wavelengths
- Passive cooling design
- Smart controller with color LCD touch screen
- Multiple mounting options (DIN rail, optical bench, rack)
- External trigger option (function generator or trigger signal)

LED light sources are ideal for fluorescence excitation and other measurements requiring narrowband illumination. The innovative optical design of the Ocean Optics LSM LED family provides highly efficient coupling into an optical fiber, ensuring high power for fluorescence excitation where every photon counts.

## Toptica FemtoFiber ultra 920 – Powerful Femtosecond Fiber Laser

*920 nm High-power Ultrafast Erbium Fiber Laser System*

The FemtoFiber ultra 920 is a new member of TOPTICA's third generation of ultrafast fiber lasers. The system delivers laser pulses of less than 100 fs in duration at a central wavelength of 920nm. The system provides more than 1 W average output power. It is a compact femtosecond laser system with turnkey operation and cost-effective design.

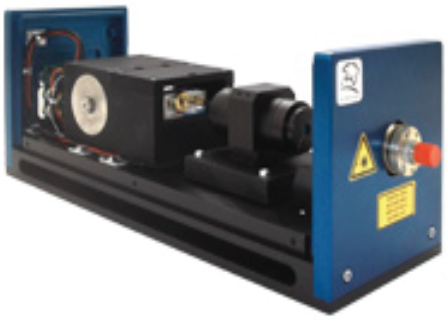
- Ultrafast fiber laser @ 920 nm
- Unique approach: < 100 fs with > 1.5 W power
- SAM mode locking, PM fiber based MOPA system
- Robust, reliable, compact, cost-effective, push-button
- Air cooled system, < 150 W power consumption

For more information please contact Lastek at sales@lastek.com.au or 08 8443 8668

## Next Generation Tunable Diode laser

**Ultra-Stable Monolithic Tunable Littrow Diode Laser Without Compromises**

The All-New Lynx S-3 System Sacher's successful Lynx Littrow Laser Series is now realized as a monolithic mechanic device without any compromise. Its design results in a highly stable laser system which is insensitive against thermal or acoustic disturbances. Operation and wavelength tuning is easy and almost hands-off. Its special features make the next generation Littrow system a well suited solution for highly demanding applications such as Bose-Einstein condensation or quantum computing. The S-3 is available at 10 wavelengths from 730nm up to 1680nm. The tuning range per diode starts with 10nm at 730nm and goes up to 100nm at 1680nm. Output power is available up to 200mW.



For more information please contact Photon Scientific at sales@photonscientific.com.au or 03 85026393

## Quantel Merion C by Lumibird


The Merion C is the latest development from Lumibird-Quantel laser diode-pumped nanosecond Nd:YAG range. The Merion C delivers 100 mJ @ 1064 nm up to 400 Hz and can be equipped with fully integrated harmonic generators, down to 266 nm, to cover a wide range of applications.

All key components such as laser diodes, gain modules and laser driver electronics are internally designed, ensuring full vertical control of the entire process.

It represents the best solution for demanding applications like LIDAR, LIBS or material processing.

- High power packed in a small footprint
- Excellent shot to shot stability and superior beam profile up to 400 Hz
- Sealed against external contaminants with an industrial design, built to last
- Easy installation and an interchangeable power supply to reduce the effects of downtime
- Pump diode warranty: 2 billion shots

## Keopsys CYFL-KILO Yb Amplifier by Lumibird

CYFL-KILO stands for Ytterbium fibre laser with kilohertz linewidth. This series deliver up to 20 W output with narrow linewidth, low phase noise and low relative intensity noise (RIN).

CYFL-KILO lasers are based on an MOFPA design. They integrate an ultra-low noise and narrow linewidth seed laser (<70 kHz), which is amplified through several highly stable Yb-doped fibre amplifier stages. Also, these lasers can be thermally tuned in wavelength over 200 MHz, and their central emission line can be modulated for locking purposes.


- Standard central wavelengths: 1030, 1064 and 1083 nm
- Linewidths of <3 kHz available
- Standard output power up to 20 W (higher power available as a semi-custom)
- Applications in Quantum optics, Optical lattice generation, BEC, Interferometry and Metrology

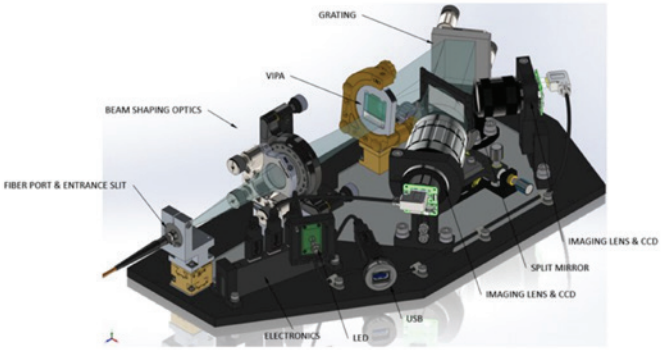
For further information please contact Coherent Scientific at sales@coherent.com.au or 08 8150 5200

## HyperFine Spectrometer


The HyperFine series of spectrometers are based on LightMachinery's patented VIPA technology. Designed for measuring hyperfine spectra and subtle spectral shifts, the HyperFine spectrometer from LightMachinery is a compact, low cost spectrometer capable of sub-picometer resolution. It is ideal for pulsed laser characterization and for measuring the small spectral shifts from Brillouin scattering. Simple PC based software allows the user to review spectra in real time and save or export for more analysis. LabView drivers enable the HyperFine spectrometer to be integrated into automated experimental setups.

**How does it work?**

Light enters the HyperFine Spectrometer though a fiber or directly imaged onto the slit. A VIPA etalon, manufactured using LightMachinery's proprietary fluid jet polishing technology, is used to produce very high dispersion in the vertical axis with sub picometer resolution. This is followed by a conventional grating to disperse overlapping orders in the horizontal direction and produce a 2D spectrum of the input light. LightMachinery software unwraps the spectrum to produce an ultra high resolution wavelength spectrum of the input light. A secondary camera provides a wide wavelength range, lower resolution view of the spectrum.




Applications

- Light sources characterization
  - * Lasers of all types
  - * Single shot pulsed laser spectrum
  - * Super luminescent diodes
  - * Gas discharge lamps, etc
- Spectroscopy
  - * Plasma spectroscopy
  - * High-precision gas spectroscopy
  - * Brillouin spectroscopy
  - * Femtosecond comb fingerprinting spectroscopy
  - * Spectral-domain optical coherence tomography, etc
- Passive components characterization
  - * Notch filters
  - * Etalons
  - * Fiber Bragg gratings, etc

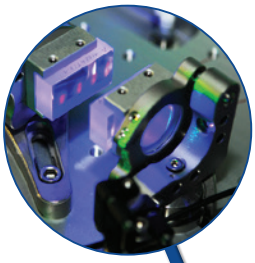
For more information please contact Raymax at info@raymax.com.au or 02 9979 7646

# Laser solutions

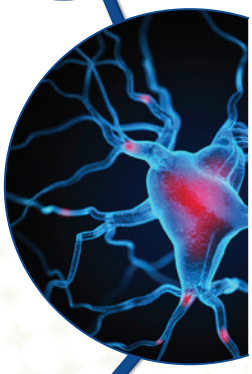
Laser QUANTUM
A Novanta Company

## Continuous wave lasers

**finesse pure**
Low noise, <0.02% RMS, pump source available from 4 W - 16 W with field replaceable diodes



**gem** family
Reliable and robust laser with 400,000 hours MTTF. Up to 2 W power, ranging from 473 nm - 671 nm



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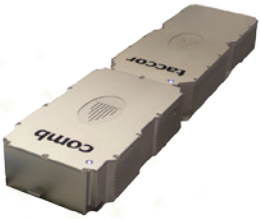

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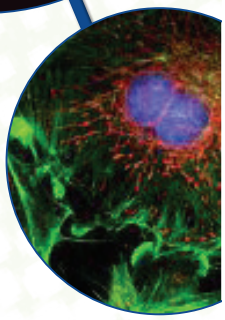

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# Optics in Everyday Life: Aperture Synthesis

*by Tony Klein*

**You will have seen earlier this year a picture reproduced in most media showing the first ever image of a black hole (figure 1). How was it obtained?**

**Figure 1.** The reconstructed image of the supermassive black hole shadow in the M87 galaxy. Image credit: Event Horizon Telescope Collaboration.

By implementing the technique known as Aperture Synthesis, an international team utilised the computer program called DiFX [1] to combine the data obtained by the largest ever combination of telescopes from all over the world, called the 'Event Horizon Telescope' (figure 2). This array of radio-telescopes operates at 230 GHz (= 1.3mm wavelength) that was necessary to get to the ~25 micro-arc-seconds resolution needed to resolve black hole shadow.

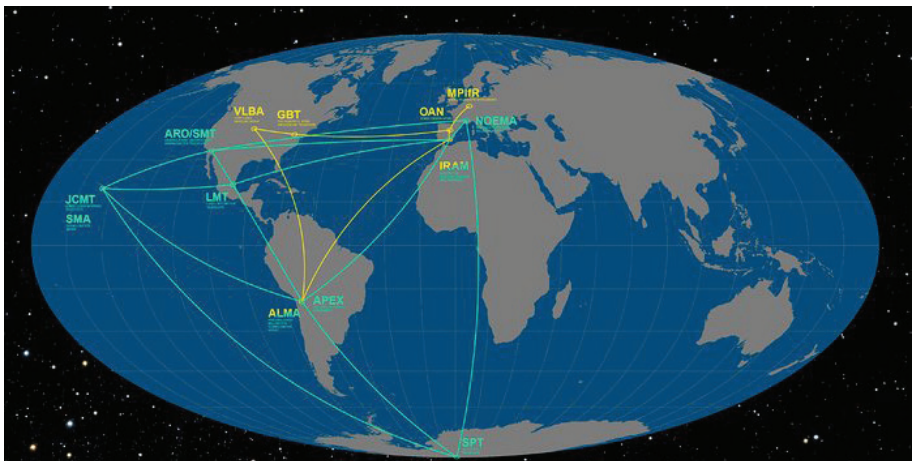


**Figure 2.** The location of the individual telescopes/arrays that collectively form the Event Horizon Telescope, shown in blue. Image credit: ESO/O, Furtak.

The open-source program DiFX, which was developed by Adam Deller at Swinburne University in Melbourne, with a worldwide team of collaborators over the last few decades, is the most versatile, successful and widely-adopted implementation of the signal-processing required to perform the technique of Aperture Synthesis. This technique was the subject of the Nobel Prize in physics awarded to Martin Ryle and Anthony Hewish in 1974 (who applied several Australian ideas by Pawsey and others). It is essentially radio-interferometry [2]. How does it work?

The size of a dish in radio-astronomy or the size of the objective aperture in an optical telescope is obviously what determines the magnitude of its signal-gathering power. (Colloquially referred to as "photon buckets"). But the size L also determines the diffraction-limited angular resolution of the receiver at wavelength $\lambda$, given by $\Delta\theta = \lambda/L$ where L is the size of the receiver. However, in the case of separate receivers, used pairwise as interferometers, with separation L (called the baseline – see below), the same formula gives the angular resolution $\Delta\theta$, via the Fourier Transform of the cross-correlation of the signals [3].

As consequence of this fact, there is no need for the receiver apertures to be filled in, it could be just a sparse array of smaller receivers (dishes or radio-telescopes) recording signals over a range of separations, each determining a Fourier component of the overall signal at the wavelength $\lambda$, when used as a set of pairs of interferometers. This means that the signal-gathering power and the angular resolution can be measured separately by using separate baselines for each pair of receivers and electronic correlators (initially analogue but later, of course, digital) and computers to perform the Fourier transforms to arrive at the brightness distribution in the sky, i.e. the "image" of the source.

The Earth's rotation also helps, of course, in pointing the telescopes in continually changing directions. (The effective baseline is always the projection of the distance between pairs of telescopes as seen from the direction of the source).

It turns out that it is not necessary to make measurements at essentially

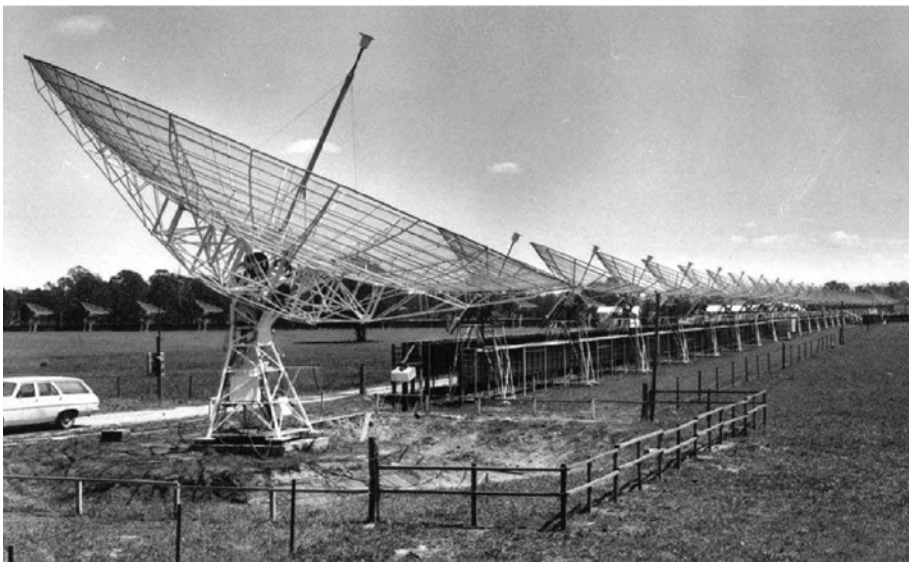

**Figure 3.** The Chris Cross at Fleurs – an early Australian Aperture Synthesis Radio-telescope (1957). Image credit: ATNF, Historic Photographic Archive, 9097-11.

**Figure 4.** The Very Large Array, (VLA) a radio interferometer in New Mexico. Image credit: Hajor (Wikipedia).

every baseline length and orientation, out to some maximum. A fully sampled Fourier transform formally contains the information exactly equivalent to the image from a conventional telescope with an aperture diameter equal to the maximum baseline, i.e. a single giant dish, hence the name *aperture synthesis*. Different arrangements of telescope arrays evolved over time, with increasingly large baselines – a few examples are shown in figures 3, 4, and 5, with the Event Horizon Telescope (figure 2) being only one of the latest, along with the Western Australia-based "SKA" – the famous Square Kilometre Array (figure 6). (Incidentally, most people don't realise that the "Square Kilometre" refers to the total area of all the receiver dishes; the overall ground surface involved in the whole installation is vastly larger!).

With the enormous bandwidths now available to radio-astronomers, and the enormous processing capabilities of super-computers, quite amazing images are routinely obtained by various international collaborations, rivalling those of optical telescopes.

At the same time, advances in optical telescope design, such as the use of large, segmented mirrors and combining their outputs by forms of interferometry, are beginning to implement types of aperture synthesis in the range of visible and infrared light. (Note that the signal processing requires both amplitude and phase information). Such techniques date back only to around the turn of the millennium and are radically different to those used in radio astronomy – even in the millimetre wavelength range - but the interferometric principles are the same. Thus, progress in astronomy will continue to provide astonishing pictures of the physical universe.

**Figure 5.** Atacama Large Millimetre/submillimetre Array in Chile. Image credit: Iztok Bončina/ESO.

**Figure 6.** CSIRO's Square Kilometre Array Pathfinder (ASKAP) radio telescope at the Murchison Radio-astronomy Observatory in Western Australia. Image credit: CSIRO.

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[3] This is a verbal re-statement of the famous "van Cittert – Zernike Theorem" which forms the mathematical basis of Aperture Synthesis.

Emeritus Professor Tony Klein is with the School of Physics, University of Melbourne.

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# Biosensing with Resonant Dielectric Metasurfaces

*by Yuri Kivshar and Hatice Altug*

**We introduce a metaphotonics approach based on resonant dielectric metasurfaces that is capable of detecting mid-IR molecular fingerprints without the need for spectrometry, frequency scanning, or moving mechanical parts. We employ dielectric metasurfaces with ultra-sharp resonances originating from the physics of bound states in the continuum, each tuned to discrete frequencies, enabling the sampling of molecular absorption signatures over the mid-IR spectral range. We also bring together the physics of dielectric metasurfaces and hyperspectral imaging to create an ultra-sensitive, label-free biosensing platform for analysing samples at spatial concentrations of less than three molecules per square micron.**

The 21st Century belongs to photonics. Many important industries, from chip manufacturing and lighting, health care and life sciences, to space, defence and the automotive sectors rely on the same fundamental mastery of light. Future technologies will push for a steep increase in subwavelength photonic integration and energy efficiency, far surpassing that of bulk optical components, silicon photonics, and plasmonic circuits. Such a level of integration can be achieved by embedding the data processing and waveguiding functionalities at the level of a material rather than a chip, and the only possible solution to meet those challenges is to employ the recently-emerged concepts of *metamaterials and metadevices* [1] based on structuring of matter at the subwavelength scale.

Metamaterials have opened important capabilities ranging from subwavelength focusing to the ability to control the magnetic response of nonmagnetic materials. However, a majority of structures with optically induced magnetic responses studied so far include metals with high conduction losses at optical frequencies that limit any useful performance. The big question now is how to remove metallic components yet maintain an effective magnetic response and enable low loss metadevices. A few years ago, it was suggested theoretically and demonstrated experimentally (see for example the review paper in reference [2] and references therein) that high-index subwavelength dielectric nanoparticles may exhibit induced magnetic resonances and, unlike plasmonic nanoparticles, do not suffer from losses due to the absence of free charges, suggesting that they could replace metallic elements in nanoscale metadevices.

Metaphotonics of high-index dielectric particles is based on optical Mie resonances which facilitate light manipulation below the free-space diffraction limit. Remarkably, dielectric nanoparticles can result in both electric and magnetic type responses of comparable strengths. Thus, high-index dielectric nanoparticles and subwavelength resonant dielectric structures associated with the physics of optical Mie resonances have emerged recently as *a new platform for modern nanophotonics* [2]. It originates from the century-old studies of light scattering, but brings a variety of electric and magnetic multipole resonances into modern studies of metadevices driven by the optical magnetic response.

More recent developments in metaphotonics rely on a different kind of collective resonance in extended planar dielectric structures enabled by the so-called *bound states in the continuum* (BICs) [3,4]. Historically, this concept originated in quantum mechanics, and BICs appeared as confined waves that remain localised within a continuous spectrum of radiating waves. Mathematically speaking, such specific modes represent discrete solutions of the Schrödinger equation in quantum mechanics for a quantum particle placed in a complex potential with the eigenvalue embedded into a continuum of positive energy states. Such bound states would be perfectly localised with an infinite quality factor (Q-factor). In practice, one can mathematically engineer a subwavelength optical "supercavity" [5] that supports a "quasi-BIC" with an extremely high but finite value of *Q-factor* and extremely narrow resonance linewidth.

Recently, the resonant response of all-dielectric metasurfaces composed of meta-atoms with broken in-plane inversion symmetry was shown to demonstrate sharp resonances in normal incidence reflection and transmission. In a very recent paper [6] it was proven that all high-Q resonances in such seemingly different metasurfaces with asymmetric unit cells can be unified by the BIC concept (see figure 1). More specifically, it was shown that an asymmetry induces an imbalance of the interference between contra-propagating leaky waves comprising BIC that leads to radiation leakage. Similarly, breaking the symmetry transversely in the direction perpendicular to a metasurface with a complex unit cell [7], allows control of the number, frequency, and type of high-Q resonances originating from the BIC physics.

Our recent research [8, 9] originating from those developments targets the application of such metadevices in biosensing. Indeed, biosensors can be the essential nodes in the internet of body networks in the future, enabling preventive health screening for early diagnosis of critical health conditions, as well as personalised medicine through frequent patient testing in the disease management stage. Unfortunately, currently available biosensing methods are cumbersome, as they require laboratory infrastructure, trained personnel, and complex bioassay protocols, and, as such, they are not suitable for point-of-care and lab-on-a-chip applications. On the other hand, nanophotonic biosensors hold great promise as they can detect biomolecules in a label-free and non-destructive manner based on the enhanced light-matter interactions with nano-engineered metasurfaces.

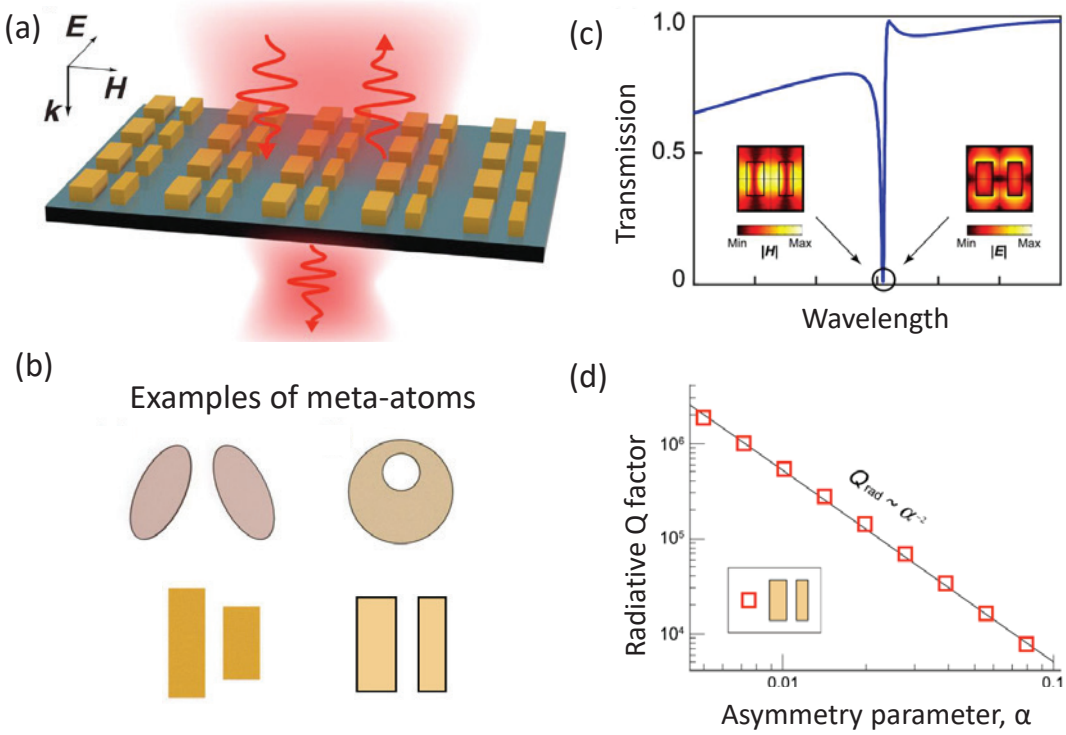


**Figure 1.** Quasi-BIC in metasurfaces with broken symmetry. **a)** Schematic of the scattering of light by an asymmetric metasurface composed of a square lattice of pairs of dielectric bars of different widths. **b)** Examples of asymmetric meta-atoms. **c)** Reflectance spectrum of the broken-symmetry metasurface with the difference in bar widths. The insets show the distribution of electric and magnetic fields of the excited quasi-BIC within the unit cell. **d)** Inverse quadratic dependence of the Q-factor on the asymmetry parameter α (log-log scale). The insert shows the specific shape of the isolated asymmetric meta-atom.

The work of our international team employs high-Q dielectric metasurface biosensing and hyperspectral imaging for ultrasensitive biomolecule detection.

Our approach is based on resonant dielectric metasurfaces for detecting molecular fingerprints, which utilises imaging-based methods to provide spectrometer-less operation in a miniaturised sensor suited for analysing complex biological systems [8, 9]. The central building block of this technique is *a pixelated dielectric metasurface*, as shown in figures 2(a, b), where the individual metapixels are engineered to provide sharp resonances (with a Q- factor > 100) at a given resonance frequency. Each metapixel employs the concept of bound states in continuum to create high-Q resonances [4]. Spectral selectivity of this metasurface allows correlation of

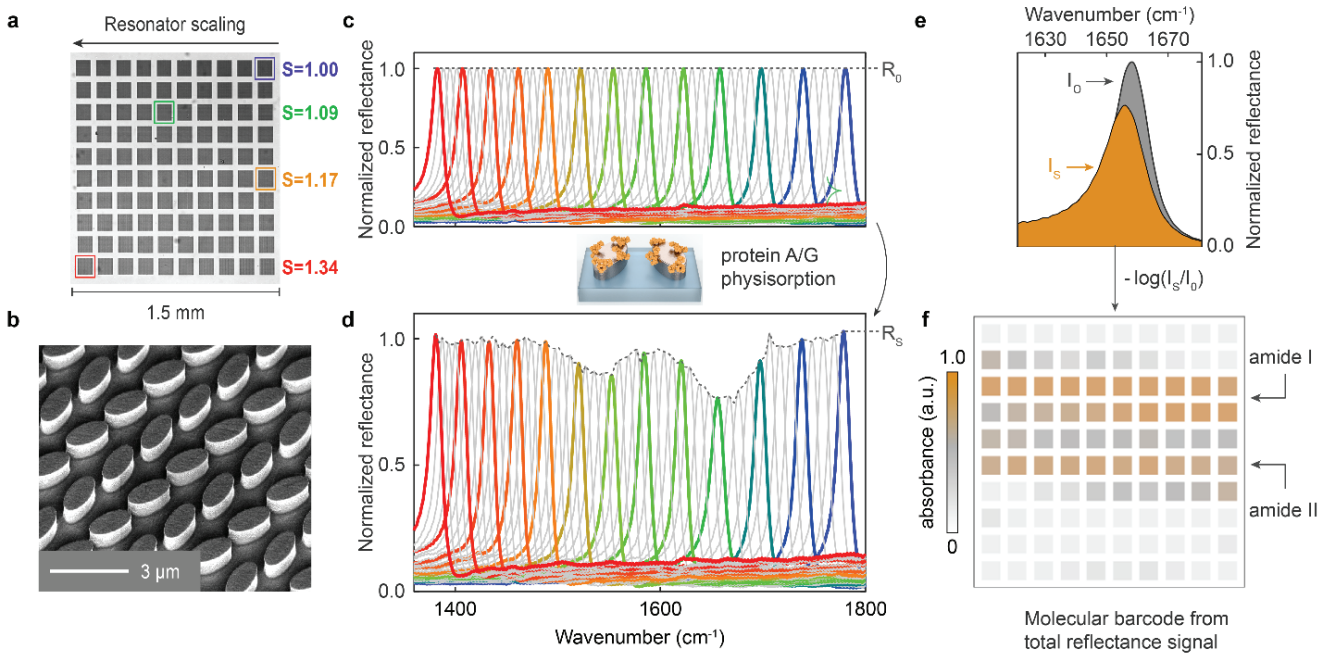


**Figure 2. a)** Optical image of the sensor consisting of a 10 x 10 pixel array of the dielectric metasurface. **b)** Scanning electron beam micrograph confirming the high uniformity, precise shape and straight side wall profile of the all-dielectric resonators. **c)** Reflectance spectra of the unperturbed pixelated metasurface. **d)** Reflectance spectra after protein A/G physisorption. **e)** Correlation of the changes of the total reflectance signal from each metapixel with the strength of the analyte's vibrational absorption bands. **f)** A distinct barcode pattern employed for specific molecule detection [8].

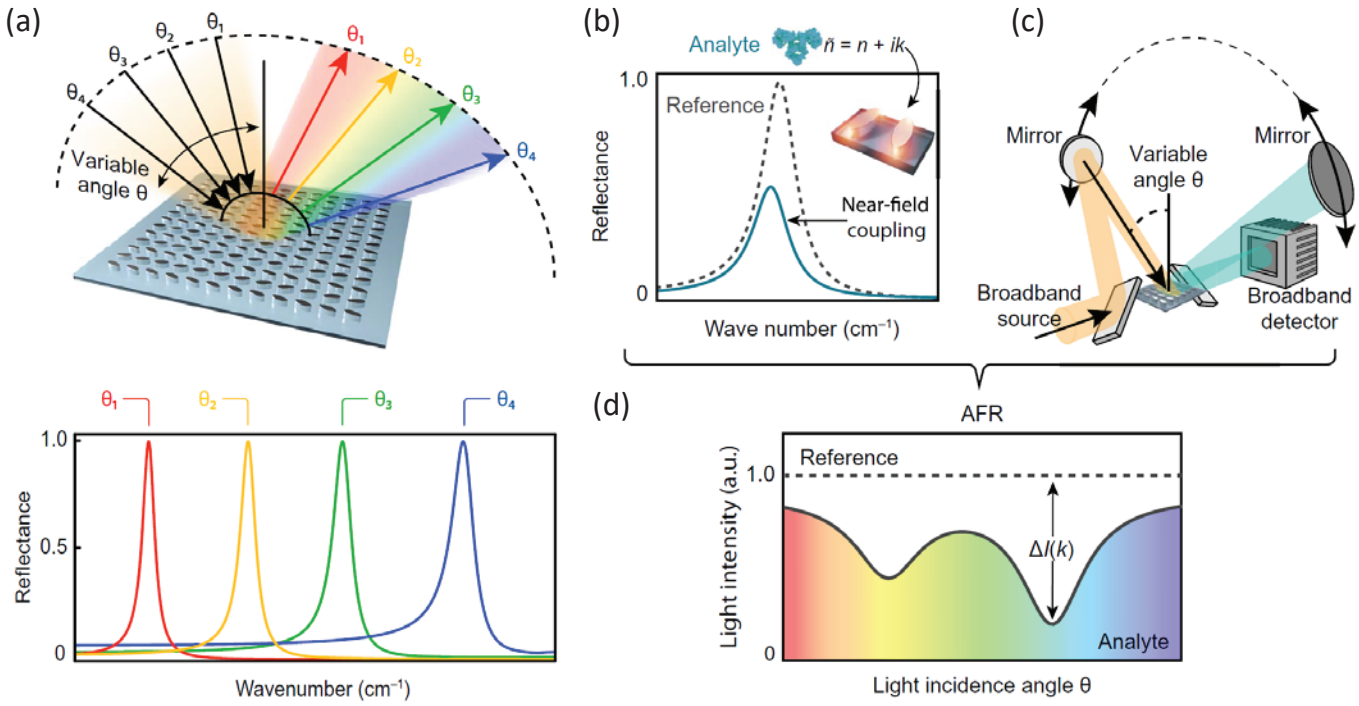


**Figure 3.** Angle-multiplexed broadband fingerprint retrieval. **a)** A high-Q all-dielectric metasurface delivers ultra-sharp resonances for every incidence angle with broad spectral coverage. **b)** Strong near-field coupling between dielectric resonators and molecular vibrations of the analyte induces a pronounced attenuation of the resonance lineshape correlated with the vibrational absorption bands. **c)** Angle multiplexing combined with the spectral selectivity of high-Q resonances allows for broadband operation and straightforward device implementation. **d)** Chemically specific output signal of the device scheme from (c), which is determined by the imaginary part of the analyte's complex refractive index [10].

the changes in total reflectance signal from each metapixel with the strength of the analyte's absorption bands. A comparison of the reflectance signals of all metapixels before and after material adsorption delivers a distinct barcode pattern used for molecule detection. This barcoding method operates under broadband illumination, providing that the chemically specific signals can be obtained without the need for spectrometry.

A metasurface device incorporating 100 individual metapixels was realised experimentally using high-resolution electron-beam lithography and dry etching [see figures 2(a, b)]. In mid-infrared reflectance measurements, the fabricated pixelated metasurface delivered resonances with a low average full-width-at-half-maximum (FWHM) of 13.7 $cm^{-1}$ and uniform tuning of the resonance frequency over the amide band range from 1370 $cm^{-1}$ to 1770 $cm^{-1}$ (figure 2c). These parameters correspond to a spectral resolution of 4 $cm^{-1}$ making the device competitive with commercial FTIR spectrometers and an average Q-factor of 115, highlighting the unique optical performance of the metasurface. The detection performance of the metasurface sensor was demonstrated by interrogating a monolayer of recombinant protein A/G molecules, which reveals the characteristic amide I and amide II absorption bands as distinct regions with attenuated peak reflectance of the resonances (figure 2d). A comparison of the total reflectance signals of all the metapixels before and after material adsorption delivers a distinct barcode pattern which can be used for chemically specific molecule detection (figure 2e and figure 2f).

In follow up work [10], we have developed germanium-based high-Q metasurfaces capable of delivering a multitude of spectrally selective and surface-sensitive resonances over a very wide spectral coverage, between 1100 and 1800 $cm^{-1}$. We have employed this approach to detect distinct absorption signatures of different interacting analytes including proteins, aptamers, and polylysine (see figure 3). In combination with broadband incoherent illumination and detection, our method correlates the total reflectance signal at each incidence angle with the strength of the molecular absorption, enabling spectrometer-less operation in a compact angle-scanning configuration ideally suited for field-deployable applications [10].

These mid-IR fingerprints can be complemented with Raman active molecular signatures to enable spectroscopic characterisation of an even wider range of samples. In recent work [11], the group of Stefan Maier has leveraged resonant Si disk dimers with small inter-particle spacing to show a novel sensor for surface-enhanced Raman spectroscopy with simultaneous strong enhancements of fluorescence signals. Raman signatures of a monolayer of β-carotenal molecules were retrieved with enhancement factors above 1000, and fluorescence signals could be increased by a factor of 500. Significantly, such dielectric structures are suited for fluorescence measurements on monolayers of emitters with intrinsically high quantum yield.

As a further development, we have brought together the physics of resonant BIC-inspired dielectric metasurfaces and the approach of hyperspectral imaging to create an ultrasensitive, label-free biosensing platform [12]. This new platform is capable of detecting and analysing samples at spatial concentrations of less than three molecules per square micron, enabling

compact portable diagnostics for personalised medicine.

To obtain the hyperspectral data from the metasurface sensor, our team used a supercontinuum laser source to illuminate the sensor, sweeping the laser through multiple, narrow-linewidth frequencies by means of a laser line tunable filter. At each frequency of incident light, a high-resolution CMOS camera captures a new image of the resonant response of the sensor. These image data are then stacked together to build a hyperspectral "data cube" that, for each of the tens of thousands of pixels in the image, captures the metasurface spectral response at each illumination wavelength. Combining this together with "data science techniques" allows us to construct a resonance map across the sensor that is highly sensitive to shifts in resonance due to the presence of individual biomolecules.

We have tested our metasurface biosensing system on bioassays involving a particular biomolecule, mouse-derived immunoglobulin G, and found that the combination of metasurface design and digital processing could detect the molecules at a density of fewer than three molecules per square micron on the detector surface. And the system's ability to provide high-resolution spectral data without the use of an actual, bulky spectrometer could help enable compact, portable diagnostics for personalised medicine. It could also offer a route to high-throughput, high-resolution optical characterisation of single-atom-thick, two-dimensional materials such as graphene, being a key requirement for advancing the technical development of those much-ballyhooed materials. More specifically, we draped single-layer graphene, a mere 3.2 angstroms thick, over the metasurface, and were able to use our hyperspectral method to resolve the optical properties of the material across an area of 3.3 $mm^2$.

Recently, our team extended the concept of bound states in the continuum to develop a new strategy for enhancing substantially the chiroptical response from dielectric structures [13]. We have predicted that optical chirality can be increased by at least a factor of 10 compared to the earlier results based on low-Q resonances. This improvement has been achieved in nanoscale dimers in the mid-IR due to the engineering of the mode structure that allows exploitation of a quasi-BIC with a high Q factor at the resonance frequency. For dielectric metasurfaces supporting quasi-BIC modes, the enhancement can reach even higher values. These results suggest great potential towards the development of a new platform based on highly-sensitive metadevices for applications in the biophotonics and pharmaceutical industry.

Our Swiss-Australian international team believes that the combination of high-Q resonant dielectric metasurfaces and high-throughput, imaging-based data acquisition amounts to a superior and versatile sensing platform. Further explorations could involve leveraging alternative materials, other dimensions such as incident-light polarisation and machine learning, and they could expand the system's flexibility still further, potentially enabling a field-deployable high-throughput single-molecule detector for biomedical applications. These novel techniques based on the unique advantages of resonant dielectric metasurfaces will pave the way towards realising sensitive, versatile and compact surface-enhanced sensors for a wide range of practical applications.

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Prof. Yuri Kivshar is Founding Head of the Meta-Optics and Nanophotonics Group and Nonlinear Physics Center at the Australian National University; he is the recipient of the 2017 W.H. (Beattie) Steel Medal of the Australian Optical Society. Prof. Hatice Altug is with the Institute of BioEngineering at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland.

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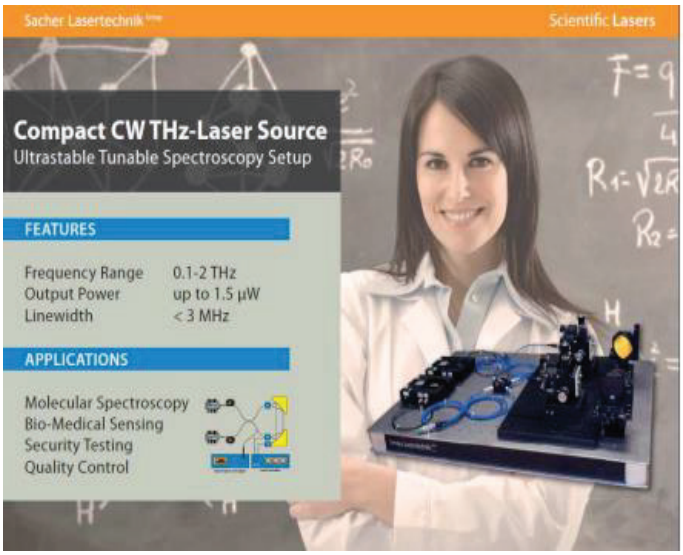


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# 70 Years of Instant Photos, Thanks to Inventor Edwin Land's Polaroid Camera

**It probably happens every minute of the day: A little girl demands to see the photo her parent has just taken of her. Today, thanks to smartphones and other digital cameras, we can see snapshots immediately, whether we want to or not. But in 1944 when 3-year-old Jennifer Land asked to see the family vacation photo that her dad had just taken, the technology didn't exist. So her dad, Edwin Land, invented it.**

*by Ann Elsner*

*This article was originally published on*

THE CONVERSATION


The original Polaroid camera freed users from needing to trek to a darkroom to develop their images. Image credit: Lindsay Moe/Unsplash, CC BY.

Three years later, after plenty of scientific development, Land and his Polaroid Corporation realised the miracle of nearly instant imaging. The film exposure and processing hardware are contained within the camera; there's no muss or fuss for the photographer who just points and shoots and then watches the image materialise on the photo once it spools out of the camera.

Land is probably best known for the "instant photo" – or the spiritual progenitor of today's ubiquitous selfie. His Polaroid camera was first released commercially in 1948 at retail locations and prices aimed at the postwar middle class. But this is just one of a host of technological breakthroughs Land invented and commercialised, most of which centred around light and how it interacts with materials. The technology used to show a 3D movie and the goggles we wear in the theatre were made possible by Land and his colleagues. The camera aboard the U-2 spy plane, as featured in the movie "Bridge of Spies," was a Land product, as were even some aspects of the plane's mechanics. He also worked on theoretical problems, drawing on a deep understanding of both chemistry and physics.

I'm a vision scientist who has touched many of the fields in which Land made great advances, through my own work on new imaging methods, image processing techniques and human colour vision. As the 2018 recipient of the Edwin H. Land Medal, awarded by the Optical Society of America and the Society for Imaging Science and Technology, my own work relies on Land's technological innovations that made modern imaging possible.

**Controlling light's properties**

Edwin Land's first optics breakthrough came as a young man, when he figured out a convenient and affordable method to control one of the fundamental properties of light: polarisation.

You can think of light as waves propagating from a source. Most light sources produce a mixture of waves with all different physical properties, such as wavelength and amplitude of vibration. Light is considered polarised if the amplitude varies in a consistent manner perpendicular to the direction the wave is traveling.

Given the right material for the light waves to pass through, the light waves may be rotated into another plane, slowed down or blocked. Modern 3D goggles work because one eye receives light waves vibrating along the horizontal plane while the other eye receives the light vibrating along the vertical plane.

Before Land, researchers built components to control polarisation from rock crystals, which were assigned almost magical names and properties, though they merely decreased the velocity or amplitude of light waves traveling at specific orientations. Land created "polarisers" by growing small crystals and embedding them in plastic sheets, altering the light passing through depending on its orientation in relation to the rows of crystals. His inexpensive polariser made it possible to reliably and practically filter light so only wavelengths with a particular orientation would pass through.

Land founded the Polaroid Corporation in 1937 to commercialise his new technology. His sheet polarisers found applications ranging from the identification of chemical compounds to adjustable sunglasses. Polarising filters became standard in photography to reduce glare. Today the principles of polarised light are used in most computer and cellphone screens, to enhance contrast, decrease glare and even turn on or off individual pixels.

Polarising filters help researchers visualise structures that might not be seen otherwise – from astronomical features to biological structures. In my own field of vision science, polarisation imaging localises classes of chemicals, such as protein molecules leaking from blood vessels in diseased eyes. Polarisation is also combined with high-resolution imaging techniques to detect cellular damage

beneath the reflective retinal surface.

**A new way to get the data out**

Before the days of high-speed digital capture of data and affordable high-resolution displays, or use of videotape, Polaroid photography was the method of choice to obtain output in many scientific labs. Experiments or medical tests needed graphical or pictorial output for interpretation, often from an analogue oscilloscope which plotted out a voltage or current change over time. The oscilloscope was fast enough to capture key features of the data – but recording the output for later analysis was a challenge before Land's instant camera came along.

A common example in vision science is the recording of eye movements. A research study reported in 1960 plotted light reflected from an observer's moving eye on an oscilloscope screen, which was photographed with a mounted Polaroid camera – not unlike the consumer Polaroid camera a family might pull out at a birthday party. For decades, research labs and medical facilities have used setups consisting of a Polaroid camera and a mounting rig to collect electrical signals displayed on oscilloscope screens. The format sizes are less than dazzling compared to modern digital resolutions, but they were revolutionary at the time.

In 1987, with the founding of my new retinal imaging laboratory, there was no inexpensive method to provide sharable output of our novel images. After a few years of struggling to obtain high-quality output for conferences and publications, the Polaroid Corporation came to our rescue, with the donation of a printer, allowing our scientific contributions to reach an audience beyond our lab.

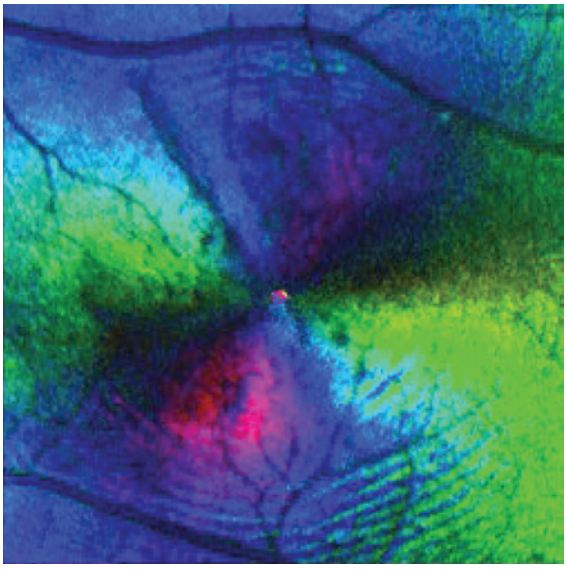
Quick prints can be shared and displayed. Image credit: Hillary Hartley, CC BY-SA.

**Eyes are not cameras**

Land's contributions go beyond patenting over 500 innovations and inventing products that millions purchased. His understanding of the interaction of light and matter promoted novel ways of characterising chemicals with polarised light. And he provided insights into the workings of the human visual system that had seemed to defy the laws of physics, coming up with what he called the Retinex theory of colour vision to explain how people perceive a broad range of colour without the expected wavelengths being present in the room.

Despite his brilliance, Land's Polaroid Corporation eventually hit hard times in the decades after his death in 1991. Heavily invested in its film sales, Polaroid wasn't prepared as all tiers of the imaging market went digital, with everyone from consumer photographers to high-end medical and optical imagers abandoning film and processing.

But rather than sink with the film market, Polaroid reinvented itself with new products that could help output the new world of digital images. And in a case of history repeating itself, Polaroid and other manufacturers of instant cameras are enjoying renewed popularity with younger generations who had no exposure to the original versions. Just like little Jennifer Land, plenty of people today still want a tangible version of their pictures, right now.



Land's inventions led to the widespread use of polarised light to characterise tissues and objects, as in this pseudo-colour image of a diabetic patient's retina that unmasks irregular structures caused by oedema. Image credit: Ann Elsner, CC BY-ND.

Ann Elsner is Professor of Optometry, Indiana University.

The original article can be found at: https://theconversation.com/70-years-of-instant-photos-thanks-to-inventor-edwin-lands-polaroid-camera-94282

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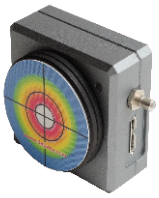

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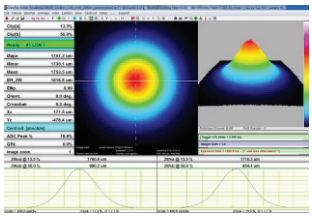

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## Welcome

The Australian and New Zealand Conference on Optics and Photonics (ANZCOP) 2019 brings together four co-located conferences with a central theme of optics and photonics. The ANZCOP conferences will connect people across all scientific disciplines associated with optics and photonics, incorporating general streams on optical science and technology and focused topical conferences on micro- and nano-materials and devices, biomedical photonics, and astronomical instrumentation.

The meeting will incorporate presentation and discussion of science in plenaries, themed sessions, speed science discussions, and industry engagement forums. The meeting will engage trainees to researcher leaders, chemists to biologists to clinicians to physicists, and academics, industry, and policy makers. With this new multi-conference format we aim to forge new transdisciplinary and translational collaborations.

The event will take place over five days, 8-12 December 2019, in the recently built 'New Academic Street' RMIT University campus on Swanston Street in the Melbourne CBD. On behalf of AOS, SPIE, and the symposium organisers, we invite and encourage you to participate in ANZCOP 2019 in Melbourne, Australia.

We hope to see you in Melbourne!

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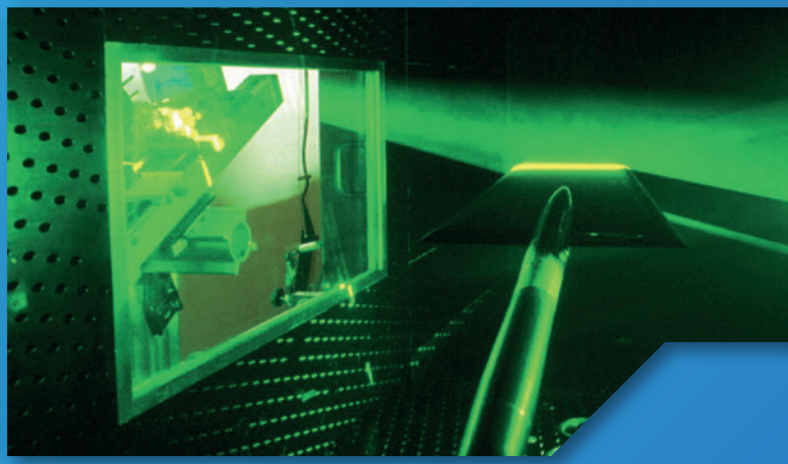

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