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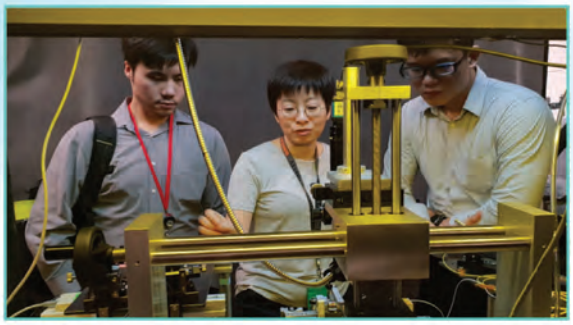
New LUX members welcomed with TPI lab tours at networking event

Five new Industry members and five new Faculty members were introduced at the LUX Photonics Consortium 2018 2nd Quarter Networking & Technical Talks on 20 Jun.

Held at the Wee Kim Wee School of Communication and Information's Lee Foundation Lecture Theatre, the session was attended by representatives from 30 companies and 10 professors across 3 universities.



New Industry and Faculty members explored the optical engineering, lasers, biophotonics and silicon photonics research centres of The Photonics Institute.

At the start of the event, participants were treated to The Photonics Institute (TPI) Lab Tours, which included visits to the centres working on silicon photonics, optoelectronics and biophotonics, as well as optical and laser engineering.

LUX Chairman Prof Tjin Swee Chuan then delivered the opening address, during which he proudly announced to the 60 guests present that the Consortium had grown to 50 Faculty and 42 Industry members.

Prof Tjin reminded those in attendance that the grant call for the second LUX Photonics Consortium Industry-IHL Collaboration Seed Grant was open. The Grant hopes to encourage Industry members to adopt IPs developed at universities, namely NTU and NUS, via small-scale collaborative projects.

In addition, he spoke about the April trip to Berlin by a LUX Photonics Consortium-led delegation, sharing that the Singapore delegates managed to connect with over 200 members of the European Photonics Industry Consortium (EPIC) at the EPIC Annual General Meeting.

Prof Tjin also shared a list of Market Reports from EPIC that are now available upon request to Industry members.

Presentations were then given by the **five new Industry Members** about their companies' profiles and activities.

The Freyr Group, a Singaporean company founded in 2016 that develops transparent thin-film Solar Energy Platforms. Applications include solar energy for agricultural use, floating fields and indoor farming.

Acexon Technologies Pte Ltd, which was established in Singapore in 2004 as a sales and technical service provider specialising in lasers, optics, electro-optics and photonics.

Moveon Technologies, an optics solutions company founded in 2006. Products and services include optical design & simulation, injection / replication & wafer level optics, nanoscale fabrication, optical tools & inserts, ultra-precision machining, optical coatings and optical metrology.

Palomar Technologies, a leading supplier of automated microelectronic assembly machines and contract assembly services with specialisation in precision die attach, wire bonding and vacuum reflow solutions. Singapore is the Asian headquarters of the American company.

Transcelestial Technologies, which seeks to develop a laser communication solution to replace existing wireless communication technology. The ultimate goal is a constellation of nano satellites that uses lasers to transfer and relay data for ground, satellite and deep space applications.

Message from the Chairman/Co-director:

Since 2016, TPI and LUX have been jointly organising annual photonics conferences in Singapore, also known as Photonics@SG. This year, Photonics@SG will be held on 26 Nov, at the School of Humanities & Social Sciences (HSS) Auditorium, Nanyang Technological University (NTU). The theme is "Materials for New Photonics Technologies and Applications". Indeed, materials are the foundation underpinning development of various new technologies and capabilities. The ability to discover or create novel materials, such as metamaterials, could have a significant impact in improving existing technologies or enabling new technologies and applications.

Several speakers from the Centres under TPI, as well other universities and industry have been lined up for the day, including renowned academics such as Profs Din Ping Tsai (National Taiwan University), Sir Peter Knight (Imperial College UK), Ben Eggleton (University of Sydney) and Satoshi Kawata (Osaka University). The talks cover a wide range of photonics-related aspects, so please mark your calendars and join us at NTU this November.

Recently, we concluded two well-received events in September – 'Optical and Illumination Seminar' held in NTU, organised by LUX member Cybernet Systems Taiwan, which specialises on optical design software solutions; and 'TechInnovation 2018', where we showcased eight different technology offers from members of LUX to reach out to the industry for potential collaborations. In October, LUX will participate in another trade show/exhibition – 'Industrial Transformation ASIA-PACIFIC (ITAP)', which takes place from 16-18 Oct at Singapore Expo.

On 21 Sep, an extended programme of the Russia-Singapore Business Forum was held at Enterprise Singapore's premises. Cinemood, a Russian start-up, expressed interest in engaging LUX and TPI, as well as sourcing for R&D partnerships in Singapore. TPI and LUX have also been gaining recognition from organisations promoting trade and enterprise around the world. Come 22-26 Oct, delegations from France and Canada, each comprising around 10 Optics/Photonics companies and research entities, will be visiting Singapore and in particular, TPI and LUX. The visit by the French Delegation is one of the key programmes under the "France-Singapore Year of Innovation", with both countries agreeing to intensify cooperation in innovation. We have prepared a week-long programme for both delegations and there will be several networking opportunities for you to engage them. We look forward to more positive outcomes from these immersive programmes that promote wider exploration and deeper exchange for companies in Singapore with optics and photonics clusters from other countries.

In this issue, we turn the spotlight back to Lasers. We take a quick glance at the trends, provide a short introduction of the various laser capabilities available in TPI, and possibilities of how these lasers can be applied in the industry. I hope you enjoy reading this issue.

TPI The Photonics Institute Singapore

LUX Photonics Consortium Singapore

Five new Industry members, including Palomar Technologies, were introduced at the event.

The five new LUX faculty members also took the opportunity to share some of the latest technologies that they have been working on.

Tech Talks by LUX Faculty members shine spotlight on exciting new technologies

Tech Talk 1 | Single-shot Multispectral Imaging without use of expensive photodetector

Asst Prof Cuong Dang discussed his technology, which has enabled the development of a lens-less camera that can capture sharp, multi-coloured images without lenses or colour filters.

- Speckle patterns (instead of conventional colour filters) are used to detect and display the different spectrums.
- An image comprising multiple spectral bands, including UV Reflected, UV Fluorescent, Digital Infrared, and Visible can be achieved.
- The technology uses only simple optic elements – a piece of ground glass and a monochrome sensor, without the need for expensive photodetectors. Potential applications include forensics and food safety.

Using only simple optic elements and speckle patterns, Asst Prof Cuong is able to capture sharp, multi-coloured images without lenses, colour filters or expensive photodetectors.

Tech Talk 2 | Transparent Projection Films

Assoc Prof Chen Tupei spoke about the potential uses of transparent projection films, which involves placing a protection film and imaging film/PSA layers over a glass substrate. Applications include:

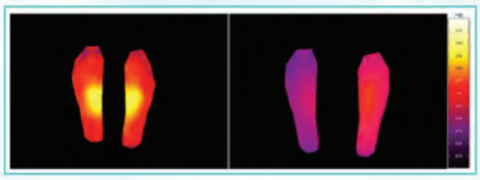
- Projection and display of advertisements, interactive media contents etc. on glass screens, glass walls or windows in commercial buildings, museums, lobby displays etc.
- AR/VR applications that bring real and virtual objects together, or even a stage performance incorporating virtual performers.
- Surgical operations or examinations, in which the patient's organs can be displayed on the transparent film as a visual aid for the surgeon.

By placing a projection film over a transparent glass panel, Assoc Prof Chen's technology makes it possible to project images such as the dancer shown here, onto the glass, while the audience can also see through the projected images.

Tech Talk 3 | Automated Thermographic Characterisation of Diabetic Feet

Assoc Prof Eddie Ng Yin Kwee discussed how diabetes could lead to complications, such as foot ulcers and lower limb amputation. He shared his methodology to analyse thermal changes on the plantar of diabetes patients. Collaborating with Ngee Ann Polytechnic, the methodology can be implemented onto hardware and used for trials in hospitals.

- Infrared thermography is used to acquire plantar thermal images. The temperature profile of the foot is then used for diagnosis and to detect abnormal areas.
- The technique is easily implemented in laboratories and polyclinics and thus can be used as an adjunct instrument to validate diagnosis of diabetic feet.
- Trial has been carried out at Singapore General Hospital's Diabetes & Metabolism Centre.

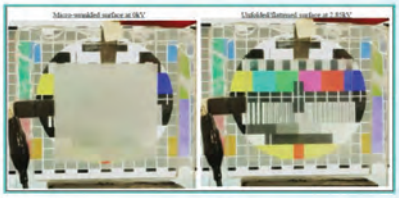


Assoc Prof Ng uses thermography of feet to distinguish between a normal (left) and diabetic (right) person.

Tech Talk 4 | Smart Glass/Windows, enabled by Soft Actuators

Asst Prof Lau Gih Keong spoke about his research, which seeks to create novel actuators and functions using interaction of engineering materials (metamaterials). In particular, he discussed dielectric elastomer actuators (DEAs).

- Low-cost smart windows can be made using DEAs with micro-wrinkled transparent compliant electrodes. The DEA's active micro-wrinkled area occupies only a small fraction of the window device.
- Transparent-to-translucent switching by micro-wrinkling and the reverse by electric-field induced unfolding.
- DEAs can potentially be used as artificial muscles for bionic fingers. Bionic fingers applied with robotic arms can have many important applications, such as industrial automation, assembly machinery, micro-surgical tools etc.

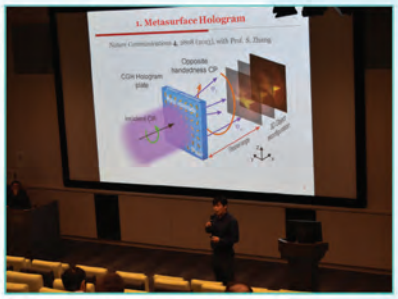


An example of Asst Prof Lau's work on translucent-to-transparent switching.

Tech Talk 5 | Synthetic Metasurface Refractive Lenses

Assoc Prof Qiu Cheng Wei rounded off the Tech Talks by describing a novel method to synthesise a metasurface with a commercially available plano-convex lens.

- Plano-convex lens is the most common item used for light focusing and collimation.
- This method is able to correct both chromatic and spherical aberrations of the lens.
- The resultant synthetic metasurface refractive lens has an entrance diameter of 1.5mm and effective focal length of 9.96mm, yielding advantages in terms of size, complexity, cost and scalability.



Assoc Prof Qiu speaking to the audience about his technology on synthetic metasurface refractive optics.

Putting the Spotlight on Lasers

A look at the latest market trends for lasers and the various laser capabilities within TPI

In a world where technology is advancing at an exponential rate, lasers are increasingly viewed as a key enabling technology to generate new developments in manufacturing, material processing and data communications. The total laser market in 2017 was reported to be slightly more than US$12b [1], with this figure expected to increase by around US$1b annually as the number of uses for laser devices continues to grow. By 2023, the total laser market is expected to be worth around US$17b.

Optically pumped semiconductor laser technology is commonly used to support laser light shows, such as the one at Marina Bay Sands.

Lasers are increasingly being used for materials processing.

Aside from being widely used in communications and data storage (UHD Blu-Ray players), lasers are growing in importance in various areas. Materials processing is one major area, which includes laser marking, sub-kW level laser micromachining processes (e.g. annealing of OLED flat screen displays for smartphones, additive manufacturing) and ≥ 1kW high-power laser material processing (e.g. welding, cutting of thick metallic materials, oil and gas drilling).

Sensors are another application of lasers in smartphones and consumer electronics. Vertical Cavity Surface Emitting Lasers (VCSELs) are a key component in 3D sensing, which is used for face recognition in smartphones, object distance ranging, as well as light detection and ranging (LIDAR), which in turn, has significant use in autonomous driving and autonomous ground vehicles/robots.

New laser applications include consumer electronics, where infrared (IR) vertical cavity surface-emitting laser (VCSEL) arrays are used for face recognition.

Lasers also find relevance in the military and medical fields (high-power directed energy weapons and wavelength-specific eye-safe lasers for cosmetics and surgery are just two examples of wide ranging laser interests in both areas), as well as in displays and entertainment, such as cinema lighting.

Semiconductor laser diodes operating in the visible wavelength range.

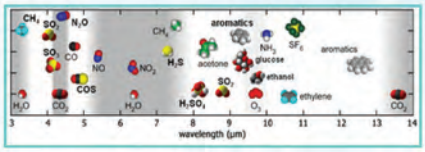
Many different types of lasers are available in the market. These include diode lasers, fibre lasers, solid-state lasers, CO2 lasers, excimer lasers and quantum cascade lasers (QCLs), to name a few. The revenues of most of these lasers are expected to continue growing year-on-year for the next 5 years, with the only exception being excimer lasers – expected to slow down slightly after 2020.

Revenues from CO2 lasers and high power diode lasers are likely to grow the fastest, at average rates of 15-20% year-on-year. Large CO2 lasers are increasingly finding their application in semiconductor photolithography for extreme UV light generation, while high power diode lasers (≥ 1W) are gaining prominence for material processing, displays (light shows, projection, cinema) and medical applications (dentistry to surgery). Revenues from QCLs and fibre lasers are also expected to grow at relatively fast rates, of around 5 – 8% year-on-year, with fibre lasers increasingly replacing CO2 lasers in the area of kW materials processing. Indeed, the future of lasers continues to look as bright as ever.

[1] *Strategies Unlimited, in their report 'The Worldwide Market for Lasers – Trends and Five-Year forecast (2017-2023)'*

At Nanyang Technological University Singapore (NTU), several research teams at The Photonics Institute (TPI) are into developing cutting-edge technology for various laser types. Some of these capabilities are described below.

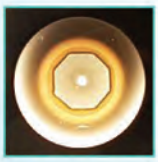
- ***Quantum Cascade Laser (QCL) in the mid-IR and THz region***
  - >> Single-mode, electrically tunable (for mid-IR region)
  - >> Mid-IR: λ = 4.7 - 15μm [i.e. 2130 - 670cm-1]
  - >> THz λ = ~80 μm [i.e. 125cm-1]
  - >> Output power: few Watts (pulsed), > 1W (continuous-wave (CW))
  - >> Applications: Low concentration (ppb) chemical/gas sensing (for environmental and pollution monitoring, industry process control and pharmaceutical uses), LIDAR, free space communication, defence countermeasures, security screening



Absorption spectrum of molecular gases in the mid-IR region. QCLs have the potential to detect these gases.

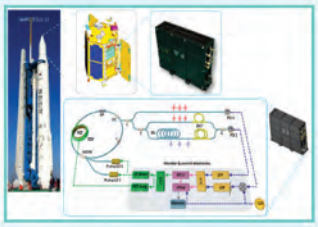
- ***Specialty Fibres for Large Mode Area, High Power Fibre Lasers***
  - >> Fibre fabrication carried out at NTU's Centre for Optical Fibre Technology
  - >> Demonstrated to lase at λ = 1μm, 2μm
  - >> For λ = 1μm, kW-level CW average output power
  - >> For λ = 2μm, 100W CW average output power
  - >> Applications: Materials processing

Specialty Fibre Design for 1um High-power Fibre Laser developed at NTU.



- ***Femtosecond Fibre Laser for Precision Metrology in next-generation space missions and defence application***
  - >> λ = 1.59μm
  - >> Output power: ~14mW pulsed with 600mW pumping
  - >> Demonstrated to work in space over 6.5 years with 1.5 mm shield thickness
  - >> Features: Short pulse duration, High peak power, broad spectral coverage, high wavelength stability, high-precision pulse timing
  - >> Applications: Next-generation space metrology missions, high-precision laser ranging, broadband spectroscopic LiDAR, precision time transfer, optical communications

Er-doped fibre fs laser device developed for satellite missions.

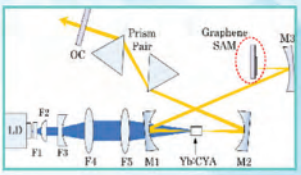


- ***High-power Semiconductor Laser Diode Array Bars***
  - >> Demonstrated to lase at λ = 808nm, 980nm
  - >> For λ = 808nm, 30W CW average output power
  - >> Applications: Pumping of DPSS lasers, medical, cosmetics

Laser array bars developed at NTU.

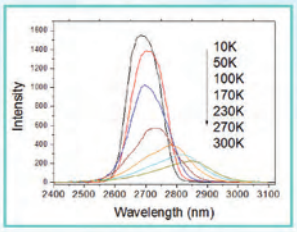
- ***Femtosecond Diode-Pumped Solid State (DPSS) Laser***
  - >> Generated stable 30fs pulse emissions – shortest 1μm pulses obtained from a DPSS laser
  - >> λ = 1μm
  - >> Output power: few mWatts (pulsed)
  - >> Applications: Laser spectroscopy, real-time imaging and analysis of samples (e.g. molecules, bio-materials)

Diode-pumped ultrafast laser setup at NTU.



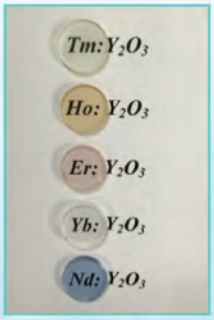
- ***Quantum Dots (QDs) for Semiconductor Lasers***
  - >> QD structure offers better temperature performance than that of normal quantum well (QW) lasers
  - >> InP substrate QD mid-IR lasers are much cheaper and better performing than traditional GaSb substrate mid-IR lasers
  - >> λ = 2.85μm at room temperature
  - >> Applications: Medical (e.g. laser scalpel, optical coherence tomography), display technologies (e.g. projection, laser TV), spectroscopy, telecommunications

Photoluminescence spectrum of InAsSb QDs at diff temps.



- ***Transparent Ceramics for Solid-State Lasers***
  - >> Single crystal ceramics
  - >> Demonstrated to lase at λ = 1μm, 2μm, 2.1μm, 3μm
  - >> For λ = 2.1μm, 25 W CW output power with 65W pumping
  - >> For λ = 3μm, 2.1 W CW output power with 20W pumping
  - >> Advantages: High material strength, thermal conductivity and efficiency
  - >> Applications: Gain media for solid-state lasers, optical windows, transparent armours for defence applications

Transparent Ceramics fabricated in-house at NTU.



Industry News

Optical & Illumination Seminar jointly organised by Cybernet Systems Taiwan and LUX Photonics Consortium

On 7 Sep 2018, one of LUX's newest industry members, CYBERNET SYSTEMS TAIWAN, together with Solutions4U, Synopsys Optical Solutions Group and the LUX Photonics Consortium successfully co-organised an event, titled "Optical & Illumination Seminar" in Singapore.

As distributor of Synopsys' optical design software, CODE V, LightTools, and RSoft in Asia-Pacific area, CYBERNET SYSTEMS usually organises such seminars annually in Japan, Taiwan and China, aiming to share insights of up-to-date optoelectronics technologies.

This year, the event made its debut in Singapore at the Nanyang Technological University Singapore (NTU), with 9 informative presentations presented by domain experts from Synopsys, CYBERNET SYSTEMS TAIWAN and NTU to 50 participants in the event.

Held at the Nanyang Executive Centre in NTU, the Optical and Illumination Seminar on 7 Sep was well attended by academics and industry representatives.

Scott Jennato, worldwide sales manager and Bruce Irving, international distribution manager of Synopsys Optical Solutions Group, gave an overview of optical and photonic industrial trends, as well as the total solutions provided by Synopsys' powerful optical design software.

Special guest speaker from NTU, Asst Prof. Nam Donguk, enlightened the seminar attendees with his speech on integrated Ge laser source on silicon platform, a technology that has significant potential for the future.

Design solutions for various applications, such as diffraction optical elements (DOEs), 3D depth sensing, automotive heads-up displays (HUDs), as well as AR/VR were also introduced in depth by Jake Jacobson, the technical manager of Synopsys Optical Solutions Group, Isa Liu and Steven Su from CYBERNET SYSTEMS' technical team.

A short introduction of the LUX Photonics Consortium was also provided by Daryl Ho, Business Development Manager of LUX, in which he spoke about how LUX aimed to serve as a catalyst and networking platform for the commercialisation of cutting-edge photonics research, as well as the services that the consortium could provide to its industry and faculty members.

"We are pleased with the completion of the Optical & Illumination Seminar in Singapore, and the cooperation between Solutions4U, Synopsys Optical Solutions Group and the LUX Photonics Consortium," said Arnie Cheng, CEO of CYBERNET SYSTEMS TAIWAN. "We believe that the optical solutions will benefit the development of optical industries and research."

Group photo of the joint organisers, Cybernet Systems Taiwan and the LUX Photonics Consortium.

LUX takes flight in Germany's optical quantum space

The LUX Photonics Consortium gained further visibility at a three-day workshop "From Quantum to KOSMOS - Optical Quantum Technologies for Small Satellites" held at the Humboldt-Universität zu Berlin in Germany.

Thomas Laurent, Head of Product Management and Founder of LUX member company Eagleyard, took the opportunity to introduce the consortium during his talk on "Qualifying laser diodes for long-, mid-, and short-term space applications" on Day 2 of the 12-14 Sep event.

The workshop looked at optical quantum technologies, which have the potential to advance many applications in space, including navigation, time and frequency distribution, Earth observation and planetary remote sensing, precision ranging, communication and networks, as well as fundamental physics.

Through talks and working groups, the workshop aimed to address scientific, technical and strategic questions around four main topics: Applications of OQT on small satellites; OQT demonstration in relevant environments; Technology developments and OQT industry; Small satellite platforms for OQT.

The workshop was supported by the university's KOSMOS programme, which looks to advance international and interdisciplinary exchange, fund young researchers and teachers, and create a sustainable tool for strengthening international partnerships. It is part of a Profile Partnership Project with the National University of Singapore.

Head of Product Management and Founder of Eagleyard, Thomas Laurent, introducing LUX Photonics Consortium to participants of the workshop.

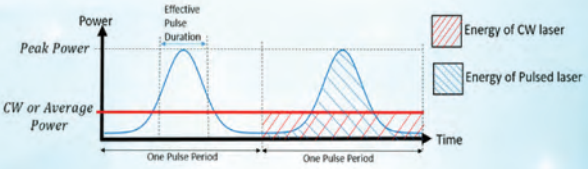
Using High Power Lasers in the Industry – Sintec Optronics

Lasers are a key component of many products, such as Blu-Ray/DVD players, bar code scanners and LASIK for eye surgery. Industrial manufacturing utilises lasers for processing such as cutting, engraving, drilling and marking on various materials.

In industrial manufacturing, the traditional 1064nm wavelength used is produced by Nd:YAG DPSS lasers, at powers of up to 1 kW. In recent years, fibre lasers based on Yb dopants in optical fibre, generating laser beams in the 1030-1080nm wavelength range, are able to generate high Continuous-Wave (CW) power from 500W up to 5kW. At these powers, lasers are able to cut through thick steel.

Different materials absorb at different wavelengths. For example, metals have higher absorption at lower wavelengths. Hence, there is demand for lasers at smaller wavelengths. When a 1064nm wavelength laser transmits through a nonlinear crystal, it is frequency doubled to generate 532nm green wavelength, or frequency tripled to generate 355nm ultraviolet wavelength. However, it is difficult to achieve high power at these smaller wavelengths, because only about ~20-30% power is converted to 532nm or 355nm from the incident 1064nm laser.

Laser pulses make material micromachining precise. Pulses take the laser energy output over a period of time and compress that energy into a short period of time, as shown in the figure below. The power of the pulse becomes very high for a very short duration of time, known as the effective pulse duration. The bulk of laser energy is confined within this effective pulse duration. The shorter the effective pulse duration, the higher peak power will become, analogous to squeezing the pulse in time while keeping the area under the curve same.



Power over time for CW laser and equivalent pulsed laser. Area under the curve is energy. Energy for CW laser (red area) is equal to the energy for pulsed laser (blue area) in one pulse period.

Pulses are advantageous in laser ablation. A small volume of material at the surface is vaporised if a large amount of laser energy (heat) is impacted on it in a very short time, such as using a pulsed laser. Supplying the laser energy gradually, in the case of using a CW laser, would only allow for the heat to be absorbed into the bulk material, never attaining sufficiently high temperature at any time.

LUX Industry member, Sintec Optronics, is developing high power pulsed DPSS lasers with low loss at smaller wavelengths. Prototypes show average power output of 60W at 532nm, and 20W at 355nm, with effective pulse durations of only a few nanoseconds. These higher average powers at smaller wavelengths and short effective pulse duration create pulses with high peak power, making laser micromachining more efficient and precise. These lasers can be used for laser processing and micromachining on materials such as metals and semiconductors.

Sintec Optronics has also embarked on a joint project with NTU through EDB's Industry PhD Programme (IPP) to develop an ultrashort pulse fibre laser at unconventional wavelengths. Ultrashort pulses have effective pulse durations of picoseconds or even femtoseconds. At such short effective pulse durations, the peak power of the pulse can go up to 100MW! Imagine supplying such huge power in an "ultrashort" period of time. Materials can be processed extremely precisely, to an accuracy of nanometres, allowing the ability to create nanometre-scale 3D structures. Indeed, with the advancement of laser technology, the potential uses and applications for the industry are endless.

Local Conferences

Photonics @ SG 2018 - Photonics Conference organised by The Photonics Institute and LUX Photonics Consortium

NTU School of Humanities and Social Sciences (HSS) Auditorium
26 November 2018, 8.00am – 5.30pm

Save the date! Register for the Photonics@SG 2018 Conference now!

We have lined up a series of high impact talks from both the academia and industry, as well as an exhibition gallery to showcase the latest technologies and research works from The Photonics Institute. Poster presentations will also be one of the highlights of this year's event.

Focusing on the theme of ***Materials for new Photonics Technologies and Applications***, below is a glimpse of what can be expected from the conference.

- **Prof Din Ping Tsai, National Taiwan University, Taiwan**
  - Meta-device for Photonics in Demand
- **Prof Ben Eggleton, University of Sydney, Australia**
  - On-chip Brillouin filtering of Microwave and Optical Signals
- **Prof Sir Peter Knight, Imperial College, UK**
  - Quantum Computing: Prospects and Impact on Information Technology
- **Prof Satoshi Kawata, Osaka University, Japan**
  - Plasmonic self-growth of plasmonic 3D nanostructures
- **Asst Prof Wei Lei, NTU Centre for Optical Fibre Technology (COFT)**
  - Advanced Functional Semiconductor Fibres
- **Asst Prof Ranjan Singh, NTU Centre for Disruptive Photonic Technologies (CDPT)**
  - Low Energy Ultrafast Superconductor THz Metamaterials
- **Dr Teng Jing Hua, A*STAR, Institute of Materials Research and Engineering (IMRE)**
  - Flat Optics for Versatile Optical Wavefront Manipulation
- **Asst Prof Nam Donguk, NTU Centre for Optoelectronics and Biophotonics (COEB)**
  - Strain-Engineered Low-Threshold Group IV Lasers for Photonic-Integrated Circuits
- **Dr Wenjuan Qi, Palomar Technologies USA**
  - Advanced Photonic Packaging: Empowering IoT and beyond
- **Asst Prof Kim Young Jin, NTU Centre for Optical and Laser Engineering (COLE)**
  - Ultrafast Photonics for Ultra-Precision
- **Asst Prof Robert Simpson, SUTD - Singapore University of Technology and Design**
  - Phase Change Material Tuned Photonics
- **Dr Phua Poh Boon, LightHaus Technologies Pte Ltd**
  - Bringing Out The New Light
- **Assoc Prof Zhou Guangya, NUS - National University of Singapore**
  - NEMS-coupled photonic nanobeam cavities and their applications

For more details, please visit http://event.ntu.edu.sg/PhotonicsSG2018/Pages/default.aspx.

We are also pleased to announce that Palomar Technologies, LightHaus Photonics and II-VI are our sponsors for this event. If you would like to contribute to our event by being a sponsor, please contact us at lux_chairman@ntuitive.sg.

Platinum Sponsor:

Gold Sponsors: