

## LUX continues to grow in size and research capabilities

The LUX Photonics Consortium showcased its expanding research capabilities at its latest Members' Networking Event on 31 May, introducing a new affiliated centre for The Photonics Institute, seven new LUX industry members and two new LUX faculty members.

Prof Tjin unveiled LUX's seven newest industry members – coming from countries such as China, the United Kingdom and Germany – bringing the total number to 25.



Held at Nanyang Polytechnic, the event was attended by representatives from the likes of NTU, NUS, Nanyang Polytechnic, Spring Singapore, and the Singapore National Research Foundation.

The seven companies are:

-  Axis-tec, a complete solutions provider for industrial automation, particularly in product handling, assembly and test
-  Eagleyard Photonics, a leading provider of high-power laser diodes covering wavelengths from 630 to 1,120nm
-  GDS Instruments, a gas sensor expert that developed the photoionization detector (PID) sensor with automatic self-cleaning capability
-  Kibing, currently China's largest glass manufacturer with 5,000 employees and 23 production lines
-  Physik Instrumente, a global market and technology leader in the field of precision positioning technology with accuracies down to nanometres
-  PureLiFi, the pioneers of Li-Fi technology: light-based technology that allows information to be transmitted at very high speeds
-  Sintec Optronics, specialists in laser systems and optical components

## Message from the Chairman/Co-director:

Like the previous quarter, LUX Photonics Consortium members – both Industry and Faculty members – have gathered again, for the exchange of technical information and new ideas in the area of photonics and its enabling product or services.

It is really encouraging for me to see five new member companies sharing about their companies and photonics technology needs, in addition to the presentations from our two new faculty members.

We want to thank Nanyang Polytechnic (NYP) for hosting this LUX networking event. The lab tours at NYP, in the areas of IoT, automation, precision engineering, etc., has provided a good insight into the engineering capabilities of our local Polytechnics, which we hope to tap into to form a comprehensive Photonics R&D ecosystems to support our industry members.

As a follow-up on the partnership with the European Photonics Industry Consortium (EPIC), I was at EPIC's Annual General Meeting in Eindhoven from 6 to 7 April, to give a talk about Singapore's photonics R&D/industry. With me were representatives from EDB and NRF who are TPI's and LUX's strong partners in the local Photonics ecosystem.

Upcoming initiatives to encourage collaboration include a LUX members visit to Germany from 9 to 11 October and EPIC Start-up Forum at Berlin from 4 to 5 October. It is my hope that our LUX members will find useful business links in Europe.

There are also exciting updates from The Photonics Institute (TPI) from these past few months. We hosted a few groups of prominent visitors at TPI to promote understanding of photonics at NTU. They include Mr Scott Wightman, British High Commissioner to Singapore, and members of his Science and Innovation team.

This year has been special for Singapore's photonics R&D community as, for the first time, the Conference on Lasers and Electro-Optics Pacific Rim (CLEO-PR), OptoElectronics and Communications Conference (OECC) and Photonics Global Conference (PGC), will be co-located at the Marina Bay Sands Singapore, from 31 July to 4 August. TPI, together with LUX, is one of the key sponsors and partners of this Mega Conference. TPI will be setting up a pavilion to showcase our research capabilities.

We welcome you to visit the TPI/LUX pavilion, to meet up with the researchers and discuss your technology needs, or hear the exciting new photonics research topics at the conference. We look forward to meeting you all at the mega photonics conference and exhibition.



An initiative of both Nanyang Technological University (NTU) and National University of Singapore (NUS), supported by National Research Foundation (NRF), Singapore.



The new LUX faculty are Prof Lee Pooi See of NTU's School of Materials Science and Engineering and Assoc Prof Murukeshan Vadakke Matham, of NTU's School of Mechanical and Aerospace Engineering.



New LUX faculty member Assoc Prof Murukeshan Vadakke Matham spoke on his key research areas to the audience of about 50.

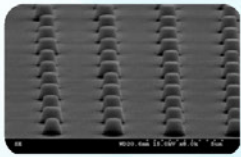
Assoc Prof Murukeshan, who is also the Deputy Director of the Centre for Optical and Laser Engineering, spoke on his three research focus areas: biomedical optics, nanoscale optics and applied optics.

Presenting to a crowd of about 50, including other LUX faculty as well as representatives from NTU, NUS, Nanyang Polytechnic, Spring Singapore, the Singapore National Research Foundation, and LUX member companies, he shared that some of his research findings are ready for commercialisation.

These include multimodality multidimensional imaging for tissue imaging and early cancer (colon, breast) diagnosis, applied optics/optical metrology for engineering applications, as well as random media and nonlinear optics for next generation optoelectronics and energy harvesting applications.

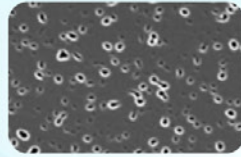
**Interferometric Lithography**

For sub-30nm feature fabrications in semicon and biomedical applications.



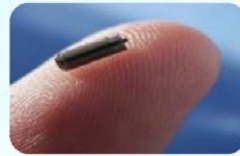
**Speckle Lithography**

Sub micro-scale patterning for aerospace, solar cells and flexible electronics applications.



**Interferometric 3D printing**

for applications in multi-analyte sensing and fabrication of micro batteries.



**Hyperspectral Imaging**

For biomedical diagnosis applications.



Fittingly, the event was held at Nanyang Polytechnic, which has facilities, technology and engineering capabilities that could potentially bring the research done by LUX faculty members closer to commercialisation.

Prof Lee discussed her work on high-performance hybrid materials and devices, which include flexible and stretchable energy harvestors that convert mechanical motion to electricity, pressure sensors which offer static and dynamic pressure detection for a wide range (0.01 to 700 kPa), and transparent conductors for touch or lighting applications.



Prof Lee Pooi See, a new LUX faculty, discussed her work on high-performance hybrid materials and devices.

**Transparent conductors**

Transparent conductive nanopaper for touch or lighting applications.



**Stretchable conductors**

Extremely stretchable and elastic conductors (>700%) for strain sensors or lighting applications.



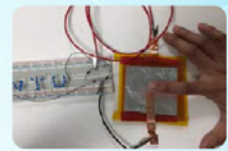
**Pressure sensors**

Wide pressure range (0.01kPa to 700kPa) sensors capable of static and dynamic pressure detection can be used in wearable applications.



**Mechanical energy harvestors**

Flexible and stretchable energy harvester that converts mechanical motion to electricity.



The duo were warmly welcomed by Prof Tjin Swee Chuan, LUX's Chairman. And he also took the opportunity to announce that the Centre for Bio Devices and Signal Analysis (VALENS) was now part of the LUX family as an affiliated centre.

Based in NTU's School of Electrical and Electronic Engineering, its key research areas include lab-on-chip, bio-imaging, e-health and neurotechnology, with a focus on healthcare and medical diagnostics technologies.

Prof Tjin also took the opportunity to update those in attendance on latest happenings in the LUX scene, including the January visit by the European Photonics Industry Consortium (EPIC) and, in turn, his speaking opportunity at the EPIC annual general meeting in Eindhoven, Holland.

And he rounded off the day by highlighting the exciting research on supercontinuum light sources being conducted at the Centre



for Optical Fibre Technology – with the work done by Asst Prof Yoo Seong Yoo, Dr Sidharthan Raghuraman, and Mr Daryl Ho most recently featured in *Electro Optics*.

Chairman Prof Tjin Swee Chuan took the opportunity to introduce the newest additions to the LUX family: seven new industry members and two new faculty members.



# Featured Research Capability

## LUMINOUS! proprietary solutions for LED epi and chip

- Strong and strategically organized patent portfolio (>30 applications)
- Proprietary turn-key LED solutions for both full process and modular packages
- High performance, quality and cost-effective LED epitaxy growth
- Full LED chip fabrication line for lateral, flip-chip and vertical devices

## LUMINOUS!, a shining beacon for LED research

LEDs – or light-emitting diodes – are a fixture in our everyday lives: from street lighting to brightening up our homes, compact machine lights in factories or surgical lights in hospitals, these energy-efficient, long-lasting lights can be found everywhere.

Little wonder then that there is a center at NTU looking to brighten up our world by further developing and exploiting LED technologies. The LUMINOUS! Center of Excellence for Semiconductor Lighting & Displays was established in August 2010 with a focus on achieving energy efficiency and high quality in lighting and displays through multidisciplinary research.

Considered a leading LED research center both regionally and globally, LUMINOUS! today has a team of over 40 research staff led by its Director, Prof Hilmi Volkan Demir, who joined NTU in 2009 after he clinched a prestigious global fellowship from Singapore's National Research Foundation for promising young international scientists.



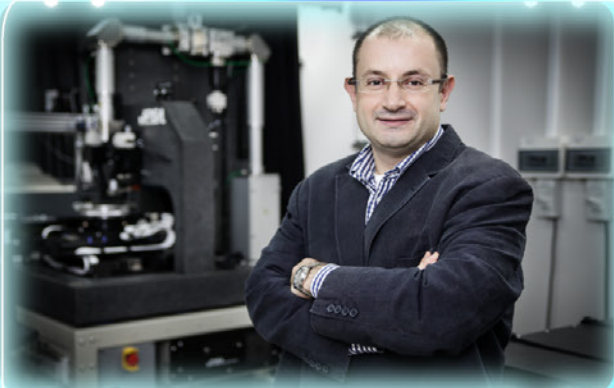
Prof Demir and his team at LUMINOUS! Center of Excellence spearheading Singapore's LED research.

Says Prof Demir, who hails from Turkey: "The key competencies of LUMINOUS! include high-quality InGaN/GaN LEDs, white LEDs, nanocrystal LEDs, perovskite LEDs, light extraction, and colloidal quantum dots."

He elaborates on some of the research conducted, saying: "We have developed full capability to epitaxially grow and fabricate high-efficiency GaN-based LED chips through crystal growth, buffer engineering, device design and modelling."

"In particular, through the optimization of epitaxial growth, we have achieved state-of-the-art crystal quality of GaN-based films. A broad knowhow of measurable materials properties, sophisticated device simulations, and final device performance, combined with innovative design of device structures provides us with a competitive R&D platform."

Equipped with state-of-the-art facilities for semiconductor device epitaxy, fabrication and testing, including showerhead III-N Metal-Organic Chemical Vapour Deposition (MOCVD), one of the center's biggest achievements to date is developing and demonstrating full capability for the epitaxial growth of III-N for high-efficiency and high-quality solid-state lighting, displays and other optoelectronic applications.



As the Founding Director of LUMINOUS! Center of Excellence for Semiconductor Lighting and Displays, Professor Hilmi Volkan Demir has made important scientific contributions in the areas of energy-saving LED lighting and displays, which led him to the prestigious Nanyang Awards for Research Excellence.



LUMINOUS!'s high performance, quality and cost-effective LED epitaxy growth.



Says Prof Demir: "The advanced knowledge, proprietary knowhow, and enabling technologies developed here provide superior performance while also changing the cost structure of packaged LED chips."

The School of Electrical & Electronic Engineering don adds that the work done at the center also includes the study of materials from synthesis to property characterization and device applications, with the help of its cutting-edge soft-material synthesis, material characterization and device fabrication capabilities.

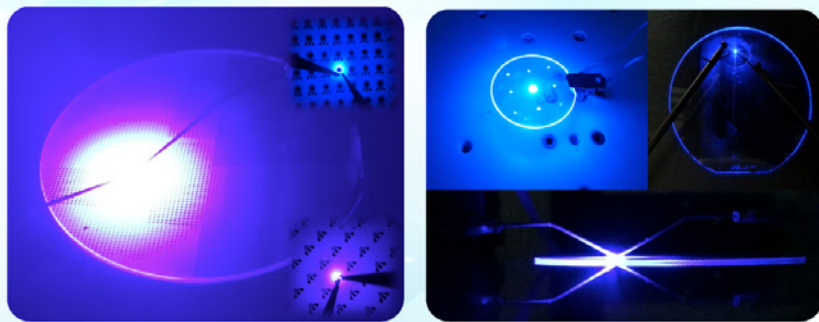
He adds: "These enable us to establish world-class expertise and generate new technologies spanning from materials to systems, with the targeted applications in colour enrichment for displays, quality indoor lighting, spectrally enhanced outdoor lighting, flexible and bendable displays, and tunable lasers."

Prof Demir is proud that the center has already patented some of its work such as vertical LED chips available in blue and near-ultraviolet that have advantages in thermal management and optical efficacy, as well as high-performance and high-efficiency flip chips.

Another source of pride is the center's flagship programme on energy-saving and



LUMINOUS! flagship programme: World-class expertise, know-how and full capability to epitaxially grow and fabricate III-nitride LED epitaxy and chips.



LUMINOUS!'s full LED chip fabrication line for lateral, flip-chip and vertical devices.

A broad know-how of measurable materials properties, sophisticated device simulations, and final device performance, combined with mature design of layer structures provide LUMINOUS! with a competitive research and development platform.

quality lighting, which is "attracting a high level of interest in the international arena".

Says Prof Demir: "Our scientific research work, together with strong innovation in LED material and device design, has generated a strong intellectual property portfolio at NTU and is now going into the commercialization phase."

"We believe our semiconductor optoelectronic solutions will strengthen capabilities and industry at a national-level, increase competitiveness and also help create a new start-up."

Going forward, Prof Demir hopes that LUMINOUS! will continue its entrepreneurial efforts and contribute to the R&SD landscape and ecosystem of Singapore, enthusing: "Through synergy and collaboration, we can continue to grow in visibility both locally and internationally."

## TPI impresses British delegation

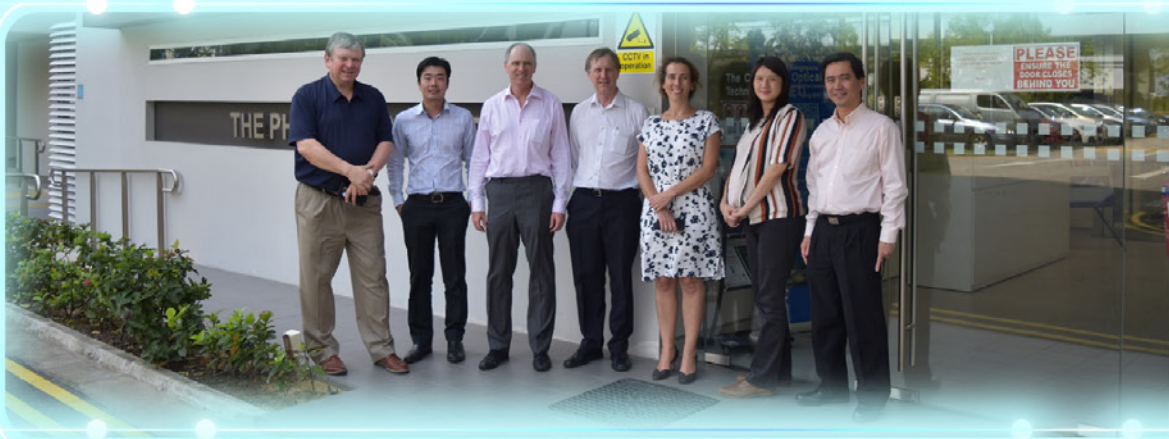
The Photonics Institute warmly welcomed British High Commissioner Scott Wightman and members of his Science and Innovation team on 19 April.

He had accepted an invite from TPI co-directors Prof Sir David Payne and Prof Nikolay Zheludev to visit and learn more about TPI's partnership with the Optoelectronics Research Centre (ORC) at the University of Southampton, which has seen TPI researchers receive extensive training at the ORC in areas like fibre fabrication and characterisation.

The group – hosted by TPI co-directors Prof Tjin Swee Chuan and Prof Nikolay Zheludev, and Prof Timothy John White, Research Director for Engineering, Physical and Biomedical/Life Sciences, President's Office, NTU – toured the Centre for Optical Fibre Technology and Centre for Disruptive Photonic Technologies, including state-of-the-art facilities like the fibre drawing tower.

Said the High Commissioner: "The relationship between NTU and the University of Southampton is a great example of the benefits of collaboration between world-class universities in the UK and Singapore."

"The success of the Photonics Institute is testament to their strong research partnership, mutual trust, and the sharing of resources and expertise. The British High Commission in Singapore is very supportive of such collaborations."



The delegation included British High Commissioner Scott Wightman (third from left) and Nicola Willey, Regional Director South East Asia UK Science and Innovation Network (third from right).



# Partnership between LUX and EPIC is maintaining the momentum

The partnership between LUX and EPIC is keeping the momentum up. LUX Photonics Consortium has been actively expanding her network globally. Chairman, Prof. Tjin Swee Chuan was invited to give a talk about Singapore's Photonics ecosystem at the European Photonics Industry Consortium (EPIC) AGM, held on 6-7 April, 2017 at Eindhoven, the Netherlands. This is shortly after the EPIC delegation visit to Singapore which spanned three days in the middle of January, and an invited speech at the "EPIC's Photonics Tech watch" at the W3+(Optics, Electronics & Mechanics), at Wetzlar, Germany in February this year.

The EPIC AGM was attended by more than two hundred members of EPIC, many of whom are CEOs, CTOs, Managing Directors, Chairmans, VPs, and Founders of companies etc. The talk by Prof Tjin struck a chord with many company

leaders in Europe who see new opportunities in Singapore, being well-equipped with deep photonics research capabilities, as an effective regional centre of the South Asia region. Keen to tap into the



network platform created by LUX at Singapore, extended to European companies in the network of EPIC, are companies like Physik Instrumente, Eagleyard Photonics, Ficontec, etc. A few of them have joined LUX Photonics Consortium as Industry associate members.

We are planning for an exploratory trip for LUX members to visit some of the EPIC member companies in Berlin and the region in October this year. With the EPIC team, meetings and visits to any of the members can be arranged, even for those companies in the wider Europe region. We encourage companies who are seeking partnerships or interested in better understanding the business opportunities in Europe to join us for this trip. The network that you can form there could be invaluable for your company in the future.



## NUS Professor Spins Off Company to Commercialize Fruits of his Research



Prof. Hong [center] explaining the technology to visitors at Innovest Unbound.

LUX Faculty member, Professor Hong Minghui from NUS, has recently spun off a company, Phaos Technology Pte. Ltd. to commercialize the fruits of his research, optical microsphere nanoscopy technology.

Optical Microsphere Nanoscope is a research outcome of Competitive Research Project (CRP), funded by National Research Foundation (NRF). The technology enables conventional optical microscopes to achieve super-resolution effect, by introducing a micro-scale sphere lens between the sample and objective lens. With the ability to image sample with sub 100 nanometer feature sizes, with pure optical means in real time, Prof Hong and team understand



Commercial prototype of optical microsphere nanoscope

the great potential for this technology to be used in the field of biomedical and pharmaceutical research.

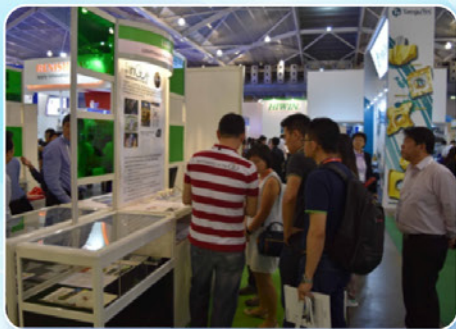
"Research should not stay in research centres, in the form of scientific publications and patents. The Government pours huge amounts of money into R&D every year, we want to see this investment turned into value, and actually make a positive impact in everyday life. A very good way is through commercialization of our research outcome," answered Prof. Hong enthusiastically when asked about his motivation in spinning off this technology.

Phaos Technology was incorporated in February 2017, and has since been working in exploring the market and converting raw prototype to commercial product. The technology has proven its great potential and the company has received interest from different industries. Moving forward, Phaos Technology is looking for private investment and at government assistance schemes to start small-scale production to cater to the interest received thus far.



# Industry News

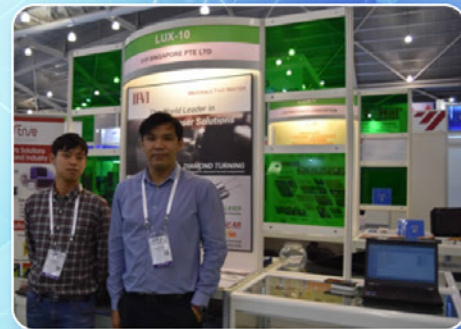
## A busy quarter for LUX Photonics Consortium



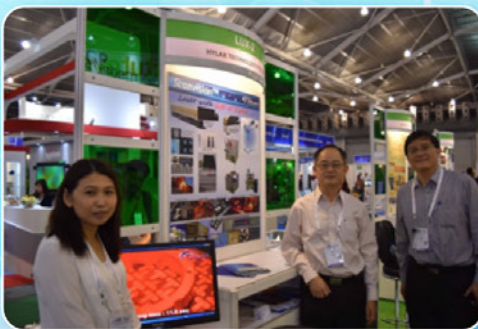
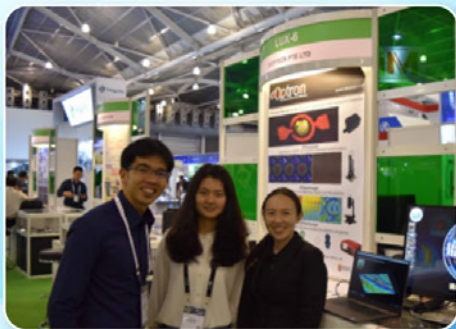
The Consortium participated in a number of trade shows and exhibitions during the past few months, actively promoting and making its presence felt at relevant industry events in Singapore. These activities have helped the consortium in reaching out to non-traditional photonics industries and sectors but using photonics to enable new applications. For example, the consortium participated in Manufacturing Technology Asia (MTA) 2017, leading a group of 9 members exhibiting at the very first Photonics and Optics Innovation Hub – a dedicated area to showcase innovative technology in optics and photonics. The 9 consortium members – made up of Anexus, D'Optron, Einst, Finisar, Hillhouse, Hylax Technology, II-IV Infrared, LightHaus and Tip Biosystems – came together and exhibited under LUX.



The Consortium also participated in Asia's biggest communication events, the CommunicASIA 2017 held at Marina Bay Sands on 23-25 May 2017. Photonics play a big part in the communications industry, and the event has brought new opportunities for the consortium as well.



The IEEE International Conference on Robotics and Automation (ICRA) 2017 held at MBS from 29 May to 3 Jun, is IEEE Robotics and Automation Society's flagship conference and is a premier international forum for robotics researchers to present their work. LUX has the opportunity to make a presence under the NTU/NTUitive booth and seek out collaboration in this domain.



Manufacturing Technology Asia (MTA) 2017 Exhibition at Singapore Expo, 4-7 April 2017



## Mark your calendar!

### Opening Ceremony & Plenary Presentations

(Sands Grand Ballroom, Level 5)  
1st Aug 8:00am

### Exhibition

(Sands Roselle & Simpor ballroom, Level 4)  
1st Aug 2:00pm - 3rd Aug 5:00pm

# CLEO-PR|OECC|PGC

31 JULY - 4 AUGUST 2017 SANDS EXPO AND CONVENTION CENTRE, SINGAPORE

## Plenary/Keynote Speakers



William E. Moerner  
Stanford Univ, USA  
Nobel Laureate 2014



John Pendry  
Imperial College, UK



Eric Swanson  
Acacia Communications, USA



Nikolay Zheludev  
Univ of Southampton, UK & Nanyang Technological Univ, Singapore



John Dudley  
Univ of Franche-Comte, France  
Chairman of International Year of Light (IYL)



Eric Mazur  
Harvard Univ, USA  
OSA President 2017



Kent Choquette  
UIUC, USA  
IEEE Photonics Society President 2017



Philip Russell  
Max Planck Institute, Germany



Vincent Chan  
MIT, USA



Antonio Helio De Castro Neto  
National Univ of Singapore, Singapore



Christoph Brabec  
Friedrich Alexander Univ Erlangen-Nürnberg, Germany



Marin Soljacic  
MIT, USA

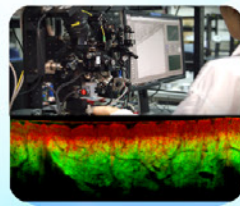


Connie Chang  
UC Berkeley, USA

## A preview of the centerpiece of the exhibition: The Photonics Institute Pavilion



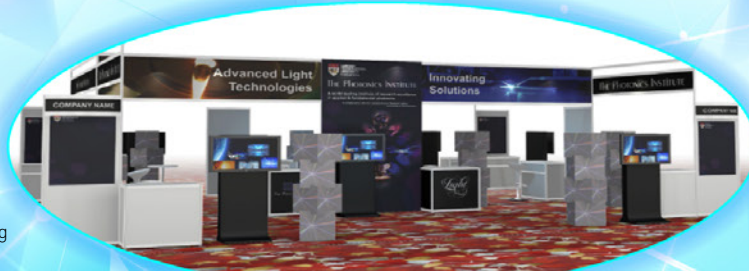
Advanced functional fibers for next generation wearables



Micro-optical coherence tomography system

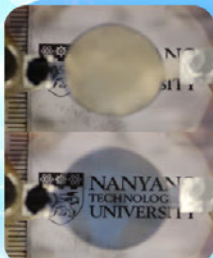


High-performance LEDs with high-quality nanoluminophors



Advanced functional fibers for next generation wearables

RGB-D Sensor, compact Bioimaging System and Smart Window



Display on Silicon-related technology



Transparent Ceramics

