

Featured Research Capability

Imagining the future of photonics

For a research centre that looks ahead to the future – generating a knowledge base for new light-based technologies with a 10-plus year outlook – the Centre for Disruptive Photonic Technologies (CDPT) has already achieved more than modest success in the present.

It has put NTU on the global map of nanophotonics research institutions by organising large-scale events like *META'14*, the 5th International Conference on Metamaterials, Photonic Crystals and Plasmonics, which saw more than 700 attendees gathered at NTU, as well as more focused, topical workshops like the *Singapore-Japan workshop on Nanophotonics, Plasmonics and Metamaterials*.

And according to the Thomson Reuters-run Web of Science, since the opening of the CDPT in 2012, NTU has become the top worldwide institution in metamaterials research by publication number and the third by publication impact.

Says the CDPT's Deputy Director, Assoc Prof Cesare Soci: "With the engagement of Prof Nikolay Zheludev, a leading scientist in the fields of photonics and metamaterials, as our Director, the CDPT was set up to consolidate the numerous but then-disjointed research activities in optics, spectroscopy and photonics at NTU, and to become a hub for nanophotonics in Singapore and Southeast Asia."

But first, it was vital that the right infrastructure was in place to support a

comprehensive research agenda. CDPT Phase 1 saw the installation of a cluster of state-of-the-art nanofabrication and optics laboratories in just a few months. CDPT Phase 2 was completed a year later, bringing with it a cluster of microwave, THz and infrared nanophotonics laboratories.

"Today, CDPT is a powerhouse for nanofabrication and optical characterisation, spanning an extremely vast range of spectral (from microwave to optical frequencies), time (down to a few femtoseconds), and space (down to a few nanometres domains)," says Assoc Prof Soci.

He shares that the CDPT has also built up a large network of international collaborators and research centres – such as the University of Southampton's Optoelectronics Research Centre, which is famed for its expertise in fibre technology and understanding of photonics – to tap on. "We have a number of outstanding research collaborators from Europe, the United States and Asia, and they are

actively working with and exchanging students and research staff with us on a regular basis."

In addition, the CDPT has invaluable partnerships with the likes of the Japan Society for the Promotion of Science and the European Cooperation in Science and Technology, the longest-running European framework supporting transnational cooperation among researchers, engineers and scholars across Europe.

Adds Assoc Prof Soci proudly: "Today, we number about 15 investigators, 10 project leaders and 20 PhD students from Europe, the United States, Asia, and, of course, Singapore. This has created a truly international, vibrant and productive research environment."

"We are also currently running about 15 research projects on various fundamental aspects of optical materials and metamaterials, as well as nanophotonics."



Assoc Prof Cesare Soci, Deputy Director of the Centre for Disruptive Photonic Technologies (CDPT).



Dr. Giorgio Adamo, Research Manager of the Centre for Disruptive Photonic Technologies (CDPT), operating the newly commissioned Time Resolved Cathodoluminescence Microscope.

Novel research and exciting technologies

Currently, the research being conducted at the CDPT encompasses three main areas: reconfigurable, dynamic and quantum metamaterials; reconfigurable micro/nano-fibres and cognitive photonic systems; and nanolasers, spasers and nano-metamaterials for electromagnetic technologies.

The centre's research may offer ground-breaking solutions for a variety of real-world applications – with a ten-plus year outlook – with the possibility of being

employed in telecommunications, energy, light generation, imaging, lithography, data storage, sensing, medicine, security and defence.

Enthuses Assoc Prof Soci: "Some of the technologies we work on are quite exciting. One project deals with super-resolution lenses based on the phenomenon of superoscillations: by using adaptive algorithms to design specific nanostructures that focus light into "needles", we are able to increase the

resolution of an optical imaging system – such as a microscope – beyond the fundamental diffraction limit." The resolution of optical microscopes is currently limited by the diffraction of visible light, so the CDPT's research could have huge implications for nanophysics, biotechnology, and pharmaceutical research – all fields that rely heavily on the optical microscope.

He mentions another research area called cognitive photonics, in which optical

networks made of optical fibres, silicon photonics or plasmonic waveguides are used to perform complex mathematical operations. "Think of the global Internet fibre-optic network as a brain, in which cognition and memory could emerge from the way fibres are connected together and signals are transmitted from one node to the others."

Assoc Prof Soci believes that the CDPT has benefited from being under The Photonics Institute's umbrella: "It has led to opportunities to apply jointly to competitive research funds like in the first Agency for Science, Technology and Research's (A*STAR) Advanced Optics in Engineering Programme."

"Then, we partnered with the Centre for Optical Fibre Technology, which is also under TPI, and successfully carried out two projects on specialty fibre-enabled super-resolution optical technologies and fibre nano-manufacturing."

CDPT'S new five-year plan

Assoc Prof Soci is excited about the potential in Singapore's photonics scene, enthusing: "In the last few years, we have seen an incredible expansion of photonics R&D here. This has created a fertile ground for spurring research from academic laboratories to industry. In addition, another significant development has been the launch of the LUX Photonics Consortium."

As for the CDPT, he reveals that its second phase is currently being mapped. "Photonics is one of the research strengths and focus areas in the NTU 2020 strategic plan."

"For this second phase, which will begin at the end of 2017 and will span the following five years, we have identified quantum and topological nanophotonics as the two

areas of major interest – where CDPT is at the forefront of the international research scene, and in which we could make a large impact."

- Established by the first Tier 3 grant of the Singapore Ministry of Education
- More than 20 million dollars in competitive funding
- 45 Investigators, Researchers & PhDs
- 800 m² of research labs, cleanroom and offices
- More than 250 journal publications in the first 4 years
- More than 500 conference presentations, 30 Keynote and Plenary & more than 150 Invited talks
- More than 40 papers in the Nature Publishing Group Journals and Science

August augurs well for LUX

The week of 22nd August was a productive one for the LUX Photonics Consortium in terms of its outreach efforts.

It took part in two events in four days: exhibiting at the Intellectual Property (IP) Ecosystem Fair from 22nd to 24th August, and then presenting at the SPETA Outreach Event organised by SPRING Singapore and Singapore Precision Engineering and Technology Association (SPETA) on 25th August.

The IP Ecosystem Fair, part of the IP Week @ SG, saw the likes of IP law firms, management and business consultancy firms, as well as technology and data service providers exhibit alongside tertiary institutions and innovation clusters. LUX was running an exhibition with its partner NUS Enterprise and its Chairman, Prof Tjin Swee Chuan spoke on the topic of "IP

Pooling Model: Photonics".

Said Prof Tjin of the event which was open to the public and attracted entrepreneurs, innovators, venture capitalists and IP professionals: "We were able to share our IP model with a larger community, and how industry members can easily partner and work with Institutes of Higher Learning to evaluate non-exclusive IPs for free for up to three years, and adopt it for commercialisation later where appropriate."

"We made many business contacts and achieved good publicity for the Consortium. A few companies approached us and were interested to find out more – we took the opportunity to invite them to our networking event held the same week to observe the proceedings with a view to joining the Consortium."

LUX Programme Director Dr Soo Choi Pheng was equally pleased with the outcome of the Consortium's participation in the SPETA Outreach Event at e2i, Devan Nair Institute. She spoke on LUX's aim to provide local enterprises with access to photonics research expertise and facilities.

As shared by the advisor of SPETA, Mr. Steven Koh: "SPETA has over 200 members and one of its key missions is to help its Precision Engineering member companies transform via innovation, integration and internationalization, as well as redirect them to higher value and growth areas like medtech, optics and photonics, and the Internet of Things."

"LUX can serve as the research platform for SPETA and its members to innovate their products and services."



LUX Chairman Prof Tjin Swee Chuan spoke on the "Intellectual Property (IP) Pooling Model: Photonics" at the IP Ecosystem Fair, part of the IP Week @ SG.



SPETA advisor Mr Steven Koh spoke at the outreach event held at e2i, Devan Nair Institute.



LUX Programme Director Dr Soo Choi Pheng shared how the Consortium can serve as the research platform for SPETA and its members to innovate their products and services.