NANYANG TECHNOLOGICAL UNIVERSITY

School of Electrical and Electronic Engineering

Changing Lifestyles Aspiring Success Stories

Singapore as a dynamic and vibrant science and technology hub, with research and development contributing significantly to a knowledge-intensive, innovative and entrepreneurial economy...

> The Singapore Government has set aside S$16 billion for research and development (R&D) from 2011-2015. This underscores Singapore's commitment to maintain R&D funding even through the economic cycles. These R&D investments will generate new knowledge, promote innovation, and build deep capabilities to sustain Singapore's competitiveness for the future.

Deputy Prime Minister TEO Chee Hean
Chairman, National Research Foundation
at Techventure 2012, 17 October 2012

At the School of Electrical and Electronic Engineering (EEE), We Look Beyond R&D

Constantly generating innovative ideas and harnessing our core competencies, we grow and strive to develop the strongest research capability in what we are best at.

We are one of the world's largest schools in electrical and electronic engineering which is internationally renowned for its high academic standards and strong research orientation. The School has more than 160 full-time faculty members with strong research and professional expertise and supported by more than 400 research, technical and administrative staff members.

Our cutting-edge research and technological innovation are in a broad spectrum of areas, such as infocomm technologies, nanoelectronics, bio-instrumentation, photonics, semiconductor lighting and displays, IC design, electrical systems for future cities, electromagnetic effects and satellite engineering. The high calibre of our faculty is matched by a well-developed teaching and research infrastructure comprising one of the most comprehensive and sophisticated constellations of research centres and laboratories in the world.

Apart from teaching, faculty members collaborate actively with renowned overseas universities, research institutes and multinational companies. The faculty's research output is widely recognized for its quality; a quality that has enabled the School to successfully and consistently attract about S$40 million of research funding annually. Faculty members also published an average of 550 SCI journal papers and 450 conference papers every year. As a measure of the high professional standing of the School's faculty members, more than 100 international journals have appointed these distinguished academics as editorial members.

INFINITUS, Infocomm Centre of Excellence

http://www.infinitus.eee.ntu.edu.sg | **Director: Prof TAN Yap Peng, email: eyptan@ntu.edu.sg**

Award-winning Immersive 3D Audio System

To create 3D audio experience, Prof Gan Woon Seng's team designed the immersive 3D system (i^{3D}) that uses the novel combination of conventional and directional loudspeakers with the Audio-Cue Extraction (ACE) algorithm. Awarded the *Best of Show Award* in Techventure 2011, i^{3D} can be deployed to a wide variety of devices such as tablet PCs, smartphones, gaming devices and home theatre systems.

i^{3D} loudspeaker prototype

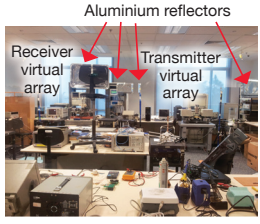
YFind, Futuristic Indoor Positioning Solutions

Prof Ting See Ho co-founded YFind Technologies which develops indoor navigation and positioning technology in 2010. Using WiFi networks, it allows any smartphone to track people and find places indoors. Its innovative commercial applications range from retail intelligence solutions that track movements in malls and retail stores to specialized location based advertising platforms. YFind received the *Start-Up of the Year* at the Singapore Infocomm Technology Federation Awards in 2011.

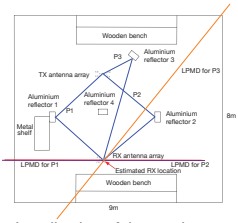
Indoor navigation and positioning technology
(Photo courtesy of NTU's HEY! Magazine)

Innovative Non Line of Sight Localization Scheme in Urban Built Up Environment

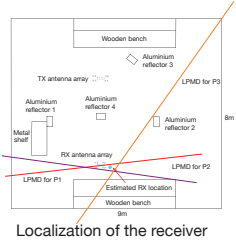
Prof Tan Soon Yim's Non Line of Sight (NLOS) localization scheme allows two peer mobile nodes at arbitrarily located positions to locate each other without the need of any reference device. Alternatively, the scheme can be used to track mobile devices using just one reference device. It will provide a precise localization platform for various mobile positioning analytics and services anytime, anywhere in commercial, retail sectors and peer to peer military and home affairs applications.



MIMO virtual array localization setup



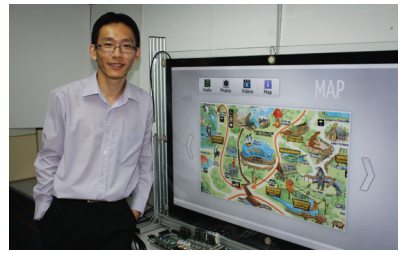
Localization of the receiver position using intersection of Lines of Possible Mobile Device (LPMD) from non line of sight paths in noiseless condition



Localization of the receiver position using intersection of Lines of Possible Mobile Device (LPMD) from non line of sight paths in noisy condition

Converting Large-sized Surfaces into a Touch Interface - The Next-generation Human-computer Interface

Awarded the *IES Prestigious Engineering Achievement Awards 2012*, Prof Andy Khong developed a vibration-based technology that converts everyday objects into touch interfaces. His invention offers low-cost solutions for the large-sized (>40") touch interface market, e.g., conversion of flat-panel displays into touch screens, flat aluminum surfaces into alphanumeric keyboards without mechanical parts and table-tops or 3D objects into touch interfaces for the gaming or food and beverage industries.



Conversion of a large display to a touch screen

NOVITAS, Nanoelectronics Centre of Excellence

http://www.novitas.eee.ntu.edu.sg | **Director: Prof NG Geok Ing, email: eging@ntu.edu.sg**

Cutting-edge Laser Technology Invention to Detect Contaminants in Drinking Water

Prof Liu Ai Qun's team invented a new detection device, Parasitometer, which manipulates light to identify and detect a single waterborne parasite in a 10-litre drinking water sample within one hour. It reduces cost by 8-fold without the need of chemical reagents and lab facilities. The discovery opens up new cutting-edge research fields between photonics and microfluidics and could possibly spark other innovations in the areas of biosensors and biomedical systems.


A working prototype of Parasitometer for waterborne parasites detection

Next Generation of Silicon Technologies - Si COE

To meet the new challenges of the next generation of silicon technologies, the Silicon Technologies Centre of Excellence (Si COE) has been set up in NTU jointly by A*STAR and NTU. Headed by Prof Ng Geok Ing, Director, *NOVITAS*, EEE, the objectives are to achieve an increased level of capabilities in Silicon technologies and process R&D for next generation applications as well as to support the needs of Singapore's semiconductor industry.


Inspection of etched wafer after reactive ion etch (RIE) process by dry etcher

VALENS, Centre of Excellence for Bio-Instrumentation, Devices, and Signal Processing

http://www.valens.eee.ntu.edu.sg | **Director: Prof SER Wee, email: ewser@ntu.edu.sg**

Optofluidics, A Multidisciplinary Research

Optofluidics is a technology at its infancy that aims to manipulate light and fluid at micro scale and exploit their interaction to create highly versatile devices and integrated systems. Prof Liu Ai Qun's team is the first to observe chirped focusing of light and interference in an optofluidic waveguide underpinned by a unique bi-directional GRIN profile in a flow channel.

This is a significant research finding and it has been published in *Nature Communications*, the first research publication in *Nature Series* in the last 30-year history of EEE, NTU. The finding has a wide spectrum of applications which include using it as a lab on a chip device for biomedical applications or water treatment. Other related research results in optofluidics have also been published in renowned scientific journals such as *Physics Reviews Letters, Advanced Materials, Advanced Functional Materials and Lab on a Chip* in 2012.

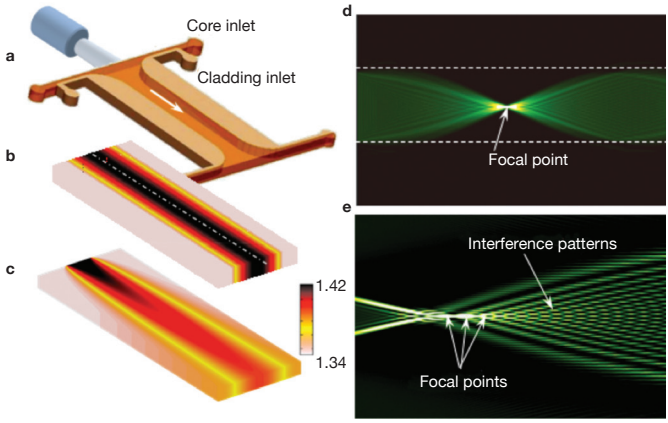


Fig. a Schematic illustration of the optofluidic waveguide (consists of three laminar flows in the microchannel)

Fig. b Gradient index profile of the microchannel in transverse direction (to realize light focusing)

Fig. c Bi-directional gradient index profile (to realize light interference). The intensity scale describes the refractive index distribution.

Fig. d Simulated light propagation in the waveguide with index profile shown in Fig. b. Light is bent and focused periodically in the optofluidic waveguide.

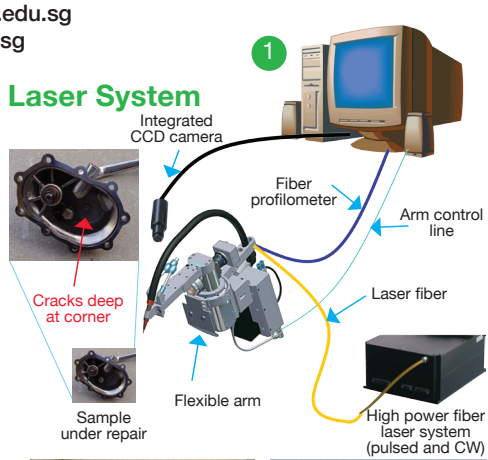
Fig. e Simulated light propagation in the waveguide with index profile shown in Fig. c. Light interference is clearly seen in the optofluidic waveguide.

OPTIMUS, Photonics Centre of Excellence

http://www.optimus.eee.ntu.edu.sg
Co-Director: Prof SHUM Ping Perry, email: epshum@ntu.edu.sg
Co-Director: Prof Kantisara PITA, email: ekpita@ntu.edu.sg

Multi-functional High Performance Fiber Laser System

Prof Wang Qijie's team developed a leading edge flexible fiber laser technology combined with high resolution depth imaging capability in one integrated system to support various refurbishing processes for remanufacturing technologies (Fig. 1). The fiber laser system has the advantages of high energy efficiency, fast processes, high precision, low maintenance and low distortion. The team's successful high performance fiber laser has been employed for cleaning processes (Fig. 2a) together with fiber imaging capability (Fig. 2b). The developed technology could lead to a highly multi-functional and flexible tool for remanufacturing industry in the near future.



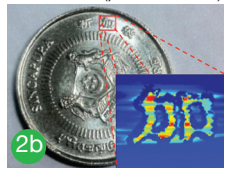


Fig. 1 Proposed multi-functional fiber laser system integrated with imaging capability

Fig. 2a Cleaning the centre part of an used piston

Fig. 2b Fiber imaging the depth information of a Singapore coin

Graphene-based Bragg Grating: A New Generation of One-dimensional Photonics Crystal

Graphene is a single two-dimensional plane of carbon atoms forming a hexagonal lattice. Recently, tremendous interest has been generated in the field of graphene plasmonics. However, most of research works on graphene plasmonics are at terahertz and infrared frequencies and it is barely visible and very difficult to realize at optical frequencies. EEE 3rd year PhD student, Ms Zeng Shuwen under Prof Yong Ken Tye's research group collaborated with Prof Yu Ting's group at School of Physical and Mathematical Sciences (SPMS) and they have designed a graphene-based Bragg grating that is capable of excitation of surface electromagnetic waves at optical frequencies. The proposed structure showed a very high sensitivity for detection of biological molecules and could even be employed in applications such as fluorescence emission enhancement and optical modulators. Their work was published in a *Nature* sister journal, *Scientific Reports*.

LUMINOUS! Centre of Excellence for Semiconductor Lighting and Displays

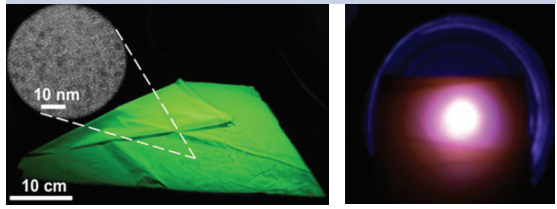
http://www.luminous.eee.ntu.edu.sg | **Director: Prof Hilmi Volkan DEMIR, email: hvdemir@ntu.edu.sg**

World's Record-breaking Largest-area Sheets of Quantum Dots for Photometric Quality White LEDs

Today, lighting efficiency is of critical importance because artificial lighting consumes about 19% of global energy generation. While improving energy utilization of lighting, it is essential to reach simultaneously photometric quality performance.

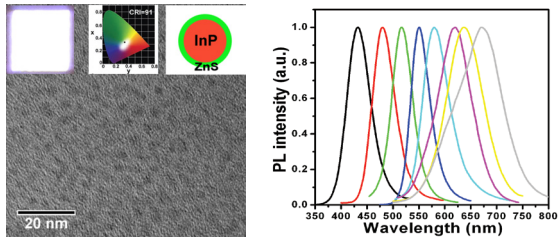
To address these problems, *LUMINOUS!* team developed energy-saving LEDs integrating nanophosphors of semiconductor quantum dots for high-photometric quality. It has achieved eco-friendly quantum dot nanocrystals for color-conversion LEDs and demonstrated the world's largest-area (over half meter by half meter) sheets of such nanocrystals for remote phosphor applications in LED lighting. These achievements lead to LEDs using excitonics of quantum dots that improve both visual acuity and color discrimination by reaching high levels of luminous efficacy of optical radiation and color rendering index.

World's largest area sheets of nanocrystals for remote phosphor applications in LED lighting



E. Mutlugun et al., Nano Letters 12 (8), 3986 (2012)

Eco-friendly nanocrystal quantum dots for LEDs



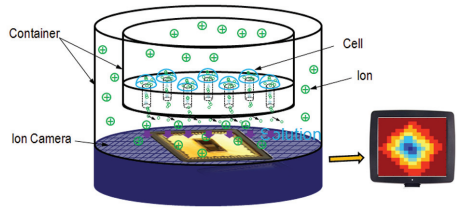
X. Yang et al., Advanced Materials 24, 4180 (2012)

VIRTUS, IC Design Centre of Excellence

http://www.virtus.eee.ntu.edu.sg | **Director: Prof SIEK Liter, email: elsiek@ntu.edu.sg**

Novel Ion Camera for Food and Drug Safety

Dr Yan Mei's Ion Camera provides a new method for rapid first-line food and drug safety screening based on the impact of the ion channels on the human central nervous systems. By leveraging CMOS image sensor technology and ion-sensitive field-effect transistor (ISFET) device, the system measures ion density and tracks ion movement in real-time. Nevertheless, compared to traditional sophisticated post-processing ISFET fabrication method, the Ion Camera ensures the fastest possible route to large scale, high quality and low-cost manufacturing by using standard CMOS process, which leads to a wide range of applications, including DNA sequencing, bio-chemical sensing and ion-related toxicology screening for food/drug safety.



Ion Channel, a real-time prescreening system

Batteryless Flexible Transceiver

Prof Boon Chirn Chye's team demonstrated a novel batteryless fully integrated transceiver at 2.4 GHz. The innovative transceiver was conceptualized, designed and silicon tested together with the energy harvesting module. Based on the energy aware and sub-threshold concept, the transceiver attains a significant power consumption reduction of 11 times compared to conventional transceiver while meeting the specifications of IEEE802.15.4. The energy harvested from Wi-Fi node can be used to power the transceiver.

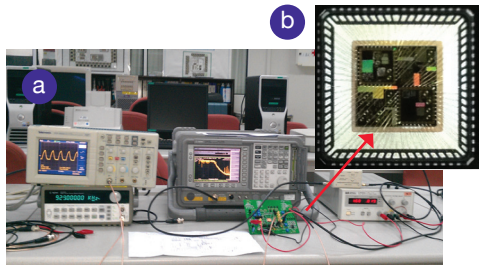
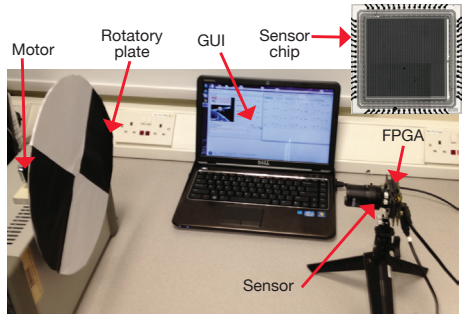


Fig. a Test setup of the transceiver
Fig. b Chip of the transceiver

Asynchronous Full-array-parallel Ultra-fast Motion Detection Imager

Prof Chen Shoushun's team designed an image sensor that allows high-speed pixel-parallel motion detection at the focal plane. Each pixel in the sensor can individually monitors the change in light intensity and reports an event if a threshold is reached. The output of the sensor is not a frame, but a stream of asynchronous digital events. Therefore, the speed of the sensor is not limited by any traditional concept such as exposure time and frame rate. It can detect fast motion which is traditionally captured by expensive and high speed cameras running at hundreds frames per second but with 100 times less data, which will drastically reduce the signal processing cost.



Experimental setup

EXQUISITUS, Centre for E-City

http://www.exquisitus.eee.ntu.edu.sg | **Director: Prof XIE Lihua, email: elhxie@ntu.edu.sg**

Large-scale Real-time Predication of Urban Traffic

As cities grow, so do the problems faced, and Singapore is no exception. Transportation and mobility issues dwell at the heart of these expanding metropolitans. Prof Justin Dauwels' team designed novel and robust algorithms to predict and avoid potential traffic jams. The prediction system developed is modular and scalable. Consequently, the algorithms can easily be parallelized, enabling real-time speed prediction for large traffic networks. Currently, the team is designing route guidance schemes that utilize the predictions and optimize routes in real-time with various constraints and objectives taken into account.

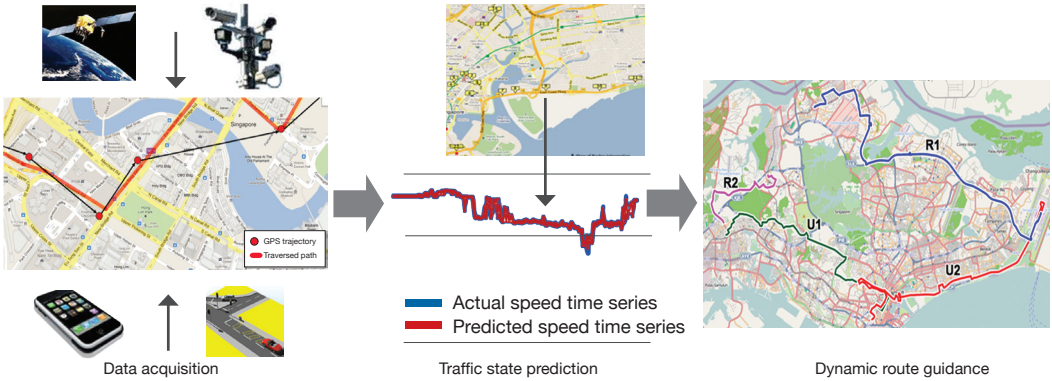


Diagram of the urban traffic prediction and route guidance system

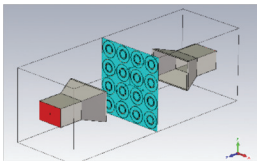
EMERL (Electromagnetic Effects Research Laboratory)

http://www.emerl.eee.ntu.edu.sg | **Director: Prof SEE Kye Yak, email: ekysee@ntu.edu.sg**

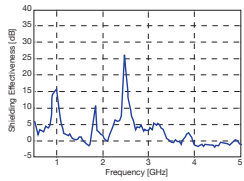
Ultra-thin Tri-band Frequency Selective Shield

Unlike conventional shields that block all the wireless signals, *EMERL*'s invention of ultra-thin, flexible and transparent electromagnetic shield blocks only undesirable wireless signals at specific frequency bands without affecting other wireless communications signals. Using the latest conductive screen-printing technology, this wall-paper like shield can be applied directly on the walls or glass windows with ease. The research work has gained international recognition by winning the *Best Student Paper Award* at the 2012 Asia Pacific Symposium on Electromagnetic Compatibility.

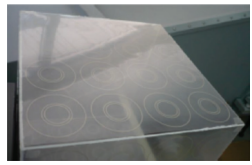
Design, modeling and simulation



Measurement results



Flexible, thin and transparent

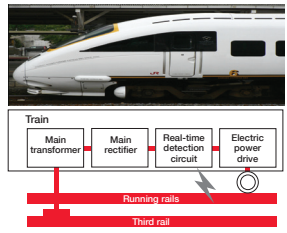


Effective blocking of GSM band

Tri-band shield blocking GSM 900 MHz, GSM 1.8 GHz and WiFi 2.4 GHz

Real-time Rail Track Detection

EMERL has developed an innovative solution by using induced RF signal to monitor the impedance of the railway electrification system. The real-time monitoring without direct electrical contact with the railway electrification system makes it an attractive method to detect the "heath" condition of the railway track and electric locomotive so that immediate remedy action can be taken before major service breakdowns happen. The invention has resulted in a U.S. patent.



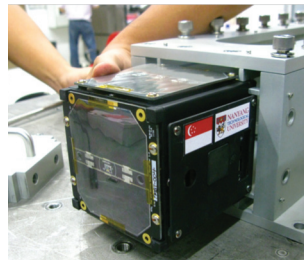
Real-time monitoring of railway electrification system

SaRC (Satellite Research Centre)

http://www.sarc.eee.ntu.edu.sg | **Director: Prof LOW Kay Soon, email: ekslow@ntu.edu.sg**

Pioneer VELOX-P, Picosatellite

Completed in July 2012, VELOX-P, a 1.330-kg picosatellite was developed under the Undergraduate Satellite Program supervised by Prof Low Kay Soon for education and technology demonstration purposes. The project provided the students with valuable hands-on experience where they built not only the satellite, but also various ground support equipment and a complete VHF/UHF ground station to support the mission. It has also inspired the students to use the knowledge and skills they learned to create something magnificent and thus opening new opportunities for commercial missions in space for testing of new sensor, component and small subsystem.



VELOX-P under vibration test

CanSat (Satellite in a Can), First of its Kind

CanSat is a can-size simulated satellite that comprises relevant systems of an actual satellite. The CanSat program started in January 2012 has witnessed three CanSats being designed, built and launched to date. The first CanSat in Singapore was launched in March 2012 by a group of EEE 2nd year students in their Design and Innovation project using a quadcopter. The program offers the students a great opportunity to apply their knowledge with hands-on experience to build a CanSat and a ground station. Additionally, it gives the students a sense of achievement coupled with teamwork experience uniting different expertise to achieve the final launch.

CanSat launched with balloon and picture taken by on-board camera

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