Welcome to the 2015 summer newsletter of Photonics@be! As usual, this newsletter will bring you up to date on all the latest news with respect to events, PhD defenses, research breakthroughs and awards from the consortium.

Events

Our next big event is the annual meeting on Friday October 16th. Erwin Bente will host us in Eindhoven. Just like last year, there will be a mixture of talks highlighting the progress of the work packages, and some interactive discussion sessions. For logistical reasons, it is expected that most participants will arrive on Thursday evening.

After a successful edition in London 2013, the next EuroDisplay conference will take place in Ghent, Belgium on September 21-23 2015. The conference is organized by the Centre for Microsystems Technology (Herbert De Smet & Dieter Cuypers) and the Liquid crystal & Photonics Group (Kristiaan Neyts & Jeroen Beeckman) from Ghent University. They aim to make EuroDisplay 2015 the ideal place for networking between all people involved in display related research and development. The conference will be a mixture of presentations by academia and industry, and a showcase of new display technologies during the exhibition (http://eurodisplay.ugent.be).

PhD defenses

In Jan 2015, Gebirie Yizengaw obtained his PhD on micro-optical multichannel imaging systems which are inspired by natural compound eyes of insects and are therefore often called artificial compound eyes. These systems contain many channels that each image a part of a wider field-of-view (FOV). In most of the demonstrated artificial compound eyes, the channels have been designed with the same imaging characteristics. However, more sophisticated imaging functionalities could be added to such systems by giving the various channels different imaging properties. In his PhD thesis, Gebirie realized a miniaturized multichannel multiresolution imaging system in which the different channels have different imaging properties, namely a different FOV and angular resolution. These imaging systems are able to capture images of different FOV and magnifications, at the same time, over different areas of an image sensor. This could allow different image processing algorithms to be implemented to process the different images. E.g., a motion detection algorithm could be implemented on the wide FOV and low resolution image, whereas a face detection algorithm could be used for the narrow FOV and high resolution image.
Yi Xie obtained his PhD in Feb 2015 on “Tunability of Vertical-Cavity Surface-Emitting Lasers”. Using Liquid Crystals, electrically driven integrated VCSEL devices have been developed and fabricated in this thesis with a liquid crystal layer close to the emission region. By incorporating such a liquid crystal layer with a VCSEL, multiple functions are realized: the polarization state, beam profile, threshold and wavelength can be controlled either thermally or electrically based on the tuning of the liquid crystal external cavity. This work was a collaboration between the UGent Liquid Crystals & Photonics group (Jeroen Beeckman & Kristiaan Neyts) and the VUB (Krassimir Panajotov).

In Apr 2015, Tigran Baghdasaryan successfully defended his Ph.D. thesis “A study of multi-photon inscription of fiber Bragg gratings in glass microstructured optical fibers”. During his defense he explained how the turn of the 21st century has marked the introduction of a new type of optical fibers, known as ‘Microstructured Optical Fibers’ (MOFs). Their cross-section is also commonly made of glass, but now with a specific pattern of air holes that run along the entire length of the fiber. A current hot topic is to develop all-MOF based devices including MOF based lasers and MOF based sensors. To do so one is currently seeking to combine fiber Bragg grating (FBG) technology with MOF technology. A FBG is a periodic variation of the refractive index in the core of an optical fiber, which acts as a wavelength selective mirror or filter. It is typically fabricated by transversely exposing the MOF core to intense laser light and consequently modifying the refractive index of the glass within this core. Fabricating FBGs inside MOFs has proven not to be straightforward. The holey structure of the MOF usually prevents the delivery of intense laser light to the core region, which complicates the formation of the required refractive index changes. Tigran’s established a dedicated methodology based on numerical modeling to study FBG fabrication in MOFs and used this methodology to design new MOF structures that will facilitate the manufacturing of FBGs in their core.

Research breakthroughs

An editor’s suggestion in the January 2015 issue of Physical Review discusses the interconversion of Gaussian entangled optical states by Raúl García-Patrón and collaborators from ULB OptIQ (QuIC team). Gaussian states (i.e., quantum states with a Gaussian-shaped Wigner function) are ubiquitous in quantum optics as they are easy to produce and manipulate experimentally with lasers or other photonic components. Likewise, Gaussian transformations (mapping Gaussian states into other Gaussian states) are of great practical importance, since they model the passive coupling effected by a beam-splitter or fiber-coupler as well as the active coupling resulting from parametric amplification in a nonlinear medium. The QuIC researchers have found out that, under some specific circumstances, transforming a Gaussian entangled state into another Gaussian entangled state may require a non-Gaussian (so-called LOCC) transformation. They have exhibited an example of this quite unexpected behavior using 4 modes only, which could open a way to novel protocols for optical entanglement enhancement.
UGent-PRG develops octave-spanning mid infrared frequency comb (Nature Communications). A frequency comb source is a light source with a spectrum containing thousands of laser lines. The development of these sources has been revolutionary for fundamental science, as it has allowed researchers to determine optical frequencies with unprecedented precision. Lately, frequency combs have been used to target more real-life applications. In several experiments, it has been shown that the specific properties of the sources can be used to do fast, high-resolution spectroscopy over a broad spectrum. However, traditional comb sources are not at the right wavelength spectrum for doing spectroscopy. Ghent University, imec, the Max Planck Institute for Quantum Optics in Garching and the Auckland University in New Zealand have developed mid-infrared frequency combs, working in the mid-infrared molecular fingerprinting region of the electromagnetic spectrum. In this wavelength region, many molecules have specific absorption bands that can be used in spectroscopy to determine the presence and concentration of these molecules in samples. These would be important for example for environmental monitoring for measuring air-pollution or in medical diagnostics as a cheap tool to do breath analysis.

UGent PRG traps Gigahertz sound waves in photonic waveguide (Nature Photonics). The field of silicon photonics builds on tiny waveguides known as silicon photonic nanowires. These wires work only because light is trapped in them by total internal reflection. Simply confining light is one thing, but manipulating it is another. This is where light-matter interaction comes into the picture. UGent-imec researchers report on a peculiar type of light-matter interaction. They managed to confine not only near-infrared light but also gigahertz sound to the nanowires. They realized that the sound could not be trapped in the wire by total internal reflection. Thus, the scientists sculpted the environment of the core to make sure any vibrational wave trying to escape it actually bounces back. Both light (left) and sound (right) were trapped in a nanoscale silicon core. Doing so, they compressed both light and sound to the same nanoscale waveguide core – where they strongly influenced one another. They anticipate this world’s first demonstration to open up new ways to manipulate optical information. For instance, optical data pulses could be converted into sonic pulses and back into light – thereby implementing much-needed delay lines.

OPTEL-LMOPS has reported on the first observation of stable super-harmonic self-pulsation in a laser diode with optical feedback, i.e. self-pulsation at frequencies being super-harmonic of the external-cavity frequency. This observation is made possible by replacing the conventional optical feedback by a phase-conjugate optical feedback, here achieved by four-wave mixing in a photo refractive crystal.
OPTEL-LMOPS and B-PHOT have reported on the physical generation of random numbers at 100 Gb/s from the digital sampling of the polarization-resolved chaotic output of a VCSEL. The achieved bit rate is 100-1000 times faster than the one obtained from other physical sources of entropy e.g. electronic or thermal noise. Moreover by contrast to existing schemes utilizing chaotic laser diodes, the proposed setup simply makes use of a free-running laser diode, i.e. without optical feedback or optical injection.

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Marc SCIAMANNA (OPTEL-LMOPS) has co-authored with K. Alan SHORE (Bangor Univ. Wales, UK) a review article on the physics and applications of laser diode chaos in the high-impact journal Nature Photonics. This article provides the historical context from which have emerged the first achievements in observing laser chaos. It also details the different schemes used so far to generate optical chaos and how these schemes have allowed the development of applications such as chaos cryptography, random number generation, chaotic sensing and chaos computing.

In an editor’s suggestion in Phys Rev B, VUB researcher V. Ginis discusses the use of the tunability of graphene for frequency combs. Graphene—a single-atom thick layer of carbon atoms arranged in a honeycomb lattice—has been a fascinating subject for scientists and engineers for several years already. One the main advantages of graphene with respect to other materials is the extraordinary tunability of its conductivity, which can be achieved electrically by means of a back gate, or optically through the excitation of photocarriers. Writing in Physical Review B, scientists from VUB, Sweden and the United States demonstrate that this tunability of graphene can be used in a novel setup for the generation of frequency combs. A frequency comb is a series of ultra-sharp electromagnetic pulses that recently gained a lot of attention because of its applicability in a plethora of disciplines, including spectroscopy, astronomical observations, chemical sensing, and attosecond pulse generation. Traditionally, these frequency combs are generated using nonlinear materials, e.g. Ti:Sapphire lasers, fibre lasers, or nonlinear microresonators. Currently, there is a lot of ongoing work to construct frequency combs for terahertz frequencies. The researchers studied the interaction between light and time-dependent graphene sheets, including both dispersion and explicit time-dependence of the conductivity. Based on this model, they demonstrated that frequency combs can be generated without material nonlinearities. Indeed, at terahertz frequencies—a frequency range where there is a large need for novel components—it is possible to modulate the linear, time-dependent conductivity of graphene to obtain a large variety of frequency combs. These results open the way for highly tunable frequency comb generation in a miniaturized setup.

High-performance bio-inspired photonic processor with low power consumption. The OPERA-Photonique and LIQ (Laboratoire d’Information Quantique) services of ULB, in collaboration with the Photonics Research Group from UGent, have recently published in Optica, the new high-impact journal of the Optical Society of America, results concerning a photonic neural network architecture processing time-dependent signals with very low error rate and low power consumption. Their system, based on a bio-inspired machine learning paradigm called “reservoir computing”, uses a coherently driven passive fiber cavity operating in transient state. Part of the experiment is depicted in the enclosed figure in which one can see the big aluminum boxes with stone wool inside used to isolate the system.
from the phonic, vibrational and thermal ambient noise that cause optical phase noise in the cavity. This reservoir computer implementation demonstrates state-of-the-art performance for hard nonlinear tasks such as speech recognition, time series prediction, and nonlinear multipath radio frequency channel equalization. The reservoir computing research team of ULB is currently working on a parallel computing version of this experiment which will aim to reach a processing speed several magnitude orders higher, paving the way to high-performance ultrafast all-optical analog computing.

**Awards**

**Lieve Lambrechts** wins best presentation award at the Annual Workshop of the IEEE Photonics Benelux Chapter. Lieve Lambrechts, doctoral researcher at the Applied Physics Research Group, received the best oral presentation award at the 18th Annual Workshop of the IEEE Photonics Benelux Chapter in May. The goal of this workshop is to provide a platform for young researchers in the field of photonics to interact, share information and discuss their latest results. Lieve presented her work on 'Reflective Properties at an Interface Using Transformation optics', her latest research undertaking under the supervision of Dr. V. Ginis, Prof. Dr. P. Tassin and Prof. Dr. J. Danckaert.

**Christophe Caucheteur** is the recipient of the 2015 Alumni award in applied sciences delivered by the Belgian American Educational Foundation (BAEF). He has received this distinction in recognition of his research work conducted in the Electromagnetism and Telecommunication Department at the University of Mons and supported by the F.R.S.-FNRS. Since 2003, his research is focused on the development of (bio)chemical sensors based on fiber Bragg grating technology.

SID Mid-Europe Student Award 2015 was awarded to **Mohammad Mohammadimasoudi**. The SID-ME Chapter Student Award is granted for an outstanding scientific or technical achievement in, or contribution to, research on information display. Recently the SID-ME Student Award Committee reached a unanimous decision to present the award to Mr. Mohammad Mohammadimasoudi from the UGent Liquid Crystals and Photonics group for his work entitled 'Thin film polarized liquid crystal backlight'. The prize amounts to 1500 euro and the award ceremony will be held during the EuroDisplay 2015 conference.

**Vincent Ginis** of VUB wins Young Scientist Award of the Belgian Physical Society. This contest aims at early-stage researchers with no more than 5 years of postdoctoral experience. He won the award for his paper on the transformation optics of Cherenkov radiation using metamaterials. In this work, Vincent and his colleagues J. Danckaert, I. Veretennicoff and P. Tassin generalise the analytical description of Cherenkov radiation inside complex material structures. To this end, they apply the geometrical formalism of transformation optics in combination with nanostructured metamaterials. In their manuscript, which appeared on the cover of Physical Review Letters, they demonstrate the power of their formalism with the design of enhanced Ring Imaging Cherenkov detectors, which could be used to identify elementary particles at higher energies.
In February 2015, B-PHOT researcher Nathalie Vermeulen received the Ignace Vanderschueren VUB-prize for Fundamental and Applied Sciences, which is awarded every 6 years. The award commission selected Nathalie as laureate for this prestigious price in recognition of the significance of her PhD research work on Raman lasers. In her PhD thesis, she challenged a well-established model for one of the physical processes occurring in Raman lasers, and she developed a novel concept to intrinsically reduce the heat dissipation in these lasers. In particular the ‘controversial’ aspects of her doctoral thesis, in line with VUB’s credo “Redelijk Eigenzinnig”, convinced the commission to present her the award.

Other

Flanders’ Chamber of Commerce and Industry VOKA has interviewed Hugo Thienpont on the economic impact of photonics at the occasion of the 2015 International Year of Light and Light-based technologies. The article (in Dutch) was published in the March 2015 issue of VOKA’s magazine “Ondernemers” and is distributed over 18.000 companies in Flanders and Brussels. In the interview Prof. Thienpont explains the impact of photonics on our global economy and emphasizes its key-enabling role in Flemish companies. He also highlights the EC funded project ACTPHAST, which he coordinates, and the facilitating role of this European Consortium in bringing cutting-edge photonics innovation to SMEs through open innovation and open access to Europe’s best high-tech photonics platforms.

B-PHOT highlights the impact of its photonics research and innovation on food and food safety at Milano’s world fair 2015. The fair opened on May 1st and explores the theme "Feeding the Planet, Energy for Life". B-PHOT grasps the unique opportunity of “EXPO 2015” and “International Year of Light 2015” to showcase the enabling power of light and the impact of light technologies on food-sorting, food-safety and health. B-PHOT’s cutting-edge contributions to TOMRA’s food sorting machines and B-PHOT’s polymer lab-on-chip technology for controlling the quality of honey, the authentication of olive oils, and the safety of drinking water are on display. The EXPO 2015 site covers 110 hectares and is expected to attract more than 20 million visitors from 01 May 2015 to 31 October 2015.

B-PHOT showcased the power of light and photonics on Saturday 9 May 2015 on the occasion of the EU Open Door Day in the Berlaymont building. Thousands of inquisitive EU citizens visited the B-PHOT booth, where B-PHOT researchers explained the basic principles of light and illustrated the impact of light technology on our daily lives. The multitude of hands-on experiments and the variety of demonstrations excited both young and old. Whereas the “solar-boat” competition was extremely popular with kids, the infrared imaging camera and its applications impressed everybody. At the opening of the event the B-PHOT booth received the visit of EC Vice-President and Commissioner Maros Sefcovic who took the time to perform several experiments himself and also commended the B-PHOT researchers on their excellent booth and very successful outreach efforts.

On June 2 2015 the Kick-off meeting of the Horizon 2020 project Swing (Development of Thin film Solar cells based on Wide band Gap kesterite absorbers) took place in IMEC. The aim of this project is to propose a low cost and reliable wide band gap solar cell technology for tandem devices application, with the aim to extend the efficiency potential of crystalline silicon above 30 %. This should be achieved by the development of upscalable synthesis routes and device architectures for the promising Cu2Zn(Sn,Si)(S,Se)4 kesterite solar cells. The Liquid Crystals & Photonics group (Kristiaan Neyts, Jeroen Beeckman & Johan Lauwaert) of UGent is one of the partners in this project and the group is involved in the detailed characterization and simulation of the kesterite solar cells.