Master of Science in Photonics Engineering - AJ 2023-2024

Alle ingediende onderwerpen

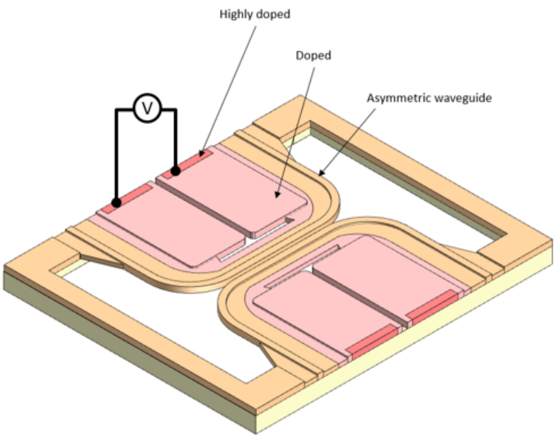
Lijst gegenereerd op: Mon, 15 Jan 2024 10:49:12 +0100. *Laatst ingediende onderwerp: 34971*

32770: A Suspended Microheater in a Silicon Photonic MEMS Process

Promotor(en):	Wim Bogaerts, Marcus Dahlem
Begeleider(s):	
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	This concerns a device concept with optical, electrical and mechanical properties

Probleemstelling:

Photonic Integrated Circuits (PICs) are chips for processing optical signals routed between different optical functional blocks through waveguides. Today, these circuits are becoming increasingly complex, incorporating hundreds or thousands of functional elements. The circuits also become more configurable, and this requires efficient tunable elements, with low optical loss, small footprint and low power consumption. Such tunable elements can be implements using microheaters, but also liquid crystals, phase change materials and MEMS. In particular, the photonic research group has been developing MEMS electro-optic actuators in silicon photonics, together with IMEC. The MEMS contain movable free-standing waveguides that can be actuated using electrostatic comb drives. These work well, but they also come with difficulties: they are fragile and sensitive to electrostatic discharge. However, one idea, sketched below, is to use the same process as the MEMS, where the waveguide is suspended, but avoid making large movements. Instead, the suspension is used to provide very good thermal insulation, and we implement a heater in the suspended part. This could be much more efficient than existing heat-based tuners, which are limited by the thermal leakage. The heater could be used as a phase shifter, but also as a tunable directional coupler where a heater is included in each arm.



Doelstelling:

The objective of this thesis is to model, design and characterize this new concept for a heater. This will involve Multiphysics modelling as the problem contains an electrical, an optical, a thermal and a mechanical component (the suspended part should be designed that it should be stiff, but it will still move). This can be done in COMSOL.

In parallel, we are planning to fabricate some initial heater designs based on this concept, and these chips are expected in the second semester. If possible, there will be opportunity to characterize these new devices, and compare that to the model.

With the gained knowledge, new designs can be proposed that can be incorporated in a future fabrication run.

Locatie:

Ardoyen (igent)

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: IMEC
Samenwerking: promotor + begeleider

Onderwerp voorbehouden voor Katayoun Vatanpour Khiavi

Deze masterproef werd reeds 1-maal toegekend!

32698: Antenna design for inductive energy harvesting and eye posture sensing in smart contact lenses

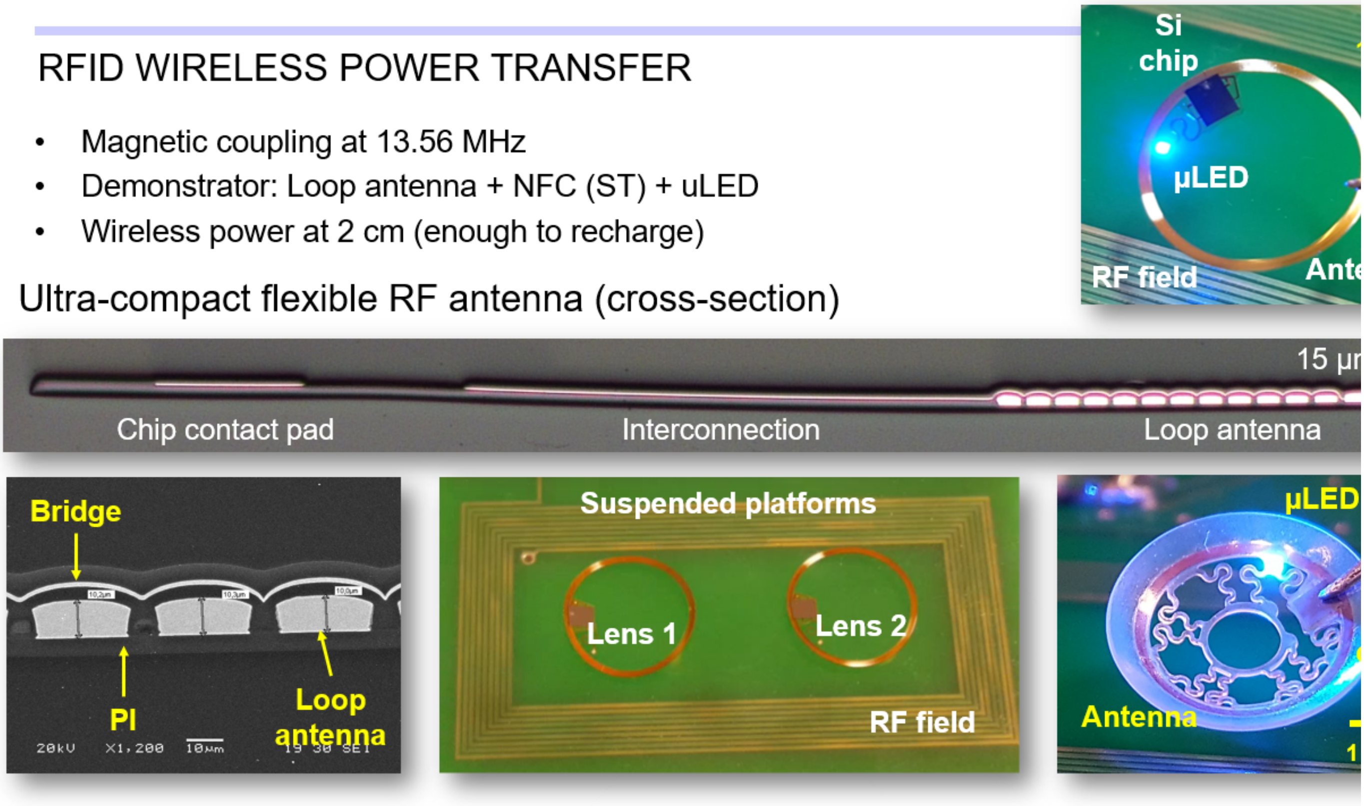
Promotor(en):	Herbert De Smet, Andrés Felipe Vasquez Quintero
Begeleider(s):	
Contactpersoon:	
Goedgekeurd voor:	Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	Master of Science in Electromechanical Engineering
Aantal studenten:	1 of 2

Aantal masterproeven:	1
Motivering voor deze opleiding:	Determining the eye orientation by monitoring the voltage waveform generated by an antenna in a contact lens when a magnet attached to the eye lid moves over it

Probleemstelling:

In smart contact lenses, one of the major challenges is to provide sufficient energy to the integrated electronics.

One of the most straightforward solutions is to integrate a multi-turn antenna around the active parts and use inductive charging of an integrated micro-battery during the nightly cleaning cycle of the contact lens. During the day, energy is then drawn from the micro-battery, provided its capacity is sufficiently large. The charging antenna can at the same time be used as a means of communicating with the lens (reading out sensor data, sending actuation commands to the integrated electro-optical components, etc.). The most mature approach is to use the 13 MHz NFC protocol for both the charging and the communication. This can be achieved with a circular 12-16 turn antenna with a diameter of around 1 cm.



For some applications it would be better if the contact lens can be powered during use. Harvesting energy from the moving eyelid is a theoretical possibility, either by exploiting the varying mechanical force it exerts on the eye (and the lens) or by attaching a light but strong magnet to it and letting it pass over an inductor or antenna that is integrated in the contact lens. The magnetic field of a small rare earth (e.g. neodymium) magnet can be very strong, but the movement speed and frequency of the human eye lid is relatively low, so it is expected that the optimum energy transfer will require a novel antenna design. Furthermore, since the exact trajectory of the magnet with respect to the antenna will change if the eye orientation changes, it is expected that a smart antenna design could enable an indirect estimation of the eye orientation from the peak voltage or the waveform shape that is measured at the output of the antenna. This information is very useful for certain applications.

Doelstelling:

In this master thesis, a study will be made of the potential of harvesting energy from the movement of a small but strong magnet over a flat antenna with a size that can be acommodated inside a contact lens. The movement of the magnet will be similar to the movement of the eye lid of a human over the cornea of the eye and the distance beteen the magnet and the antenna will be similar to the thickness of a human eyelid.

The work will involve in a first phase collecting information about human eye lid movement and thickness, magnetic field strengths of commercially available mini magnets and inductive harvesting circuits.

In a second phase, the inductive energy harvesting will be simulated for a realistic eyelid configuration and different primitive antenna shapes that can be fit into a contact lens. The idea is to eventually come to an optimal design for maximum energy harvesting. A conclusion about the usability of such a harvesting system will be drawn, in view of the different existing smart contact lens applications and their typical power consumption.

In an optional third phase, it will be investigated if a special antenna shape can be used to determine the eye orientation by looking at the output voltage of the antenna when the magnet travels over it.

Finally, depending on the progress in the first 2 or 3 phases, an optional phase will target the experminental verification of the simulation results by fabricating the optimal antenna design in thin-film technology in our clean room and combining it with suitable energy harvesting electronics. This setup will then be tested by moving a small magnet over it in a fashion that is similar to the way an eyelid moves.

Locatie:

Ardoyen-iGent, thuis, cleanroom Zwijnaarde

Deze masterproef werd reeds 1-maal toegekend!

32771: Capturing thermal crosstalk in Programmable Photonic circuits

Promotor(en):	Wim Bogaerts, Umar Khan
Begeleider(s):	Yu Zhang
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	

Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	This subjects combines electrical, optical and thermal devices and modelling

Probleemstelling:

Photonic integrated circuits (PIC) are chips where optical signals (light) are being transported and processes in waveguides. Such circuits are already widely used in fiber-optic communication, and are now slowly finding their way into other applications such as LiDAR, sensing and biomedical instrumentation.

A new trend today is to go to programmable photonics, where the flow of light is controlled by network of interconnected tunable optical elements. The key building block in these large circuits are electrically controlled phase shifters. These need to be low-loss, low power, but they should also be stacked close together. This can give problems: today the most common way to implement phase shifters is heaters: a small electrical resistor placed close to the waveguides. When a current is sent through, it generates heat, locally raising the temperature of the waveguide. This is a simpeland very effective way of implementing phase shifters, and recent developments resulted in very efficient heaters, using only a few milliwatts of power for a pi phase shift

One of the main problems with heaters is thermal crosstalk: a heater will not only heat the target waveguide, but also surrounding waveguides. This can reduce the overall efficiency, but also complicates the control. So when driving multiple heaters at the same time, how do we make sure that every waveguide gets the right temperature?

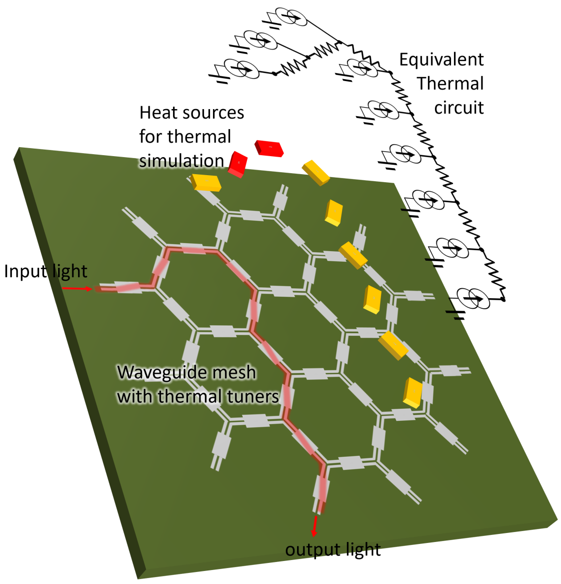
Doelstelling:

The concrete goal of the thesis is to develop a method to capture the thermal crosstalk behaviour, so we can predictively adjust the control of the heaters. This boils down to a thermal problem, affecting optical waveguides. In a first approximation, this problem can be described as an equivalent electrical circuit, where the heaters act as current sources (of heat, not electricity) and the temperatures of the waveguides are described as voltages. Between the heaters are equivalent (thermal) resistors. The idea is to construct such a thermal circuit model: with this, it is possible to invert the necessary drive signals for each heater to achieve the correct temperature for each waveguide.

The thesis will approach the problem in two ways:

- Modelling: Using simple thermal simulations in COMSOL, an estimate for simple thermal circuit will be derived. This will give us an initial starting point to finetune the model for the entire circuit.
- Measurement: Based on existing fabricated devices, we will map the thermal crosstalk through the optical response of going through the circuit. The idea is to devise a sequential measurement scheme, driving one heater at the time, to systematically construct the equivalent thermal circuit.

With the thermal circuit model of our chip, we will then optimize the control of the larger circuits, which we again can do in simulation and in measurements.



Locatie:

Ardoyen (iGent)

32508: Chiral molecular sensing with nanophotonics

Promotor(en):	Alberto Curto
Begeleider(s):	Tom Sistermans
Contactpersoon:	Alberto Curto
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Nanophotonics project that exploits metasurfaces for enhancing the sensitivity of the detection of chiral molecules

Probleemstelling:

Light gives us information about the chemical and structural composition of matter. Circular dichroism (CD) is one of the most successful and precise optical spectroscopy techniques. It reveals tiny asymmetries in the conformation of nanometric objects of interest like proteins or drugs. CD signals reflect the normalized difference in absorption of a compound when illuminated with light of right- and left-handed circular polarizations. Chiroptical signals are, however, very weak, limiting their potential applications to samples with high concentrations or large volumes.

Doelstelling:

In this project, you will experimentally investigate the enhancement of chiral light-matter interaction using nanostructures known as optical nanoantennas. The project revolves around nanofabrication using electron beam lithography and etching of crystalline silicon films for achieving high-quality optical resonators. The resonances are tailored to increase fluorescence and circular polarization contrast, thus improving chiral molecular detection. Using circular-polarization-resolved photoluminescence microscopy, the goal of this project is to achieve stronger chiroptical signals by exploiting the optical resonances of the nanoantennas. The ultimate goal of this research line is to increase the sensitivity of chiral sensing to the regime of single molecules.

Locatie:

Ardoyen

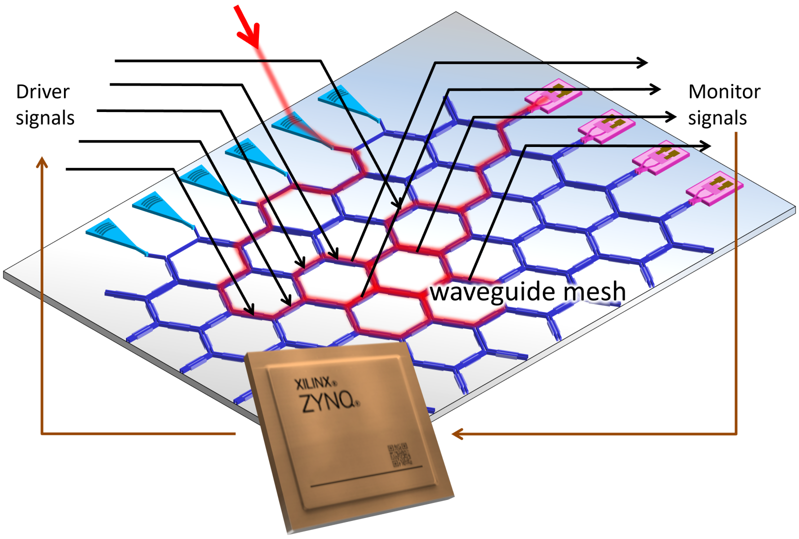
32803: Circuit Control for Programmable Photonics

Promotor(en):	Wim Bogaerts, Nagarjun Katta Pradeep Kumar
Begeleider(s):	
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Programmnable photonics (the last word is a hint)

Probleemstelling:

Photonic integrated circuits combine many optical building blocks on a chip, enabling complex functions. However, their functionality is usually determined during the chip design, and cannot be changed after fabrication. A new class of programmable photonic chips is conceived to be more flexible, and has many electrically controlled tunable optical elements that can be addressed during run time to change the functionality and connectivity on the chip.

Programmable photonic chips obviously add an additional layer of complexity: all these electro-optic actuators need to be controlled, which requires an electronics and software layer to read out monitor photodetectors and feeds this this information back into the tunable couplers and phase shifters that make up the photonic circuit. These are analog devices, so precise control is needed to minimize losses and crosstalk. Many of these feedback loops need to operate in parallel, which requires good integration of the photonic, electronic and software layers. This can be complicated by variation between devices and crosstalk (electrical, thermal, …)



Doelstelling:

In this thesis, we want to build a control architecture for programmable photonic circuits. The basic feedback loop consists of a photodetector readouts which are used to adjust the state of one or more phase shifters and tunable couplers. This combines both electronics (from readout and driving) and software (for control). There has already been initial work on drivers for both microheaters and MEMS devices, so there is a basic set of electronics to work with. But the feedback loops for control are in a very rudimentary state, and new routines are needed to govern the photonic circuit with a large number of tunable elements.

This thesis will look at system identification of the individual building blocks, and start with control loops for small subcircuits. This then needs to be scaled up. This will first be done in simulation, after which the actual hardware can be plugged in. The Photonics Research Group has been building prototypes of these programmable chips that can be used for the purpose of this thesis.

For performance reasons, it might be needed to implement the control loops in a microcontroller or an FPGA. This will require a good affinity with programming or programmable hardware languages (VHDL).

Locatie:

Ardoyen (iGent)

32685: Colloidal Bulk Nanocrystals as enabler for Integrated Full Spectrum Lasing

Promotor(en):	Pieter Geiregat, Dries Van Thourhout
Begeleider(s):	Ivo Tanghe, Servet Ataberk Cayan
Contactpersoon:	Ivo Tanghe
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	4
Motivering voor deze opleiding:	Design, simulatie, fabricatie van photonic devices + natuurkundig begrip van nanomaterialen

Probleemstelling:

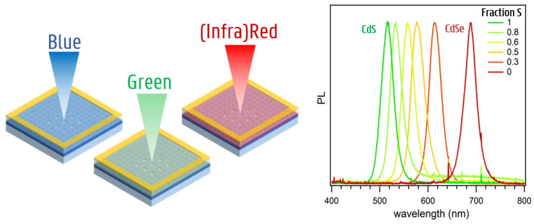
The field of integrated photonics is quickly growing, with applications now extending far beyond just the telecom. However, the main bottleneck still remains: the lack of a good integrated light source. At the Photonic Research Group (PRG, Faculty of Engineering), various roads are followed to tackle this problem. One of these is the use of colloidal Nanocrystals, created at the Physics and Chemistry of Nanostructures group (PCN, Faculty of Science). By manipulating sizes of materials on the quantum scale, we can create powerful emitters operating in the visible and near-infrared spectrum.

In this collaboration, PRG and PCN has succeeded in creating integrated red laser sources (~620-640nm), by using the state-of-the-art Quantum Dots (based on a CdSe/CdS core/shell material system). This material system, although currently the furthest developed, has some drawbacks in terms of gain properties. Because of this, we are investigating alternatives through using bulk nanocrystals which are showing much promise. As a workhorse material, large diameter CdS nanocrystals show record gain properties and have demonstrated lasing action in the green and cyan region (470-540 nm). We are currently extending this spectral range more to the blue by using ZnSe, and to the red by using CdS:Se nanocrystal alloys.

Doelstelling:

In this master thesis you will investigate using different novel nanocrystals to create fully integrated full spectrum light sources. You will learn about the quantum mechanical properties of the colloidal materials and together with us try to understand their optical properties by doing ultrafast pump-probe spectroscopy (PCN group, Sterre S3). You will be immersed in our own cleanroom environment (PRG, Zwijnaarde) to create and optimize current laser designs, and try to increase the spectral range of these by incorporating new bulk nanocrystals. Here, you can learn how to use typical cleanroom tools that we have available, like ebeam and optical lithography, SEM, RIE, CVD, …

This subject is at the crossroads between spectroscopy, chemistry, photonic engineering and quantum physics, ideal for the students that wants to broaden their horizon as much as possible!



Locatie:

Deze masterproef werd reeds 1-maal toegekend!

32681: Colloidal Nanocrystals for integrated Mach-Zehnder Interferometers

Promotor(en):	Dries Van Thourhout, Pieter Geiregat
Begeleider(s):	Ivo Tanghe, Korneel Molkens
Contactpersoon:	Ivo Tanghe
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Design, simulatie, fabricatie van photonic devices + natuurkundig begrip van nanomaterialen

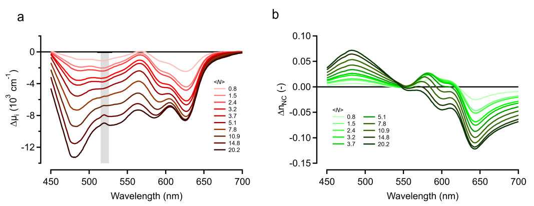
Probleemstelling:

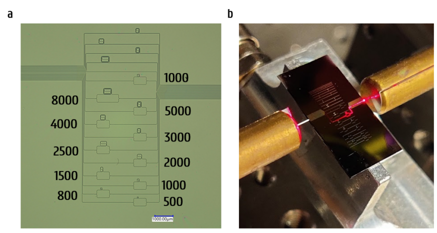
Colloidal Nanocrystals are made through wet chemical synthesis at the Physics and Chemistry of Nanostructures (PCN) group. By collaborating with the Photonics Research Group (PRG), we at UGent aim to create cheap, scalable integrated active devices, mainly concentrated on integrated LEDs, lasers and photodetectors. We investigate the properties of the nanocrystals through advanced pump-probe spectroscopic techniques to measure changes in absorption by strong optical excitation, from which we can deduce optical gain properties. However, besides the direct interpretation of the changes in absorption, the influence of the optical excitation extends to changes to the refractive index. This “secondary” effect – which is linked to the absorption through the Kramers-Kronig relations – can be derived from the experiment through an iterative algorithm. We have seen that these effects are very large and can be used to our advantage: by creating integrated, optically switched modulators.

Doelstelling:

In this Masters Dissertation, you will work with our team to create the first integrated Mach-Zehnder Interferometers (MZIs), based on Colloidal Nanocrystals (NCs). The starting point is the theoretical understanding, basic designs available for processing, and passive characterization can be performed. Here, we will take it to the next step by trying to measure actual modulation on the made devices. For this, we can look into using different colloidal NCs, but we will start with the CdSe/CdS system, the most advanced material available for solution processible integrated devices. The challenge here will be first and foremost in learning to perform, and building, a setup to measure passive losses in MZIs. This can then be combined with an optical excitation source to check the actual modulation occurring in these devices. With these first results at hand, we can continue by looking into how to increase the devices operation metrics.

This master thesis will rely heavily on understanding of photonic circuits, quantum physics, and data analysis. Perfect for the student interested in combining simulation work with processing and working in the lab.





Locatie:

Campus Sterre, Campus Zwijnaarde

Deze masterproef werd reeds 1-maal toegekend!

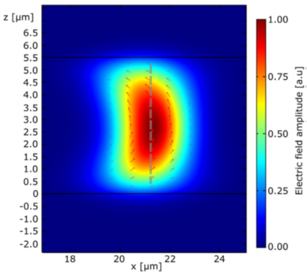
32112: Coupling of light in liquid crystal waveguides

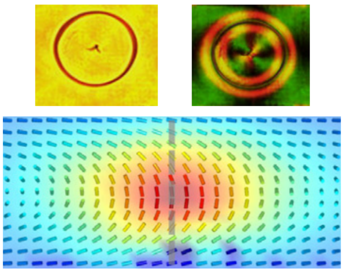
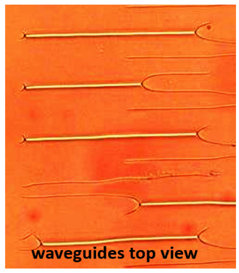
Promotor(en):	Kristiaan Neyts, Jeroen Beeckman
Begeleider(s):	Xiangyu Xue, Brecht Berteloot
Contactpersoon:	Kristiaan Neyts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	soft matter, elasticity, optics, electric fields, material science

Probleemstelling:

Liquid crystals are anisotropic materials that have a larger refractive index (leading to slower light propagation) when the light is polarized parallel to the long axis of the molecules. By varying the liquid crystal orientation in space it is possible to create a region with a higher refractive index, which acts as an optical waveguide for light with polarization in a particular direction. In the figure, vertically polarized light is wave guided in a liquid crystal region with vertical orientation. The figure on the right shows five waveguides in a microscope realized in our group.

Coupling light into a waveguide can be realized by a diffractive grating to transform the wave vector of a plane wave into the wave vector corresponding to the liquid crystal waveguide. Such structures require a short period, because visible light has to be used. Recently our group has realized liquid crystal gratings with submicrometer pitch by photoalignment. The images below show circular and straight waveguides that have already been realized.



Doelstelling:

The aim of the thesis is the realization and testing of optical waveguides in liquid crystals in combination with coupling gratings. The device will use a polymerized liquid crystal grating coupler to transform light from a plane wave into the waveguide. The grating can be designed and realized by photoalignment. In this setup two UV laser beams are used to generate an interference pattern on the surface of a substrate coated with a photo-sensitive layer. After illumination, the layer is covered by a thin film of polymerizable liquid crystal, which follows the designed photoalignment pattern, and will acts as the grating coupler. After polymerization, a solid thin film grating is obtained. The second layer will be the liquid crystalline waveguide itself. This waveguide will also be formed by first writing a photoalignment pattern on a photosensitive layer with polarized UV light, and then pouring liquid crystal over the layer. Complex waveguides with curves can be written by photoalignment based on a spatial light modulator that can determine the polarization independently in two million pixels.

The grating and the waveguide will first be separately tested, and then combined with an incoupling and an outcoupling section. When the combination is realized many experiments become possible. The waveguides may have curves and complex shapes that the light can follow. By adding photoluminescent material in the liquid crystal, the path of the light in the waveguide may be made visible in the microscope. The liquid crystal that forms the waveguide may be modified by subjecting it to an electric field, which can change the light path.

These two papers describe the status of current work in the group on waveguides and gratings.

Berteloot et al., Journal of Molecular Liquids 337 (2021) 116238

Nys et al., Adv. Optical Mater. 2019, 1901364

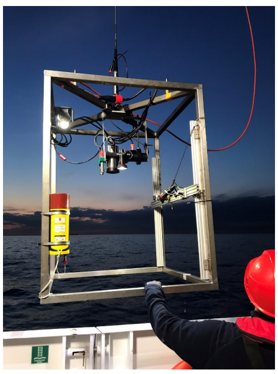
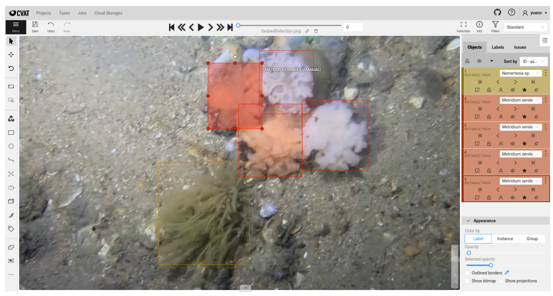
Locatie:

iGent (Technologiepark), thuis

32617: Deep active learning applied to the joint benthic fauna detection and seafloor characterization in underwater imagery: Case study in the Belgian part of the North Sea

Promotor(en):	Aleksandra Pizurica
Begeleider(s):	Yoann Arhant, Giacomo Montereale Gavazzi
Contactpersoon:	Yoann Arhant
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering, Master of Science in de informatica, Master of Science in Photonics Engineering
Niet behouden voor:	Master of Science in Biomedical Engineering
Nog onbeslist voor:	International Master of Science in Biomedical Engineering
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Dive into real world data and computer vision applications

Probleemstelling:

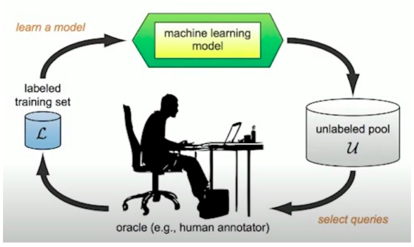
Challenges associated with improving the automatic evaluation of characteristics of interest (e.g., the seafloor, fish species, processes, ...) at various distances and spatial scales have been difficult to overcome due to the inherent dissipative nature of light waves in seawater (absorptive and scattering nature of seawater). Mitigating these effects has been the focus of the underwater imaging community for decades, but recent concurrent advances in hardware, software and methodologies is leading to significant improvements in various domains (e.g., biology, geology, archaeology, offshore engineering, seafloor mapping, ...). Importantly, the exploration, exploitation, documentation and recording of underwater environments remain challenging tasks that stimulate the research, design and development of new sensors, devices, techniques and methods for recording underwater environments. But even then, the large amount of data collected demands the establishment of methodologies to extract parameters of interest (e.g., recognition of conspicuous features, species, biotic and abiotic parameters, etc.). Available tools [1-4] perform recognition, detection, segmentation, tracking, density estimation, etc., and become increasingly challenging to design with the number of characteristics of interest. However, such tools and procedural workflows are of keystone importance to make sense of the submerged environment, and the development of routines addressing the quantitative parametrization of underwater imagery are of crucial importance. In this context, this project aims to exploit the recent developments of Artificial Intelligence with the imagery annotation challenges faced by marine scientists. This can be achieved via state-of-the-art algorithms and routines, such as deep active learning: a core topic of particular interest within the GAIM research group which uses these techniques for numerous applications, ranging from Art Restoration to Seabed characterization. Active learning is an iterative machine learning method addressing the search for a better procedure for data annotation. Starting with a small annotated set, the model predicts labels altogether with a measure of uncertainty, that will enable it to query annotation for data from the unlabeled from which it will learn most.

This thesis is in collaboration with the Royal Belgian Institute of Natural Sciences (KBIN - Koninklijk Belgisch Instituut voor Natuurwetenschappen), a world-class research institute with more than 250 scientists and scientific collaborators covering a wide range of disciplines from biology to geology, oceanography to taxonomy and palaeontology to ecology. The student will receive guidance directly from a KBIN expert specializing in Marine Ecology & Remote Sensing.

Left caption : The VLIZ Video Frame deployed in the Belgain Part of the North Sea

Right caption : Example of Annotation on the GAIM shared CVAT server of an underwater optical video transect of the seafloor

Bottom caption : Diagram presenting the active learning loop



References :

[1] Andrius Šiaulys, Evaldas VaiÄ□iukynas, SaulÄ— MedelytÄ—, Sergej Olenin, Aleksej Šaškov, Kazimieras Buškus and Antanas Verikas, A fully-annotated imagery dataset of sublittoral benthic species in Svalbard, Arctic, Data in Brief, Volume 35, 2021, 106823, ISSN 2352-3409, https://doi.org/10.1016/j.dib.2021.106823.

[2] Mona Lütjens and Harald Sternberg, Deep Learning based Detection, Segmentation and Counting of Benthic Megafauna in Unconstrained Underwater Environments, IFAC-PapersOnLine, Volume 54, Issue 16, 2021, Pages 76-82, ISSN 2405-8963, https://doi.org/10.1016/j.ifacol.2021.10.076.

[3] Peter Feldens, Patrick Westfeld, Jennifer Valerius, Agata Feldens and Svenja Papenmeier, Automatic detection of boulders by neural networks: A comparison of multibeam echo sounder and side-scan sonar performance. 2021, 119. 6-17. 10.23784/HN119-01.

[4] Montereale Gavazzi, Giacomo, Danae Athena Kapasakali, Francis Kerchof, Samuel Deleu, Steven Degraer, and Vera Van Lancker. 2021. "Subtidal Natural Hard Substrate Quantitative Habitat Mapping: Interlinking Underwater Acoustics and Optical Imagery with Machine Learning" Remote Sensing 13, no. 22: 4608. https://doi.org/10.3390/rs13224608

Doelstelling:

Starting with a state of the art of the field, the student will participate in the development of a complete procedural workflow for the application of deep learning models for the improved annotation of underwater imagery acquired by means of drop-frames in offshore Belgian waters, including Data Curation, Data Annotation, Dataset preparation, Model Training, Model prediction and Post Processing steps. First, the student will focus on the data preprocessing (the tracking of objects of interest in videos to propagate labels, automatic selection of a starting set of well defined frames, etc.) and annotation (the procedure, its evaluation, and other automatic tools) in close supervision. The student will then dive into active learning (uncertainty metrics, retraining strategies, and their effects on the active learning loop) and possibly another step depending on the student interests and background (model architecture either YOLOv5 or Faster R-CNN, transfer learning, additional post-processing steps for improved accuracy, etc.). The project will be fullfilling as it will help KBIN data exploitation and has also the potential to be beneficial to a wide spectrum of marine scientific applications, such as seabed characterisation with sonar data.

Right caption : Operators controling the VLIZ video frame and acquiring transects from the Belgica

Locatie:

Technicum

Opmerkingen:

A challenging project that will involve a close supervision.

33041: Design and simulation of gratings for on-chip UV Raman spectroscopy

Promotor(en):	Nicolas Le Thomas, Roel Baets
Begeleider(s):	Chupao Lin
Contactpersoon:	Nicolas Le Thomas
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	photonics design and Fourier experiment

Probleemstelling:

On-chip Raman spectroscopy is currently under development for healthcare applications, in particular for diagnostics. The Photonic Research Group (PRG) is one of the leading groups in this fields. We have already demonstrated that the detecting limit of on-chip Raman spectroscopy in the near infrared was much better than standard microscopy-based Raman spectroscopy. However, the detection limit is still one order of magnitude too large for potential application in clinical environment. To circumvent this issue, we have recently developed integrated waveguide working at UV wavelength. The underlying idea is to take advantage of the resonant Raman effect that increase the scattering cross section by more than five decades.

Doelstelling:

The goal of the master thesis project is to design gratings for sensing of biomolecules such as recombinant proteins or other biotherapeutics. The grating will have to be compatible with a spectral analysis in the far-field via a Fourier space imaging technique. The project includes simulations with Lumerical and optical characterization with an advanced Fourier space imaging set-up.

Locatie:

Ardoyen

Deze masterproef werd reeds 1-maal toegekend!

32128: Design of Invisibility Cloaks

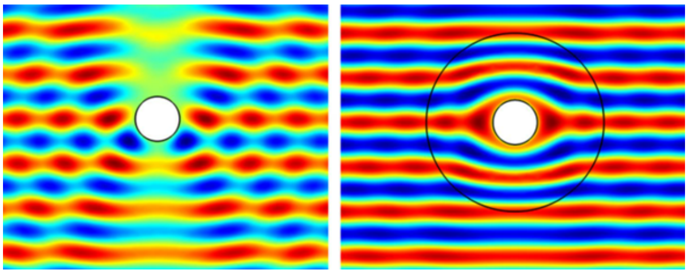
Promotor(en):	Kristof Cools, Hendrik Rogier
Begeleider(s):	
Contactpersoon:	Kristof Cools
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	2
Motivering voor deze opleiding:	This project studies propagation in special Optical Materials. The methods to analyze propagation is taught in Mathematics in Photonics.

Probleemstelling:

Invisibility cloaks have always fascinated people. It turns out that given the correct materials, their construction is in fact feasible. The way they are designed is by first finding a mapping from space excluding the cloaked region to the entire space. A simple plane wave propagating in the transformed space will correspond to a field configuration that circumvents the cloaked area in the original coordinate system, rendering everything inside invisible for observers.

According to the rules of general relativity, these transformations will affect the material properties (permittivity and permeability) of the layers surrounding the cloaked area. This means that the design of invisibility cloaks requires the ability to simulate wave propagation in systems characterized by complicated material properties.

What we need is the ability to model a cloak made out of complicated non-uniform anisotropic materials placed in a large radiation environment. To model this with high accuracy we need to couple a solver that can deal with the complicated interior region to a solver that can deal with a large empty environment. To model propagation through the complicated cloak material, finite element methods can be used. To model propagation in the exterior region, integral equations methods are the tools of choice. We want to find a method to couple these two methods. In particular we want to be able to use the building blocks offered by existing software without the need for further modification.



Doelstelling:

In this project, you will model an invisibility cloaks using a hybrid finite element/integral equation solver. You will investigate how to best couple the two approaches.

- You will learn about invisibility cloaks and their applications. You will learn about the methodologies that can be used to model invisibility cloaks.
- You will choose the best modelling approach based on your research. You will investigate how to glue together the complicated interior of the cloak and its large radiating environment.
- You will apply this methodology to simulate the workings of existing designs for invisibility cloaks. Can you improve upon them?

This project is suitable for students with both academic and application focused interests.

The project is suitable for a single student or a team of 2 students.

Locatie:

Ardoyen, thuis

Website:

Meer informatie op: users.ugent.be/~krcools/fyps/

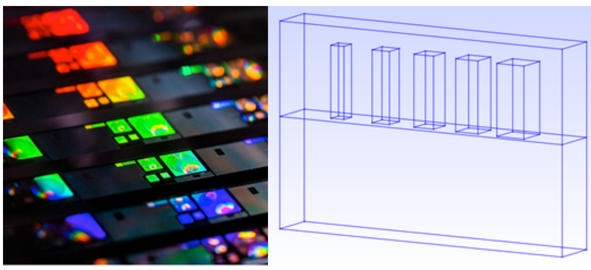
32129: Design of planar meta-material lenses

Promotor(en):	Kristof Cools, Hendrik Rogier
Begeleider(s):	
Contactpersoon:	Kristof Cools
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	2
Motivering voor deze opleiding:	The domain of application is the design of advanced imaging systems. The tools relate directly to the learning goals of courses such as mathematics for photonics.

Probleemstelling:

Meta-lenz is a Harvard spin-off that develops and fabricates flat optical components for next-gen consumer electronics and sensor technologies, such as cell phones or 3D imaging. These highly compact optics can be designed by judiciously placing cylinders of varying diameter on a dielectric substrate. The optical and radiation characteristics of this lens are highly sensitive to the exact location of these cylinders.

The only accurate means of modelling such a system is the use of boundary integral equations. Boundary integral equations are built on top of the Green function and can represent exact solutions of the wave equations in unbounded regions. Applying boundary integral equations to this problem is extremely challenging because the number of degrees of freedom in the electromagnetic field in the device can easily run into the millions. A second challenge is to write down integral equations that are fit to model transmission through a multi-material device of complex geometry. The design contains important details on the nano-scale that need to be tuned precisely for the macroscopic component to exhibit the desired behaviour.



Doelstelling:

The two challenges posed above can be tackled by a combination of matrix compression techniques and the use of so-called multi-trace integral equations.

Matrix compression techniques, and in particular the so-called adaptive cross approximation can be used to extract, from a matrix, the minimal amount of actual physical information and to construct a highly efficient compressed representation of this interaction in memory. Impressive design exercises can be completed on even a single laptop computer. In this project you will use the adaptive cross approximation to compress discrete representations of the Green’s function.
These representations are at the core of integral equation solvers. Your work will immediately result in a ten-fold speed-up of state-of-the-art modelling algorithms!

Multi-trace integral equations start from the idea that a complex structure can be taken apart in its components and that the equations governing interactions with this device can be written down for the simplified system comprising these free floating subcomponents. A limiting procedure allows to return to the assembled device under study. In this project you will find a suitable geometric decomposition, design CAD models of the resulting sub-components, and use this representation to model highly advanced meta-lenses.

During the thesis we will be in conversation with researchers at MetaLenz. They will be able to advise us on what aspects of your research are most relevant to the industrial practice and where the most urgent challenges lie.

In this project you will learn about modelling methods (which have applications in electromagnetics, but also in elastodynamics, fluid dynamics, thermodynamics, geophysics, and climate modelling) and the toolchain needed to use them. The project has both a strong academic and industrial component. You will have the opportunity to discuss with interested parties from high-tech startups.

This project can be undertaken by a single student or a team of two students.

Locatie:

Ardoyen, thuis

Website:

Meer informatie op: users.ugent.be/~krcools/fyps/

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: MetaLenz
Samenwerking: use case

32462: Development and characterization of a quantum photonic chips

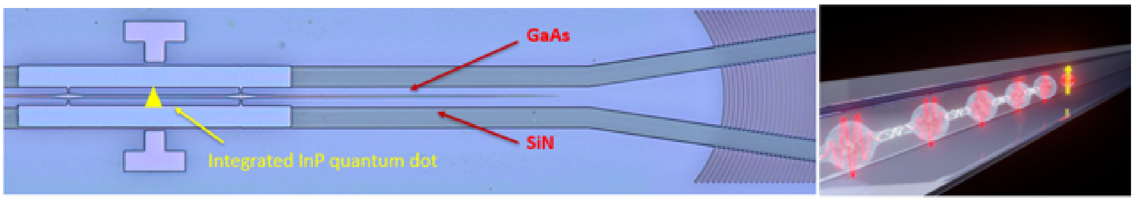
Promotor(en):	Dries Van Thourhout, Bart Kuyken
Begeleider(s):	Jasper De Witte, Isaac Luntadila Lufungula
Contactpersoon:	Jasper De Witte
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	1
Motivering voor deze opleiding:	Since this topic focuses on research related to physics and photonics, it is accessible to students of the European Master of Photonics and the Master of Engineering Physics. Furthermore, the topic is closely related to fundamental physics (advanced light-matter interactions, quantum optics) and contains a strong engineering component as it concerns chip-scale devices.

Probleemstelling:

In the field of quantum information processing, single photons are promising candidates as quantum information carriers because they are naturally mobile and barely interact with their noisy environment. Current state-of-the-art single-photon sources such as quantum dots embedded in GaAs waveguides [1] have matured thoroughly and deterministically generate high-purity, indistinguishable single photons on-demand ready to be applied in quantum information processing applications [2].

At the Photonics Research Group in Ghent, we developed the integration of such single-photon sources on integrated photonic chips based on SiN. These chips provide stable optical paths, are very small and make it possible to combine a lot of components on a single chip. This work in collaboration with the Niels Bohr Institute (NBI, University of Copenhagen) facilitates a so-called quantum photonic integrated circuit (QPIC) ready for usage in quantum communication and information processing applications.

Fig. 1 integrated single photon source (Photonics research group)



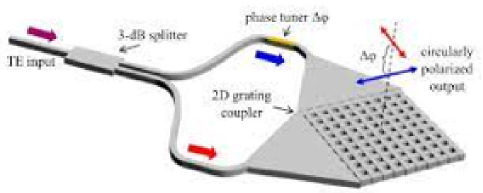
These single-photon sources have not yet been fully characterized with our dedicated measurement equipment at cold temperatures. This includes a 3.8 K closed-cycle cryostat to mount the source chip and an external superconducting nanowire detector setup cooled down to 800 mK. With these, the setup can be optimized to perform e.g. Hanburry-Brown-Twiss (HBT) and Hong-ou-Mandel (HOM) experiments for quantum optics. Finally, because of the recent deployment, applications of these state-of-the-art quantum photonic integrated circuits (QPICs) have been largely unexplored. In the field of quantum communication, the integration and low-temperature operation of otherwise discrete optical components on to this chip platform remains to be the next challenging opportunity.

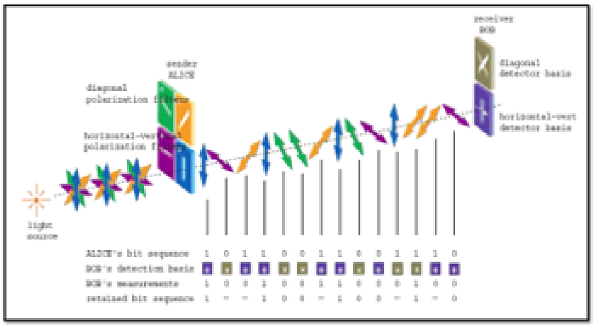
Doelstelling:

After a deep-dive in the existing literature on QPICs, the student will prepare the measurement lab to asses single-photon measurements. This will include an introduction to the low-temperature equipment as well as the finalization of the external measurement setup. With this, HBT and HOM experiments can be performed on available quantum light sources as well lifetime and optical linewidth studies to fully characterize the single-photon source. Single-photon purity and coherence at different timescales will determine the influence of quantum decoherence processes such as phonon coupling, nuclear spin noise, charge noise, and so forth. While well-understood and suppressed in the original GaAs platform, a comparison will be made for the heterogeneous platform and possible improvements can be suggested and tested.

Equiped with a source of single photons, we can focus further on the study of implementing cryogenic compatible devices to extend the platform for quantum applications. One clear pathway is the inclusion of quantum state encoding on the photonic chip. Such encoding of quantum bits of information is usually implemented with free-space polarization controllers, subject to component losses and recalibrations because of the discrete components. With on-chip integration, lower coupling losses and device stability can be achieved in a very small footprint. For this, coupling to polarization diversity gratings can be studied combined with cryogenic switches. After the student gets familiar with these options, depending on his or her interest the design – fabrication and characterization of such a transmitter can be studied for applications in quantum key distribution.

Fig.2 a) polarization diversity grating translating different paths on-chip to different polarizations off-chip b) Quantum key distribution woth polarization encoding





The student will have a lot of freedom on which aspects to emphasize. Dedicated design software is available in our group to thoroughly optimize of the components of interest. Fabrication of single-photon sources can be performed in our cleanroom as well as the integration of cryogenic switches based on available technologies such as CMOS-compatible or integrated thin-film lithium niobate modulators. Also full access to the cryostat setup along with the required femtosecond pump laser and superconducting nanowire detectors will be available.

This master thesis is deeply rooted in our own core research owing to the strong physical modelling, engineering and fabrication at the nanoscale aspects. This makes it relevant both for students aiming to pursue a career in academia or in dedicated high-tech industry. Furthermore, students can build upon the expertise of both the Niels Bohr Institute of the University of Copenhagen and the Photonics Research Group (PRG) of Ghent University.

References:

[1] Uppu, R. et al (2020). On-chip deterministic operation of quantum dots in dual-mode waveguides for a plug-and-play single-photon source. Nature Communications, 11(1), 1–12. https://doi.org/10.1038/s41467-020-17603-9

[2] Uppu, R., Midolo, L., Zhou, X., Carolan, J., & Lodahl, P. (2021). Single-photon quantum hardware: towards scalable photonic quantum technology with a quantum advantage. 1–15. http://arxiv.org/abs/2103.01110

Locatie:

Technologiepark Zwijnaarde (Ardoyen), thuis

Deze masterproef werd reeds 1-maal toegekend!

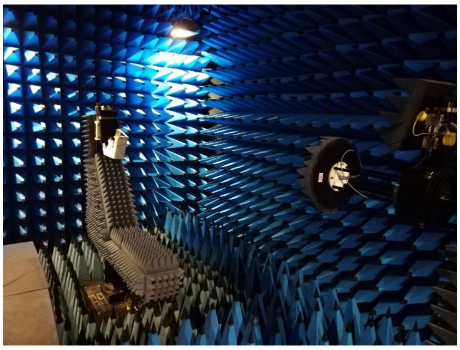
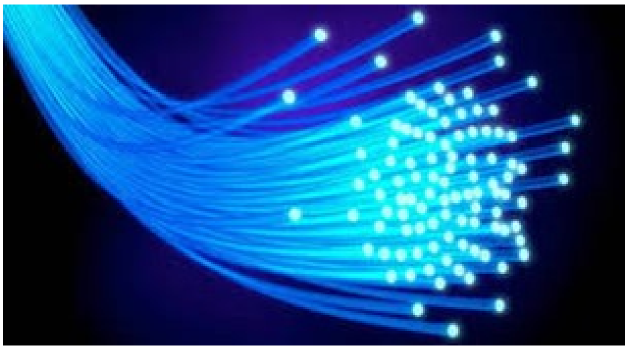
32208: Development of an optoelectronic transducer for antenna characterization

Promotor(en):	Hendrik Rogier, Bart Kuyken
Begeleider(s):	Arno Moerman, Olivier Caytan, Patrick Van Torre, Sam Lemey
Contactpersoon:	Olivier Caytan
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	2
Motivering voor deze opleiding:	Since this topic focuses on research related to Antennas and Propagation, Photonic Integration and EM-aware High Frequency Design, it is accessible to students of the European Master of Photonics, students of Master of Science in Electrical Engineering (Electronic Circuits and Systems and Communication and Information Technology) and Master of Science in de industriÃ«le wetenschappen (elektrotechniek, elektronica-ICT).

Probleemstelling:

Accurate characterization is a must when developing antenna systems for future generation networks. With the ever-increasing frequency trend, antennas are getting smaller and the influence of the measurement setup becomes problematic (leaking of measurement cables, undesired radiation reflections on cables). To this day, it still remains one of the biggest challenges in the development of 5G/6G wireless systems.

Optically routed feeding networks have been proven to be one of the most promising solutions to minimize the measurement setup influence, whilst providing accurate and broadband characterization. As the signal is no longer fed in the electrical domain, no interference can occur during measurements due to leakage. Furthermore, reflections are minimized because of the absence of metallic conductors. This measurement strategy is enabled by the development of an opto-electrical transducer, allowing the antenna to be fed by a dielectric optical fiber.

Doelstelling:

In this master's thesis, the student will develop an opto-electrical transducer for integration in our current antenna measurement setup. First of all, the student will perform a study on state-of-the-art techniques to reduce the influence of the measurement setup on the antenna characteristics, and on the state-of-the-art regarding power over fiber. In parallel with this, the student will develop the aforementioned system. To be effective, the system should be fed only by one or two dielectric optical fibers, have a very small footprint, and transmit sufficient RF power. The developed opto-electrical transducer will be prototyped and validated in our anechoic chamber by comparing the results of classical electrical measurements using coaxial cables with those obtained with the newly developed opto-electrical system.

Locatie:

iGent Tower

Website:

Meer informatie op: idlab.technology

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: imec
Samenwerking: use case

32539: Development of Interferometric scattering microscopy for nanoparticle studies

Promotor(en):	Filip Strubbe
Begeleider(s):	Lucas Oorlynck, Ingrid Amer Cid
Contactpersoon:	Filip Strubbe
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	International Master of Science in Biomedical Engineering
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

The Nobel-prize-winning technique of super resolution fluorescence microscopy has been a key method for visualizing intricate biological phenomena and nanoparticle behavior in liquids. With resolutions several times smaller than the Abbe limit objects with a size less than 50 nm have been imaged (about 5000 times smaller than the width of a human hair). However, due to the fluorescence requirement the objects under study need to be labeled with fluorescent marker molecules and these molecules bring some restrictions. Firstly, they are limited by their photon statistics and can bleach which limits the speed and length of acquisition, and secondly the labeling may introduce artifacts in the behavior of the object under study. Therefore, a new technique called interferometric scattering microscopy is being introduced in the scientific community. By relying on the interference of a laser illumination source and the Rayleigh-scattered light of the object (a nanoparticle or molecule), resolutions down to 20 nm at high framerates can be obtained without the need for fluorescent labeling.

Doelstelling:

The aim of this thesis is to investigate and develop the interferometric scattering microscopy technique in our confocal fluorescence microscopy setup. To achieve this, the current optical setup will be adapted to support both fluorescent and scattering microscopy. At the start of the thesis a literature study on interferometric scattering will be performed along with some theoretical analysis and simulation in Comsol. These simulations are intended to give an indication on the obtained interferometric contrast as a function of the nanoparticle size and material. Next, the optical setup will be adapted to study nanoparticles within the range of 50 to 200 nm. Images will be captured using a sensitive high-speed camera and processed either in real time or in post processing to extract the interferometric image. The obtained interferometric contrast will then be compared to the simulations. Once this proof-of-concept is completed, a particle system in a microfluidic mixer will be studied. The particle system consists of a large core particle (200 nm to 500 nm) that is functionalized with binding sites for smaller functionalized gold nanoparticles (25 nm to 50 nm). As the core particle suspension and the gold nanoparticles mix in the microfluidic mixer the images will be analyzed using the previously developed method to study the binding affinity as a function of gold nanoparticle concentration. Using interferometric microscopy the difference between a bare core particle and core particle with multiple gold nanoparticles attached to the surface can then be distinguished.

Reference: V. Sandoghdar et al. Interferometric Scattering Microscopy: Seeing Single Nanoparticles and Molecules via Rayleigh Scattering, Nano Lett. 2019, 19, 4827−4835.

Locatie:

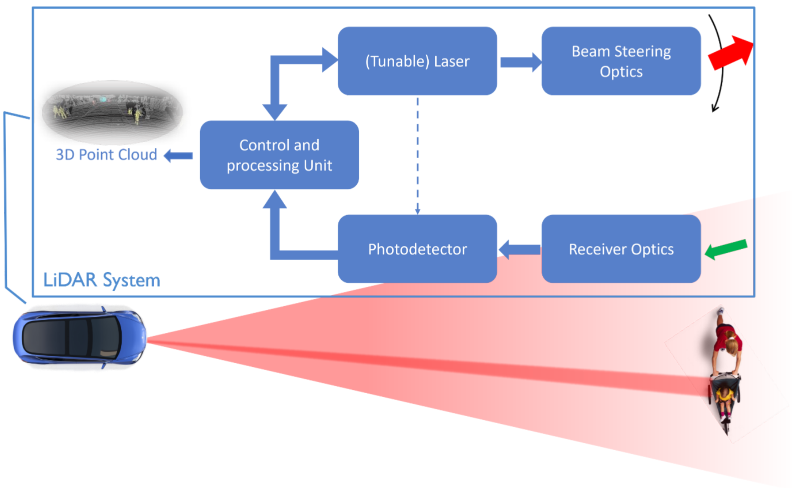
iGent, thuis

32801: Distribution Network for a Low-power passive lidar system

Promotor(en):	Wim Bogaerts, Marcus Dahlem
Begeleider(s):	Mennatallah Ali Zakaria Kandil
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	LIDAR is a photonic technology ('Li' stands for 'Light', not 'Lithium')

Probleemstelling:

Light Detection and Ranging (LiDAR) provides high resolution detection of objects over large distances using light. However, fulfilling the performance metrics of mass-reproducible solid-state LiDAR is an ongoing challenge. Particularly, automotive forward-looking LiDAR requires projecting and receiving light at distances over 200m. The two main functionalities that photonics contribute to the LiDAR engine are ranging (determining the distance to an object) and beam steering (pointing the beam in a certain direction). There is a strong push to reduce the cost of LiDAR by bringing both functions to a photonic chip. This is building on technologies like Silicon Photonics or Silicon nitride waveguides.



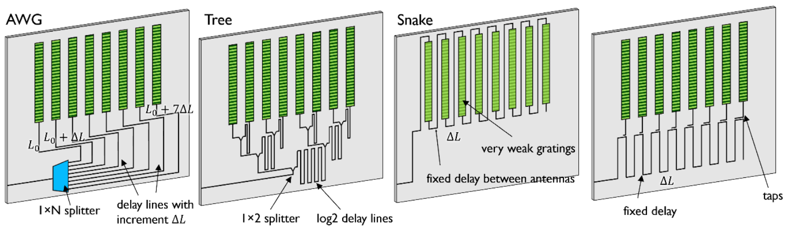
Fully passive optical phased arrays (OPAs) are one of the promising photonic implementations for the steering engine on a single chip. They consist of an array of many on-chip emitting antennas, where the direction of emission is tuned by controlling the phase between the antennas. In order to achieve scalable OPAs that meets LiDAR requirements, a large number of these antennas are needed, spaced closely together.

One way to control the steering is to feed the antennas through a distribution network with delay lines, so the wavelength can be used to induce a phase delay and control the angle of emission. However, one of the key bottlenecks of scaling this implementation is reducing the area of the distribution network that feeds these antennas, while maintaining low loss and good performance over a broad wavelength range. Some of the possible building blocks to explore are compact delay lines, compact bends, and waveguide superlattices for circuit routing.

Doelstelling:

The goal of this thesis is to create a framework for designing, prototyping, and testing different building blocks to reduce the footprint of the distribution network. Different distribution networks will be tried out, and evaluated how they can scale to 1000 or 10000 antennas. It is also the idea to test some of these experimentally by fabricating them in silicon or silicon nitride and then measuring them.

This thesis will be done in a collaboration between Ghent University and IMEC (Leuven), and some of the work (e.g. free-space measurements) will be carried out in Leuven.



Locatie:

Ardoyen (iGent), IMEC (leuven)

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: IMEC
Samenwerking: promotor + begeleider + use case

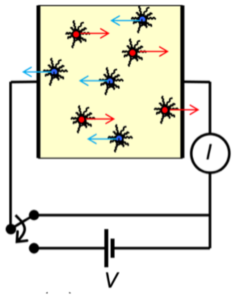
Deze masterproef werd reeds 1-maal toegekend!

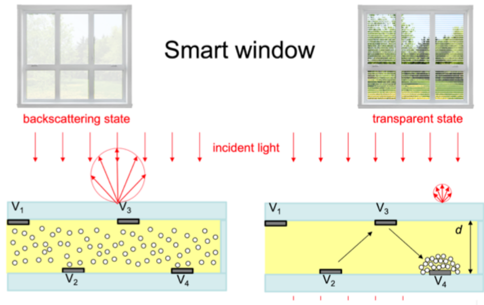
31638: Effect of induced hydrodynamic flow on the motion of charged particles in non-polar liquids

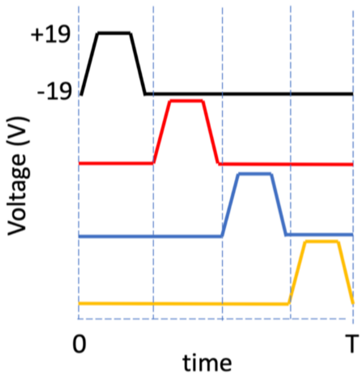
Promotor(en):	Martijn van den Broek, Kristiaan Neyts
Begeleider(s):	Mohammadreza Bahrami
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The student will get the opportunity to work in the Liquid Crystals and Photonics group, where similar master and PhD theses were completed in this area. The topic combines several aspects of the study programme of Master of Science in Photonics Engineering and has potential applications in display technologies.

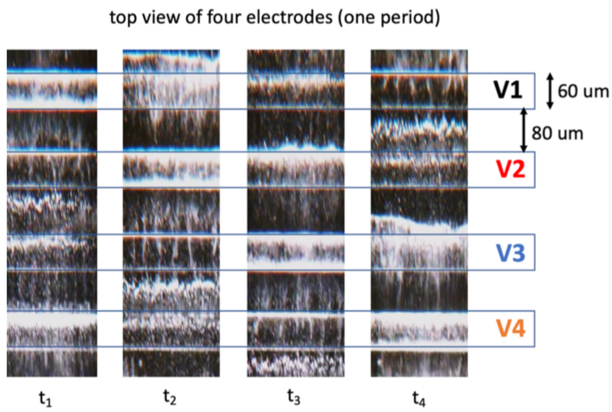
Probleemstelling:

The controlled motion of electrically charged particles in liquids has several interesting or promising applications. Well known are electrophoretic displays used for example in e-readers and digital price tags. Here, charged pigment particles (typically white and black, but more colours are possible) are suspended in a transparant, non-polar liquid, while their motion is controlled by applying voltages on electrodes. The liquid is non-polar to minimise electric conduction and power consumption in the device. To allow stable charged pigment particles to exist in such an environment, surfactant is added to the liquid. Surfactants can also encapsulate other charges in the liquid by forming inverse micelles. Several other applications are in development or imaginable.









The LCP research group is involved in the smart windows project where windows can be darkened using electrophoretic switching. Four electrodes are used in this mechanism. In devices that go beyond the simplest two electrode system, the effect of hydrodynamic flow can become relevant. The motion of inverse micelles can induce the flow of liquid in the device which in turn influences the motion of the suspended particles. This effect can alter the technical performance. As well, established models and simulations of the motion of inverse micelles based on the Nernst-Planck-Poisson equations may no longer be accurate in certain situations and need to be modified.

Doelstelling:

Over the years several experimental setups have been built in the LCP group to study the properties and motion of charges and inverse micelles in non-polar liquids. Based on this expertise and guided by the promotors, a setup will be designed and built by the student that is dedicated to the study of the effect of induced hydrodynamic flow in a multi-electrode system. In parallel, a simulation in Comsol is made. A student interested in theoretical modelling is invited to add the Navier-Stokes equations to the current theoretical description of drift and diffusion of inverse micelles. Numerical calculations can be done in Python or Matlab. The aim of the thesis is (1) to determine in which cases the effect of induced hydrodynamic flow becomes relevant and (2) to gain insight in the mechanism through simulation and/or theoretical modelling of typical and extreme but perhaps simpler cases.

Locatie:

Ardoyen, thuis

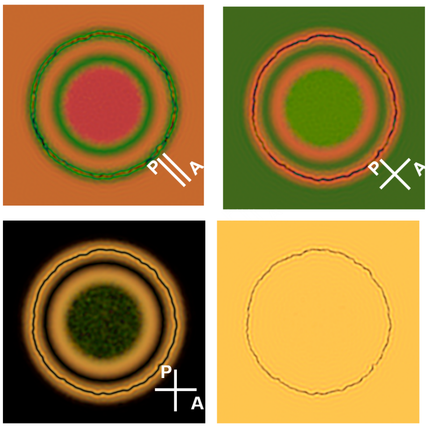
31739: Electronically switchable bistable liquid crystal devices for smart windows

Promotor(en):	Kristiaan Neyts, Inge Nys
Begeleider(s):	Brecht Berteloot
Contactpersoon:	Kristiaan Neyts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

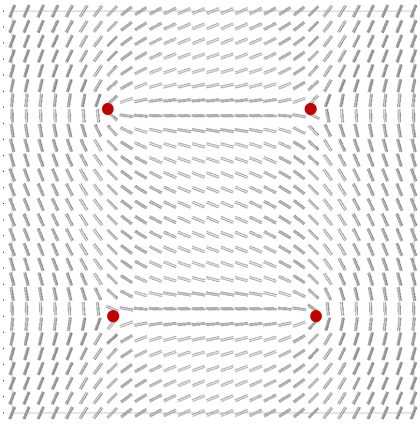
Probleemstelling:

Liquid crystals are anisotropic materials consisting of long molecules. Usually the molecules are aligned parallel to each other because any variation of the main direction requires elastic energy. Such a change in orientation can be driven by an electric field or by the alignment at the surface. Most liquid crystals tend to orient parallel to the electric field (positive dielectric anisotropy), but some materials also prefer to orient perpendicular to the electric field lines (negative dielectric anisotropy). Recently a new setup has been realized in our research group to fix the orientation of liquid crystal by an arbitrary pattern at the surface of the glass substrate. This pattern is written onto the surface by a spatial light modulator with 2 million pixels, with each pixel providing a different orientation. With this principle it is possible to realize complex liquid crystal configurations that can be used in smart windows, virtual reality components or lenses. Smart windows is an emerging technology that makes it possible to dynamically tune the daylighting conditions, the privacy and possibly also heating of the room. Some different technologies exist nowadays to produce smart windows but they suffer from disadvantages such as slow switching speed, high energy consumption, low transmission in the transparent state, limited flexibility, etc. We want to tackle these issues by using photopatterned liquid crystal devices.

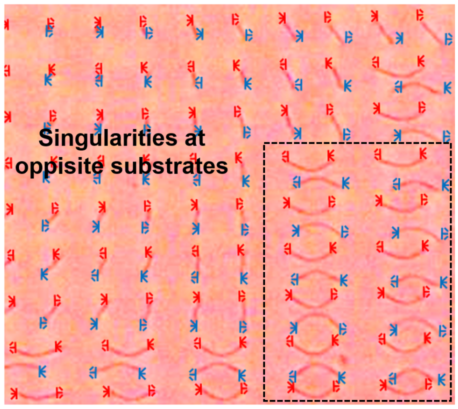
Orientation patterns at the surface with singularities (where the orientation rotates rapidly over 180°, see figure) lead to liquid crystalline configurations with defect lines in the bulk. The middle picture illustrates an array of defect lines that either connect singularities on the same substrate or on opposite substrates. These configurations have interesting properties that can be used in bistable devices (two possible configurations for the same boundary conditions) that have different stable optical states. In other words, the different metastable liquid crystal configurations can be used to realize another optical functionality (scattering, beam steering, etc.). Also alignment patterns without defects at the surface can be used to create metastable liquid crystal configuration in the bulk, especially when chiral liquid crystal or dual-frequency liquid crystal is used. Switching between different states can be obtained with the help of electric fields.



Liquid crystal with a defect ring



● Singularity defined at the surface



Singularities at the same substrate

Doelstelling:

The aim of this thesis is the exploration of the behavior of metastable states in photo-patterned cells filled with dual-frequency liquid crystal. Dual-frequency liquid crystal has the special property that it has a positive dielectric anisotropy in one frequency range while it has a negative dielectric anisotropy in another frequency range. In other words, the liquid crystal will tend to align parallel or perpendicular to the electric field lines depending on the frequency of the applied electric field. This frequency dependent E-field tuning can be used in photopatterned cells to obtain reliable switching between different metastable states. Photopatterned cells with and without defects at the surface will be tested and both the alignment pattern and the electric field treatment will be adjusted to obtain metastable states with desired (optical) functionality. The liquid crystal configuration in the bulk will be investigated by comparing microscope images and numerical simulations.
Another research question is related to the exploitation of these novel structures. How are the obtained liquid crystal structures influenced by temperature, electric field, mechanical stress or illumination? Can they be used in bistable smart windows, or shock detectors, etc.

Two substrates will be prepared with a photo-sensitive layer in the clean room in Zwijnaarde. You will illuminate the two substrates with different alignment patterns (with and without defects) and fill the cell with liquid crystal. By microscopy the orientation of the liquid crystal will be investigated to determine the three-dimensional nature. Different electric fields (with different frequency and amplitude) will be applied to adjust the device properties and reversible switching between metastable states will be tested. A switchable smart window (with strong scattering in one state and large transmission in another state) will be realized by optimizing the alignment pattern of the liquid crystal at the substrates.

The liquid crystal structures can also be investigated with the help of numerical simulations to get detailed insight in the device behavior. For different alignment configurations at the surfaces, 3D finite element modeling of the liquid crystal orientation in the bulk can be performed as a function of the applied voltage. These results can then be used to simulate the light propagation through the structure and reproduce the experimental microscopy images. Some simulation tools are available in the Liquid Crystals & Photonics group to perform these tasks.

Depending on the interest of the student, the focus can be shifted between simulations and experiments.

Locatie:

Campus Ardoyen (Zwijnaarde), home

Deze masterproef werd reeds 1-maal toegekend!

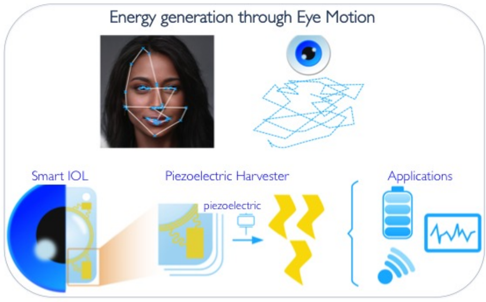
32546: Energy harvesting interface for opto-electronic implants powered by eye motion

Promotor(en):	Herbert De Smet, Andrés Felipe Vasquez Quintero
Begeleider(s):	Pablo Perez Merino
Contactpersoon:	Pablo Perez Merino
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	International Master of Science in Biomedical Engineering, Master of Science in Electromechanical Engineering
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Photonics aspect: powering a smart intraocular lens using energy harvesting form the rapid saccadic eye movements.

Probleemstelling:

Energy harvesting from body movement at low frequency band and multidirectional vibrational sources is a very promising technology for biocompatible sensors and implantable monitoring devices in remote and inaccessible locations. Displacements inside the body such as lung motion, the heartbeat, blinking and muscle contraction possess an abundant amount of waste energy that can be harvested. Of particular interest here are our eyes, which flutter quickly from side to side exploring a visual scene or during sleep. The muscles of the eye execute continuous movements over a great range of amplitudes and velocities, no other muscle in the body shows such a dynamic range. Thus, eye motion is an excellent candidate to provide continuous mechanical vibration energy.

Smart materials exhibit some observable effect in one domain when stimulated through another domain. For instance, electro-active polymers are functional flexible materials that can turn the mechanical deformation into electrical energy or vice versa. This uniqueness allows the implementation of the material as a soft actuator or as a piezoelectric energy harvester. The piezoelectric effect has been widely adopted to convert mechanical energy into electricity due to its high-energy conversion efficiency, ease of implementation and miniaturization. Translating ocular vibrations into a self-powered smart platform would allow developing functional blocks for real-time intraocular sensing.



Doelstelling:

The purpose of this master thesis is to make the sensitivity analysis, simulations and preliminary experiments to estimate the amount of energy that can be safely harvested. The generation of electromechanical finite element (FE) models will provide the basis for modeling the piezoelectric energy harvester. The cantilever structure will be modeled as the spring-mass damper that generates maximum potential when the structure's resonant frequency corresponds to the natural frequencies of the ocular vibrations. Furthermore, computational 3D models will contain the ocular dimensions and the conditions for saccadic generation (3D rotations, viscous friction and muscle-like actuators) will be also generated. The project will conclude with the design in a tape-out of the designed circuits, layout and post-layout simulations.

Locatie:

Technologiepark - Zwijnaarde (iGent building - 6th floor), home

Website:

Meer informatie op: www.cmst.be/

32093: Event-based vision and spiking neural networks for enhanced label-free flow cytometry

Promotor(en):	Peter Bienstman
Begeleider(s):	Muhammed Gouda Ahmed Gouda
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Flow cytometry is a technology used in the biomedical industry to separate different types of cells based on various characteristics. Traditionally, cells are labeled with biomarkers, but this can alter the cells' properties and affect the validity of results. Label-free imaging flow cytometry, which captures images of cells using a camera, is an alternative approach. However, it has two issues: the memory issue (due to the large amount of data generated) and the background noise issue. Filtering out the background signal can be used to address the latter, but it is not ideal and adds computational cost.

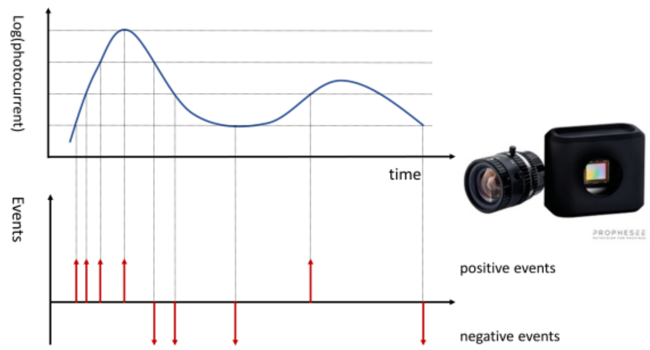


Figure 1: The figure shows the operating principle of the event-based camera. The intensity of the light is sampled by the camera, and an event is fired whenever the intensity exceeds by a certain value. Based on whether there is an increase or a decrease in the intensity, a positive or a negative signal is recorded.

Doelstelling:

By using an event-based sensor instead of a traditional CMOS camera, the amount of data generated can be reduced, and higher classification accuracy could be achieved without the need for background subtraction. The goal of this thesis is to use the event-based camera to classify different biological cells. Experiments in the past classified micro-particles of different sizes. In this thesis, the student will conduct experiments involving fungal cells. In addition, he will train spiking neural networks which are more suited for the spiking data he will be generating. Depending on the interest of the student, the focus can lie on the simulation part, the experimental part or both.

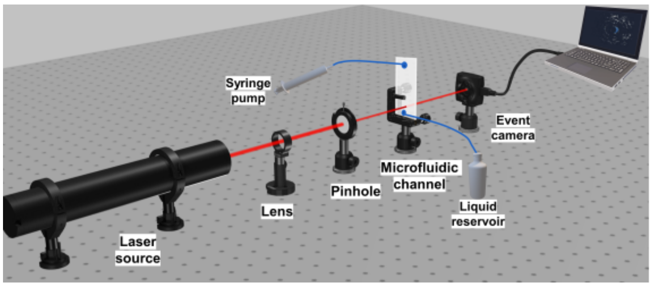


Figure 2: The figure shows the experimental setup build for this work. Light coming from a laser is focused by a lens on a pinhole. Behind the pinhole is a vertically-mounted PMMA microfluidic channel inside which microparticles are flowing downwards. The diffraction pattern caused by a flowing particle is captured by the event-based camera which is connected to a laptop with a dedicated software for recording the events fired at different pixels.

Locatie:

32676: Global optimization of integrated photonic devices using quantum tensor network algorithms

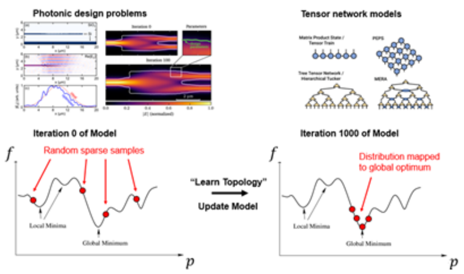
Promotor(en):	Peter Bienstman
Begeleider(s):	Thomas Van Vaerenbergh
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Evolution in processing capabilities of photonic chips allow for ever tinier feature sizes of photonic devices. Consequently, inverse design techniques based on adjoint optimization or upcoming machine learning algorithms have been proposed to take advantage of these new degrees of freedom. This allows photonic engineers to either create devices with new functionality or with previously unachievable low losses for a given fabrication process. Unfortunately, current algorithms still have their drawbacks, as the wave nature of light often results in multi-modal figure of merits with many local minima that prevent finding the global minima of interest. Additionally, as AI algorithms are often designed based on the assumption that an abundance of data is available, many algorithms still need way more iterations than can be realistically obtained for devices where electromagnetic field simulations are computationally expensive. One approach to mitigate this problem is by imposing the intrinsic symmetries of the problem by decomposing these problems into a set of appropriate base functions. However, for problems with many degrees of freedom (i.e., many design variables), it quickly becomes intractable to express all the resulting interactions between these base functions.

This is where we could learn from the field of quantum chemistry, where tensor networks have been developed to allow us to find ground states of quantum many body systems where the intractability of the interaction between the base functions is avoided by doing a clever dimensionality reduction. Unsurprisingly, these techniques have lately also found traction in the machine learning community. This thesis would be a first attempt to apply them to the optimization challenges in photonic device design.

This work can be seen as part of the “AI for science” evolution – instead of recognizing cats and dogs in YouTube videos, we want to apply machine learning techniques to scientific and engineering problems by developing novel intrinsically physics-inspired algorithms.



Relevant background literature:

- Example optimization problems for photonic device design:

https://www.osapublishing.org/jlt/abstract.cfm?uri=jlt-38-13-3422 , http://metanet.stanford.edu/ , https://ieeexplore.ieee.org/abstract/document/8805390

- Previous work on applying tensor networks to optimization problems: https://arxiv.org/pdf/2101.03377.pdf
- Previous attempts to apply tensor networks to machine learning problems: https://tensorworkshop.github.io/NeurIPS2020/accepted_papers.html , https://libstore.ugent.be/fulltxt/RUG01/002/782/897/RUG01-002782897_2019_0001_AC.pdf

Doelstelling:

The goal of this exploratory master thesis is to develop new global optimization algorithms by introducing the benefits of the dimensionality reduction of tensor network techniques into existing state-of-the-art inverse design approaches in the integrated photonics community. You would select a couple of representative toy problems, demonstrate the applicability of your methods and towards the end of the thesis you would apply your methods to a stretch goal: one or two integrated photonic devices of your choice which are computationally expensive to simulate (eg 3D FDTD) and have lots of global minima.

During this thesis, you will collaborate with the team of researchers in Hewlett Packard Labs (part of HPE) that is developing inverse design techniques for integrated photonic devices. This topic is a perfect fit for an ambitious student with a strong interest in programing (in Python, but Julia is also an option), electromagnetism, computational physics (FDTD, FDFD) and applied mathematics. A prior background in quantum mechanics is strongly advised, but prior knowledge on tensor networks is not a prerequisite. Your thesis research is an attempt to bridge the gap between two currently unconnected research fields.

Locatie:

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: HP
Samenwerking: begeleider

33095: High speed acousto-optic phase shifters for SiN based PICs

Promotor(en):	Dries Van Thourhout, Frederic Peyskens

Begeleider(s):	Ahmed Khalil
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Photonics is main topic

Probleemstelling:

Acousto-optic interactions have recently shown great promise for integrated photonic devices. In particular, bulk acoustic wave resonators (BAWs) are interesting since they provide a CMOS-compatible route to enable low-power, low-loss and high speed (up to GHz) phase-shifters when combined with passive Si or SiN PICs. These acousto-optic devices could serve many application areas, such as LiDAR, holography, life science, microwave photonics and quantum computing.

Doelstelling:

The thesis will leverage existing know-how in this field by bringing together the advanced foundry-ready chip manufacturing capabilities of imec in both SiN photonics and ultrasound transducer technology. The student will collaborate in testing and characterizing the performance of high speed BAW transducers which modulate SiN photonic integrated devices.

Locatie:

imec Leuven

Onderwerp voorbehouden voor Khaled.AboElSoud@UGent.be

Deze masterproef werd reeds 1-maal toegekend!

32757: Highly Efficient On-Chip Opto-Electric Antenna for THz communication

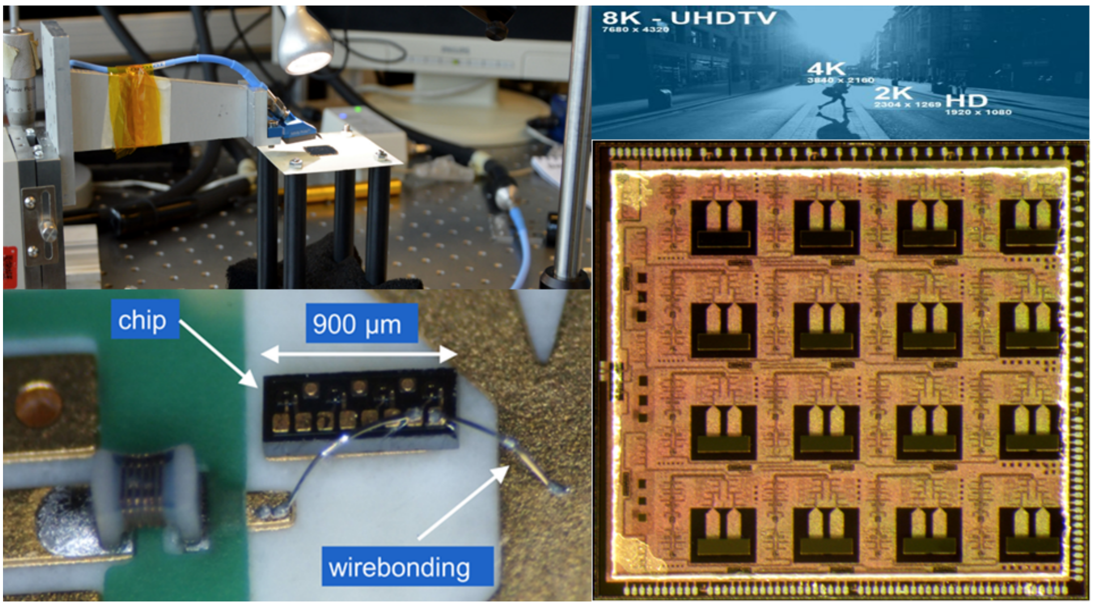
Promotor(en):	Sam Lemey, Bart Kuyken
Begeleider(s):	Reinier Broucke, Guy Torfs, Peter Ossieur, Hendrik Rogier, Dennis Maes
Contactpersoon:	Quinten Van den Brande
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	2
Motivering voor deze opleiding:	

Probleemstelling:

Due to their limited bandwidth, current-generation wireless systems cannot accommodate the ever-increasing demand for higher data-rates. Fifth-generation wireless systems address this problem by enabling broadband wireless communication at much higher frequencies, resulting in bandwidths up to 7 GHz. However, the explosive growth in use of mobile multimedia services leads to the prediction that soon 5G networks won't suffice to address the stringent demands for future applications. Recently, the terahertz (THz) frequency band ([0.1 – 10] THz) has piqued the interest of many researchers as a possible candidate for next-generation wireless systems.

Though achieving data-rates of at least 10 Gb/s under well-controlled conditions, THz communication systems have one major drawback. Atmospheric attenuation of THz signals is considerably larger than for mmWave signals and, as such, highly directional and steerable antennas are imperative for THz communication systems to guarantee the ultra-high data-rates.

One very promising solution is the use of large opto-electric antenna arrays with optical beamforming. The compact, low-loss optical feeding and steering network outperforms its all-electronic equivalent with bulky and lossy phase-shifters. Furthermore, the use of optical true-time delay technology allows for beam steering of broadband signals without beam squint errors.



Doelstelling:

In this master thesis, a highly efficient on-chip opto-electric antenna system with optical beamforming will be designed at THz frequencies. Special attention will be paid to combine the key benefits of photonic integrated circuits, active electronics and the potential of substrate-integrated-waveguide antenna elements.

As a starting point, the challenges and opportunities related to both THz communication and opto-electric antenna array feeding will be investigated thoroughly. Subsequently, a system architecture will be devised from which the requirements for the standalone opto-electric antenna will be determined. In a final step, a stand-alone opto-electronic antenna element will be designed and co-optimized to guarantee peak performance.

Because of the multi-disciplinary challenges of the topic, the subject is open for groups of two students. If individual students are interested, the subject can be split up to focus on one of the subsystems. In either case, the thesis requires the ability to combine knowledge from different disciplines (high frequency design, antennas and propagation, photonics), keep the overview and spot opportunities that arise.

This master thesis has a strong academic component and is relevant to the high-tech industry worldwide, making it interesting for both students with ambitions in academia or industry. In addition, the student(s) can build upon the expertise of the INTEC Electromagnetics Group (Antenna design, co-optimization), INTEC Design Group (High frequency design) and the INTEC Photonics Research Group (PRG) (Photonic integration techniques, photonic generation of carrier signals, …).

Since this topic focuses on research related to Antennas and Propagation, Photonic Integration and EM-aware High Frequency Design, it is accessible to students of the European Master of Photonics, and to students of both the Electronic Circuits and Systems and the Communication and Information Technology subject areas.

Locatie:

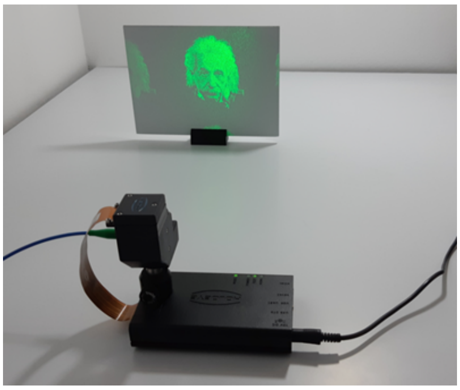
Technologiepark Zwijnaarde (Ardoyen)

32113: Holographic projection using geometric phase optics

Promotor(en):	Jeroen Beeckman, Kristiaan Neyts
Begeleider(s):	Brecht Berteloot
Contactpersoon:	Jeroen Beeckman
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Optical holograms using geometric phase optics will be fabricated using an optical setup with a spatial light modulators. A dedicated routine for the generation of the geometrical optical element needs to be programmed.

Probleemstelling:

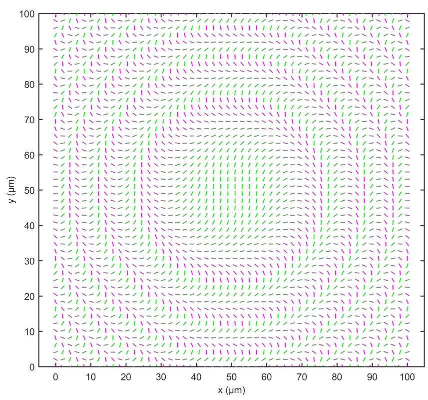
In regular projectors, the image on the screen is formed by imaging the pattern on a microdisplay. The microdisplay changes pixel by pixel how much light is reflected back, which means that this devices modulates the amplitude of the light. In holographic projection systems, a spatial light modulator (SLM) is used, which modulates the phase of the light. The image on the screen is the fourier transform of the phase image on the SLM. Such holographic projectors have a number of advantages and disadvantages with respect to regular projectors. One of the advantages is that it is a low cost projector (among others, due to the fact that no expensive imaging lens needs to be used) and such projectors are commercially available, for example in head-up displays in cars.

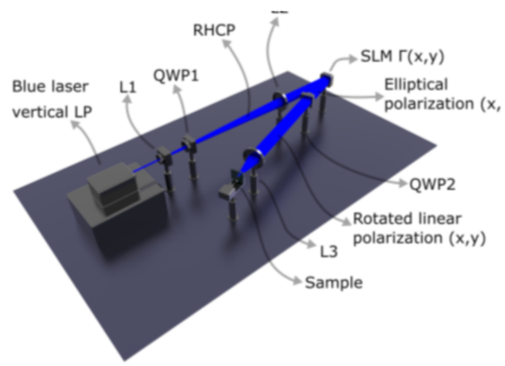


Source: holoeye.com

Typical spatial light modulators and optical diffractive elements change the optical path length of the light beam. In the past decade more and more research is devoted to a completely different optical effect based on the geometric phase or the Pancharathnam-Berry phase. In this effect, the phase of the light is not altered by an optical path difference, but by a change of the geometric phase. The most common was to control the geometric phase is to make use of uniaxial material in which the direction of the optical axis is controlled. The advantage is that the layer is uniform in thickness and in principle 100% diffraction efficiency can be obtained. In literature, diffraction efficiencies more than 99% have been reported. Using this effect it is possible to create highly efficient gratings or lenses. The picture below on the left shows a typical pattern if a geometric phase lens.

In the LCP research group, different optical setups are available to fabricate geometric phase optical components. One of the setups, shown on the right makes use of an SLM to control the optical axis orientation on the sample.





Doelstelling:

A lot of research in the LCP group is devoted to such geometric phase optical components application in lenses, holographic gratings, waveguides, augmented and virtual reality and light beam management. Several research projects with companies are ongoing to develop such optical components. In this thesis, the aim is to create holographic optical elements using geometric phase optics that create an predefined image.

The main tasks in this thesis is:

- The development of an algorithm to generate the pattern for an arbitrary image. Such algorithms exists for SLMs, but these will need to be adapted.
- Realization of the holographic optical elements in the lab.
- Measurement of the performance and efficiency of the holographic optical elements. This data will be used to optimize the algorithms developed in the first step. Different effects will need to be examined, such as how to handle the transition region between different 'pixels' in the holographic optical element.

Locatie:

iGent

Website:

Meer informatie op: lcp.elis.ugent.be

Deze masterproef werd reeds 1-maal toegekend!

32431: Integration of thin-film photonic sensors on flexible substrates for biomedical applications

Promotor(en):	Geert Van Steenberge, Jeroen Missinne
Begeleider(s):	Harindra Kannojia
Contactpersoon:	Harindra Kannojia
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The topics deals with the design, fabrication and testing of an optical component (Bragg grating sensor on chip)

Probleemstelling:

Photonic sensors are used in a wide variety of applications, e.g. to monitor temperature, refractive index, pressure, etc. One popular type of photonic sensor is based on Bragg grating, realized as the periodic modulation of the waveguide structure's effective index. These Bragg grating sensors rely upon the reflection of the specific wavelength satisfying the Bragg condition. Therefore, a shift in the reflecting wavelength is used to measure physical parameters, such as temperature, strain etc. Such sensors can be realized on a photonic integrated chip, but a chip is relatively thick and rigid. For biomedical application for example, very thin and flexible sensor realizations are desired.
Goal of the Master thesis is to fabricate a thin integrated photonics sensor by using an inductively coupled plasma – reactive ion etching (ICP-RIE) process, after which the sensor will be integrated on a flexible substrate for characterization. To allow for this, the ICP-RIE technique will be developed and optimized, allowing for a Si substrate removal and preparing the thin-film photonic waveguide circuitry ready for transfer to a flexible substrate .

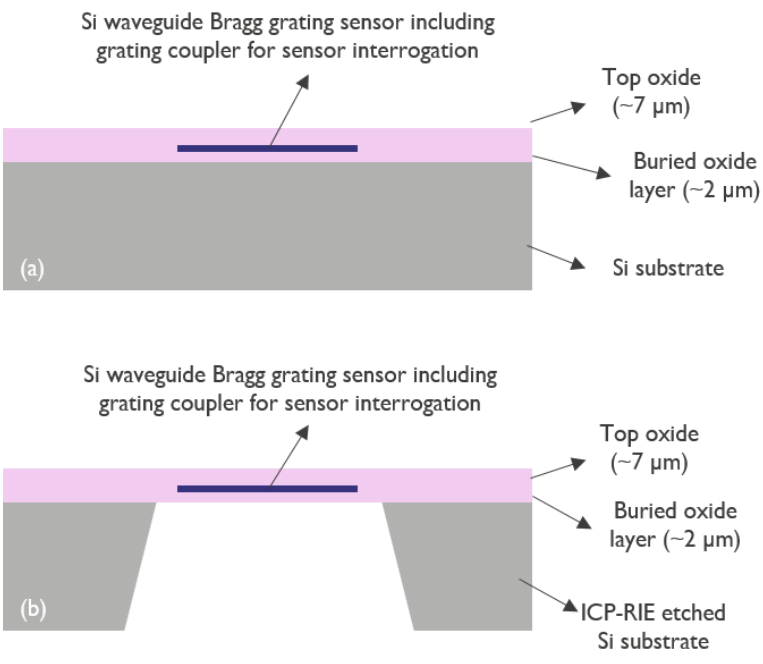


Fig. 1: Cross-sectional layout of the thin-film photonic sensor. (a) Before the thin-film release step, and (b) after the thin-film release using ICP-RIE etching.

Doelstelling:

During this thesis, the ICP-RIE process needs to be optimized to achieve precise and controlled etching of silicon, while enabling a selective etch stop on the buried oxide layer . Initially, the process will be optimized on dummy silicon substrates. The effect of different process parameters like ICP power, RF power, gas flow rate, pressure and temperature on silicon etch rate, sidewall inclination and surface quality will be investigated. Once the process is optimized, the silicon substrate of available Si waveguide Bragg grating sensor chips will be etched. Finally, the thin-film photonic sensors will be integrated on a flexible substrate, making use of a thin adhesive layer. As handling of thin-film structures is very challenging, a novel approach based on laser-induced forward transfer (LIFT) printing will be investigated. After developing the different processing steps, the thin-film photonic sensor characterization will be carried out, including sensitivity measurements versus temperature and strain.

The thesis will, coarsely, be organized as follows:

1. Literature study regarding photonic sensors and to identify ICP-RIE process parameters
2. Optimization of the ICP RIE etching of Si dummy substrates
3. ICP-RIE etching of available Si waveguide Bragg grating sensors and integration on the flexible substrate using LIFT

4. Characterization of the thin-film photonic sensor

The student will work in the UGent cleanroom and labs for all experimental work, including the ICP-RIE, LIFT along with microscopic characterization. Proper trainings will be given to the student, to allow for using the high-end tools independently.

Locatie:

Ardoyen (for practical work in the clean rooms and labs) and at home or in the iGent building (literature, design work)

Deze masterproef werd reeds 1-maal toegekend!

32653: Inverse design and fabrication of pulse-shaping laser elements for optical clocks

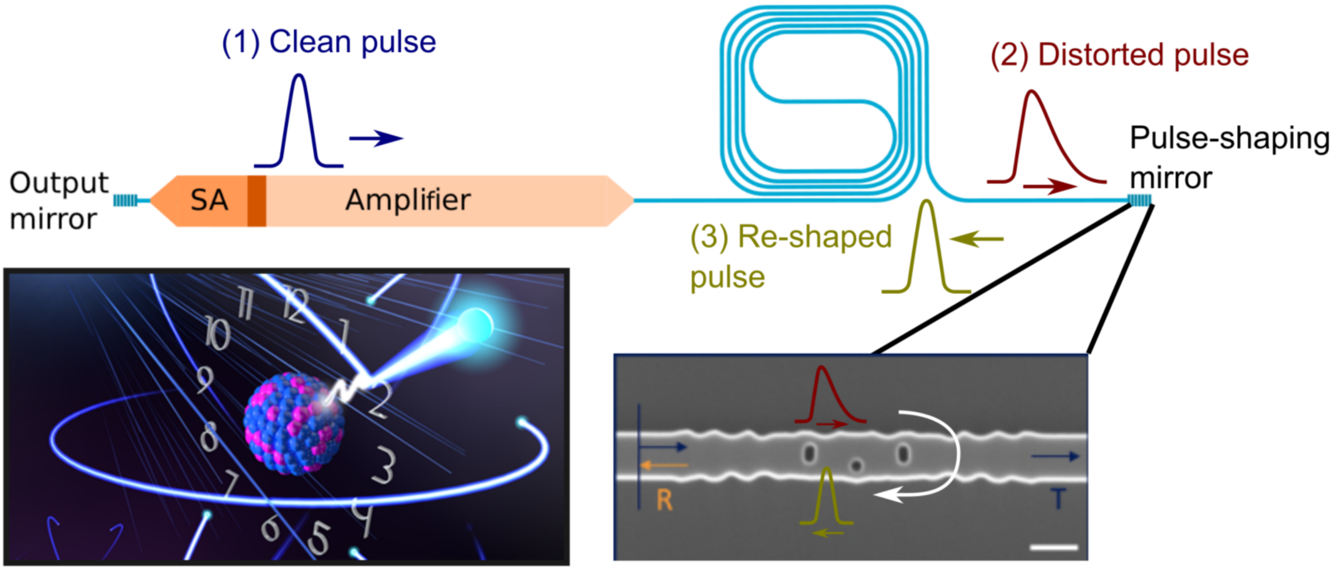
Promotor(en):	Bart Kuyken
Begeleider(s):	Max Kiewiet, Tom Reep
Contactpersoon:	Max Kiewiet
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	2
Motivering voor deze opleiding:	Since this topic focuses on research related to physics and photonics, it is accessible to students of the European Master of Photonics and the Master of Engineering Physics. Furthermore, the topic is closely related to fundamental physics (the Nobel prize in physics of 2005 was awarded for work on optical frequency combs) and contains a strong engineering component as it concerns chip-scale devices.

Probleemstelling:

Ultra-precise atomic clocks are instrumental for global navigation, telecommunications and fundamental frequency metrology. Atoms make ideal identical and therefore reproducible frequency references. Thus far, Cesium-based microwave clocks have been the standard for reliable timekeeping. However, clocks based on optical transitions are being explored as the higher frequency of light permits orders of magnitude improvement in the achievable time resolution.

To achieve such a new precise standard, an ‘optical frequency comb’ being a light source that emits a large number of coherent equally spaced laser frequency lines is needed. In time domain, this means creating a pulsed (mode-locked) lasers. To get the highest precision, short pulses are desired which require a wide optical spectrum. Having a wide optical spectrum does not automatically lead to short pulses however. Many components in these pulsed laser cavities distort and widen the generated pulses. To counteract this, we propose to use the laser mirror to compress the pulse inside the cavity as a pulse-shaper.

To unlock practical uses of an optical clock, such a source should be cost-effectively small, energy efficient and mass producible. In practice, this leads us to integrated photonics: the field of making lasers and optical circuits on chip.



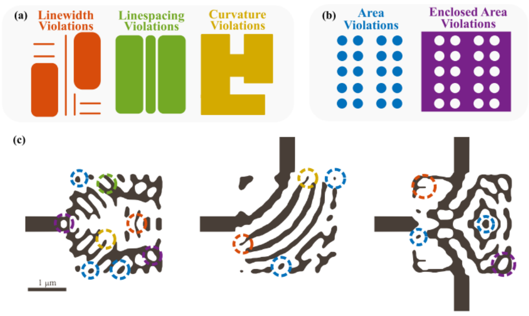
Doelstelling:

In this master thesis, we will design a pulse-shaping mirror for use in a pulsed (mode-locked) laser. This is done through a field called “inverse design”, which is a popular optimization method emerging in the field in photonics.

The classical method in designing optical components comes through optimizing known architectures and then simulating and testing them to see if they work. In inverse design, the opposite is done; You give a clever machine-learning algorithm the desired optical spectrum, after which the algorithm starts generating an architecture to get the desired result. This means the final architecture directly follows from the desired input function.

The work will consist of inverse design and simulation of the desired optical component. The structures will be manufactured and characterized. If time allows, the components can be put in an integrated mode-locked laser.

This subject is highly relevant for both students pursuing a career in academia and R&D in industry and for students still undecided on these two career paths.



Locatie:

Ardoyen

32538: Investigating nanoparticle interactions using laser-scanning microscopy

Promotor(en):	Filip Strubbe
Begeleider(s):	Lucas Oorlynck
Contactpersoon:	Lucas Oorlynck
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Biomedical Engineering, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	International Master of Science in Biomedical Engineering
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	A large part of this thesis involves optimising the laser-scanning microscope and nanoparticle systems, which have a large photonics component: Single-photon-counting, laser-scanning microscopy using AODs, fluorescence of nanoparticles and luminescent quantum dots

Probleemstelling:

Understanding interactions of nanoparticles with their environment is essential for a whole range of biomedical, pharmaceutical, nanotechnological and environmental applications. But many fundamental aspects of how nanoparticles behave are not yet fully understood. To investigate such nanoparticle interactions in detail, a laser-scanning microscope has been developed in the Liquid Crystals and Photonics group. This setup allows to make movies of luminescent nanoparticles at very high frame rates and with single-photon sensitivity. This opens new ways to investigate nanoparticle interactions with unprecedented detail.

Doelstelling:

The aim of this Master thesis is to use the existing laser-scanning microscope to investigate nanoparticle interactions and properties. Firstly, the interaction between two types of nanoparticles will be analysed. A model system will be studied consisting of core particles (100 nm polystyrene, biotinylated) and target particles (50 nm gold, avidin-coated and fluorescently labelled). Because of the functionalisation respectively with biotin and avidin, there is a specific binding between these two nanoparticles. As a result, depending on the concentrations of these nanoparticles, particle clusters will be formed with zero, one, three, or more fluorescent gold nanoparticles bound to a core particle. By analysing the data from the laser-scanning microscope, three parameters are determined per particle. The fluorescent intensity of the cluster provides information on how many gold nanoparticles are involved. The diffusion coefficient informs on the cluster size. And the electrophoretic mobility provides additional information on the interaction between these nanoparticles. Depending on the outcome of the study of this model system, also other nanoparticles can be investigated, from quantum dots to fluorescent micelles. Secondly, nanoparticles can be studied at much higher concentrations such that they can no longer be individually tracked. In this case, fluorescence correlation spectroscopy can be carried out using the same laser-scanning microscope. Here, the aim is to extract the diffusion coefficient and electrophoretic mobility of large ensembles of luminescent nanoparticles.

Since the laser-scanning setup is already operational, the thesis work will focus on optimizing the setup for the specific experiments, gathering experimental data and analysing this data off-line (Python, Matlab).

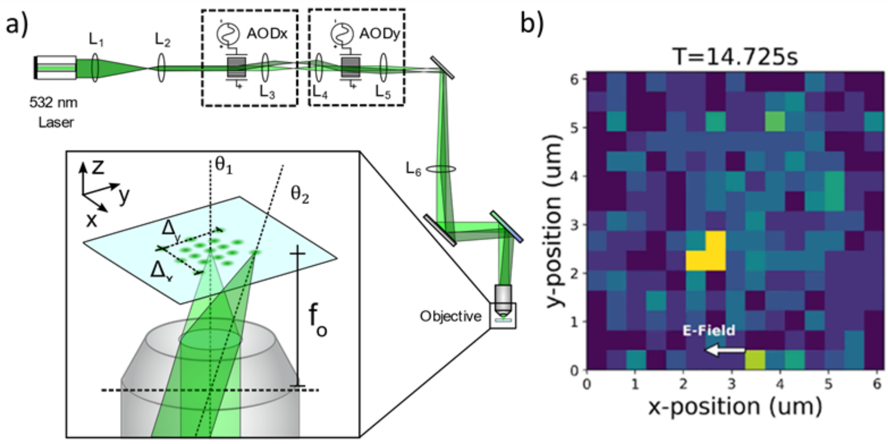


Fig. 1. a) Fast imaging by laser-scanning and single-photon-counting (detection part is not shown), b) snapshot of a single nanoparticle (100 nm fluorescently labeled PS) during electrophoresis.

Locatie:

iGent, thuis

32348: Investigation of feedback sensitivity of heterogeneously integrated DBR lasers

Promotor(en):	Geert Morthier, Günther Roelkens
Begeleider(s):	
Contactpersoon:	Geert Morthier
Goedgekeurd voor:	Master of Science in Photonics Engineering

Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	This topic requires sufficient pre knowledge that is taught only in the MSc of photonics engineering

Probleemstelling:

Sensitivity of laser diodes to external feedback has to be as low as possible, to avoid the use of optical isolators in certain applications since these isolators can't be integrated in photonic integrated circuits. It has already been shown that heterogeneously integrated lasers with long passive sections (or high Q rings) are theoretically less sensitive to such external reflections, i.e. their linewidth and RIN vary less due to external feedback.

Doelstelling:

The goal of this master thesis is to design and measure such lasers with different passive section length and to evaluate their feedback sensitivit.

The work will include the design of the laser cavities and particularly the passive silicon waveguides, up to the design of gds files necessary for fabrication. After full fabrication, the fabricated lasers will be extensively characterised (in terms of LIV, linewidth, intensity noise spectrum, etc.) vs. amplitude and phase of external reflection,

Locatie:

iGent, 4th floor

Deze masterproef werd reeds 1-maal toegekend!

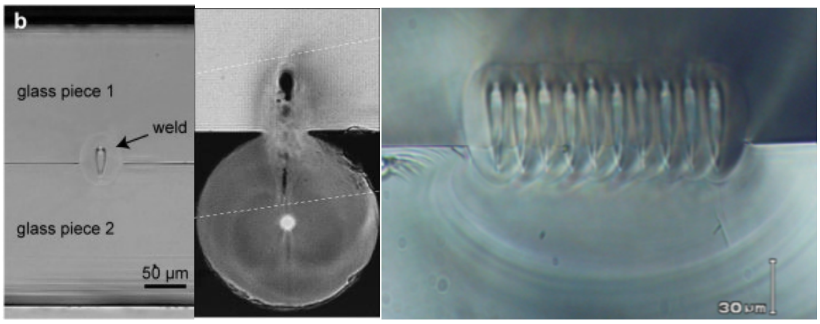
32307: Laser welding for robust and reliable packaging of photonic circuits

Promotor(en):	Jeroen Missinne, Geert Van Steenberge
Begeleider(s):	Viktor Geudens
Contactpersoon:	Viktor Geudens
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Topic deals with packaging of photonic integrated circuits and femtosecond laser technology

Probleemstelling:

To interface photonic integrated circuits, optical fibers are required. In the field of silicon photonics, grating couplers are a popular method to transfer the light from fiber to chip and back. This requires active alignement and finally the fibers are fixated. Alternatively, (glass) interposers can be used. For glass integrated circuits, edge coupling is employed. This can be facilitated by the use of V-grooves for passive alignement. In both cases, however, the fiber must remain at its exact position thoughout the complete lifetime of the device. This can be challenging when the device is subjected to external influences, such as high temperatures, or high frequency vibrations (in e.g. accelerometers).

Laser welding optical fibers and interposers to the photonic circuits in one method that is able to provide a sufficiently strong, robust and reliable connection that survives in extreme environmental conditions.



References

J. Bovatsek, A. Arai and C. B. Schaffer, "Three-dimensional micromachining inside transparent materials using femtosecond laser pulses: New applications," 2006 Conference on Lasers and Electro-Optics and 2006 Quantum Electronics and Laser Science Conference, Long Beach, CA, USA, 2006, pp. 1-2, doi: 10.1109/CLEO.2006.4627978.

Isamu Miyamoto, Kristian Cvecek, Yasuhiro Okamoto, Michael Schmidt, Novel fusion welding technology of glass using ultrashort pulse lasers, Physics Procedia, Volume 5, Part A, 2010, Pages 483-493, ISSN 1875-3892, https://doi.org/10.1016/j.phpro.2010.08.171.

Oleg B. Vorobyev, Young Hwan Kim, Jianzhao Li, Michael Bakaic, Nicholas Burgwin, Abdullah Rahnama, Peter R. Herman, "Femtosecond laser welding of silica glass fiber for robust Bragg grating sensing in high temperature environment," Proc. SPIE 11676, Frontiers in Ultrafast Optics: Biomedical, Scientific, and Industrial Applications XXI, 1167618 (30 March 2021); doi: 10.1117/12.2584331

Doelstelling:

During this thesis, different materials and laser systems will be investigated. A (glass) photonic circuit is fabricated to which optical fibers are welded. Lasing parameters will be swept. Characterization of the welding will be performed with optical microscopy as well as putting the weld under test in real life conditions.

The student has freedom to steer the focus of the thesis in their direction of interest. The thesis will, roughly, be organized as follows:

1. Literature study to indentify lasing parameters and materials
2. Laser welding using different laser setups
3. Characterization of the weld
4. Reliability testing in climate chamber and universal testing system

The student will use the installed state-of-the-art laser systems for realizing laser-welded photonic packaging. They will work in a cleanroom environment for experimental work and microscopic characterization. Proper training will be given to work in a cleanroom and to use all the other tools needed for characterization involved in this work.

Locatie:

UGent campus Ardoyen, cleanroom, at home

Deze masterproef werd reeds 1-maal toegekend!

31793: Machine learning with quantum optical networks

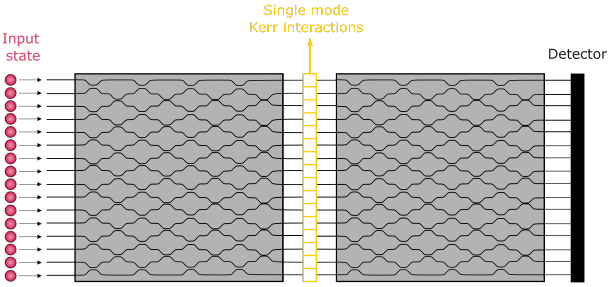
Promotor(en):	Peter Bienstman
Begeleider(s):	Robbe De Prins
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering, Master of Science in de fysica en de sterrenkunde, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	This study program provides the necessary background in quantum mechanics and photonic devices. Students in this program also have experience in making computer simulations and programming.

Probleemstelling:

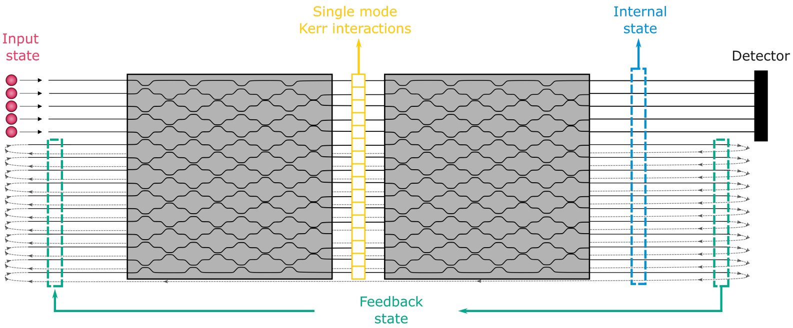
Over the last few decades, quantum computing and quantum information has grown into a rich and highly attractive research field. Both from a theoretical and an experimental standpoint, remarkable progress has been made, fueling hopes that quantum information processing will have a significant impact on society in the coming decades. A promising candidate to achieve this is photonic quantum computing. It is one of the leading approaches to universal quantum computing and allows to build on vast experience in integrated photonics fabrication and scalability. Other advantages of photons are their natural mobility and low-noise nature that allow for outstandingly long coherence times - even at room temperature.

In the pursuit of scalable and fullâ€fledged quantum computing, there is also an increasing emphasis on using techniques from the field of machine learning (ML). As ML models learn from experience â€ similar to a biological brain â€ they can for example help to sidestep the complex synthesis of quantum algorithms. More generally, building on the established possibility to outperform classical ways of computing, quantum machine learning (QML) investigates how to design and deploy quantum software that harnesses the complexity of quantum systems. This can either serve as an improved method to tackle the tasks that classical ML models try to solve or as a way to tackle tasks that are intrinsically quantum.

At the Photonics Research Group, we investigate quantum optical networks using classical simulations. We study how such networks can be optimized to solve computational tasks, similar to how neural networks (NN) work. An example of such a network is shown in the first figure below. Quantum states (which may encode classical input data) are transformed by a set of quantum optical gates (e.g. optical squeezers, displacers, beamsplitters, phase shifters, Kerr interactions, etc.) and measured subsequently. Apart from tackling classical computational tasks, such networks can also extend further into to the quantum domain. For example, they can be used to analyze quantum data from a physical experiment. By removing the detector from the network, they can also generate useful quantum states.



Another type of quantum optical network is shown in the figure below. Because of its delay lines, this network can tackle temporal tasks (i.e. process time series) in a way that is similar to recurrent neural networks (RNN). Moreover, we are studying how this network can be leveraged for another quickly growing QML paradigm: quantum reservoir computing (QRC). Similar to classical reservoir computing, QRC allows to exploit the natural dynamics of physical systems with recurrent connections without having to train their internals. This is done by sending these physical systems streams of information and capturing their responses at different locations. A trained linear combination of only these responses has been shown to be sufficient to solve interesting tasks. Reservoir computing (RC) approaches like these have already shown to be much simpler and computationally cheaper than fully optimizing the internals of the recurrent structures themselves.



Since quantum systems show exponential scaling in their number of degrees of freedom when increasing their number of components, they show great potential to outperform their classical counterparts. Moreover, we know that the creation of entanglement in such networks can lead to forms of quantum supremacy. Finally, from QML the benefit arises that quality requirements of the components of the considered quantum system are reduced. This is a direct result of the fact that hardware imperfections are taken into account when training, i.e. when determining a bespoke set of parameters for each model instance. This last property can help to cope with the current imperfections of quantum computers, exactly showing why QML can be powerful in the current noisy intermediateâ€scale quantum (NISQ) era.

Doelstelling:

Since this relatively new research topic resides in a highly interdisciplinary and rapidly growing field, several paths exist through which a master's thesis could build on it. One of the initial proposals is to investigate how recent advances in classical ML can help to simulate the optimization of quantum networks. More specifically, Direct Feedback Alignment (DFA) has recently been proposed as a promising alternative for backpropagation. Instead of backpropagating the error layer by layer, DFA proposes to use random feedback weights. For some models, this has been shown to work evenly well, because the network can learn how to make the feedback useful. To the best of our knowledge, this hasn’t been investigated yet for quantum neural networks.

We want to note that the master thesis can also head in different directions. Examples are the introduction of new tasks for the networks that we currently study, other quantum networks (e.g. models that are not gate-based) and other ML strategies.

Locatie:

iGent, Campus Ardoyen

32615: Making a fully-integrated laser that operates at the exceptional point

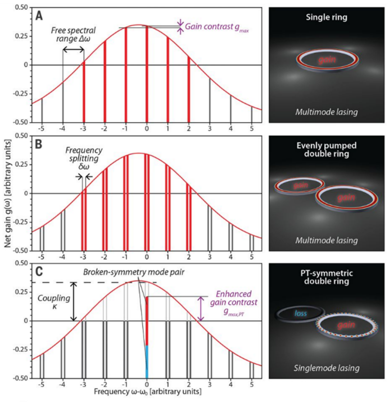
Promotor(en):	Dries Van Thourhout, Pieter Geiregat
Begeleider(s):	Korneel Molkens, Ivo Tanghe
Contactpersoon:	Korneel Molkens
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	2
Motivering voor deze opleiding:	Design, simulatie, fabricatie van photonic devices + natuurkundig begrip van nanomaterialen en gekoppelde resonatoren

Probleemstelling:

Some time ago, in a collaboration between the Photonics Research Group (PRG) and Physics and Chemistry of Nanostructures (PCN) group at Ghent university, we showed the first integrated laser based on colloidal quantum dots [1]. The laser took the form of a ring in which optical modes form a closed loop. However, given the gain spectrum width of semiconductor materials, and colloidal quantum dots in particular (around 20 nm), more than one mode starts lasing in a ring with a realistic size. However, for many applications, single mode lasing is required.

A possible solution to this problem is to operate the laser at the exceptional point. Here, two multimode lasers are coupled together. If one ring amplifies the light, and the other absorbs the light in an equal amount, the laser can become single-mode. The theory popped-up in quantum field theory in the nineties but founded practical applications in photonics. The idea was pioneered by Hodaei et al.[2] and is was extensively used over the last decade. The experimental realization usually relies on pumping both rings differently. Since they are very close to each other, this requires an advanced measurement set-up and is not practical for a real and compact device.

***(A)** The lasing spectrum of a single ring resonator. Multiple modes are present **(B)** The spectrum of two coupled rings. The modes split in a bonding and anti-bonding mode (as in in the binding of two H-atoms to form a H_2 molecule). **(C)** The same structure operating at it exceptional point. Here, single mode behavior is possible*



[1] Xie, W., Stöferle, T., Rainò, G., Aubert, T., Bisschop, S., Zhu, Y., Mahrt, R. F., Geiregat, P., Brainis, E., Hens, Z., Van Thourhout, D., On-Chip Integrated Quantum-Dot–Silicon-Nitride Microdisk Lasers Adv. Mater. 2017, 29, 1604866.

[2] Hodaie H., Miri M., Heirich, M, Christodoulides D. and Khajavikhan M. Parity-time=symmetric microring lasers, Science 2014, 346, 6212

Doelstelling:

In this work, you will investigate the possibility to make a laser work at its exceptional point without the need of non-uniform pumping. This can be achieved by adding a lossy material to one of the resonators. The difficulty lies in choosing the right amount of loss, because it can't be changed once it is on the cavity. The project involves a theoretical component for designing the lasers. Also, the student can gain practical experience in the PRG-cleanroom in where we can do the full processing in-house. Lastly, the samples should be characterized in the PCN- laser lab.

Applications range from fundamental physics (is the postulate of Hermiticity really necessary to formulate quantum mechanics?) to practical devices (single mode lasers for sensors).

Locatie:

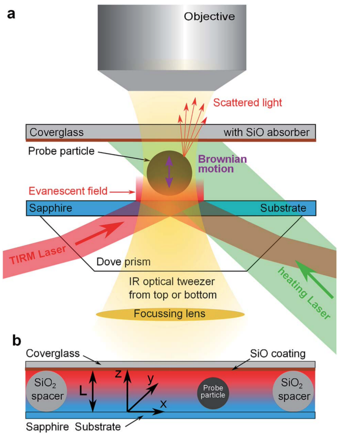
Campus Ardoyen (zwijnaarde), De Sterre

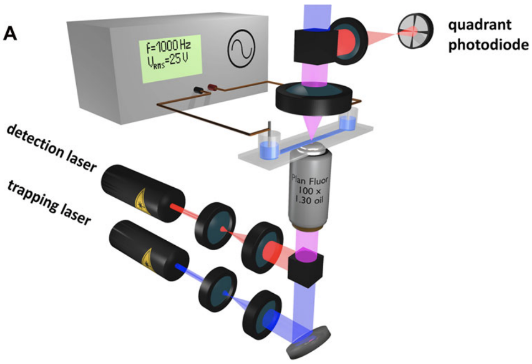
32634: Measurement of thermophoresis in an optical particle trap

Promotor(en):	Martijn van den Broek, Filip Beunis
Begeleider(s):	
Contactpersoon:	Martijn van den Broek
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The student will get the opportunity to work in the Liquid Crystals and Photonics group adapting and using the optical particle trap setup.

Probleemstelling:

In contrast with electrophoresis (the motion of charged particles due to an electric field), thermophoresis, where particles move through the influence of a temperature gradient, is less known and less understood. Especially in liquids, the theoretical description contains several unknowns and more experiment is needed to discriminate between existing models [1]. Thermophoresis is used in the separation of colloids (or to prevent mixing), in particle filters, for manipulating single biological macromolecules and for the study of protein interactions, and the phenomenon is thought to have played a role in the origin of life. Also in the design and operation of electrophoretic or microfluidic devices (lab-on-a-chip) that involve temperature differences, an understanding and quantitative description of thermophoresis is desired.

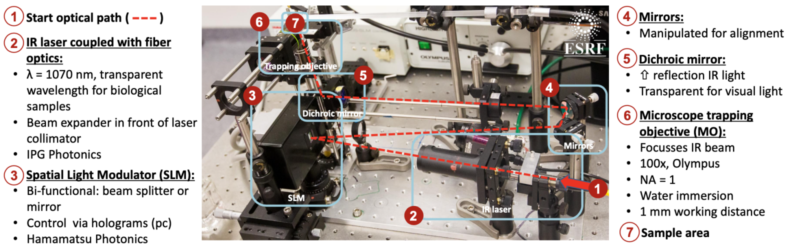




Doelstelling:

In research groups in Germany and Sweden experiments were performed that allowed to study thermophoresis of so far inaccessible particle sizes and particle solvent combinations [2]. Optical tweezers hold the particle in place and essentially limit the motion to one dimension. In these experiments, total internal reflection microscopy (TIRM) was used to measure the trajectory of the particle. The limitation of this technique is that it only allows to detect the particle in the vicinity of a flat wall. In this area the hydrodynamic friction factor differs drastically from the bulk.
In the LCP group of Ghent University we propose to use a different experimental method to study thermophoresis. A setup for particle motion measurements using optical tweezers is available. We use back focal plane interferometry to determine the particle location, in principle allowing to study thermophoresis not only near the wall but also in the bulk. A constant thermal gradient can as in [2] be generated by coating on a glass cover that serves as an optical absorber for laser light. Alternatively a temperature gradient can be generated in the liquid through focussing of IR laser light. The master thesis student will be involved in the adaptation of the existing setup, the measurement of thermophoresis of several particles (sizes, material), and the comparison of results with existing theory.

[1] e.g. Piazza, R. & Parola, A. Thermophoresis in colloidal suspensions. J. Phys.: Condens. Matter 20, 153102 (2008).
[2] Helden, L., Eichhorn, R. & Bechinger, C. Direct measurement of thermophoretic forces. Soft Matter 11, 2379–2386 (2015).



Locatie:

iGent

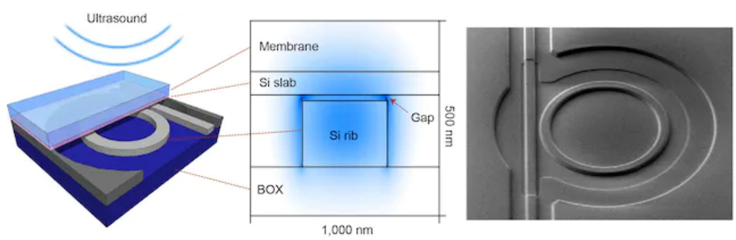
31994: Measuring Ultrasound with Light

Promotor(en):	Mathias Kersemans, Yanlu Li
Begeleider(s):	Xavier Rottenberg, Yusheng Ma
Contactpersoon:	Mathias Kersemans
Goedgekeurd voor:	Master of Science in de industriële wetenschappen: elektrotechniek - Campus Schoonmeersen, Master of Science in Electromechanical Engineering, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	Master of Science in de industriële wetenschappen: elektromechanica - Campus Schoonmeersen
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Photonics, laser interferometry, mechanical waves, signal analysis, sensor technology

Probleemstelling:

Ultrasound is a high-frequency mechanical wave and can be found in various applications: medical doctors use echo-location to visualize a fetus, researchers manipulate/separate particles via ultrasonic haptic technology, while engineers exploit ultrasound scattering phenomena for structural health monitoring. Crucial in all these applications is a sensor which is able to capture ultrasound signals in a reliable and sensitive manner. Nowadays, piezo-electric sensors are often used to convert an ultrasound signal to an electric signal for digitization. However, these piezo-electric sensors come with certain disadvantages in terms of sensitivity and bandwidth, and this limits further applications.

Recent work at UGent and IMEC has led to the development of light-based sensors for the detection of ultrasound (see figure). The fact that light is employed to measure an ultrasonic signal opens up a whole range of new contactless sensing applications and imaging modalities.



Doelstelling:

The student will get access to these state-of-the-art light-based sensors for measuring ultrasound signals. The student will first critically characterize these novel sensors in terms of their performance (for example sensitivity, dynamic range, bandwidth …). Then, the student will use the sensors to achieve novel ultrasonic applications, e.g. ultrasonic imaging of the 3D internal structure of an object.

This thesis fits in the framework of a running collaboration between UGent and IMEC. The student will be guided by photonic/ultrasonic/analysis experts in both UGent and IMEC. It is advised that the student has a strong interest in experimental work, signal/data analysis and sensors.

Locatie:

Ardoyen

32797: Microheater Characterisation for Programmable Photonics

Promotor(en):	Wim Bogaerts, Umar Khan
Begeleider(s):	Aladdin Al Haffar
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	combines electruical, optical and thermal characterization and equivalent circuit modelling

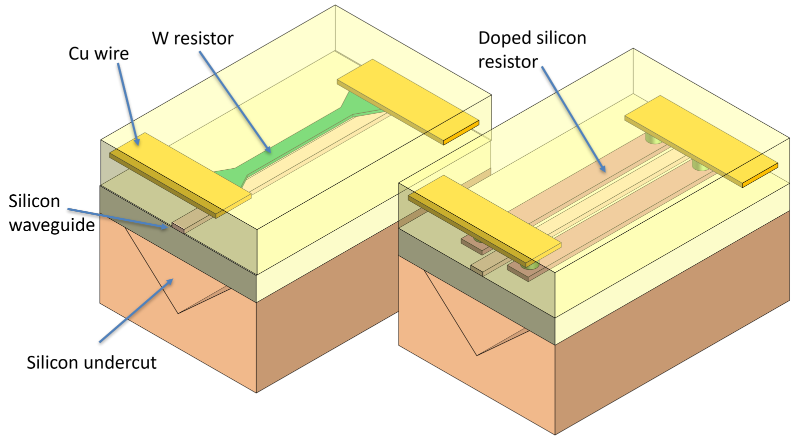
Probleemstelling:

Photonic integrated circuits (PIC) are chips where optical signals (light) are being transported and processes in waveguides. Such circuits are already widely used in fiber-optic communication, and are now slowly finding their way into other applications such as LiDAR, sensing and biomedical instrumentation.

As PICs become more complex, they also become more tunable and programmable, by incorporating electrically driven phase shifters to control the flow of light. An extreme version of this can be found in 'programmable PICs', sometimes called 'photonic FPGAs' or 'photonic processors'. These consist of a regular mesh of waveguides connected together with many electrically tunable elements, so the flow of light if fully configurable.

Important for such large circuits is the availability of efficient phase shifters. These should be short, optically transparent and have low power consumption. The most common mechanism to realize these are based on heaters: small electrical resistors placed near the optical waveguides. In our silicon photonics platform, these heaters are implemented as resistors on top of the waveguide, or on the side. And to increase their efficiency, the underlying silicon substrate can be removed, which reduces the thermal leakage.

Such heaters still consume power: 25-30mW for regular heaters, and 6-7mW for undercut heaters. We want to reduce this, and we have set up a large experiment with new heater designs. We need to map their performance, and use this as a basis for new, improved designs.



Doelstelling:

The concrete goal of the thesis is to get a good understanding of the heater performance and behaviour of the current generation of heaters, and come up with designs that will give an improved performance.

This will involve the following activities:

- Electrical and optical characterization of existing fabricated heater variations on silicon chips. This includes both static and transient measurements.
- Identify trends in efficiency and power consumption, but also crosstalk (a heater affecting nearby waveguides)
- Perform thermal + optical simulations to quantify the performance (and compare with measurements)
- Use these insights and thermal simulations to design new thermos-optic phase shifters with a higher efficiency

Increasing the efficiency can be based on multiple mechanisms, such as waveguide superlattices (closely stacking many waveguides together, but tuning their cross section to avoid unwanted coupling), thermal insulation measures (e.g. etching a deep trench – this could involve some clean room processing) and optimizing the electrical characteristics.

Locatie:

Ardoyen (iGent)

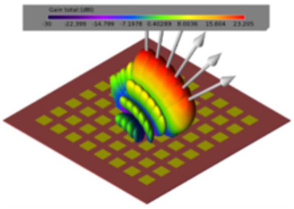
32487: mmWave Photonic Antenna Array for 5G and beyond

Promotor(en):	Bart Kuyken, Sam Lemey
Begeleider(s):	Olivier Caytan, Arno Moerman, Hendrik Rogier, Margot Niels, Dennis Maes
Contactpersoon:	Margot Niels
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2

Aantal masterproeven:	2
Motivering voor deze opleiding:	The research component of this master thesis lies in the design, fabrication and characterization of novel antenna systems with integrated onboard optoelectronic circuits that directly convert the optic signal to the RF signal radiated by the antenna. Since this topic focuses on research related to Electromagnetics, Antennas and Propagation, Photonic Integration and EM-aware High Frequency Design, it is accessible to students of the European Master of Photonics, Engineering Physics, and to students of both the Electronic Circuits and Systems and the Communication and Information Technology subject areas.

Probleemstelling:

5G mobile networks set extremely ambitious goals in terms of throughput and capacity. As the sub-6 GHz spectrum is severely congested, a significant portion of the infrastructure will need to operate at mmWave frequencies (28GHz, 39GHz, ...) if these ambitions are to become reality. Although higher propagation loss is inevitable at mmWave frequencies, large antenna arrays (consisting of tens or even hundreds of antenna elements) with high-gain steerable beams can overcome this limitation. The signal distribution to such a high number of densely spaced antennas is extremely challenging. All-electronic approaches are highly problematic and typically suffer from low bandwidth, high loss and crosstalk.



Microwave/mmWave photonics, which leverages optical techniques for the distribution of RF signals, proves to be a powerful approach to alleviate these issues. Indeed, photonic technology naturally supports very large RF bandwidths, exhibits low losses and is immune to EMI issues. Therefore, the performance of future wireless network hardware can be pushed to the next level by bringing photonic building blocks, such as photodetectors and/or optical modulators ever closer to the antenna element.

Doelstelling:

In this master thesis, a highly efficient and scalable photonic antenna array will be developed for operation at mmWave frequencies. In a photonic antenna array, the RF signals are distributed to the different antenna elements by means of low-loss and high-bandwidth optical interconnects. After a thorough literature study to position the project with respect to the state-of-the-art, a suitable antenna topology will be selected and co-designed with an optoelectronic transducer. Subsequently, the attention will shift to an efficient optical interconnection scheme to feed the high number of closely spaced antenna elements in a scalable way. The end goal of the project is to fabricate prototypes of the photonic antenna array and validate them both at component-level (measurements in the anechoic chamber) and system-level (validation in high-speed data links).

The proposed project is highly multi-disciplinary. The student will build expertise on optoelectronics, the design, prototyping and measurement of high-speed interconnects (electrical and optical) and mmWave antennas. The research component of this master thesis lies in the design, fabrication and characterization of novel antenna systems with integrated onboard optoelectronic circuits that directly convert the optic signal to the RF signal radiated by the antenna.

Locatie:

iGent

Website:

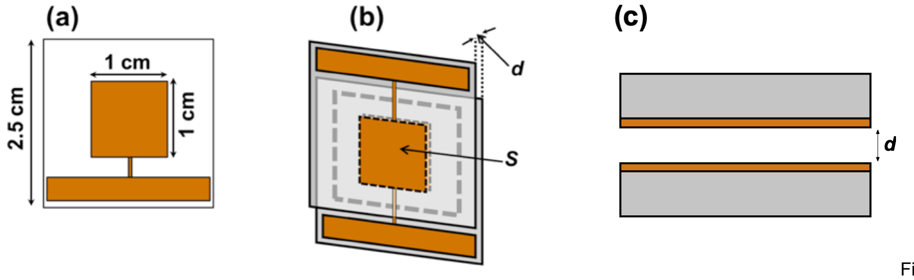
Meer informatie op: idlab.technology

33103: Modelling and simulation of two-dimensional electrophoresis

Promotor(en):	Martijn van den Broek, Filip Strubbe
Begeleider(s):	
Contactpersoon:	Martijn van den Broek
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The subject involves the study of physical phenomena with potential engineering applications. The development of a model/simulation of diffusion and drift of charged particles in a viscous environment relies upon knowledge and skills gained in the study programme of the Master of Science in Engineering Physics.

Probleemstelling:

The motion of charges in a viscous medium under the influence of an electric field in microstructures is a very general problem. It lies at the basis of our understanding of electrolytes, colloidal systems, electrophoretic and microfluidic devices and many other systems and applications. In general, the Poisson-Nernst-Planck (PNP) equations model the effects of diffusion and drift in the electric field on the charges and the induced change in the electric field by the charges. Over the years, the research group Liquid Crystals and Photonics (LCP), has gained a lot of expertise in these systems, by means of modelling, simulations and experiments. In particular, many aspects of the motion and generation of charges (colloidal particles or inverse micelles) in non-polar liquids has been investigated. However, with few exceptions, the model system was always a planar system as illustrated in Figure 1. Such a system can in very good approximation be modelled in one spatial dimension (1D): the direction perpendicular to the electrode planes. In the literature, only a few systems are reported where the one-dimensional



approximation is no longer valid. Fig. 1: Schematic of the planar microstructure, with glass plates in grey and electrodes in orange. (a) A glass substrate of thickness 1.1 mm coated on one side with a 20 nm thick layer of indium tin oxide. (b) The device is made by assembling the two substrates so that the electrodes overlap as indicated by S and the contact areas are not covered. Glass spacers are used to hold the substrates together at a distance d from one another. (c) Side view of the planar structure.

Doelstelling:

The aim of this thesis is to develop a simulation model for two-dimensional electrophoresis. Microstructures with significant deviations from the planar geometry such as in Figure 2 will be studied. New configurations can also be proposed. A previous effort (see [1] and Figure 2a) to solve the Poisson-Nernst-Planck (PNP) equations in two dimensions could be improved to reach better numerical stability. With the methodology developed within the LCP group for planar structures [2] as a guideline, the aim is to find reliable and robust simulation models, also for the extreme scenarios of high and low charge concentrations and high and low applied voltage. As in the 1D case, it may as well be possible to derive analytical expressions for the dynamical behaviour. Results can be compared with the 1D model and with available measurement data. A student interested in experimental work is invited to fabricate new typical non-1D microstructures and perform measurements.

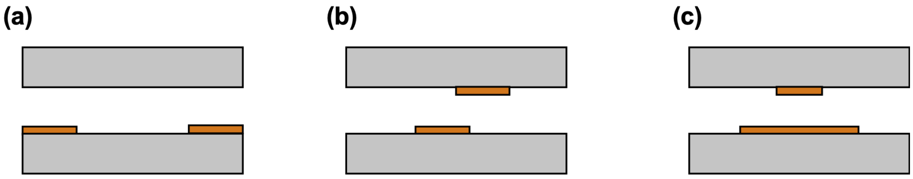


Fig. 2: Alternative microstructures with electrodes (orange) on glass substrates (grey).

Locatie:

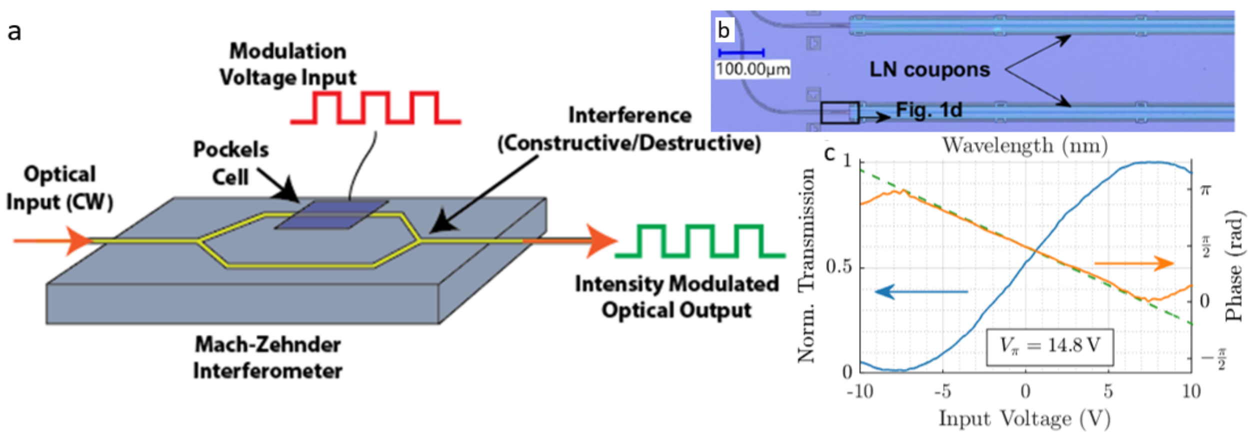
iGent, thuis

32465: Next generation integrated lithium niobate modulator for telecom and quantum applications.

Promotor(en):	Bart Kuyken, Stéphane Clemmen
Begeleider(s):	Tom Vanackere, Tom Vandekerckhove, Jasper De Witte
Contactpersoon:	Tom Vanackere
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	1
Motivering voor deze opleiding:	Since this topic focuses on research related to Photonic integration of nonlinear materials, photonic integrated circuit design and entails telecommunication and quantum optics research, it is accessible to students of the Photonics Engineering Master.

Probleemstelling:

Lithium niobate modulators use the Pockels effect to achieve high speed optical modulation and are used in a lot of telecommunication application today. The Pockels effect is a nonlinear effect that changes the refractive index of a material based on an electric field applied over the material. Chip scale integrated versions of these devices are being developed all over the world in multiple research groups. Recently we have developed and optimized a new fabrication technique for these highly sought after integrated devices [1]. We have successfully demonstrated high quality basic functionality of these devices, opening up exciting new possibilities to use these devices in many different applications [2, 3, 4].



[1] T. Vanackere, M. Billet, C. O. de Beeck, S. Poelman, G. Roelkens, S. Clemmen, and B. Kuyken, "Micro-transfer printing of lithium niobate on silicon nitride," in 2020 European Conference on Optical Communications (ECOC) (2020) pp. 1–4

[2] Yu, M., Barton III, D., Cheng, R. et al. Integrated femtosecond pulse generator on thin-film lithium niobate. Nature 612, 252–258 (2022). https://doi.org/10.1038/s41586-022-05345-1

[3] Wang, C., Zhang, M., Chen, X. et al. Integrated lithium niobate electro-optic modulators operating at CMOS-compatible voltages. Nature 562, 101–104 (2018). https://doi.org/10.1038/s41586-018-0551-y

[4] Zhang, M., Buscaino, B., Wang, C. et al. Broadband electro-optic frequency comb generation in a lithium niobate microring resonator. Nature 568, 373–377 (2019). https://doi.org/10.1038/s41586-019-1008-7

Doelstelling:

We are excited by our recent success with these modulators and would like to explore many different applications of these modulators or even other properties of the lithium niobate. These applications include data- and telecom applications but also multiple nonlinear and quantum application that can see use in quantum information systems like quantum computers (such as for photon pair generation [5]) are within the possibilities. Depending on the interest of the student we can tailor the project to one or more of these applications. All applications will include a strong modelling and simulation element but depending on the progress and interest of the student a fabrication and measurement part can be included in the project.

[5] Zhao, J., Ma, C., Rüsing, M., Mookherjea, S. High Quality Entangled Photon Pair Generation in Periodically Poled Thin-Film Lithium Niobate Waveguides. Phys. Rev. Lett. 124, 163603 (2020). https://doi.org/10.1103/PhysRevLett.124.163603

Locatie:

Technologiepark Zwijnaarde (Ardoyen), Thuis

Deze masterproef werd reeds 1-maal toegekend!

33159: On-chip 1x4 switches for quantitative phase imaging in the UV range: modelling and characterization

Promotor(en):	Nicolas Le Thomas, Wim Bogaerts
Begeleider(s):	Chupao Lin
Contactpersoon:	Nicolas Le Thomas
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	PICs topic

Probleemstelling:

Photonic integrated circuits (PIC) have already sparked a tremendous amount of applications using the light spectrum from visible to mid-infrared, but not yet in the ultra-violet (UV) range. The small wavelength associated with UV light is however appealing as it implies better optical resolution for microscopy. What currently hinders the widespread use of UV light for novel bioimaging applications is the cost and low performances of the existing bulky optical approaches. Developing a UV photonic integrated platform that is compatible with the materials and processes found in a CMOS-foundry, i.e. that can be scaled to 200- or 300 mm diameter wafers, will be a game-changer. It will represent a technological leap forward with many diverse potential applications in healthcare.

In the Photonic Research Group (PRG) at UGent we have already started to explore PICs in the UVA range, namely at 360 nm, and in the UVC range, at 266nm, in single mode waveguides made of aluminium oxide deposited with an atomic layer technique on thermal oxide wafers. As a first application, this achievement allowed us to fabricate UV-PICs for demonstrating a label-free, far-field, super-resolved structured light microscopy for which the UV-PICs provide the coherent structured illumination. In addition to imaging applications that are based on fluorescence, we have started to explore UV PICs for quantitative phase imaging (QPI) in view of sensing of bacteria. Such PICs are made of four integrated gratings that alternatively provide for different orientations a quasi plane wave illumination of the sample under test. The scattered light is imaged for each orientation. Applying the Kramers-Kronig relationships to the space domain and properly choosing the illumination angle, the dephasing induced by the sample is retrieved from the four collected images. As a result, the topography of the sample can be retrieved with a phase precision corresponding to 1.5nm for a current optical resolution of 400nm.

Doelstelling:

To automatize our QPI technique and push further the phase detection limit beyond the state of the art, we are investigating 1x4 switches made of MZI and thermal phase shifters. These integrated switches are controlling the alternate triggering of each gratings. Proper operation of these devices requires understanding the impact of the heat management in the photonic circuit. The master thesis project will focus on the modelling the impact of the heat transfer from and between the different MZI on the operating point of the circuit. Several heating schemes will be explored and simulated with the Comsol software or the Lumerical software. The switches will be characterized with an advanced optical set-up.

Locatie:

Ardoyen

32826: Optical characterization of smart contact lenses

Promotor(en):	Herbert De Smet, Andrés Felipe Vasquez Quintero
Begeleider(s):	
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Building and using an optical setup to characterize (among others) MTF and haze of smart contact lenses

Probleemstelling:

In a smart contact lens, a microsystem is integrated into the lens material. This can include a sensor, an electro-optical element to improve the vision or even a miniature projector to project images directly onto the retina.

Especially for the class of smart lenses that aim at actively improving the vision, for example the artificial iris lenses or the tunable dioptric power lenses, the effect of the electro-optical element on the overall lens quality is an important specification.

Standard lens characterization tools often are not suited to take into account the presence of such elements inside the lens.

Doelstelling:

In this master thesis, the student will explore the possiblity of building a dedicated optical setup to characterize smart contact lenses with integrated electro-optical elements.

Two of the specifications to be measured are the amount of haze and the MTF of the lens, but other optical properties may also prove to be relevant.

The student will create a well-thought optical setup with which some of the relevant optical properties can easily and reliably be measured. This setup will be applied to a number of available smart lens samples.

Locatie:

Optical lab in Ardoyen building 125 + home

Samenwerking met bedrijf of non-profit organisatie

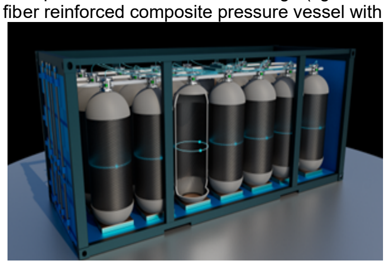
Bedrijf: Azalea Vision
Samenwerking: copromotor

31965: Optical connector for smart composites

Promotor(en):	Jeroen Missinne, Eli Voet
Begeleider(s):	Thibault Juwet
Contactpersoon:	Thibault Juwet
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Schoonmeersen, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The topic deals with optical sensors and optical connections

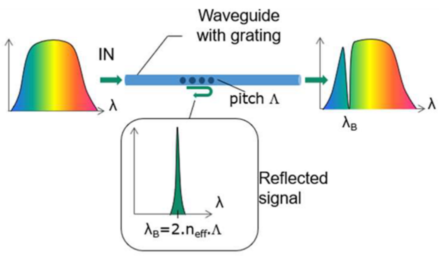
Probleemstelling:

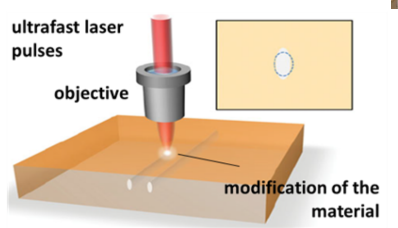
Glass or Carbon reinforfced composites are widely used in high end applications like aerospace vehicle components and pressure vessels for H2 storage (figures on the right depicting a stack of H2 pressure vessels which can act as fuel cell for e.g. a cargo ship and a real life glass fiber reinforced composite pressure vessel with embedded fiber Bragg grating sensors). Thes composites offer a high strength, low weight and very high degree of design flexibility. These composite structures can be made smart by embedding optical fibers which can be used to monitor the deformation and/or temperature in the composite in real time. Different optical sensing techniques can be used one of which is the use of fiber Bragg gratings (see figure below). Smart composites offer an extra advantage as it helps in design validation and lifecycle monitoring. With this information the safety of the composite can be ensured while less testing is needed and safety factors can be lowered considerably which results in a huge decrease in production cost.

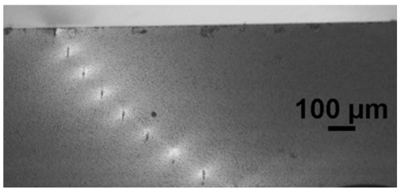


However to be able to produce high volumes of smart composite in automated production lines we need good techniques to connect the embedded optical fibers with an external optical read-out fiber (connect to a laser source and spectrum analyser). In this thesis the goal is to investigate methods for connecting an optical fiber based on evanescent waveguide coupling [1-2]. In an intermediate step the coupling between waveguides in glass will be studied. To tackle this we make use of femtosecond laser waveguide inscription in glass [3] because it gives us a lot of designing opportunities. Very short laser pulses are focused in the glass substrates creating very local structural changes in the glass. A pattern of locally modified glass can then be created in the glass by moving the laser around and thus creating waveguides. The technique is schematically shown in the right figure below together with a cross section of a glass piece with waveguides inscripted at different depths. In addition the inscription of Bragg gratings in the glass using the same technique will be studied.

This thesis is in collaboration with the company Com&Sens (https://com-sens.eu/). Depending on the progress testing with coupon composite pieces can be performed at Com&Sens in Eke.







[1] J. Lapointe, M. Gagné, M. Li, and R. Kashyap, "Making smart phones smarter with photonics," Opt. Express 22, 15473-15483 (2014).

[2] https://optics.ansys.com/hc/en-us/articles/360042304694-Evanescent-waveguide-couplers

[3] Low, D., Xie, H., Xiong, Z. *et al.* Femtosecond laser direct writing of embedded optical waveguides in aluminosilicate glass. *Appl. Phys. A* **81**, 1633–1638 (2005). https://doi.org/10.1007/s00339-005-3324-z

Doelstelling:

The goal of this thesis is to:

1) Produce and characterize laser written waveguides

2) Make couplers between said waveguides. Optimize the design and methods.

The work varies between experimental work (producing samples, polishing, measurements) and simulation work depending on the students capacieties and preferences. The concrete content of the thesis will be determined in consultation with the student. Roughly, the thesis will be organized as follows:

1. Literature study to get acquainted with the laser written waveguide (LWW) technique and concept of evanescent waveguiide coupling.
2. Realization and characterization of LWWs in glass
3. Design, realisation and evalutation of couplers between the laser written waveguides in glass
4. (Simutaneaus with 3) simulate and optimize the used configurations

Locatie:

UGent campus Ardoyen (Elis department) (fabrication, testing, design), Com&Sens offices in Eke (reachable by bus) (fabrication and testing), at home

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: Com&Sens
Samenwerking: promotor + begeleider + use case

Opmerkingen:

Experimental work mostly in Technology park in Zwijnaarde. Simulations can be performed from home (depending on the students preferences). Possibility to test on real life composite samples in Eke depending on the progress.

Deze masterproef werd reeds 1-maal toegekend!

34971: Optical connector for smart composites

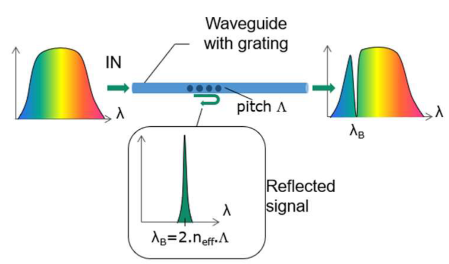
Promotor(en):	Jeroen Missinne, Eli Voet
Begeleider(s):	Thibault Juwet
Contactpersoon:	Thibault Juwet
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

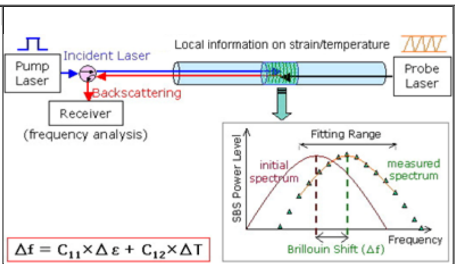
Glass or Carbon fiber reinforced composites are widely used in high end applications like aerospace, space, vehicle components, flexible pipelines and composite rod reinforced (high voltage) power lines, see picture below.

Carbon composite rods. Courtesy of Epsilon composite (https://www.epsilon-cable.com/)

These composites offer a high strength, low weight and very high degree of design flexibility. Such composite structures can be made smart by embedding optical fibers which can be used to monitor the deformation and/or temperature in the composite in real time. Different optical sensing techniques can be used to monitor the composite structure such as the use of fiber Bragg gratings (FBG) with semi-distributed sensing points along the optical fiber or also distributed fiber optic sensing techniques such as BOTDA, OFDR, etc.



FBG principle



BOTDA principle

Smart composites offer an extra advantage as it helps in design validation and lifecycle monitoring. With this information the safety of the composite can be ensured while less testing is needed and safety factors can be lowered considerably which results in a huge decrease in production cost.

However to be able to produce high volumes of smart composite in automated production lines we need good techniques to connect the embedded optical fibers with an external optical read-out fiber (connect to a laser source and spectrum analyser).

In this thesis, the goal is to investigate and optimize methods for connecting (multiple) optical fibers embedded inside carbon or glass fiber reinforced rods, plates or pipes based on self-written waveguide technology [1-2].

[1] http://hdl.handle.net/1854/LU-8532538

[2] http://hdl.handle.net/1854/LU-5657286

Doelstelling:

The work varies between experimental work (producing samples, polishing, measurements, python programming) and simulation work depending on the students capabilities and preferences. The work will mostly be performed at the company Com&Sens (https://com-sens.eu/) and in the technologiepark in zwijnaarde or at home (simulations).

The goal of this thesis is to:

1) Design, produce, characterize and optimize fiber optic connections with self-written waveguides

2) Optimize the design and read-out methods.

The concrete content of the thesis will be determined in consultation with the student. Roughly, the thesis will be organized as follows:

1. Literature study to get acquainted with the self-written (SWW) technique and concept of embedded fiber optic sensing.
2. Realization and characterization of SWWs using different approaches for smart composites with FBG sensors and distributed sensing technology using the optical connection setup at Com&Sens
3. Optimize approaches and automation
4. Design, realisation and evaluation of different protection/packaging methods for the optical connection
5. Connect multiple fibers embedded within the rod (oriented at 120°, 240°,360° of the rod)

Locatie:

Company Com&Sens (https://com-sens.eu/) and in the technologiepark in zwijnaarde or at home (simulations)

Onderwerp voorbehouden voor Robin Goedefroot

Deze masterproef werd reeds 1-maal toegekend!

33148: Optical Diagnostics: Antibiotic-Susceptibility-Testing via Surface-Enhanced Raman Spectroscopy

Promotor(en):	Heidi Ottevaere
Begeleider(s):	Mehdi Feizpour
Contactpersoon:	Heidi Ottevaere
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Opleiding Fotonica is vereist om deze masterproef succesvol af te werken

Probleemstelling:

Surface-Enhanced Raman Spectroscopy (SERS) is a surface-sensitive technique that enhances Raman scattering by using rough metal surfaces or nanostructures with metallic coatings [1]. Spectroscopy based on SERS has been applied increasingly to reach higher detection sensitivity by integrating Au- and Ag-nanosubstrates, nanoparticles or specific SERS- biotags in microfluidic systems for drug and cell detection. The enhancement is mainly initialized by localized surface plasmon resonance (LSPR) [2] of the electromagnetic field. The enhancement factor of SERS can be as large as ~1011. This increased sensitivity, makes SERS a suitable candidate for the analysis of small concentrations of (bio-)molecules/cells. This is especially beneficial for biomedical diagnostic applications such as diagnosing bacterial infections [3,4]. After such diagnosis, proper antibiotic treatment should be decided upon. Doctors use antibiotic susceptibility testing (AST) to make this decision [5]. However, this is usually a time-consuming process as it involves long and complex steps. Thus, this master thesis will focus on a combination of SERS and microfluidic approaches for a fast, reliable, and cost- efficient real-time optical analysis which can overcome the limitations of the standard techniques. The project starts with a SERS investigation of safe bacterial samples using a Renishaw InVia confocal Raman microscope (see Fig 1). This will consequently lead to the on-chip study of bacterial interactions with antibiotics. An optimization of the microfluidics and the optical read-out will follow to include the findings in a final lab-on-a-chip capable of the aforementioned analysis. Obtained results will be compared with the state-of-the-art results. The final results of this project will potentially help the doctors in a rapid decision on a treatment, hence improving the rate of mortality and recovery of the patients. Furthermore, the wide-spread use of antibiotics is causing antibiotic resistance in common pathogenic bacteria. The developed AST strategy should also enable the doctors to prescribe more accurate doses of antibiotics.

1. Le, Fei, et al. "Metallic nanoparticle arrays: a common substrate for both surface- enhanced Raman scattering and surface-enhanced infrared absorption." ACS nano 2.4 (2008): 707-718.
2. Perney, Nicolas MB, et al. "Tuning localized plasmons in nanostructured substrates for surface-enhanced Raman scattering." Optics express 14.2 (2006): 847-857.
3. Locke, A.; Fitzgerald, S.; Mahadevan-Jansen, A. Advances in Optical Detection of Human-Associated Pathogenic Bacteria. Molecules 2020, 25, 5256. https://doi.org/10.3390/molecules25225256
4. E. Akanny, A. Bonhommé, F. Bessueille, S. Bourgeois & C. Bordes (2020) Surface enhanced Raman spectroscopy for bacteria analysis: a review, Applied Spectroscopy Reviews, DOI: 10.1080/05704928.2020.1796698
5. Khan, Zeeshan A et al. “Current and Emerging Methods of Antibiotic Susceptibility Testing.” Diagnostics (Basel, Switzerland) vol. 9,2 49. 3 May. 2019, doi:10.3390/diagnostics9020049

Doelstelling:

Specific objectives

10% literature study; 30% Physics modelling and signal processing; 60% experimental work

1. Study the state-of-the-art of Raman spectroscopy, surface-enhanced Raman spectroscopy, and the applications of SERS in health-care related sensors and diagnostics.
2. Perform bacterial cell studies to understand the characteristics of the control samples (see Fig 1):
    - Learn to cultivate the samples and prepare them for Raman measurements.
    - Make the measurements in cuvettes using the Renishaw InVia confocal Raman microscope.

o Try different protocols (liquid, dry, etc.) and use complementary tools such as a scanning electron microscope to visualize the cells.

- Study the peak attributions and biochemical interaction sites of the cells and the substrate.
- Assessment of the challenges with SERS sensing of bacteria.

1. On-chip measurements with antibiotic mixing:
    - Select a commercially available microfluidics design (no-flow) suitable for the antibiotic susceptibility testing (cultivation steps might be required).
    - Study the Raman spectrum of the chosen antibiotic to be able to differentiate the peaks. Look for processing techniques that can subtract those effects.
    - Make measurements under the Raman microscope and investigate the changes to the formerly characterized peaks and new peaks formed due to the antibiotic.
    - Study the spectral changes over time and try to find the earliest cell-deactivation unset.
    - Assess the state of the cells (e.g. dissolved/ripped cell walls) via atomic force microscopy or scanning electron microscopy and make comparisons to the control cells.
    - Draw conclusions based on the results and find aspects to be optimized.
2. Final design:
    - Come up with a final design for the microfluidic chip capable of measuring in flow considering the optimization aspects concluded in the previous task.
    - Try what you learned so far to arrive at the final result of minimum effective dose of two different types of antibiotics and for two types of bacteria (both gram-positive and -negative bacteria types) and their mixture.

Locatie:

VUB

Onderwerp voorbehouden voor Halewijn Van den Bossche

Deze masterproef werd reeds 1-maal toegekend!

32114: Optical manipulation and detection of microparticles with non-Gaussian beams

Promotor(en):	Filip Beunis, Kristiaan Neyts
Begeleider(s):	Yera Ussembayev
Contactpersoon:	Filip Beunis
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Optical tweezers are used for characterizing micrometer-sized particles in fluids. Particles with a higher refractive index than the surrounding liquid are attracted to the focus and can remain trapped if the power of the laser is sufficient. The source of this ‘classical’ trap is the intensity gradient of the beamÎ¾ the particle is attracted towards the region with the highest optical density. Recently, attention has been drawn to developing new types of traps that are non-Gaussian. In the LCP group, we have built a setup that can transform an incident Gaussian beam into any type of beam or trap. This opens a lot of possibilities, such as Laguerre-Gaussian beams, Bessel beams, optical solenoid beams, phasegradient line traps, etc… When a particle is not spherical, the orientation of the particle can be observed with the microscope. Linearly polarized laser beams or laser beams with rotational momentum can cause an optical torque on a particle.

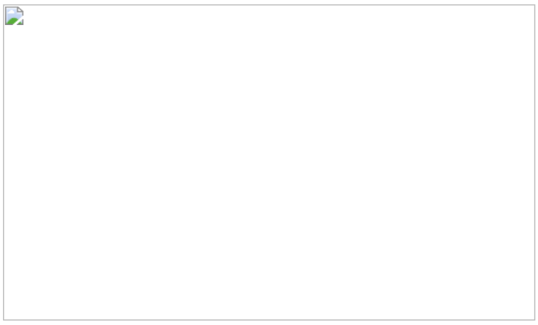


Figure: Different kinds of laser beams allow control, not only over the particles position, but also over its orientation.

Engineering physics aspects: the focus on physical phenomena used to achieve useful applications fits perfectly within engineering physics
This thesis proposal is linked to the following clusters of elective courses: Photonics, Nano, Materials

Doelstelling:

Non-Gaussian beams have complex phase profiles and intensity distributions. These tailored traps can offer stronger traps and more accurate detection beams. The extra degrees of freedom allow to exert a torque on a colloidal particle, to trap low index particles or to apply a force that is in the opposite direction as the beam propagation. Using the existing setup, you will design the wavefront by steering a spatial light modulator (SLM) and generate optical beams that can realize particular manipulations. This project involves designing SLM patterns that generate the desired diffractive beams and performing measurements with trapped particles.

The staff of the LCP group will provide you with all the necessary help and know-how, but we also encourage you to take the initiative to come up with your own ideas to tackle the project. Where feasible we will support you to develop these ideas.

Locatie:

iGent, Zwijnaarde

Website:

Meer informatie op: lcp.elis.ugent.be/

32115: Optical trapping in complex media

Promotor(en):	Filip Beunis, Kristiaan Neyts
Begeleider(s):	Yera Ussembayev
Contactpersoon:	Filip Beunis
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Biomedical Engineering, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	International Master of Science in Biomedical Engineering
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Optical tweezers are a powerful instrument to examine micrometer-sized objects immersed in a fluid and are a widespread tool in various fields of research, ranging from molecular biology over fundamental cell research to colloidal science and nanotechnology. With optical tweezers it is possible to hold particle in place and manipulate its position by using a laser beam tightly focused by a microscope setup. Moreover, they allow for very sensitive force measurements to investigate various kinds of interactions between the microobjects.
The performance of the optical tweezers relies mainly on the quality of the diffraction limited focus of the laser beam and on the intensity distribution of the light. Various aberrations, originating from the microscope optical components, the suspending fluid or the micro-object itself, deteriorate the beam quality and reduce the optical tweezers operation. The goal of this thesis is firstly to investigate novel ways to compensate for these aberrations by manipulating the phase front of the laser beam with a spatial light modulator (SLM). Secondly, this SLM will be used to generate arbitrary optical landscapes, enabling the trapping of complex structures.

As a proof of concept water droplets in a larger oil droplet (a double emulsion) will be trapped and manipulated. This allows us to investigate the fundamental principles behind the osmotic swelling/shrinking of these droplets under changing conditions. A better understanding of these processes in double emulsions is important for e.g. pharmaceuticals, food processing or water treatment.

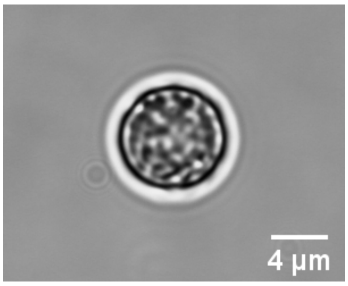


Figure: Trapped double water-in-oil-in-water particle.

Engineering physics aspects: the focus on physical phenomena used to achieve useful applications fits perfectly within engineering physics
This thesis proposal is linked to the following clusters of elective courses: Photonics, Nano, Materials, Bio

Doelstelling:

This master project starts from an existing optical tweezing setup where a spatial light modulator is already introduced. The SLM creates a holographic image of the trapping beam using phase modulation of the beam. For this, various new algorithms will have to be developed and programmatically applied. Next, the algorithms will be used in a feedback loop resolving static and dynamic aberrations of the system. In a final step these algorithms will be used to generate optical landscapes, eventually resulting in the optical trapping of complex structures such as a water-in-oil-in-water double emulsion droplet.

The staff of the LCP group will provide you with all the necessary help and know-how, but we also encourage you to take the initiative to come up with your own ideas to tackle the project. Where feasible and within the scope of the project, we'll support you to develop these ideas.

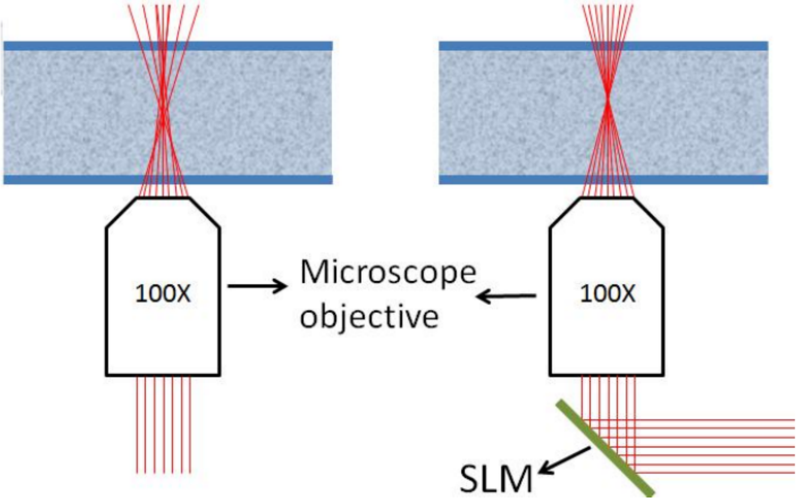


Figure: Aberrations introduced by a suspending fluid deteriorate the performance of optical tweezers (left). This master thesis uses a spatial light modulator (SLM) to compensate for these aberrations and create optical landscapes to trap complex structures.

Locatie:

iGent, Zwijnaarde

Website:

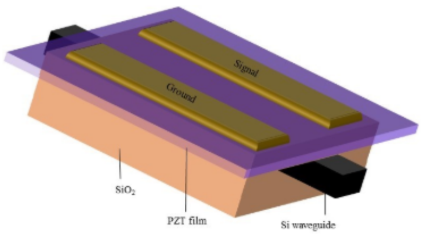
Meer informatie op: lcp.elis.ugent.be/

31884: Optimization of electro-optic modulators for photonic neuromorphic circuits

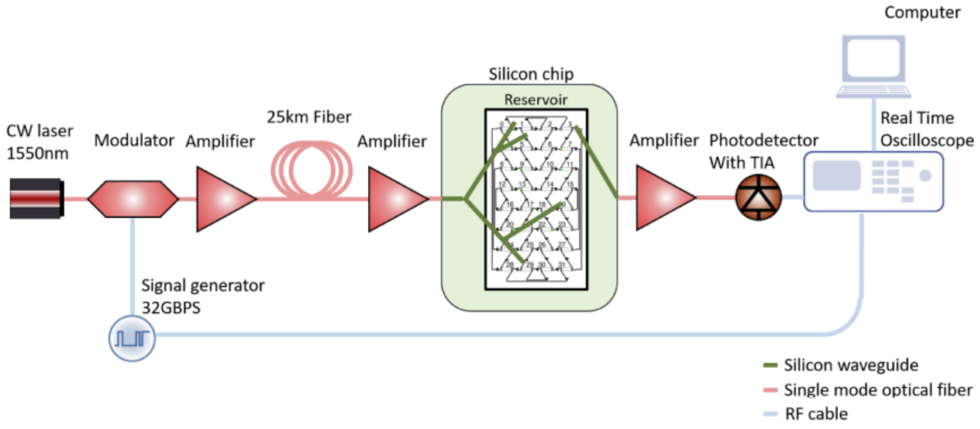
Promotor(en):	Jeroen Beeckman, Peter Bienstman
Begeleider(s):	Enes Lievens
Contactpersoon:	Enes Lievens
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The optimization of waveguides and modulators for integrated photonics on silicon is closely related to the MSc Photonics Engineering.

Probleemstelling:

Lead zirconate titanate (PZT) is a perovskite materials which exhibits both a piëzoelectric and electro-optic effect. In our research group, novel techniques have been developed in thin-film deposition of this material on photonics integrated circuits (PICs). Deposition of this material on these photonic components opens up a wide array of applications through the interaction of this material with the light travelling through the waveguides beneath it, creating electro-optic modulation [1]. In this thesis, these electro-optic modulators are designed and used specifically for photonic neuromorphic computing, which is a photonics-based implementation of machine learning.



Currently, almost all machine-learning based work is done through a software implementation on a computer. Our goal is to go one step further and design a state-of-the-art photonic chip with hardware based machine-learning implementation. The transition from software-based to hardware-based neuromorphic computing opens up new opportunities in research as well as industry, as this technology offers both extremely high bitrates (>10Gb/s) together with very low energy consumption due to the passive nature of these devices [2]. In order to achieve this, a neuromorphic network based on reservoir computing is used [3]. Here, we create a nonlinear network of nodes (the reservoir), connected to a linear set of training weights (the readout). The electro-optic modulators are a perfect candidate for these training weights, as the modulation intensity presents a ready to train parameter.



Doelstelling:

The goal of this thesis is to design and optimize tuneable modulator devices in order to integrate them on on-chip, fully photonic neuromorphic networks. The student will be involved in a multi-disciplinary team of PhD researchers and will gain first-hand experience in the design of photonic chips. A starting point is provided through existing modulator devices, and main work will involve the optimization of these device designs through simulation and experiments. By being a part of this project, the student will have to opportunity to work in various stages of photonic circuit design while learning various skills applicable in later stages of their career, going from undestanding and setting up (multiphysics) simulations, working with experimental setups up to aiding in processing of silicon photonic chips. This gives the student the ability and freedom to explore different aspects of research with close guidance. All aforementioned aspect are necessary in order to integrate tunable modulators on photonic neuromorphic networks.

Locatie:

iGent

Website:

Meer informatie op: lcp.elis.ugent.be

Deze masterproef werd reeds 1-maal toegekend!

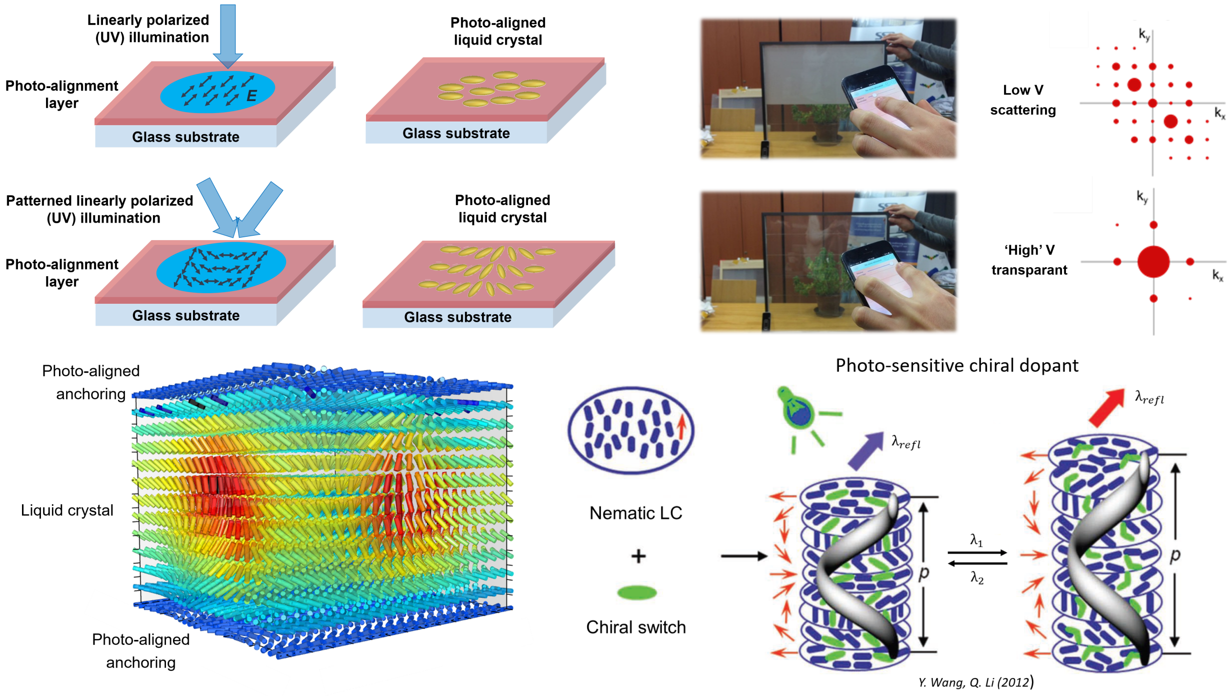
31738: Photo-sensitive liquid crystal gratings and smart windows

Promotor(en):	Kristiaan Neyts, Inge Nys
Begeleider(s):	Brecht Berteloot
Contactpersoon:	Kristiaan Neyts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

Probleemstelling:

Optical and especially electro-optical components that modulate the properties of a light wave have become indispensable in our daily lives. They are the enabling components in displays, lasers, LEDs, cameras, optical filters etc. Liquid crystal is an interesting type of organic soft material that is often used in electro-optical devices. The material is liquid but also has a certain degree of long-range ordering. The liquid crystal can self-organize into complex structures and is responsive to different external stimuli such as heat or electric field. Thanks to the long-range ordering of the anisotropic molecules, liquid crystal devices can have unique electro-optic properties. The stimuli-responsiveness of the liquid crystal makes the devices easily tunable.

Nowadays liquid crystals are widely used in flat panel displays (known as LCDs or liquid crystal displays) but they can also be used in other applications such as tunable filters, lenses, smart windows, etc. In this thesis the use of liquid crystals in tunable gratings and smart windows will be investigated with the help of photosensitive liquid crystal (see figure). The alignment at the substrates will be patterned with the help of a photo-alignment techique and a chiral dopant with photosensitive helical twisting power will be added in the liquid crystal mixture to obtain post-fabrication tunability. Tuning of the device properties with the help of an applied electric field and/or illumination will be tested.



Doelstelling:

The aim of this master thesis is to realize liquid crystal cells that can electrically and/or optically switch between different optical states (transparent, scattering, reflective, etc.). Optical tuning of the device properties will be investigated by adding a light sensitive chiral dopant in the liquid crystal. This will allow to obtain reversible switching (with e g. UV and red illumination) between liquid crystal structures with a large and small amount of chirality. In combination with well-designed alignment patterns at the substrate, devices with the desired electro-optical properties (e.g. grating with efficient reflection, smart windows with strong scattering, etc.) will be obtained.

To control the surface alignment, a photo-alignment technique will be used in which a photo-sensitive alignment layer is spincoated on the substrate and illuminated with polarized (UV of blue) light (see figure). With this technique the liquid crystal near the substrate can be oriented according to the polarization direction of the light. Recently the LCP group has obtained extensive expertise in the realization of photo-alignment patterns with the help of two different illumination setups. By locally varying the polarization direction of the UV or blue light, complex alignment patterns can be created near the surface. Because liquid crystals are a kind of soft matter, the orientation close to the surface also influences the behavior in the entire layer. Before filling the cell with the photo-sensitive LC mixture, the alignment pattern at the substrates can be fixed, so that it is not influenced anymore by subsequent illuminations (to tune the device properties).

To design a liquid crystal device with the desired optical properties, the cell thickness will be optimized and different alignment patterns, different types of liquid crystals and different dopants will be tested. The device properties will be measured experimentally and, depending on the interest of the student, can also be simulated (with software that is available in-house). In the most ambitious scenario, a liquid crystal smart window will be produced that only consumes power for a short time when switching between the different states. To produce such a low-power device, bistablility (tristability) of the obtained liquid crystal configurations is necessary. This should be possible by optimizing the device parameters (alignment pattern, liquid crystal material, thickness, voltage treatment).

Locatie:

iGent (Zwijnaarde), home

32594: Photonic Design Automation via Bayesian Active Learning

Promotor(en):	Tom Dhaene, Wim Bogaerts
Begeleider(s):	Thijs Ullrick
Contactpersoon:	Thijs Ullrick
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

The design of state-of-the-art photonic devices is a complex task. Indeed, designers have to make the proper tradeoffs between conflicting design requirements while considering photonic phenomena such as wavelength dispersion, back-reflections, and scattering. In this scenario, Computer-Aided Design (CAD) simulations are an essential tool. However, due to the complex geometries of the devices and the increasing precision of the electromagnetic simulators, simulations are often expensive, both in terms of computational time and resources. Hence, it is of paramount importance to limit the number of (expensive) simulations during the design phase. A machine learning technique that deals with such a problem is known as Bayesian active learning and while being well-established for electronics design, the technique is now also gaining attention from both academic and industrial researchers for implementation in the photonics design flow.

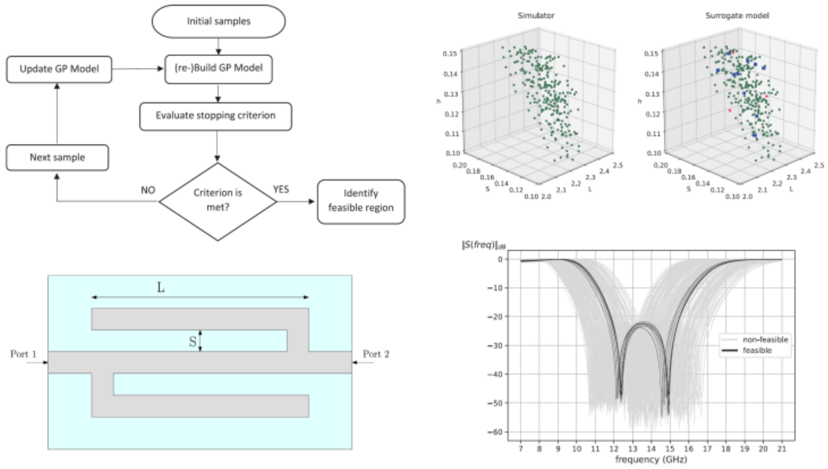


Fig. 1: Feasible region identification of a microwave microstrip band-stop filter using Bayesian active learning. In this thesis we will transfer this method to the photonic domain to optimize silicon photonic components and circuits.

Doelstelling:

Bayesian active learning intelligently and sequentially extends the dataset to reveal the desired properties of the device under study. The goals of this thesis are to investigate Bayesian active learning techniques and to develop a modeling tool based on these techniques for photonic design purposes. Such an approach allows the identification of feasible regions and the maximum location of a function during the design phase, resulting in photonic devices with optimized performance. To obtain an efficient modeling scheme, state-of-the-art machine learning techniques will be applied. The developed methodology will be tested on the design of photonic devices characterized by many (geometrical and material) design parameters.

Locatie:

iGent Tower, Zwijnaarde

Opmerkingen:

Theory (50%), implementation (50%)

32138: Photonic Reservoir Computing for Equalizing Optical Communication Systems

Promotor(en):	Peter Bienstman
Begeleider(s):	Sarah Masaad
Contactpersoon:	Sarah Masaad
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Photonics

Probleemstelling:

Computers are powerful for performing algorithmic tasks but leave much to be desired when it comes to abstract problems like speech recognition. The human brain, on the other hand, is better suited to perform such tasks efficiently and effectively. In attempts of emulating this, Artificial Neural Networks (ANNs) were loosely built on the concept of biological neural systems. The Recurrent Neural Network (RNN) is a type of ANN that introduces a “memory” to the network by having feedback connections and loops between its neurons (or nodes). The weights of these connections need to be optimized in the training process, allowing the RNN to perform classification or regression. While such networks are powerful for time-dependent tasks, their optimization is computationally expensive.

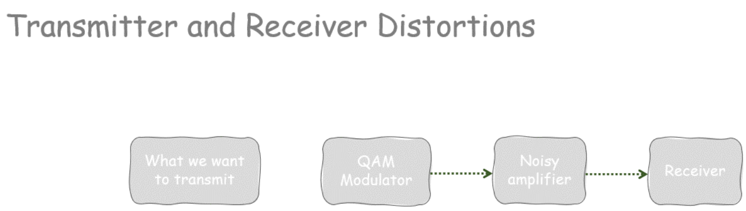
Reservoir Computing (RC) is a paradigm initially devised to train RNNs by reducing the number of optimization variables. The reservoir has random but fixed connections between its nodes. The only change occurs at the output layer, where the reservoir states are weighted and summed. Thus, the training optimizes these output weights but leaves the internal weights unchanged. Although reservoir computing was originally invented in computer science as a software solution to bypass the computational cost of optimizing RNNs, it is perfectly suited for implementation in various hardware platforms. The reservoir can be physically implemented using “any” nonlinear dynamic system. These implementations do not suffer from classical digital computer bottlenecks and are by nature more convenient to operate neuromorphic (i.e. brain-like) computing schemes.

Silicon photonics is a CMOS-compatible platform in which waveguides, splitters and combiners are used to guide light through a silicon chip. It has the advantages of being compact, inexpensive to produce in high volumes and having a mature fabrication process. Optics also supports much higher bandwidths than electronics and in principle, one can exploit many nonlinear processes in photonics.

To this end, an integrated photonic reservoir chip is a promising model for computing with light. An optical input is injected into the reservoir where it is manipulated and a desired optical output is retrieved. The reservoir can be optimized through simply changing the readout weights, which allows it to be easily used in different applications. One such application where photonic reservoir computing fits in naturally is optical telecommunication. Currently, optical signals are detected and processed using electronic solutions which are power hungry and introduce latency. Through leveraging photonic reservoirs, distorted optical signals can be processed optically to correct for some errors that occur during transmission.

Doelstelling:

Fiber optic communication systems experience a set of problems that are challenging to resolve be it individually or together. Such problems can arise at the transmitter (non-linear response of MZM's, phase noise ..), in the fiber (dispersion, Kerr nonlinearities, crosstalk...), or at the receiver (nonlinear signal-signal-beat-interference...). Some of these problems are modelled below.



A reservoir can be used as an optical equalizer, which helps undo such distortions before the signal is detected by the receiver. The reservoir can also be integrated in an equalization pipeline, such that it would work alongside standard DSP methods by tackling some of the problems optically first. In the example below, a reservoir is trained to equalize dispersion and nonlinear effects for a 64 QAM signal detected using a Kramers-Kronig receiver.

Recent simulation and practical work have shown that we can successfully address many of these problems using reservoir computing, but there's still many more to go. In this project we will tackle a set of problems with the goal of improving the overall performace of a new communication system. The thesis combines machine learning concepts, integrated photonics, and optical communication. It will mainly consist of simulation work using Python, where exisiting frameworks for machine learning and photonic circuit simulation will be used. VPI Photonics will also be used for the generation of communication signals. Depending on the student's interests, there is also a possibility to test the simulation outcomes using a high-speed measurement setup.

Locatie:

iGent (or remote)

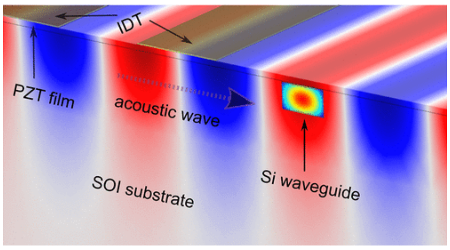
Deze masterproef werd reeds 1-maal toegekend!

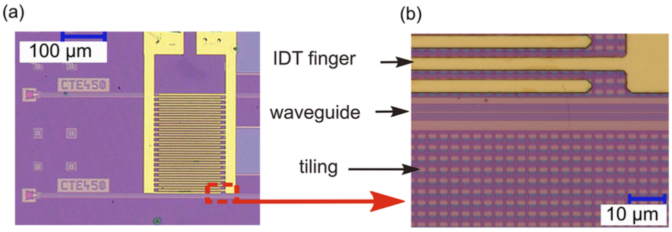
32017: Piezoelectricity of thin films for applications in energy harvesting and acousto-optics

Promotor(en):	Jeroen Beeckman, Hannes Rijckaert
Begeleider(s):	Enes Lievens
Contactpersoon:	Jeroen Beeckman
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Measurements of the piezoelectric coefficient will be done in this thesis using a optical interference setup that is available in the group. When the topic is chosen by a photonics student, the thesis will focus more on acousto-optic applications.

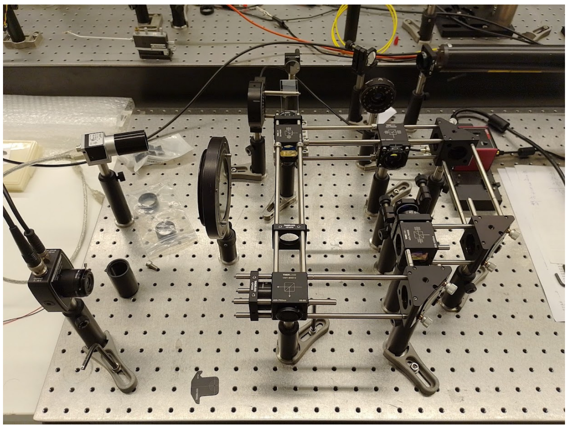
Probleemstelling:

Piezoelectric materials have the ability to convert mechanical deformation into an electric field through the piezoelectric effect and vice versa (through the converse piezoelectric effect). Today, piezoelectric materials play an important role in numerous applications such as sensors, actuators, transducers and energy harvesters. Piezoelectric energy harvesters cannot reach the efficiency and scale of solar cells or wind turbines, but they are excellent power sources where electrical cables are undesired and miniaturization is a key parameter. For supplying power to portable electronics, wearable and implantable devices for monitoring human health and wellness, piezoelectric energy harvesters with very high performance and minimal footprint are required, while biocompatibility is another major requirement. The focus of piezoelectric materials used to be on bulk materials, but a lot of interest is shifting towards thin films. Piezoelectric thin films play a vital role in acoustic wave based electronic amplifiers and filters. In photonic integrated circuits, piezo-electric actuators are used to manipulate light. But also acoustic waves can be generated on chip. Integrated acousto-optics has become a mayor research topic due to a multitude of physical effects that appear when acoustic waves interact with light waves. Recently, a collaboration between the LCP group and the photonics research group resulted has demonstrated that acoustic waves generated using a PZT (lead zirconate titanate) thin film can modulate light in a waveguide up to GHz frequencies (https://pubs.acs.org/doi/10.1021/acsphotonics.1c01857?ref=PDF).





PZT is a good piezoelectric material, but more advanced thin films are being developed in a research project that involves, among others, the chemistry department of Ghent University. Using these advanced materials, it is expected to go beyond what is possible with materials that are available today. For the characterization of these materials, a setup has been developed that can measure displacements down to 10 pm (10e-11 m!!!). This setup is based on the interference of a reference laser beam and a beam reflected from the vibrating surface. A photo of the setup is shown below.



Using this setup it is currently possible to measure one of the piezoelectric components (the d33 component), but it should be possible to extend the setup and to get more information from the piezoelectric film (d13 components, elastic properties, etc.). This information is indispensable for desigining and optimizing novel electronic and photonic components using the piezoelectric effect.

Doelstelling:

The aim of this master thesis is to extend the optical setup so that other piezoelectric components can be measured for thin films. To achieve this, a number of things need to be done:

- Perform simulations of the piezoelectric induced strain in devices and verify that this can be measured.
- Adapt the optical setup and adapt the automated measurement program.
- Work out procedures for obtaining the different piezoelectric components and other material parameters.

Once the setup is ready a number of newly developed materials can be characterized and compare their properties with values in literature for their bulk counterparts.

Design a practical component based on the new materials. Depending on the background of the student, this can be an electronic filter, an acousto-optic filter or a micro energy harvester.

Locatie:

iGent, home

Website:

Meer informatie op: lcp.elis.ugent.be

32796: Plasmonic Logic System Modelling

Promotor(en):	Wim Bogaerts, Pol Van Dorpe
Begeleider(s):	Christian Haffner
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	exploring new plasmonic logic circuits and systems

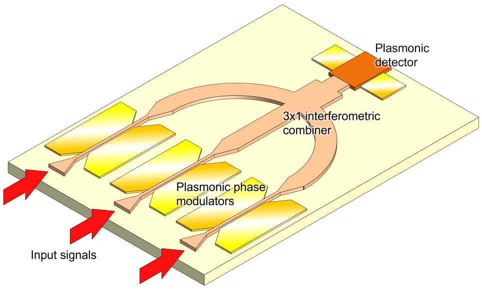
Probleemstelling:

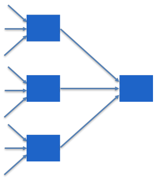
CMOS technology through transistor scaling has been the main driver for the huge productivity growth registered over the past 50 years. However, transistor scaling is approaching its physical limits and new devices, circuits and architectures are being investigated to continue the performance scaling, including architectures that step away from using electronic signals, moving into the optical or photonic domain.

To replace the silicon transistor, many devices have been proposed and are currently at varying levels of maturity – from concept to experimental demonstration. Conceptually they range from transistors with a different channel material (III-V semiconductors, graphene or other 2D materials) to devices where energy filtering can be employed (tunnel FET) to devices which are based on spin or to excitons or surface plasmons.

A very different approach is to implement logic through photons. These are typically not good at strong nonlinear operations, but there have been some proposals to make very high-speed gates using optical interference. While these can be extremely fast, optical structures are generally much larger than transistors. A possible solution is to use plasmonics: these are optical structures with metal where the surface effects provide very strong field confinement, making it possible to scale down optical waveguide elements with an order of magnitude. The drawback: the metal introduces loss.

In spite of the fast advances in plasmonics, there are still important missing blocks before logic plasmonic circuits become feasible. Especially the system-level tradeoffs in such a logic system have to be explored in more detail. This includes the combination of compact, coherent plasmon excitation, ultrafast and compact phase modulation, waveguiding and electrical detection. It is important, when building a new architecture for digital logic, that the underlying analog behaviour of the building blocks and the system is well understood.





Doelstelling:

The main target in this thesis is to generate a circuit-level and system-level simulation model of the entire plasmonic logic system to gain this deeper understanding and evaluate the potential and limitations of such a plasmonic logic architecture. This includes building simplified models of the different components, with the primary goal to predict system performance and to elucidate system level trade-offs, especially in the presence of imperfections (e.g. parasitic reflections, or variation between building blocks).

This thesis will mostly take place in IMEC (Leuven), where they have been studying such alternative approaches for logic systems.

The candidate ideally has a background in electrical/photonic engineering or physics and is proficient in the use of Python and/or Matlab.

Locatie:

IMEC (Leuven), Ardoyen (iGent)

Samenwerking met bedrijf of non-profit organisatie

Bedrijf: IMEC
Samenwerking: promotor + begeleider + use case

Opmerkingen:

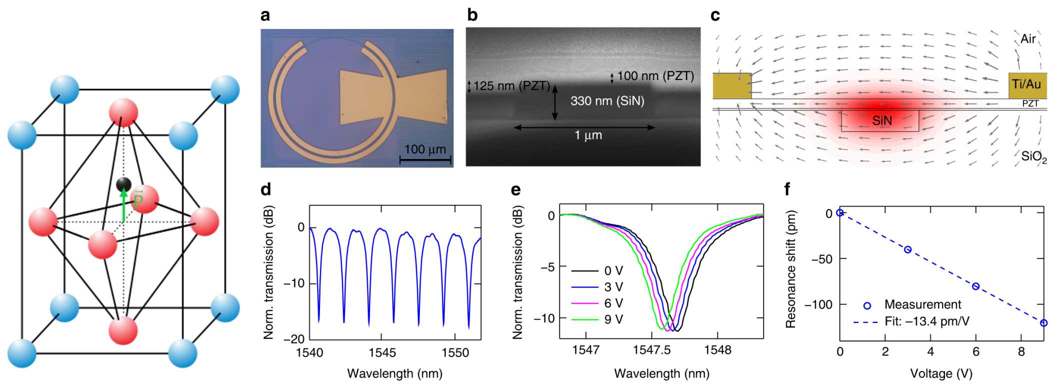
This thesis is primarily driven from research in IMEC (Leuven). However, as this is mostly related to system analysis, a lot of work can be done remotely.

31885: Probing domain orientation via electro-optic measurements on thin films

Promotor(en):	Jeroen Beeckman
Begeleider(s):	Enes Lievens
Contactpersoon:	Jeroen Beeckman
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The thesis involves optical measurements using an electro-optic setup, together with simulations of the electro-optic effect.

Probleemstelling:

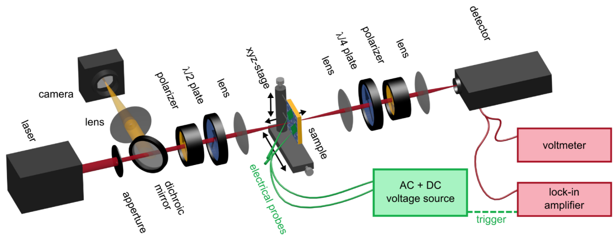
Ferroelectric thin films such as lithium niobate, barium titanate (BTO) and lead zirconate titanate (PZT) are prominent materials today for both electro-optic and piëzoelectric applications due to both a high Pockels coefficient (linear electro-optic effect). PZT is the best piezoelectric material and recently it was also shown that it has an excellent electro-optic response. Compared to BTO, the poling can be performed once and the material keeps its preferential polarization direction. With this material, for the first time high speed electro-optic modulators were demonstrated on a silicon nitride photonic plaform by our group [1].

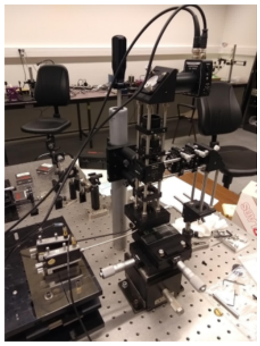


To increase the modulation speed and improve the efficiency of modulators on integrated photonic chips, one needs to increase and optimize the electro-optic coefficients of the thin film. For that, it is vital to understand the domain distribution and the distribution of the polarizaiton density inside the layer. Using a newly developed setup, it will be possible to probe different orientations between the electric field for poling the material and the high frequency electric field.

Doelstelling:

Before, electro-optic measurements have been performed only when the direction of the polarization density was parallel to the applied electric field for modulation. The setup for is shown schematically on the left and a picture from the actual setup is shown on the right.





These measurements provide a value for the effective electro-optic coefficient. But in integrated electro-optic modulators, also the other electro-optic coefficients may play a role and it is vital to measure the full electro-optic tensor. For that reason, it is required to also perform measurements with an angle between the poling electric field and the field for modulation. Using the data from these measurements the electro-optic coefficients can be extracted through theoreteical and/or numerical modeling. In turn, the information on the electro-optic coefficients can than be used to extract the domain orientation of the thin film. This information is vital for the selection of the best electro-optic materials and the design of integrated electro-optic modulators on the silicon or silicon nitride photonic platform.

The material deposition and sample preparation in clean room will be carried out by the supervisors. The student will mainly work on the following tracks:

- Electro-optic measurements. The optical setup will need to be adapted and the automated measurement program may need to be altered.
- Numerical and/or theoretical modeling to extract the electro-optic coefficients from the measurement data. Extraction of the domain orientation in the thin film.
- Providing optimized design rules for future integrated optical modulators with enhanced efficiency. When there is sufficient time left, integrated electro-optic modulators based on these principles can be fabricated and tested.

Locatie:

iGent

Website:

Meer informatie op: lcp.elis.ugent.be

32225: Quantum Key Distribution with continuous variables

Promotor(en):	Karel Van Acoleyen, Xin Yin
Begeleider(s):	Cédric Bruynsteen, Kevin Vervoort
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Het onderwerp van quantum key distribution is een heel actuele toepassing van (quantum) photonics.

Probleemstelling:

Quantum key distribution (QKD) is one of the emerging **quantum technologies** with a high potential impact. The essence of QKD protocols is that the natural laws of quantum physics itself, with for instance the 'no-cloning principle,' according to which quantum information cannot be copied, provide a **framework for secure communication**. In our global digital world secure communication is of course of primordial importance. Furthermore, future quantum computers could break some of the classical cryptographic schemes that are currently widely used. All this motivates **the current worldwide research efforts into QKD**.

Any QKD protocol relies on the encoding of information in non-orthogonal quantum states. The best studied case is that of digital variables QKD (DVQKD), which makes use of states that live in a finite dimensional Hilbert space, e.g. the different polarization eigenstates of single photons. Alternatively, **continuous variables QKD (CVQKD)** makes use of states that live in an infinitely dimensional Hilbert space. Specifically, CVQKD relies on the production, transmission and detection of **coherent laser pulses**, which are indeed characterized by a continuous complex variable.

One advantage from the practical viewpoint is that CVQKD does not have to rely on single-photon detectors which are notoriously imperfect. Instead it uses so called **homodyne or heterodyne detection** of coherent laser pulses (with the information encoded in amplitude and phase). CVQKD can achieve high key rates over long distances using optical components at room temperature, making it a promising candidate for practical implementation in real-world communication systems. On the theoretical side it adds the twist of continuous variables to the quantum information theoretic analysis of QKD, with many open questions on the possible protocols and security proofs. As such the field of CVQKD research consists of an exciting blend of **quantum information theory and quantum optics**.

Doelstelling:

The overall goal of the thesis is to study and explore CVQKD. As part of the thesis the student will have the **unique opportunity to experiment with a cutting-edge CVQKD system**. In the context of a European research project we will have a test-link between campus Zwijnaarde and campus de Sterre, with CVQKD equipment at both nodes. One goal here is to understand and benchmark both the CVQKD system (e.g. what are the precise protocols it uses) and the test-link (e.g. what is the transmission loss). Another part of the thesis will entail a study of the literature on the existing CVQKD protocols and security proofs. Depending on the student's preference and skill we can orient the project more towards theory or more towards experiment.

Contact us for more information.

Locatie:

campus Zwijnaarde, campus Sterre

Website:

Meer informatie op: quantumghent.github.io/thesistopics.html

Deze masterproef werd reeds 1-maal toegekend!

32547: Realization of a smart intraocular lens demonstrator

Promotor(en):	Herbert De Smet, Andrés Felipe Vasquez Quintero
Begeleider(s):	Pieter Bauwens, Pablo Perez Merino
Contactpersoon:	

Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal masterproeven:	1
Motivering voor deze opleiding:	Interdiscliplinair onderwerp, met als belangrijk onderdeel het bouwen van een elektro-optisch systeem met een tunable liquid crystal lens en een fotodiode

Probleemstelling:

Advances in wearables and in microsystem technology have paved the way to enable smart intraocular lenses. This could help cataract surgery patients to regain the ability to accommodate.

Patients with cataract suffer from the fact that the crystalline lens inside their eye has become cloudy. The standard treatment is cataract surgery, whereby the cloudy crystalline lens is removed and replaced by a clear artificial lens. While the shape and the optical power of the original lens could be influenced by the ciliary muscles surrounding the lens, allowing the patient to accommodate (focus on nearby or far objects), the replacement lens has a fixed shape and dito optical power. Normally, the power of the lens is chosen so that the patient has sharp remote vision. For reading, a pair of spectacles is needed to provide the extra optical power required by the shorter focal distance.

Liquid crystals (LC) have anisotropic optical and electrical properties, which allows to control their optical properties by means of an electric field. The best known application is the liquid crystal display, but also tunable lenses can be made. An LC tunable lens integrated in an artificial intraocular lens could bring back the possibility to focus on nearby objects. One possible way to command the LC lens would be to send a coded infrared signal into the eye that is picked up via a small photodiode and detected by the controller chip.

Doelstelling:

The aim of this master thesis is to design and build a demonstrator setup with which the complete system can be demonstrated. This setup would comprise an LC lens (available at the CMST research group), the controller electronics (can be microcontroller-based), a photodiode and a small battery. While it is clear from the start that the sum of the components will be too large to be built into an actual smart intraocular lens, building this system is an important step to better understand and master the interaction between the individual components and the operation of the whole system.

Locatie:

Ardoyen + thuis

Opmerkingen:

Interdisciplinary topic, could benefit from collaboration between a photonics and an electronics student.

32545: Size and charge analysis of lipid nanoparticles with laser-scanning microscopy

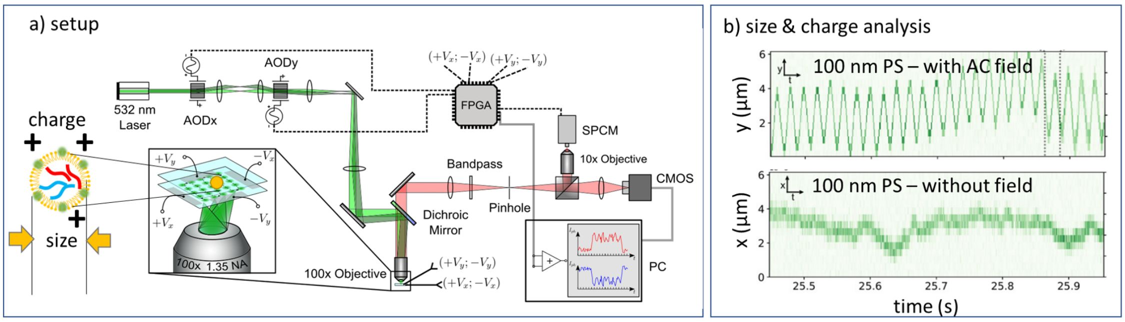
Promotor(en):	Filip Strubbe, Katrien Remaut
Begeleider(s):	Lucas Oorlynck, Sumit Sumit
Contactpersoon:	Filip Strubbe
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Biomedical Engineering, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	A laser-scanning microscope system will be used involving lasers, acousto-optic deflectors, single-photon counting modules, fluorescence of nanoparticles. There is a large engineering component (optimizing and working with the setup)

Probleemstelling:

Lipid nanoparticles (LNPs) are used as vehicles for the delivery of mRNA into cells. For example, in 2021 and 2022 the FDA approved two mRNA-based vaccines developed by respectively BioNTech/Pfizer (Comirnaty) and Moderna (Spikevax) in the fight against Covid-19. Up to date, more than 300 billion mRNA-LNP doses have been injected worldwide, demonstrating an excellent efficiency and safety profile. However, there is a general lack in understanding of the heterogeneity in size, composition, drug loading, and charge of LNP samples. For example, a recent study showed that in a benchmark LNP system 40%-80% of the LNPs are empty (i.e., not carrying mRNA) [1]. This shows a large need for characterization of LNPs at a particle-to-particle level [1,2]. At the Laboratory for General Biochemistry and Physical Pharmacy LNPs are formulated and investigated by prof. Katrien Remaut [3]. One of the unresolved questions concerns what the heterogeneity is in terms of size and charge and correlations between these parameters, which requires a particle-to-particle approach. However, measurements of size and charge of individual nanoparticles are highly challenging, requiring advanced optical techniques.

Doelstelling:

At the LCP group, a laser-scanning microscopy platform has been developed that allows fast and sensitive measurements of individual fluorescent nanoparticles [4]. By analysis of the trajectories of individual nanoparticles in the presence or absence of an electric field, both the size and the charge can be determined. The aim of this thesis is to carry out experiments on fluorescently labelled LNPs and to measure the size (in the range of 80 nm - 180 nm) and charge for each particle. Analysis with fluorescent beads will be carried out to determine the accuracy of the method. Additionally, careful analysis of electroosmosis will be carried out following the procedure of Oorlynck et al. [4], and potential Joule heating effects will be investigated.



References:

[1] S. Li et al., Payload distribution and capacity of mRNA lipid nanoparticles, Nature Communications (2022) 13:5561, https://doi.org/10.1038/s41467-022-33157-4.

[2] A. Kamanzi et al., Simultaneous, Single-Particle Measurements of Size and Loading Give Insights into the Structure of Drug-Delivery Nanoparticles, ACS Nano 2021, 15, 19244−19255. https://doi.org/10.1021/acsnano.1c04862

[3] H. Zhang et al., Fluorescence Correlation Spectroscopy to find the critical balance between extracellular association and intracellular dissociation of mRNA complexes, Acta Biomaterialia 75 (2018) 358–370, https://doi.org/10.1016/j.actbio.2018.05.016.

[4] L. Oorlynck et al., Laser-Scanning Microscopy for Electrophoretic Mobility Characterization of Single Nanoparticles, Part. Part. Syst. Charact.2023, 40, 2200152, https://doi.org/10.1002/ppsc.202200152

Locatie:

iGent, thuis, Ottergemsesteenweg (LNP formulatie)

32591: SPICE Modeling and Simulation of Photonic Circuits

Promotor(en):	Tom Dhaene, Wim Bogaerts
Begeleider(s):	Thijs Ullrick
Contactpersoon:	Thijs Ullrick
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	The research component of this Master thesis lies in the development of novel modeling techniques for photonic integrated circuits. Since this topic focuses on research related to electrical and photonic engineering concepts, it is accessible to students of both the masters in photonics and electrical engineering.

Probleemstelling:

Photonic integrated circuits (PICs) are experiencing rapid growth in complexity, functionality, and integration scale. Today, however, there's a large gap between what the technology can deliver and the complexity of designs that can be managed with existing tools. One of the main bottlenecks is that there are still no standard models for photonic circuit simulation. An approach that addresses this problem by directly adopting industry standards from the electronic design automation (EDA) world is to simulate photonic devices in a standard SPICE environment. While this approach benefits from the maturity of the EDA flow, it also holds the potential for photonic-electronic co-simulation where electronic and photonic circuits can be simulated in the same environment.

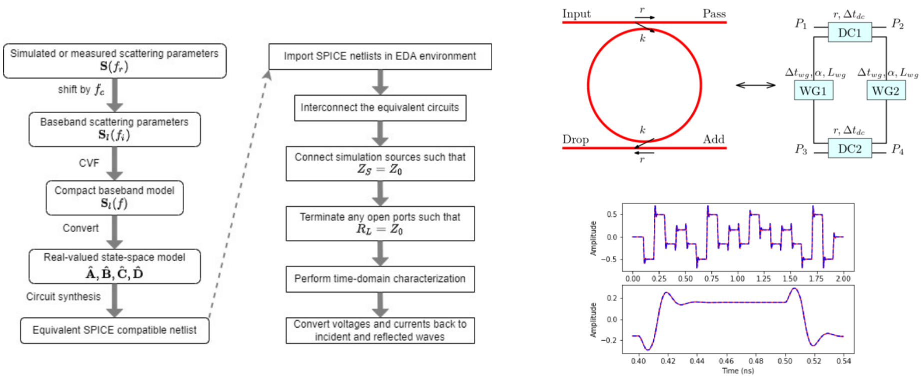


Fig. 1: Flowchart of the novel methodology for rigorous time-domain modeling of linear photonic devices as SPICE circuits (left) and the transient simulation of a microring resonator in drop configuration via the novel technique (right).

Doelstelling:

A framework has been defined for precise time-domain simulations of linear and passive photonic devices in a standard SPICE environment. However, the framework does not yet support the representation of active devices such as lasers, modulators and photodetectors. The aim of this thesis will be to develop and improve parametric macromodels that accurately capture the dynamic behaviors of the active devices and to investigate the co-simulation of active and passive device circuit models. Through this research, the student will gain familiarity with concepts such as multivariate macromodeling, microwave circuit theory, PIC design and photonics simulation techniques. Furthermore, this research may result in an opportunity for a collaboration with Luceda Photonics.

Locatie:

iGent Tower, Zwijnaarde

Opmerkingen:

Theory (50%), implementation (50%)

32116: Stochastic Thermodynamics within a critical bath

Promotor(en):	Kristiaan Neyts, Ignacio Aquilino Martínez Sánchez
Begeleider(s):	
Contactpersoon:	Ignacio Aquilino Martínez Sánchez
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	Experiments involve critical fluids, optical trapping and heat transport

Probleemstelling:

Criticality has been argued to provide biological and physical systems with a balance between robustness against perturbations and flexibility to adapt to changing conditions. The progressive increment of the correlation once the system approaches the critical point also confers on them with optimal computational capabilities, large dynamical repertoires, unparalleled sensitivity to stimuli, etc. However, very little is known about how systems exchanges energy within a critical bath. Moreover, the non-equilibrium performance of this kind of system remains completely unexplored.

Doelstelling:

This project aims at studying the role of criticality in the transfer of energy at the mesoscale. The goals are to analyze the statistics of the thermodynamic fluxes between a colloidal particle and a critical bath. The experimental approach will consist of the combination of optical trapping for creating arbitrary energy seascapes and light-induced heating for modulating the correlation length and time of the critical bath. The experimental results must pave the way for a generalization of the second law of thermodynamics. The results will have a direct impact on the designing of artificial nanodevices and on the understanding of natural systems embedded in critical environments. The work is situated in the field of complex systems, photonics, thermodynamics, and micelle-solvent mixtures.

Locatie:

iGent campus Ardoyen, thuis

32619: Time-resolved microscopy for the study of mode-dynamics in complex lasers.

Promotor(en):	Dries Van Thourhout, Pieter Geiregat
Begeleider(s):	Korneel Molkens, Ivo Tanghe
Contactpersoon:	Korneel Molkens
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	2
Motivering voor deze opleiding:	Design, simulatie, fabricatie van photonic devices + natuurkundig begrip van nanomaterialen

Probleemstelling:

Laser science has evolved beyond the classical Fabry-Perrot cavity containing just two mirrors. For example, researchers from Imperial College London showed lasing on of a so-called “nanophotonic graph” (Fig 1) [1]. These type of lasers find applications in super-resolved spectroscopy and photonic computing. They used a polymer dye to fabricate the lasers, but these samples are notoriously unstable. Very recently, lasing was observed in a similar structure but with colloidal quantum dots as a gain material, improving the stability of the samples. A typical lasing spectrum can be seen in Fig 2. The improved stability allows a more systematic study of the behavior of these exotic cavities.

Modern experimental techniques like hyperspectral imaging allows to spatially locate the different laser modes inside the cavity (fig 3). These measurements suggest that some modes occupy the same location in the resonator, at least partly. It is well-known from the theory of multi-mode lasers, that the modes will interact with each other in a non-linear way. This leads to a very interesting temporal behavior of the lasing light. This temporal behavior has not been investigated yet for these kind of cavities, although it is part of a full comprehension of the system.

Doelstelling:

The goal of this thesis is to investigate this highly non-linear behavior. On one hand, the existing models [2] have to be combined with rate equations to get an idea of the temporal behavior of the modes. On the other hand, the student will characterize this experimentally. Although challenging, the nanosecond time-scales that typically occur in laser mode dynamics is accessible via experimental techniques.

The project will be executed together with researcher from Imperial college in London. A research visit for the student is possible.

Fig 1: example of a fabricated random lasing Network.

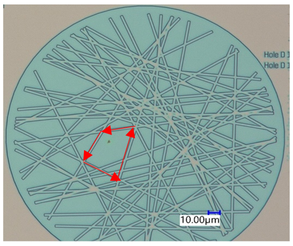


Fig 3: hyperspectral imaging.

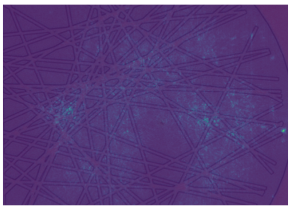


Fig 2: Typical lasing spectrum.

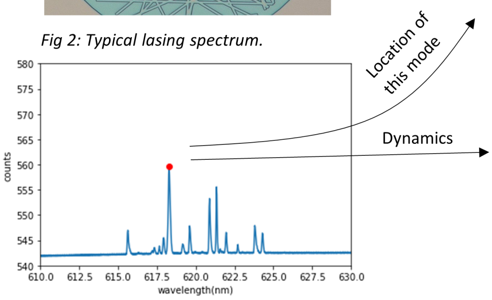
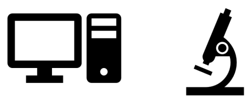


Fig 4: your work.



[1] Gaio, M., Saxena, D., Bertolotti, J. et al. A nanophotonic laser on a graph. Nat Commun 10, 226 (2019). https://doi.org/10.1038/s41467-018-08132-7

[2] Saxena, D., Arnaudon, A., Cipolato, O. et al. Sensitivity and spectral control of network lasers. Nat Commun 13, 6493 (2022). https://doi.org/10.1038/s41467-022-34073-3

Locatie:

31742: Towards electro-optic applications by combining ferroelectric nematic liquid crystal with surface topography

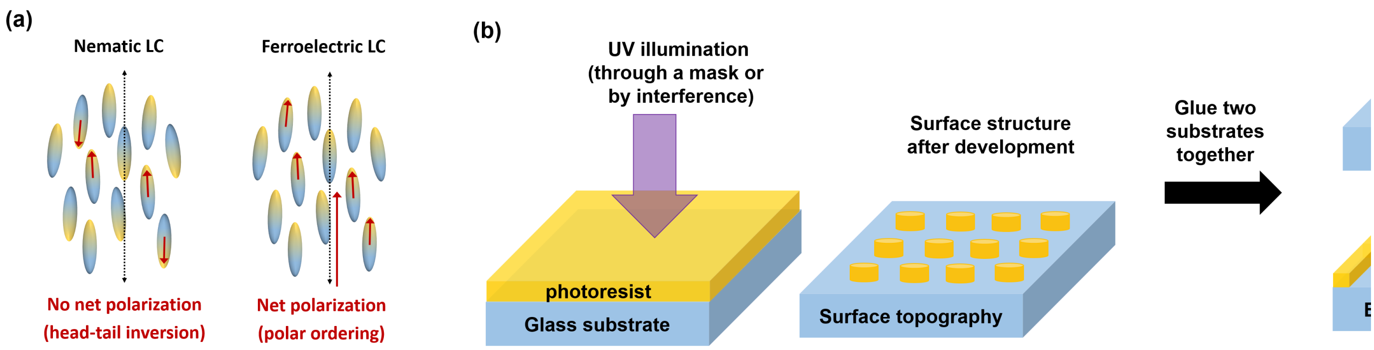
Promotor(en):	Inge Nys, Kristiaan Neyts
Begeleider(s):	Yu-Tung Hsiao
Contactpersoon:	Kristiaan Neyts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials, electrical switching

Probleemstelling:

Recently nematic liquid crystals have been discovered that have a permanent polarization in a certain temperature range. This means that the elongated molecules are not only aligned parallel to each other, but all molecules have their heads and tails pointing in the same direction (see figure (a)). Stable macroscopic ordering of molecular dipoles occurs and extremely high polarizations have been reported. This liquid material lacks centro-symmetry and behaves as a ferro-electric material: it can be poled by an electric field (by aligning the dipoles in a particular direction); it has a strong electro-optical effect (Pockels effect, change in refractive index when a field is applied); and second harmonic generation (emits the double frequency when illuminated with a strong laser beam). The soft matter also responds strongly to small electric fields, leading to fast electro-optical switching, which may be used in displays or optical applications. In other words, since it's discovery this polar nematic phase with excellent ferroelectric properties is changing the research landscape it especially attracts attention due to its enormous potential for technological applications

In the LCP group some ferroelectric liquid crystal material (DIO) has been obtained from the University in Hull and a series of very interesting measurements have been performed so far. Recently, another type of ferroelectric liquid crystal material (RM 734) has become commercially available and has been ordered for further investigation. Although some promising results have been demonstrated by us and other research groups, the behavior of this material is still rather poorly understood, because of the complex interaction between elastic liquid crystal properties and electric fields.

Domains with a different orientation of the polarization can be formed spontaneously upon cooling and they can be switched by applying very low electric fields (~100 V/m). The domain structures in the ferroelectric liquid crystal phase show remarkable electro-optic effects due to the spatially varying polarization and the accompanying presence of bound charges. Recently we started to investigate how the domain formation and electrical behaviour can be influenced by alignment patterning at the substrates and in this thesis we also want to research how the organization of ferroelectric domains is influenced by the presence of a surface topography. Surface impurities, such as boundaries between electrode and non-electrode areas, are known to give rise to charges and therefore domain creation in the ferroelectric liquid crystal phase. However, no studies have been performed so far where surface impurities have been intentionally created to steer the domain formation.



Doelstelling:

The aim of this thesis is to use well-designed topographical structures at the surface to steer the growth of polar domains in the ferroelectric liquid crystal phase. The electro-optic switching behaviour of the created devices will be investigated in detail to explore the application potential. Different electric field treatments will be tested and the effect on the alignment quality and switching behaviour will be investigated.

Since we are aiming at the creation of relatively large domains (with dimensions of a few tens /hundreds of micrometers), no surface structuring with very high resolution is required. At first instance, UV photolithography will be used to create relatively simple surface structures such as lines or circles. A photomask will be used for the illumination or alternatively the illumination can be done with the help of an interference setup. Depending on the type of resist that is used (positive or negative photoresist), the illuminated or non-illuminated regions will be removed by development. In this way a topographical pattern is created on top of the glass substrate, with alternating regions with and without photoresist (see figure). The height of the surface structures will be varied by spincoating a thinner or thicker photoresist layer and the type of surface structure that is created will be modified by adjusting the illumination pattern. After investigating the effect of line-like and circular structures, more complex shapes will be tested.

The patterned substrate will be glued together with another substrate to form a cell. The anchoring properties at the (unpatterned) top substrate can be chosen on demand. The cell thickness can be accurately controlled by dissolving spacer balls with a certain diameter in the glue. Apart from the effect of different shapes and heights of the surface structures, also the effect of the cell thickness on the domain formation in the ferroelectric nematic liquid crystal phase will be investigated.

Moreover, to investigate the electro-optic switching behavior, different electrode configurations and different electric field treatments (amplitude, frequency, waveform) will be tested. Uniform or patterned electrodes at the top and/or bottom substrate of the cell will be combined (see figure). A specific electrode configuration could be designed, that is tailored for the topographical patterned imposed at the surface.

The detailed investigation as proposed in this thesis subject should strongly increase the understanding of the self-assembly behavior in the ferroelectric nematic liquid crystal phase and shine a light on the application potential of this recently discovered material type.

Locatie:

iGent (campus Ardoyen), thuis

32802: Tuning Subwavelength Gratings with Liquid Crystals

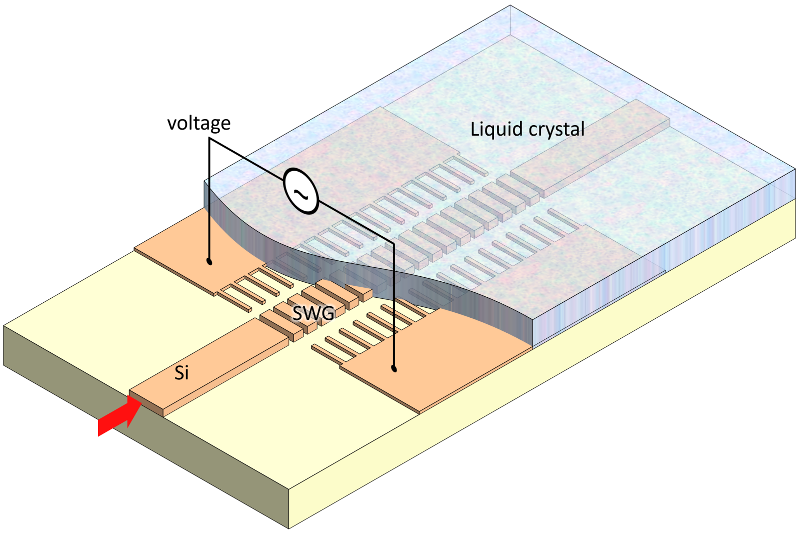
Promotor(en):	Jeroen Beeckman, Wim Bogaerts
Begeleider(s):	Lukas Van Iseghem
Contactpersoon:	Jeroen Beeckman
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	0
Motivering voor deze opleiding:	Somewhere in there, you will find a photon

Probleemstelling:

Liquid crystals are an optical material with very high electro-optic coefficients. By combining the liquid crystal with nanophotonic devices, the 'passive' photonic structures can be made actively tunable. A voltage is used to change the orientation of the liquid crystal, which subsequently changes the refractive index around the waveguide and the light propagation inside the waveguide can be controlled. The groups at Ghent University are recognized worldwide for their ground breaking work in this field. In 2009, the first widely tunable ring resonator was demonstrated. In 2015, for the first time, a waveguide with tunable lateral leakage loss was demonstrated. Up till now, UGent also still holds the record for the lowest tuning efficiency ever reported (a VpiL of 0.0224 V.mm).

The tuning of the liquid crystal cladding is very effective if there is a large fraction of the light in the cladding, and not in the waveguide core. This can be achieved with slot waveguides, but also with sub-wavelength gratings (SWG). These are periodic structures with a period much smaller than the wavelength, so the light sees it as a homogeneous medium.

However, it is not straightforward to predict how the liquid crystal will behave in such structures: the LC molecules tent to align themselves according to the surfaces, but an SWG has a very irregular surface profile, making the orientation of the LC molecules unpredictable. While in a regular waveguide it is possible to use 2D models, an SWG needs 3D modelling of the LC.



Doelstelling:

In this thesis, we want to study how LC behaves in SWG structures. For this, we will make use of the state-of-the-art modelling capabilities in the Liquid Crystals and Photonics (LCP) group. This is the main focus of the work, as this modeling is far from trivial. The behaviour of the LC can then be transferred to an electromagnetic solver to inspect the flow of light in such structures. This will involve a workflow with multiple simulation tools, where automation can definitely help.

There will also be an opportunity to test the LC on such structures. We have already silicon photonic SWG structures fabricated, and if needed additional devices can be patterned in the UGent clean room. These devices then need an LC overcladding and electrodes, after which the optical transmission can be characterized as a function of the applied electrical signals.

These results can then be compared with the expected values of the modelling.

Locatie:

Ardoyen (iGent)

32609: Using the versatile SiN-quantum dot platform for the study of 1D topological lasers

Promotor(en):	Dries Van Thourhout, Pieter Geiregat
Begeleider(s):	Korneel Molkens
Contactpersoon:	Korneel Molkens
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics, Master of Science in Photonics Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal masterproeven:	2
Motivering voor deze opleiding:	Design, simulatie, fabricatie van photonic devices + natuurkundig begrip van nanomaterialen en gekoppelde resonatoren

Probleemstelling:

Integrated photonics allows to make lasers on the micrometer-scale. They are very interesting in terms of small footprint on a chip and the large spacing between the optical modes, allowing even single-mode operation without ‘special tricks’. However, their power output is inherently limited due to the small amount of gain material. To overcome this drawback, we have been trying to create arrays of coupled lasers, making them all work together to yield a higher output power yet keeping the interesting properties of small devices.

The fabrication constraints on these devices is very strict: even small variations in the fabrication can break the symmetry and make the ‘supermode’ collapse (fig 1). A way around this problem is the use of topological protection (fig 2). The underlying geometry of the cavities will force the light into a large optical mode. Topological photonics has gained a lot of interest recently, since it allows to make devices that are inherently robust against any type of fabrication defects.

In this master thesis, you will use colloidal quantum dots as the gain material to fabricate a topological protected laser. The platform to integrate these materials has been developed in a close collaboration between the Photonics Research Group and the Physics and Chemistry of Nanostructrures group. It allows for a very flexible design, ideally suited to study these kind of systems.

Fig 1: current lasing cavity and mode profile.
Only one resonator is effectively used.

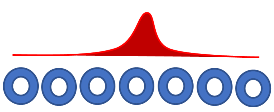
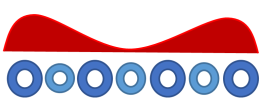


Fig 2: topological cavity and mode profile.
It allows to use a larger part of the cavity.



Doelstelling:

You will design a 1D array of alternating coupled rings, based on the Su–Schrieffer–Heeger (SSH) model. We can design the difference in resonance of the different rings, and the coupling strength and feet these parameters to the SSH-model to describe the topology of our device. The goal is to make the laser opterate in this toptologically protected mode, hence supress all the other modes that are present in the cavity. The device can be fully fabricated in the PRG cleanroom. After fabrication, the lasing properties of this device will be measured, in particular the robustness against variations in fabrication.

Locatie:

Campus Ardoyen (zwijnaarde)