European Master of Science in Photonics - AJ 2019-2020

Goedgekeurde onderwerpen

Lijst gegenereerd op: Wed, 06 Nov 2019 09:57:52 +0100. Laatst ingediende onderwerp: 22114

21586: "Lasergun" (silicon photonics) technology for cardiovascular screening and treatment follow-up: good vibrations!

Promotor(en):	Patrick Segers, Roel Baets
Begeleider(s):	Yanlu Li
Contactpersoon:	Patrick Segers
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	silicon photonics, physics of wave propagation in tissues

Probleemstelling:

As part of an Horizon 2020 funded project, we (UGent, imec and 6 other partners), have developed a prototype mobile, low-cost, point-of-care screening device for cardiovascular disease through measurement of the propagation speed of the arterial pulse. The device aims for measurement in a fast, reproducible and reliable way with minimal physical contact with the patient and minimal skills from the operator. The operating principle of the device is Laser Doppler Vibrometry (LDV), in which a very low-power laser is directed towards the skin overlying an artery (Figure 1). The skin's vibration amplitude and frequency, resulting from the heart beat, are extracted from the Doppler shift of the reflected beam. The device includes two rows of six beams, thereby scanning multiple points on the skin above the artery in parallel. At the heart of the system is a silicon photonics chip containing the optical functionality of the multi-beam LDV device.

We performed a clinical feasibility study at the Georges Pompidou European Hospital in Paris where we collected a substantial clinical dataset, both from healthy subjects as well as from patients with cardiovascular conditions. The quality of the device readings was found to be very good and adequate measurement results could be obtained in all subjects. The group will continue working on (i) a second generation prototype of the device; (ii) signal processing; (iii) validation of a novel measure of arterial stiffness. Figure 1 shows the device in operation, pointed on the carotid artery of a volunteer, and Figure 2 illustrates the estimation of the time delay between 2 signals using the instantaneous cross-correlation method.

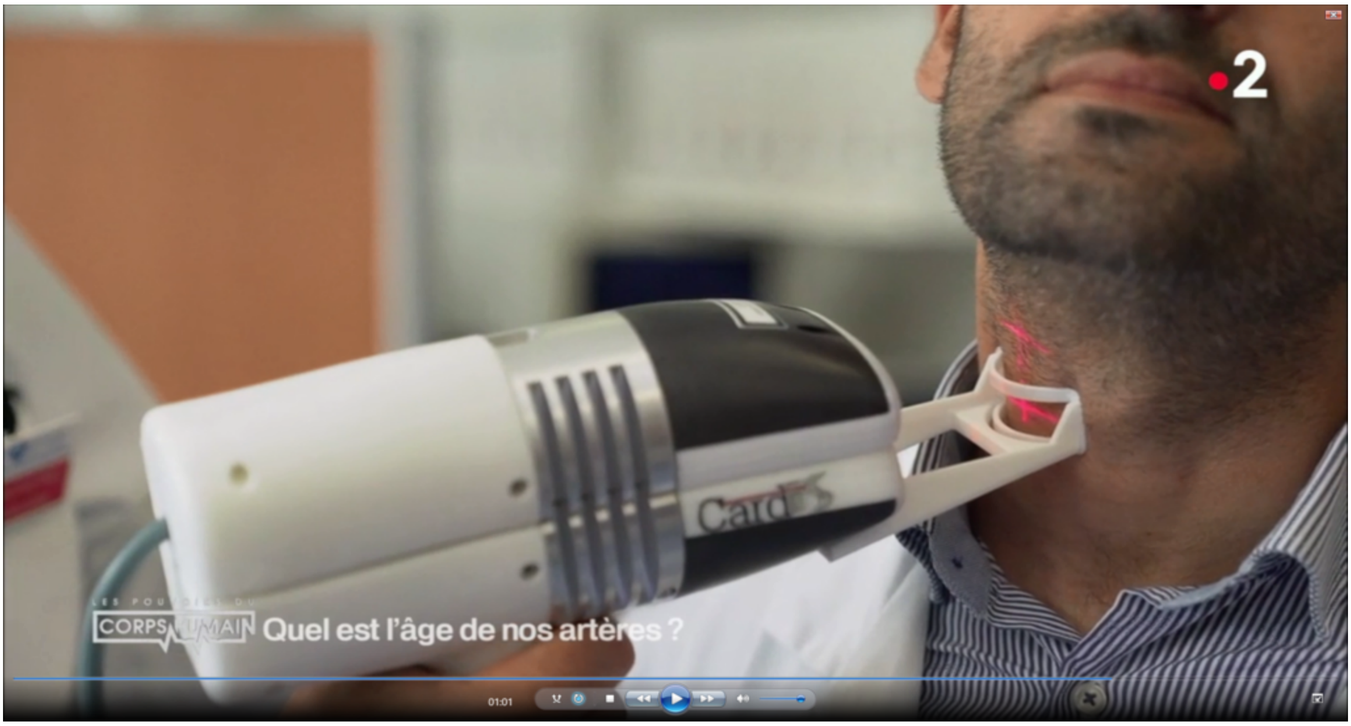


Figure 1: prototype during measurement of the stiffness of the carotid (neck) artery.

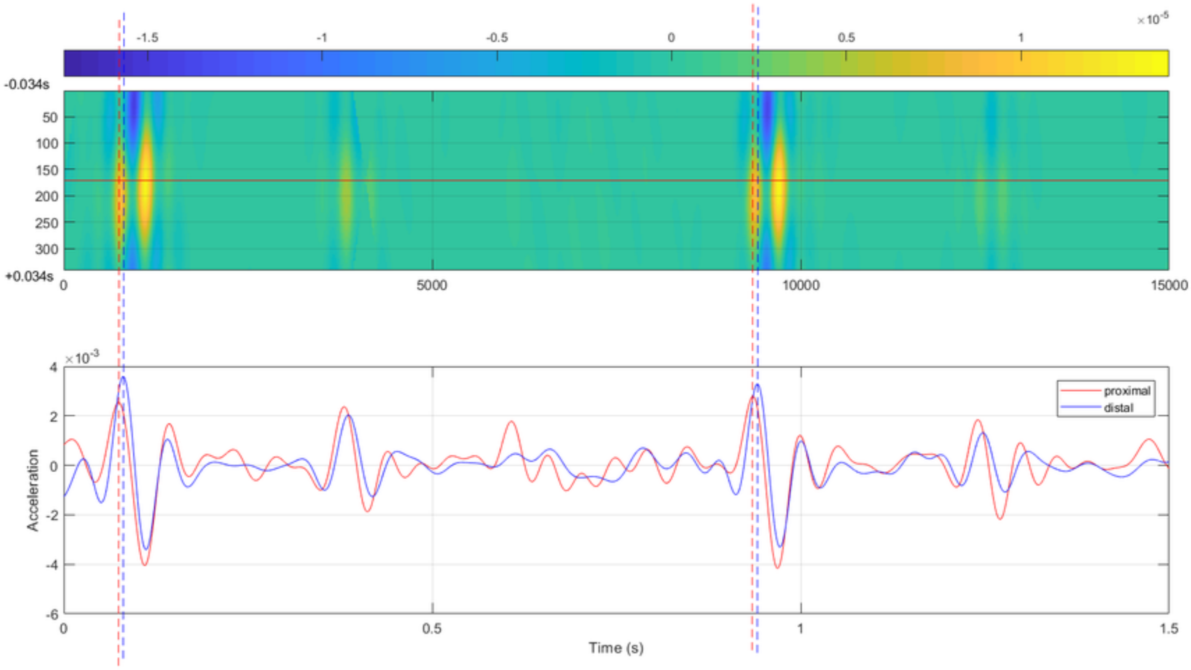


Figure 2: Estimating the time delay between the acceleration signal measured between two laser beams pointed to the skin level, 2.5 cm apart.

Doelstelling:

The aim of the thesis is to set further steps in the validation of the methodology, further development of the prototype and peripherals to bring the device into clinical routine. Depending on the background and interest of the student(s), the thesis topic can include

- development and testing of novel algorithms for signal processing: the robust detection of the individual heart beat in longer data sequences needs to be be improved in terms of speed and robustness. More advanced techniques, including wavelet analysis or machine learning may be mandatory

- development and validation of a novel biomarker of arterial stiffness: we are exploring the measurement of the time that it takes for the arterial pulse to travel from the heart to the neck. This requires accurate detection of the moment of aortic valve opening. We have indications that this can be measured with LDV, but our algorithms need validation and further development to make them more robust.

- data interpretation: we hypothesize that the presence of pressure wave reflections in the arterial circuit may intefere with the measurement of pulse wave velocity when measured over short propagation distances, such as at the carotid. A systematic modeling/experimental study should be set up to test this hypothesis.

For the thesis, the student(s) can make use of existing datasets that were recorded in our patient/volunteer study in Paris. In addition, given the availability of the demonstrator in our laboratories, students can generate their own data from experiments on hydraulic bench models, or from small-scale studies on volunteers where LDV measurements can be performed side-by-side with other non-invasive measurements using ultrasound.

Locatie:

Home, iGent, UZ Gent

Samenwerking met bedrijf

Bedrijf: imec; Medtronic
Samenwerking: project partners

Deze masterproef werd reeds 1-maal toegekend!

21101: 2D Nanocrystal Single-Photon Sources

Promotor(en):	Iwan Moreels, Pieter Geiregat
Begeleider(s):	Carmelita Rodà
Contactpersoon:	Iwan Moreels
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The measurement and use of single photons emitted by nanoscale light emitters is a key element in the second quantum optics revolution and fits the scope of research Photonic engineers will contribute to.

Probleemstelling:

The second quantum revolution is rapidly unfolding. Several devices that realize quantum communication and computation are either already commercially available, or at an advanced stage of technological development. A key component for quantum technology is the single-photon source, which forms the basis of optical communications and quantum cryptography. Typical single-photon sources are NV-centers in nanodiamond, or epitaxial quantum dots.

A potentially low-cost and highly flexible alternative is offered by colloidal nanocrystals. Prepared via chemical routes, they can be synthesized as bright and optically stable single-photon emitters. For instance, several groups have demonstrated that CdSe/CdS colloidal quantum dots can be synthesized with near-unity fluorescence quantum yields and emission traces free from intermittency (on/off fluorescence blinking). However, these quantum dots have a lifetime that is typically longer than 100ns, limiting optical communication speeds.[1]

Doelstelling:

A possible solution to the issue above is realizing single-photon emission via a new generation of quasi-2D colloidal nanoplatelets.[2] Such nanoplatelets are currently being synthesized in the Physics and Chemistry of Nanostructures Group, and show great promise due to their fast emission lifetime (below 10 nanoseconds at room temperature), narrow and homogeneous emission line widths, and the recent capability to produce a wide range of emission colors (Figure 1).

In this project, you will investigate the potential of nanoplatelets for single-photon emission. Using materials with different composition and size, the goal is to understand the mechanisms that underlie fluorescence blinking, carrier trapping and coherence of emitted photons. Time-resolved fluorescence spectroscopy on single nanoplatelets will form the central experimental technique throughout the project. Targeted synthesis (size control) and dedicated optical measurements (spectral tuning) will enable you to reach the single-photon emission regime across the visible spectrum, which will lay the foundation for future quantum emitters.

For **students in engineering physics:**

- physics aspects of this topic: The interplay between quantum confinement and single photon / quantum optics.
- engineering aspects of this topic: Using semiconductor theory to model the aspect of quantum confinement.
- this thesis subject is closely related to the following clusters of elective courses: MODELING, MATERIALS and NANO

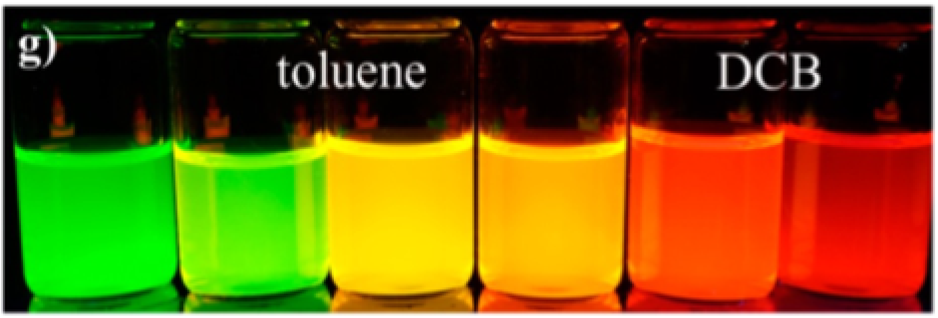


Figure 1: Series of CdSe-based nanoplatelets, with emission tunable from green to red.[2]

References

[1] Grim et al., A sustainable future for photonic colloidal nanocrystals, Chem. Soc. Rev. 2015, 44, 5897-5914.
[2] Polovitsyn et al., Synthesis of Air-Stable CdSe/ZnS Core–Shell Nanoplatelets with Tunable Emission Wavelength , Chem. Mater. 2017, 29, 5671−5680.

Locatie:

De Sterre (S3)

Website:

Meer informatie op: www.nano.ugent.be

21102: 2D nanomaterials - paving the road towards room temperature exciton bose-einstein condensation

Promotor(en):	Iwan Moreels, Pieter Geiregat
Begeleider(s):	Chandra Sekhar Mutyala
Contactpersoon:	Pieter Geiregat
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1

Motivering voor deze opleiding:	The exploration of room temperature quantum optical materials fits the scope of Photonics Engineering to enable next-generation quantum light sources.

Probleemstelling:

Nanoscale materials are an attractive class of opto-electronic materials as they combine low cost of fabrication with remarkable and tunable optical properties. In particular so-called colloidal quantum dots are suitable for this purpose and several advanced applications such as tunable lasers, light-emitting diodes and solar cells have been produced. Within this class of materials, the so-called **two-dimensional semiconductors**have attracted much attention over the past years as they show, opposed to metallic graphene, strongly excitonic features, enabling unique light-matter interactions such as large optical gain coefficients and formation of exciton complexes, so-called biexcitons. Excitons are also bosons with a mass several orders of magntiude lower than that of atoms. It is this property that will enable them to condense into a single quantum ground state, a condensate, at much higher temperatures than atoms, reaching up to several 100K. The latter could bring the unique quantum physics of exciton condensates such as superfluidity, ultralow threshold coherent light emission, ... in a more experimentally accesible temperature range, even suited for consumer applications. The latter fits the ambition of Europe to invest in a second quantum revolution, evidenced by the QuantERA program (http://qurope.eu/manifesto).

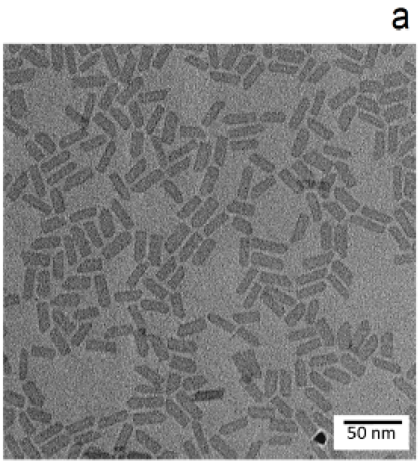


Figure (left) Two dimensional CdSe quantum wells obtained via wet chemical synthesis. The "plates" are 1.3 nm thick, with a lateral area of 34 x 15 square nanometers. (right) Luminescence of CdSe QDots under UV light, going from small (left, blue) to large (right, red) particles.

Doelstelling:

In this thesis, you will take up the challenge to connect the material design parameters (such as thickness, lateral area, heterostructure dimensions, ...) to the exciton/multi-exciton parameters required for exciton condensation. In particular, we need to have fast exciton thermalization, repulsive exciton-exciton interactions and suppressed non-radiative recombination. These parameters are directly accessible through femtosecond pump-probe spectroscopy, a unique ultrafast tool that allows you to map out the dynamics of these bosons in the 2D CdSe system on femtosecond (!) timescales. These measurements are always on an ensemble (millions of) of particles. To improve our understanding of the photo-physics, we will also measure in parallel single (!) nanoplatelets using a state-of-the-art single particle microscope able to detect single photons emitted by single excitons. Finally, we will explore the possibility of exciton condensation in the most promising architectures of the 2D system using cryogenic microscopy, which allows us to vary the temperature from 4K to room temperature, all the while measuring on a single nano-object.

Clearly, this thesis is challenging both on the theory level (can excitons condense in a finite 2D system ?) as well as experimentally, managing both ultrafast femtosecond spectroscopy and single particle microscopy. The thesis will also expose you to the inorganic chemical synthesis of these nano-objects, though the supply of nanomaterials can/will be taken care of by other researchers in the group, and an international environment of researchers active in the PCN group. PCN is also part of several international networks which enrich the research experience. You will mainly work at Campus Sterre under the guidance of Dr. Chandrasekhar Mutyala and Profs. Moreels and Geiregat.

For students in **engineering physics**:

- physics aspects of this topic: The study of fundamental material properties (exciton oscillator strength, exciton cooling, exciton binding energy, multi-exciton scattering, …) in relation to a real application.
- engineering aspects of this topic: The use of advanced optical spectroscopy in close connection with modeling of the material properties.
- this thesis subject is closely related to the following clusters of elective courses: MODELING, MATERIALS and NANO

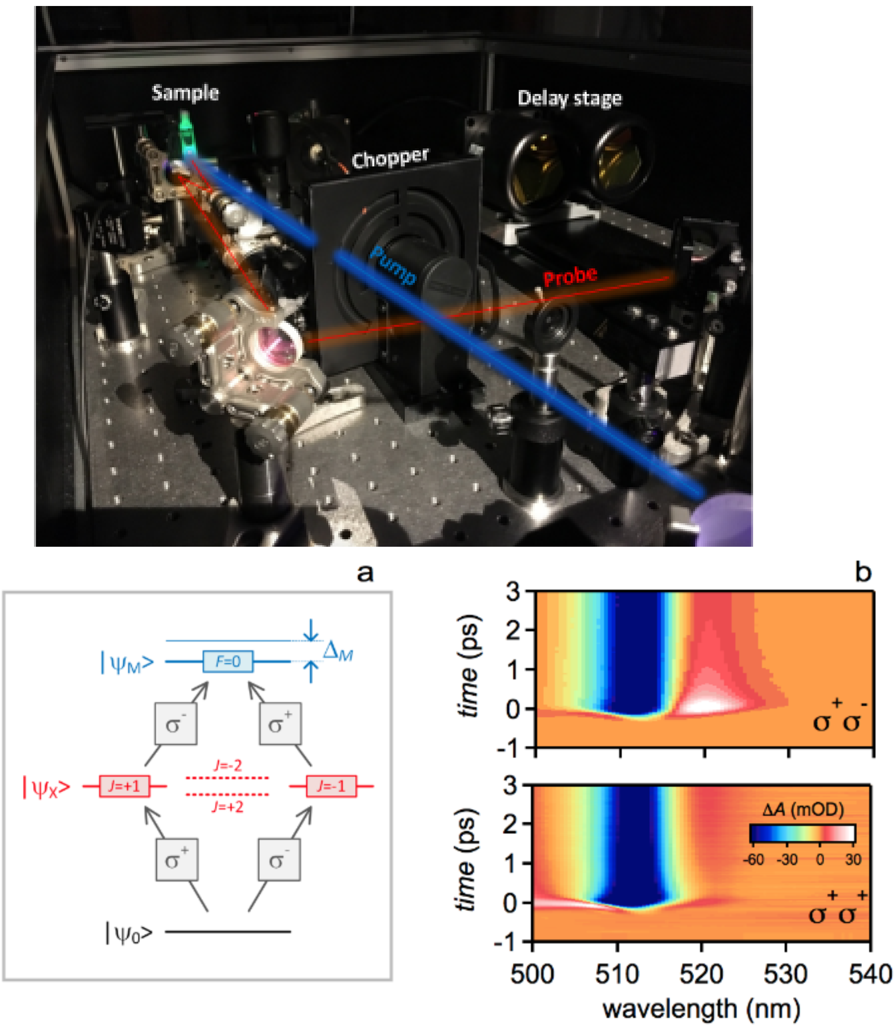


Figure: (left) Ultrafast laser spectroscopy at UGent, Campus Sterre. More info on the lab can be found here. (Middle) Polarization selective pump-probe spectroscopy to generate spin-polarized excitons and excitonic molecules. (right) Experimental verification of the pathways sketched in (middle) using femtosecond spectroscopy with circularly polarized light.

Additional references:

1. *Nature Materials* volume 13, pages 247–252 (2014)
2. *Nature Materials* volume 10, pages 936–941 (2011)

Locatie:

De Sterre

Website:

Meer informatie op: www.nano.ugent.be

22114: A III-V-on-Silicon DBR laser for the spectroscopic sensing of CO2

Promotor(en):	Günther Roelkens, Geert Morthier
Begeleider(s):	Xiaoning Jia, Bahawal Haq
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	master thesis rond integrated photonics

Probleemstelling:

There is a need for low-cost and miniaturized sensors that can probe the concentration of different gases in the environment. Sensors based on measuring the absorption spectrum of air at specific wavelengths allows to unambiguously measure the presence and concentration of specific molecules. Current solutions however are based on discrete components, which makes that the final systems are too expensive and not rugged. A solution based on a photonic integrated circuit - especially when implemented using silicon photonics - would address that problem. However, in silicon it is very difficult to realize an integrated laser. For this III-V semiconductors need to be integrated.

Doelstelling:

In this master thesis you will design and characterize a III-V-on-silicon tunable laser based on distributed bragg reflectors (DBR laser). In order to obtain single wavelength operation narrow reflection band gratings will need to be designed, as well as high Q-factor ring resonators. The III-V integration will happen through a new integration technique developed in the Photonics Research Group, micro-transfer-printing. An alignment tolerant optical interface will need to be designed between the III-V and silicon. Integrated micro-heaters will allow tuning of the emission wavelength. The heater structures will need to be optimized to minimize the power consumption. After the lasers are fabricated in the UGent cleanrooms, you will characterize the lasers (threshold, output power, tuning behavior) and use the lasers in a spectroscopic sensing system to measure the concentration of CO2.

Locatie:

iGent, UGent cleanrooms

Deze masterproef werd reeds 1-maal toegekend!

21144: A Monolithic Integrated III-V Photonic Crystal Laser on Silicon

Promotor(en):	Dries Van Thourhout
Begeleider(s):	
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	

Nog onbeslist voor:
Aantal studenten: 1
Aantal bachelorproeven: 1
Motivering voor deze opleiding: The topic contains an important component of photonics

Probleemstelling:

The potential of leveraging well-established manufacturing processes developed initially by the electronics industry has been the main driver fuelling the massive research into Si photonics over the last decade. Despite considerable achievements, the lack of a laser source monolithically integrated on silicon remains a fundamental obstacle. Silicon has an indirect bandgap, preventing efficient light generation. Finding a novel way of integrating highly efficient light generating materials such as III-V semiconductors on silicon has triggered worldwide efforts. Recently, together with IMEC (one of the worlds largest nanoelectronic and CMOS technology research institutes), the Photonics Research Group of UGent has demonstrated a monolithically integrated distributed feedback laser array grown directly on silicon (Nature Photonics 9, 837–842 (2015), Optica 4, 1468-1473 (2017)). This result attracted world wide attention and is generally considered as a breaktrough for th efield.

However, in the current design a relatively wide III-V waveguide needs to be used. This reduces the material quality – and hence the laser operation - due to an increased stress in the defective boundary layer between silicon and the III-V material.

Therefore, there is a strong motivation to explore laser configurations that can use higher quality nano-scale III-V materials grown on silicon. In addition, novel laser configurations, such as photonic crystal lasers, provide more insight into the photon-material interaction and may make it possible to achieve low-threshold or even threshold-less lasing.

Doelstelling:

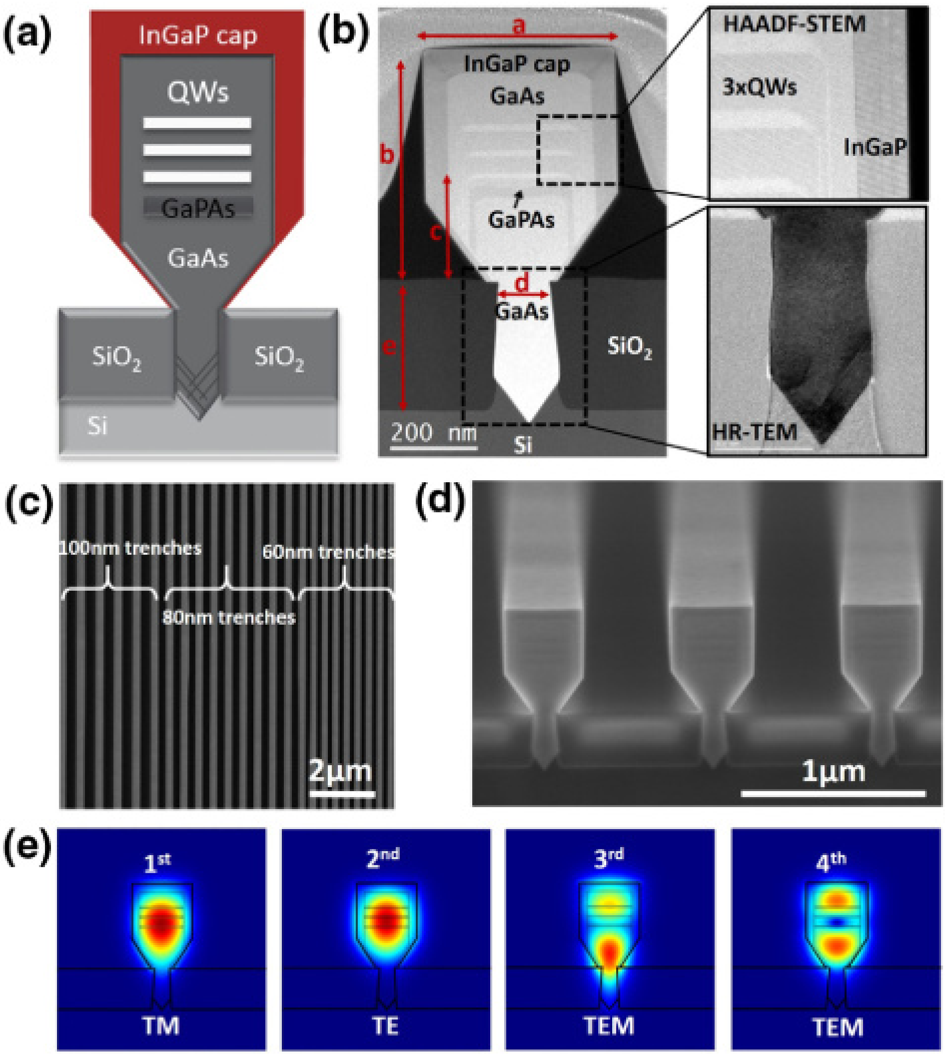


Fig. 1 Sketch and SEM images of the GaAs nano-ridge laser stack (from Optica 4, 1468-1473 (2017))

In this master thesis, you will design a novel silicon integrated laser, based on the most advanced GaAs-on-Si direct growth technology provided by IMEC. Compared to our earlier work on InP discussed above, this technology offers more design freedoms as it already solves the difficult of growing heterostructures. Arrays of GaAs waveguides with InGaAs QWs with different sizes and pitches have been grown by selective area epitaxy. The main challenge now is the electrical injection. In this thesis you will simulate and optimise different scenarios for optimsing the electrical injection of these nanolasers. This involves both optical simulations and solid state physics (self consistent solution of the Schrodinger and Poisson equation), using advanced modelling tools. In a second phase you will characterise devices fabricated in imec's pilot line.

Part of the work is carried out in collaboration with IMEC.

For background information, papers on this topic can be downloaded here

Locatie:

Ardoyen, imec Leuven

21329: All optical single photon detection on chip

Promotor(en):	Stéphane Clemmen
Begeleider(s):	
Contactpersoon:	Stéphane Clemmen
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The works is a multi physics problem involving electronics, photonics, and light-matter interaction.

Probleemstelling:

Quantum photonics is emerging as a field that combines quantum optics with integrated circuits. Many building blocks are necessary for optical quantum processing (circuits, photon sources, detectors, modulators, ...). Many of these building blocks exist and are already mature as a result of developments arising in silicon photonics (photonics chips made of silicon) but others are really still in their infancy. Single photon detector integrated on chip have bee reported but so far they require extreme cooling requirement and a large latency that prevents any on-chip feedback.

The project proposes to combine single photon detection and optical feedback in one single device. The idea behind this is to use an PN junction acting as a single photon avalanche photodiode [1]–[3]capable of detecting NIR photons while simultaneously the junction acts as a fast light modulator [4].

[1]   D. Renker, "Geiger-mode avalanche photodiodes, history, properties and problems," Nucl. Instrum. Methods Phys. Res. Sect. Accel. Spectrometers Detect. Assoc. Equip., vol. 567, no. 1, pp. 48–56, Nov. 2006.

[2]   A. Samusenko et al., "Integrated silicon photodetector for lab-on-chip sensor platform," in 2015 XVIII AISEM Annual Conference, 2015, pp. 1–4.

[3] M. M. P. Fard, C. Williams, G. Cowan, and O. Liboiron-Ladouceur, “High-speed grating-assisted all-silicon photodetectors for 850 nm applications,” Opt. Express, vol. 25, no. 5, pp. 5107–5118, Mar. 2017.

[4] A. Liu et al., “High-speed optical modulation based on carrier depletion in a silicon waveguide,” Opt. Express, vol. 15, no. 2, pp. 660–668, Jan. 2007.

Doelstelling:

The work is theoretical. A first step will be to build a proper model for an avalanche photodiode using Comsol. The geometry and doping levels will be adjusted for best performance and compatibility with existing nanofabrication. In a second step, the combination of the PN-junction with photonics ICs will be modeled. Several configurations could be explored depending on the results obtained in the preliminary work.

Locatie:

iGent, Tech Lane Ghent Science Park - Campus A, Zwijnaarde

Website:

Meer informatie op: photonics.intec.ugent.be

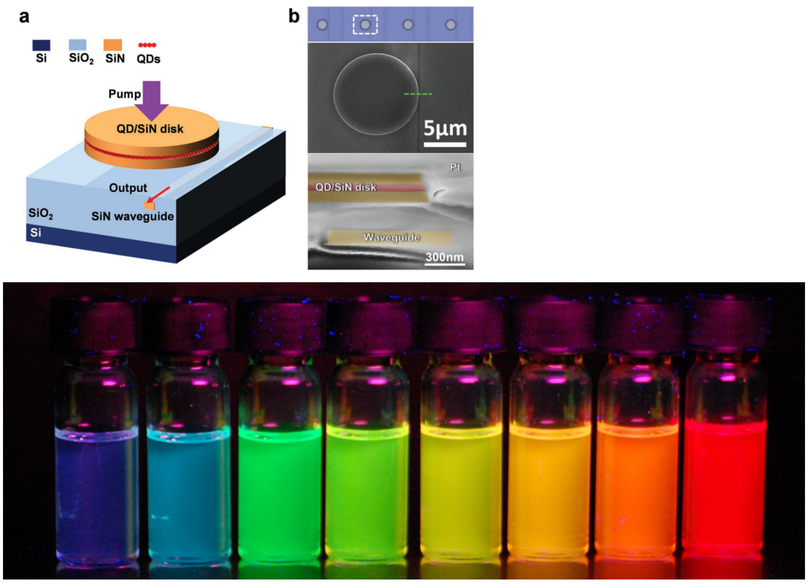
21136: Broadband integrated light sources using colloidal quantum dots for lab-on-a-chip spectroscopy

Promotor(en):	Dries Van Thourhout, Pieter Geiregat
Begeleider(s):	Ivo Tanghe
Contactpersoon:	Dries Van Thourhout
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Integrated photonics and the development of nanoscale light emitting materials fits the scope of a Photonics Engineer.

Probleemstelling:

On-chip light sources are in high demand in the integrated photonics community. At the Photonics Research Group(PRG, Faculty of Engineering) this is an active area of investigation, mainly by hybridization of various materials on the silicon or silicon nitride platform. Amongst these materials we find colloidal Quantum Dots (cQDs), the core of the research of the Physics and Chemistry of Nanostructures group (PCN, Faculty of Sciences). Using quantum confinement, these nanometer-sized semiconductor crystals emit and amplify light across the visible and near-infrared spectrum.

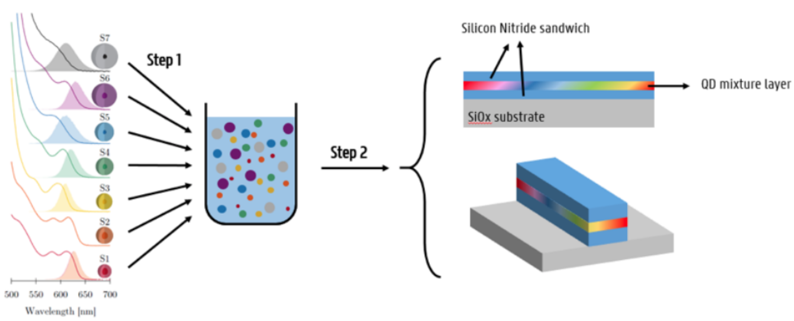
The unique collaboration between PRG and PCN has shown advancement of integrated light emitters using cQDs, creating integrated lasers operating under pulsed optical excitation at ca. 600 nm. Now, the goal is to expand both the wavelength range of these light sources, mainly to include also green lasers and a broader gain spectrum, and the operational conditions of the lasers, such as pumping using continuous-wave radiation.



(left) Microdisk laser with colloidal quantum dots embedded, coupled to a single mode waveguide (middle,b) Microscopy images of the microdisk with the embedded quantum dots. (right) CdSe quantum dots in solution. The size increases from left (blue) to right (red) due to quantum confinement of the electron-hole pairs that emit light.

Doelstelling:

In this master thesis, you will first take up the task to characterize various types of quantum dot blends using ultrafast femtosecond pump-probe spectroscopy. The goal is to identify the best combination of materials to achieve an expansion of the gain spectrum. In parallel, you will develop methods to depost different types and blends of these quantum dots onto silicon photonic chips to develop application relevant broadband light sources, either relying on single burst amplification or true lasing. You will work in the ultrafast optics lab at Campus Sterre (PCN group), the cleanroom facilities of PRG (Zwijnaarde) and the optical labs of PRG (Zwijnaarde, iGent tower). The thesis will expose you to physics, chemistry and photonic engineering involved in using nanoscale materials to realize integrated miniature light sources for lab-on-a-chip spectroscopy.



This thesis proposal is linked to the following cluster(s) of elective courses:

“Modelling”, “Photonics”, “Materials” and “Nanoscale Sciences”

Locatie:

Sterre, iGent, Cleanroom Zwijnaarde

Website:

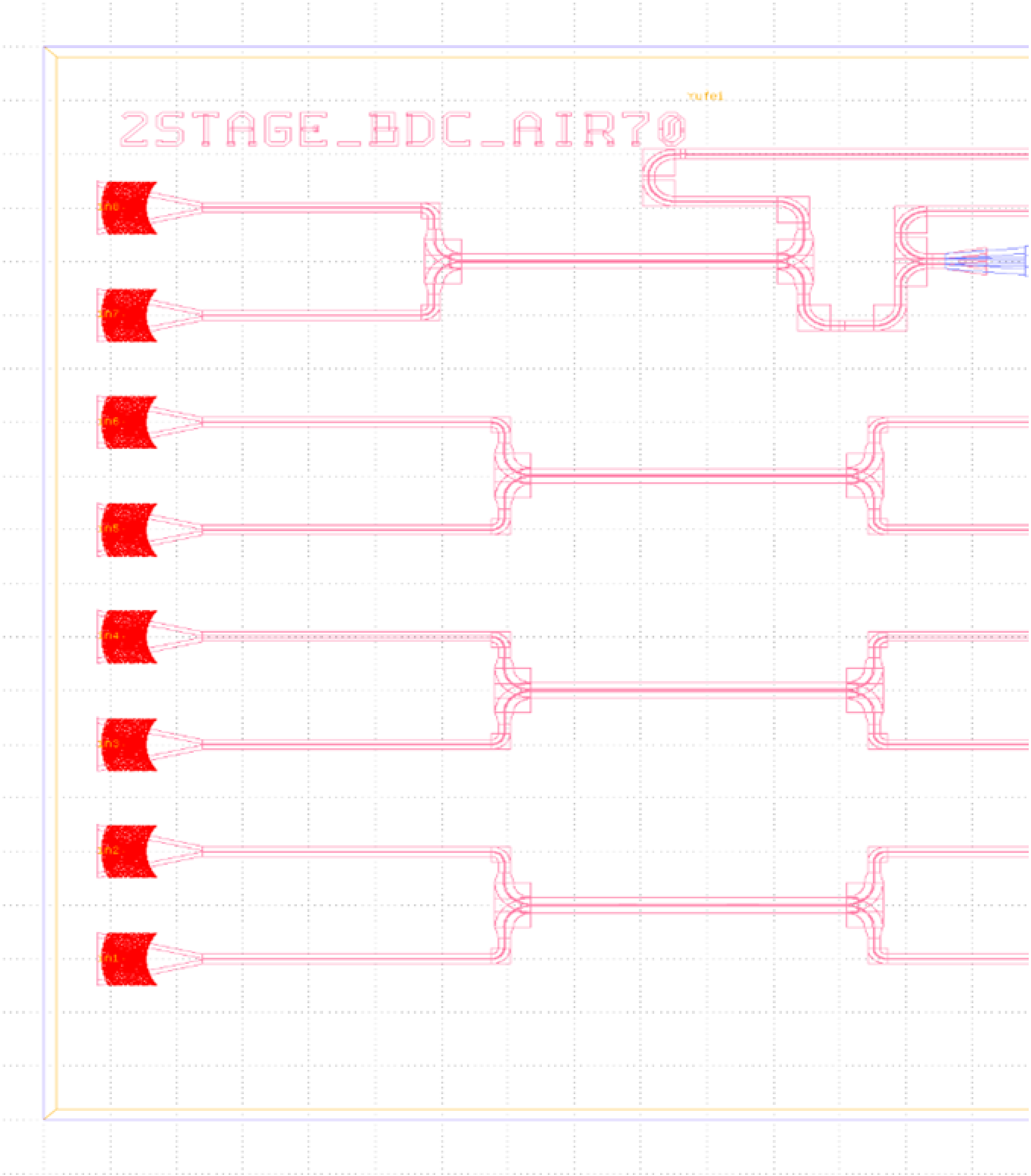
Meer informatie op: www.nano.ugent.be

21551: Broadband optical 2x2 couplers

Promotor(en):	Wim Bogaerts
Begeleider(s):	Mi Wang, Umar Khan
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Dit onderwerp focust op de ontwikkeling van een fotonische component, en vereist basiskennis van optische componenten en optische circuits

Probleemstelling:

Broadband optical power couplers are the essential devices used for splitting and combining of optical power in photonic systems. In photonic integrated circuits (PIC), a compact, wavelength-independent, power coupler is highly desired, especially for data communication applications, such as wavelength-division multiplexing and signal switching. Directional couplers (DCs) have been widely used as power couplers in the photonic integrated circuits (PICs) especially for silicon-on-insulator (SOI) platform. However, the coupling ratios of conventional DCs are known to be highly sensitive to their operating wavelengths. Therefore, an optimized design for a broadband optical coupler is required



Doelstelling:

In this master thesis, the student will optimize the performance of the already designed broadband directional coupler and explore the optimization of more broadband devices such as MMI splitters. This optimization will help the student to learn simulation and optimization skills. The optimized device will be fabricated and measured using the in-house facilities. This thesis will enable the student to acquire simulation, measurement and analysis skills.

The detailed process flow is illustrated as following:

- Optimization : The basic design structure of the device has already been chosen. You will use the model built in Fimmwave or FDTD to do the optimization of the device. By carefully choosing the optimization method, target function and design parameters, you should be able to reach the desired spectral response of the broadband coupler.
- Fabrication : The device will be fabricated in-house using the e-beam system. You will learn the whole process from generating the GDS file to the e-beam fabrication of the chip (although you will not operate the e-beam writer yourself).
- Measurement and data analysis : You will measure the device and write a data analysis report.

Locatie:

iGent, Technologiepark-Zwijnaarde

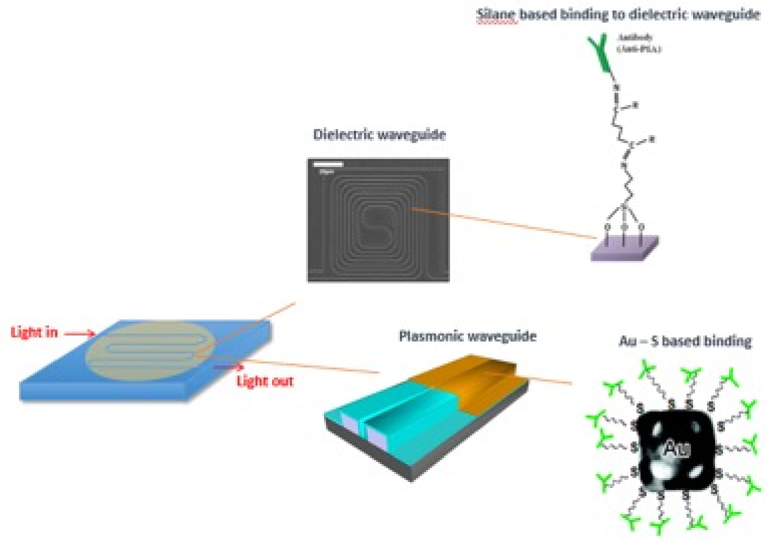
Deze masterproef werd reeds 1-maal toegekend!

21589: Chip-based Raman sensors for disease diagnosis

Promotor(en):	Roel Baets
Begeleider(s):	, Giuseppe Antonacci
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Opportunity to design and test new photonics integrated circuits

Probleemstelling:

Antibodies are the immunoglobulin molecules produced by the host immune system. The main function of antibodies is to latch onto the invading substances (antigens) and mark them for destruction, thus helping to fight against diseases. The ability to bind with the foreign substances makes them ideal probes in cell study [1]. Being a building block of our immune system, the study of antibodies-antigens is essential. Conventional methods of detection in optical biosensors are based on refractive index sensing, where a change in the effective refractive index along one arm or an integrated interferometer results in a shift in the output wavelength. However, these methods are strictly linked to the chip surface.



Raman spectroscopy is a powerful tool because it yields unique fingerprints of chemical compounds. As such, Raman spectroscopy is a promising candidate for a selective detection of antibodies [2]. The Photonics Research Group has recently demonstrated how Raman spectroscopy can be miniaturized on an integrated photonic chip for gas sensing, but this method for disease detection is currently unknown. In this work, advanced Raman technique, waveguide-enhanced Raman spectroscopy (WERS) using dielectric waveguides [3] or plasmonic waveguides [4] will be investigated, in-flow sensor allows the study of antibodies-antigens interaction on a chip scale. This will involve accurate signal processing in order to analyse the spectra and to remove the inevitable background signal generated by Raman scattering arising from the waveguide.

[1] Yang, G., Velgos, SN, Boddapati, SP, & Sierks, MR (2015). Probing Antibody-Antigen Interactions. In Antibodies for Infectious Diseases (pp. 381-397). American Society of Microbiology.

[2] Kneipp, K., Kneipp, H., Itzkan, I., Dasari, RR and Feld, MS, 2002. Surface-enhanced Raman scattering and biophysics. Journal of Physics: Condensed Matter, 14 (18), p.R597.

[3] Dhakal, A., Wuytens, PC, Peyskens, F., Jans, K., Thomas, NL, & Baets, R. (2016). Nanophotonic waveguide enhanced Raman spectroscopy or biological submonolayers. Acs Photonics, 3 (11), 2141-2149.

[4] Raza, A., Clemmen, S., Wuytens, P., Muneeb, M., Van Daele, M., Dendooven, J., Detavernier, C., Skirtach, A. and Baets, R., 2018 ALD assisted nanoplasmonic slot waveguide for on-chip enhanced Raman spectroscopy. APL Photonics, 3 (11), p.116105.

Doelstelling:

The goal of this thesis is to present a study of antibodies-antigens interaction using a photonic integrated chip. Firstly, the student is expected to investigate Raman signal in a photonic / plasmonic waveguide. This will be done by simulating the behavior of electromagnetic field propagating through waveguides or different geometries. Then student will explore different antibodies binding recipes together with experts at Ghent University and imec. To ensure the coverage of the waveguide, the student is also the accessibility of antibodies in a narrow gap. Moreover, the student will do the on-chip enhanced Raman experiment using the coated dielectric or plasmonic waveguide. In the last step, the student will perform some signal processing to analyse the Raman spectra and to remove the unwanted background signal arising from the light-waveguide interaction.

Locatie:

Photonics Research Group, iGent Tower

Deze masterproef werd reeds 1-maal toegekend!

21065: Compact and efficient metasurface optical couplers for lab-on-chip applications

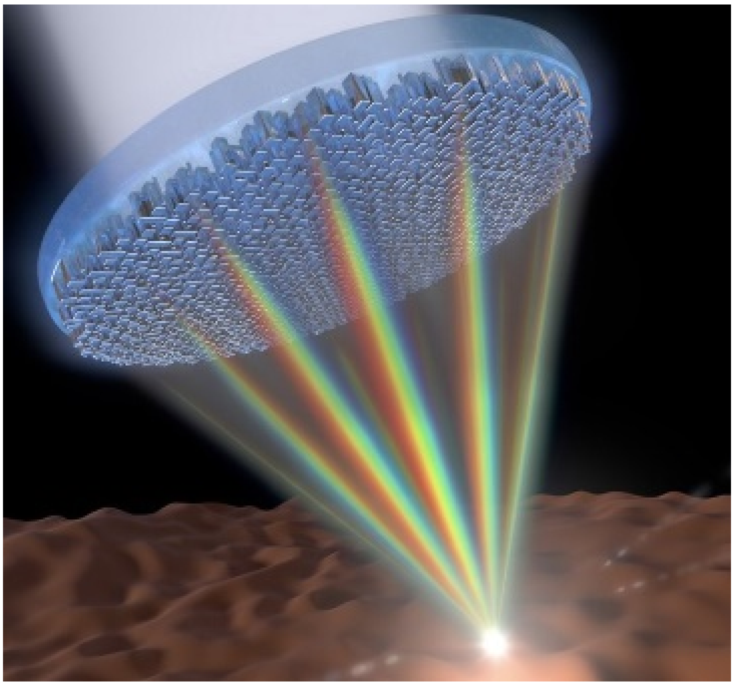
Promotor(en): Kristiaan Neyts

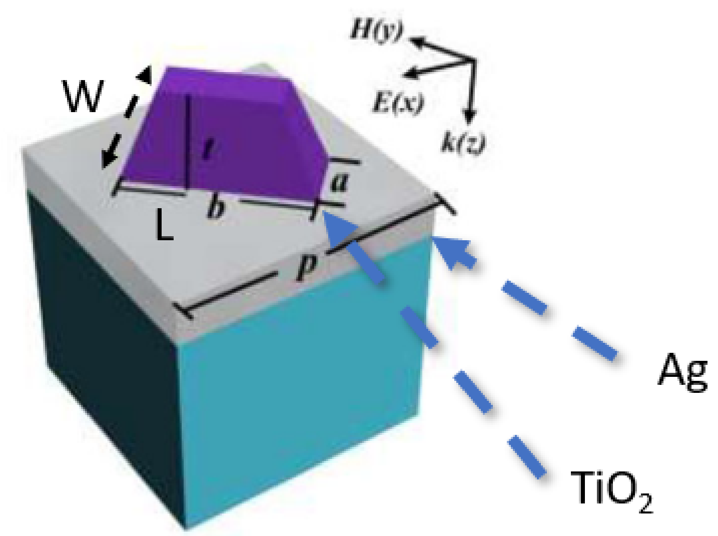
Begeleider(s):	Lieven Penninck
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

Probleemstelling:

On-chip fluorescence and spectroscopic measurements have enormous potential for improving medical diagnostics by widespread adaptation of low-cost polymer sensors. For this reason, numerous sensors have been designed in R & D labs. In practice the large scale deployment of these sensors has been hindered by a lack of efficient ways to couple light from an external light source into the device.

Metasurfaces are an emerging technology that uses the properties of subwavelength structures to create planar and compact components with a high degree of design freedom. By arranging different nanostructures in a grid surfaces which control the reflection, polarization and spectral responses can be created that are not possible by traditional components (lenses, polarizers) can be created.





Doelstelling:

In this thesis you will design metasurface components for coupling of an LED into a polymer lab-on-a-chip sensor. This will include:

1. Designing a metasurface for coupling between a green LED and a polymer waveguide.
2. Determining the performance of different incoupling concepts like: blazed grating couplers and reflective lenses

The design of a metasurface requires the design of the individual subwavelength structures which control the phase, amplitude and polarization response of the surface via full wave simulations of Maxwell 's equations and the arrangement of hundred thousands of individual structures to create the desired far-field projection by diffraction simulations.

This thesis is organized in collaboration with PlanOpSim (www.planopsim.com), a photonics start-up developing design software for metasurfaces in Ghent. In this thesis you will use the PlanOpSim software and expand the software's capabilities.

Locatie:

Ardoyen (iGent), thuis, planopsim

Website:

Meer informatie op: www.youtube.com/watch?time_continue=2&v=JH3YbgzUL-U

Samenwerking met bedrijf

Bedrijf: Planopsim
Samenwerking: begeleider

Opmerkingen:

in samenwerking met de spin-off firma Planopsim

21550: Configuring programmable photonic circuits using electronics

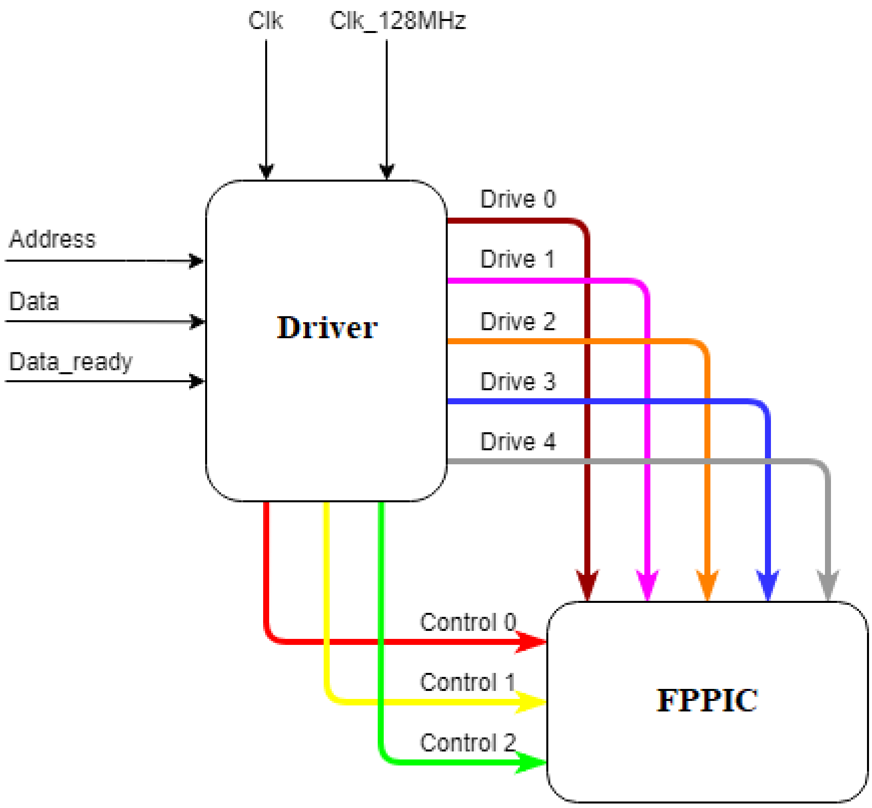
Promotor(en):	Wim Bogaerts
Begeleider(s):	Umar Khan, Antônio Ribeiro Alves Júnior
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The thesis can either focus on the electronics development or the photonic functionality

Probleemstelling:

Programmable photonic integrated circuits (PIC) have gained a lot of interest in the past few years. Programmable photonic circuits consist of a vast number of individually controllable elements which, when configured in a certain way, result in a certain behavior of the chip. This is similar to electronic FPGAs (field-programmable gate arrays). Programmable photonic chips are usually configured using electro-optic tuning elements that can alter the paths of light on the chip. Until now, the most complex PICs have a few tens of such tuners, but programmable chips need to accommodate many hundreds and potentially thousands of such elements, that need to be controlled electronically. Controlling thousands of elements is itself a challenge and requires dedicated electronic drivers and control algorithms that need to be implemented in electronics, e.g. in an FPGAs.

Doelstelling:

In this master thesis, the student will use the FPGA based electronic driver boards to configure the programmable optical circuits. In a similar thesis in 2018-2019, we already have demonstrated FPGA-based electronic driver boards for programmable photonic circuits, and showed that we could use them for a novel technique matrix addressing control elements in a photonic circuit.



The thesis will involve aspects of experimental measurements (both optical and electronic), hardware programming (VHDL) and electronic system design for measurements. The student will implement the feedback loops to configure the programmable circuits in the desired functionality, by reading out optical powers on the optical chip using photodetectors, and then adjusting the driving signals for the many electro-optic tuners. The functionalities include the optical filters and optical transceivers using the programmable photonic circuits. Use of multiple FPGA boards in synchronization will be required to control larger programmable photonic circuits. The configured circuits will be optimized for the performance after the basic implementation.

This work relates to two European projects. In PhotonicSWARM the fundamental concepts of programmable PICs are being researched. MORPHIC is a project where we participate as IMEC, collaborating with groups in Switzerland, Sweden and Ireland, as well COMMSCOPE in Leuven and VLC Photonics in Valencia.

Locatie:

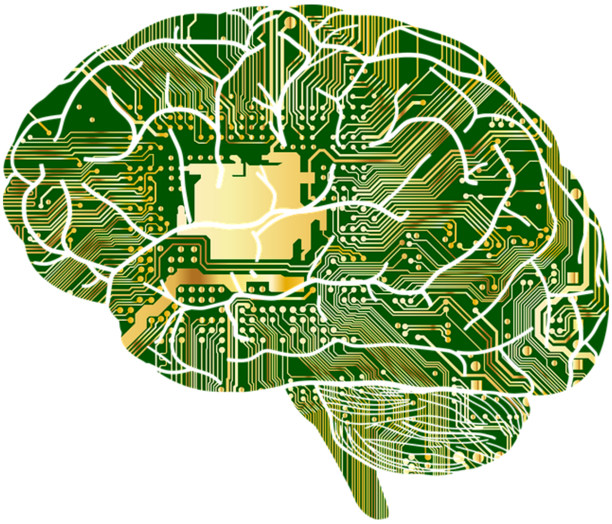
iGent, campus Technologiepark Zwijnaarde

21119: Deep Learning with analog optical networks in PyTorch

Promotor(en):	Joni Dambre, Peter Bienstman
Begeleider(s):	Matthias Freiberger, Floris Laporte
Contactpersoon:	Joni Dambre
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	This project targets a novel approach to designing and optimising photonic systems, by exploiting the workhorses that made deep learning successful: GPU accelerated gradient descent.

Probleemstelling:

In recent years, deep learning, i.e. deep neural networks have obtained state-of-the-art results on the vast majority of machine learning benchmarks. Amongst other reasons, this rapid progress has been made possible by the ease-of-use of current deep learning frameworks like PyTorch, which enable researchers to prototype new, often unconventional network architectures very quickly. The main advantage of such a framework is the automatic calculation of gradients for the backpropagation algorithm as well as the automatic parallelization of computations on graphics processing units (GPUs). At the same time, due to the increasing need to extract information from large amounts of data, ideally during data transmission with high speed while consuming little power, a significant amount of research has been conducted to find feasible hardware implementations of neural networks. Possible building blocks of such systems have been realised using optical circuits and silicon photonics. These circuits are usually simulated in commercial optical circuit simulators, which bears the drawback that all occurring gradients must be calculated by hand and inherent parallelization using GPUs is not available.



Therefore we have started to implement a framework that enables the simulation optical neural networks in PyTorch, and more importantly, their parameter optimisation by using backpropagation. Such a framework in turn would enable the exploration and development of potential network architectures with the same efficiency as what has been happening for neural networks in software in recent years.

References:

https://pdfs.semanticscholar.org/14de/f2c7c8188e873feb9c26a1d200e7c1488756.pdf

Doelstelling:

In this thesis, you will investigate how to exploit the potential benefits of automatic differentiation and inherent parallelization in the best possible way when simulating and optimising optical circuits. Many different questions can be addressed:

Since the analog recurrent neural networks (RNNs) of interest are intrinsically a time-discrete approximation of a continuous system, their optimization process differs slightly from the process applied in conventional RNNs. For instance, whereas delay occurs only implicitly for digital systems (since every operation in an RNN takes exactly 1 discrete time step), this delay must be carefully tuned in analog systems. A possible route to explore might be to research ways to train optimal network delay using PyTorchs autograd mechanism.

Another difficulty is the fact that we are targeting coherent optical systems. This means that all signal and weight values need to be modeled by complex numbers. While PyTorch performs automatic differentiation, complex gradients are currently not officially supported.

Besides the mere implementation of complex-valued gradient computation and backpropagation, the mathematical operations that result from this context may pose additional problems. Whereas recent evolutions, such as the use of ReLus, in deep learning were targeted at allowing the gradients to propagate through the network more easily, we do not have that liberty in analog photonic networks, in which we sometimes need to switch between real/imaginary and magnitude/phase representations and where the eventual transition to the electrical domain is equivalent to taking the squared magnitude of the complex signals. In this setting, all commonly used techniques from deep learning, such as typical learning rate schemes, need to be re-evaluated.

Furthermore, parts of your work might be published in a peer-reviewed conference/journal paper listing you as a contributor.

Locatie:

iGent, home

20694: Depolarisation of liquid crystal based direct view displays

Promotor(en):	Kristiaan Neyts, Jeroen Beeckman
Begeleider(s):	Brecht Berteloot
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Esterline is a worldwide manufacturer for the aerospace and defense market. Esterline Belgium, located in Kortrijk, is the headquarter for the "Advanced displays" and "Simulation Visual Systems" department. Within the Advanced displays department, three types of displays are being developed: avionics-, rugged- and air traffic control displays. In these displays, liquid crystal technologies are being used as they are the most affordable, performant and mature technology. The operating principle of an LCD (liquid crystal display) is as follows: light coming from a backlight (LED) is linearly polarized in a certain direction (e.g. the horizontal direction). This polarized light is then modulated by a liquid crystal panel which will modify the polarization of the light at a specific position (the subpixel) based on the voltage that is driven to that subpixel. A color filter then specifies the color of that subpixel which can be red, green or blue. After the color filter, a second polarizer is placed which only transmits that part of the light that has a polarization direction orthogonal to the first one (thus vertical in this example). Therefore the light output of a liquid crystal display is always polarized.

In the cockpits of airplanes, pilots often wear sunglasses as there is always a high amount of sunlight present. A common type of sunglasses is polaroid sunglasses which only transmit the vertical polarizing component of light. The advantage of this is that it suppresses the large s component of the sun reflection. But as it is also a polarizer, it has a strong effect on the readability of liquid crystal display dependent on the eye point position of the pilot.

Doelstelling:

The goal of this project is to investigate possible thin "depolarizers" which can be placed on top of a liquid crystal display and depolarize the output light so that it always gives the same brightness when observed by a person wearing polaroid sunglasses.

Part of this thesis is devoted to a literature study in which possible technologies are investigated with regards to performance, manufacturability, scalability and cost. Possible technologies are patterned wave retarders, micro-retarders based on liquid crystals and components based on geometric phase retardation.A (small) prototype of a depolarizer should be fabricated and its performance should be tested. The characterization should take into account diffusion, transmission, diffraction, color-shifts under different viewing angles.

Locatie:

IGent (Technologiepark Zwijnaarde), Esterline (Kortrijk)

Samenwerking met bedrijf

Bedrijf: Esterline Belgium
Samenwerking: begeleider + use case

Opmerkingen:

The thesis can be partially done at UGent and partially at Esterline (Kortrijk). An optimal location can be discussed throughout the thesis.

21424: Design of a Highly Efficient On-Chip Opto-Electric Antenna for THz communication

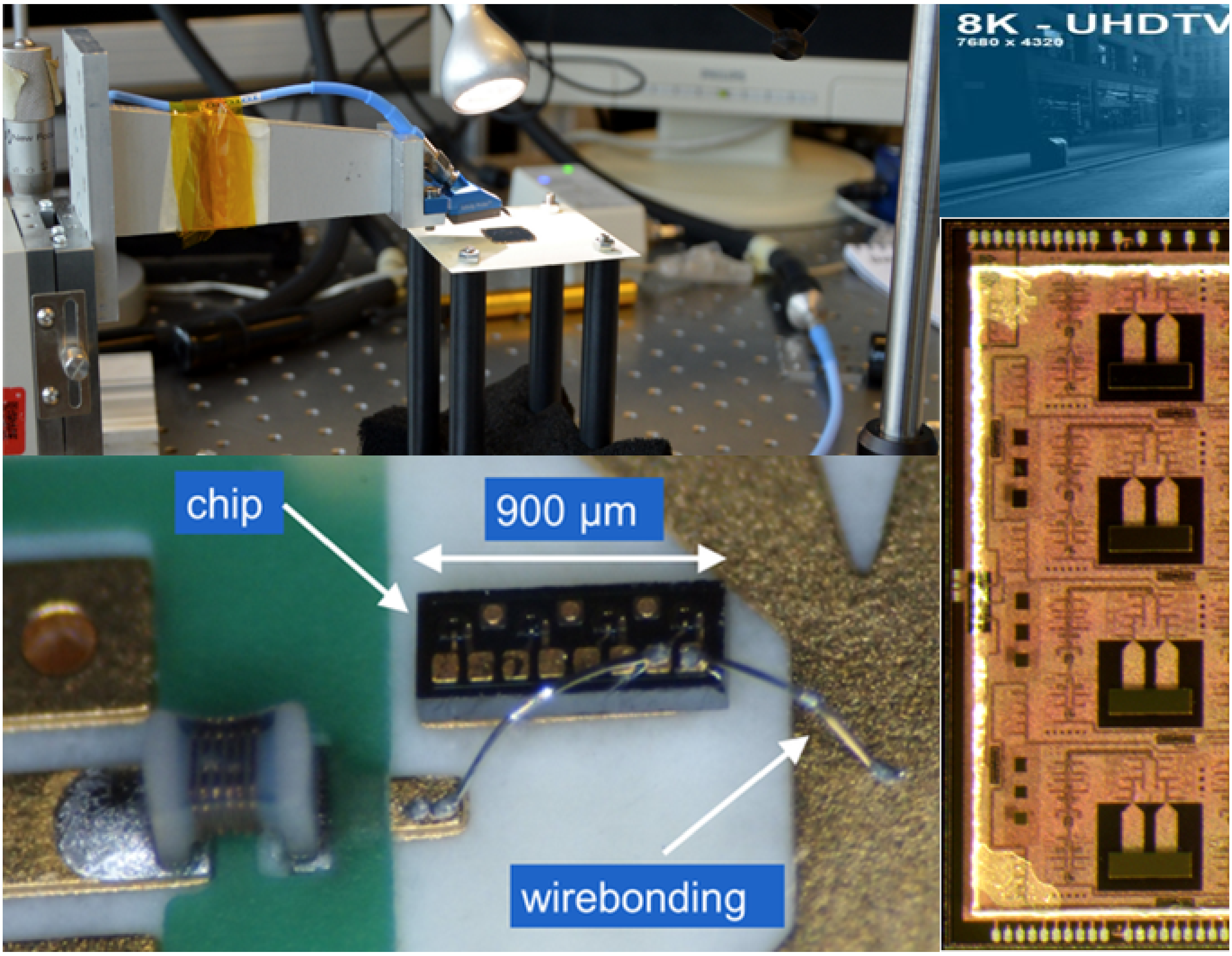
Promotor(en):	Sam Lemey, Bart Kuyken
Begeleider(s):	Quinten Van den Brande, Dries Vande Ginste, Hendrik Rogier
Contactpersoon:	Quinten Van den Brande
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal bachelorproeven:	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, and to students of both the Electronic Circuits and Systems and the Communication and Information Technology subject areas.

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)

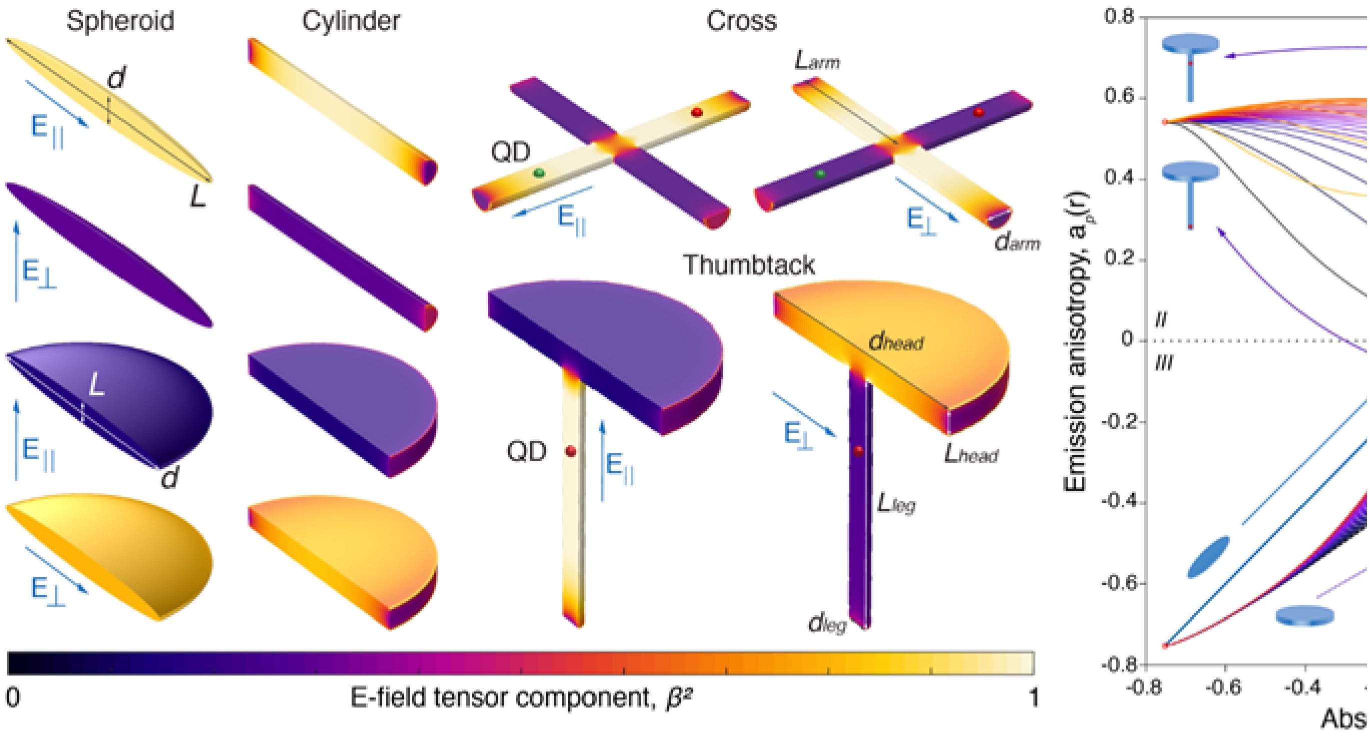
Deze masterproef werd reeds 1-maal toegekend!

20976: Design of quantum-dot-containing semiconductor nanoparticles for the enhancement of anisotropy in photon absorption and emission

Promotor(en):	Kristiaan Neyts
Begeleider(s):	Yera Ussembayev
Contactpersoon:	Yera Ussembayev
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
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Nanoparticles are used in photonic applications light emission in LEDs, OLEDs and solar cell concentrators.

Probleemstelling:

Quantum dots (QD) have unique optical and electronic properties, which make them widely used in different technology, including lasers, LED, bioimaging, quantum computing, display and solar cell devices. The encapsulation of a QD inside a semiconductor nanoshell provides novel means to manipulate their light absorption and emission in a desired manner1. The high refractive index of the nanoparticles compared to the surrounding medium is the driving mechanism for this effect. At this point it is not clear how the nanoshell geometry and the position of the embedded QD influences the anisotropic absorption and photoluminescence. By employing numerical modelling, developing an analytical framework and/or conducting experimental characterization, one can identify and design optimal nanoparticle topologies, which will satisfy the growing demands of modern technology.



Yera. Ye. Ussembayev, Zeger Hens, Kristiaan Neyts, “Contrasting anisotropy of light absorption and emission by semiconductor nanoparticles”, ACS Photonics, 2019

Doelstelling:

The plan is to design of novel nanoparticles that show anisotropic absorption and emission characteristics. The radiative decay rate may be influenced by the Purcell effect due to the optical environment to show increased or reduced emission. The aims are:

- Development and operation of numerical tools based on Matlab, Python, Comsol or other software environments to determine light absorption and emission in complex 2D or 3D nanoparticle topologies;
- Development of an analytical framework for dielectric screening of the electric field by a nanoparticle;
- Experimental verification based on high-resolution measurements with fast-acquisition imaging and single photon detection.

Locatie:

Ardoyen (iGent), thuis

Website:

Meer informatie op: pubs.acs.org/doi/10.1021/acsphotonics.8b01405

21225: Device modelling of perovskite solar cells

Promotor(en):	Johan Lauwaert, Stefaan De Wolf
Begeleider(s):	Sheng Yang, Johan Lauwaert
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal	1

bachelorproeven:	
Motivering voor deze opleiding:	This proposal fits within the scope of the European Master Photonics as it is focused on the modelling and characterization of solar cells

Probleemstelling:

Perovskites are an emerging class of semiconducting materials with great promise to enable high-efficiency thin-film photovoltaics at acceptable cost. This can be largely attributed to its appealing optical and electronic properties. However, defects such as non-coordinated ions at their grain boundaries and surfaces do contribute to non-radiative photo-carrier recombination. This undesirably inflates the open-circuit voltage deficit (i.e. the difference between its bandgap and voltage under open-circuit conditions) and is a likely contributor to the widely reported phenomenon of hysteresis in the current-voltage characteristics. Using interfacial treatments and by developing so-called passivating contacts, detrimental phenomena may be avoided..

Doelstelling:

In this project, the candidate will perform detailed interface-defect studies on series of relevant perovskite solar cells. Specific emphasis will be laid on the characterization of sub-bandgap states, characterized by methods such as deep-level transient spectroscopy. With the aid of numerical modelling, these results will be correlated to the solar cell parameters

Locatie:

Ardoyen

Deze masterproef werd reeds 1-maal toegekend!

20696: Direct-lit led backlight with minimal thickness

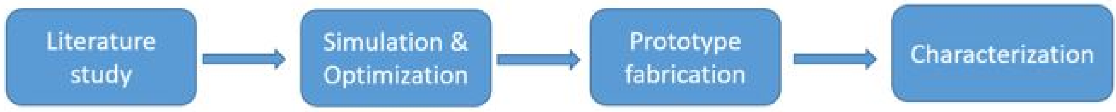
Promotor(en):	Kristiaan Neyts, Jeroen Beeckman
Begeleider(s):	Brecht Berteloot
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Esterline is a worldwide manufacturer for the aerospace and defense market. Esterline Belgium, located in Kortrijk, is the headquarter for the “Advanced displays” and “Simulation Visual Systems” department. Within the Advanced displays department, three types of displays are being developed: avionics-, rugged- and air traffic control displays. In these displays, liquid crystal technologies are being used as they are the most affordable, performant and mature technology. Liquid crystal displays make use of a backlight based on LEDs. Two types of backlights exist, edge-lit backlights which make use of a light guide plate or direct-lit backlights in which the LEDs are directly placed behind the display. Most consumer displays make use of an edge-lit backlight which generally results in a much thinner display. There are however disadvantages with regards to thermal and structural stability. That is why avionics displays still regularly use direct-lit backlighting. The disadvantage of this is however that it requires a substantial thickness to provide a high uniformity.

Doelstelling:

In this project, we want to investigate alternative ways to get a compact direct-lit backlight while maintaining a high uniformity. Based on a literature study, optical components, sheets can be investigated which could be placed between the LEDs and the LCD. After the literature study, these components should be designed, simulated and optimized in ray-tracing software (Zemax OpticStudio). Based on these simulation results, a prototype can be fabricated and characterized to show the real performance taking into account the transmission, thickness and uniformity of the designed backlight.



Locatie:

IGent (Technologiepark Zwijnaarde), Esterline (Kortrijk)

Samenwerking met bedrijf

Bedrijf: Esterline Belgium
Samenwerking: begeleider

Opmerkingen:

The thesis can be partially done at UGent and partially at Esterline (Kortrijk). An optimal location can be discussed throughout the thesis.

21770: Efficient waveguide couplers for nano-rdige lasers

Promotor(en):	Dries Van Thourhout, Yannick De Koninck
Begeleider(s):	
Contactpersoon:	Dries Van Thourhout
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Photonics simulation and characterisation

Probleemstelling:

The potential of leveraging well-established manufacturing processes developed initially by the electronics industry has been the main driver fuelling the massive research into Si photonics over the last decade. Despite considerable achievements, the lack of a laser source monolithically integrated on silicon remains a fundamental obstacle. Silicon has an indirect bandgap, preventing efficient light generation. Finding a novel way of integrating highly efficient light generating materials such as III-V semiconductors on silicon has triggered worldwide efforts. Recently, IMEC (one of the worlds largest nanoelectronic and CMOS technology research institutes) and the Photonics Research Group of UGent have demonstrated a monolithically integrated distributed feedback laser array grown directly on silicon (Nature

Photonics 9, 837–842 (2015), Optica 4, 1468-1473 (2017)). This result attracted world wide attention and is generally considered as a breaktrough for the field. Fig. 1 shows a cross-section of the fabricated lasers.

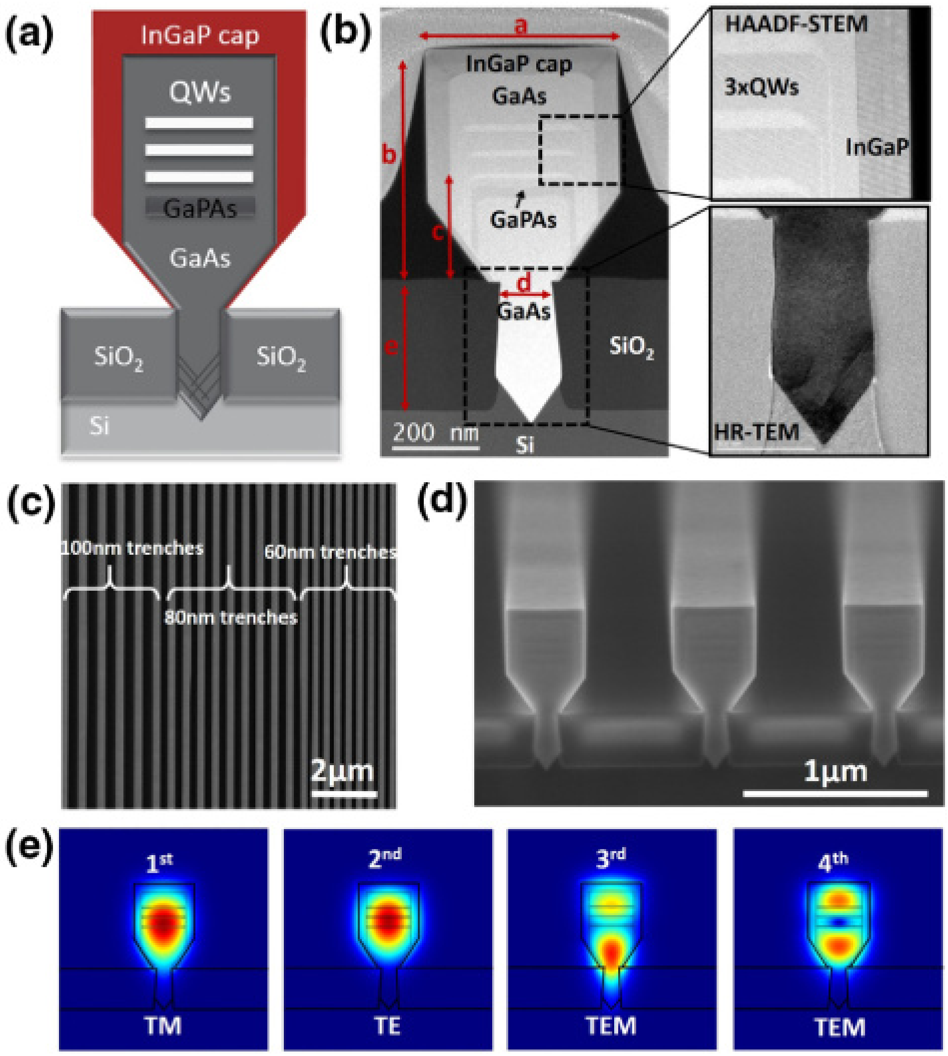


Fig. 1 Sketch and SEM images of the GaAs nano-ridge laser stack (from Optica 4, 1468-1473 (2017))

Doelstelling:

The next big milestone in the development of monolithically integrated laser sources and amplifiers is to efficiently couple the light generated in the III-V nano-ridges into a silicon waveguide that feeds into photonic circuit. In this master thesis, the student will characterize and benchmark different silicon/III-V coupling schemes to identify the most promising approach for low-loss coupling. The work will be carried out in close collaboration with and partly at the optical interconnect group of imec (Leuven).

Fig. 2. Simulation of coupler (accepted for ECIO2019)

Locatie:

Ardoyen, imec leuven

Samenwerking met bedrijf

Bedrijf: imec
Samenwerking: promotor

21522: Electrical trapping of nanoparticles

Promotor(en):	Filip Strubbe, Filip Beunis
Begeleider(s):	Bavo Robben
Contactpersoon:	Filip Strubbe
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	Master of Science in Engineering Physics
Nog onbeslist voor:	European Master of Science in Photonics, Master of Science in de ingenieurswetenschappen: elektrotechniek, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Electrical trapping is the principle of keeping a single particle at a fixed position by applying electrical fields, preferably in three dimensions. Electrical trapping of particles in a liquid is a useful tool if one wants to study the properties of single particles, including size, electrical charge and refractive index, for long durations of time. Practically, there are two steps in the process of electrical trapping: firstly the 3D-position of the particle is determined and secondly a suitable electric field is applied to push the particle towards the desired position.

Doelstelling:

The aim of this Master thesis is to electrically trap nanoparticles in a nonpolar liquid using a device with electrodes in an octupole configuration. The particles are fluorescent PMMA nanoparticles or scattering gold nanoparticles in a nonpolar liquid. In the case of fluorescent particles the particle position is calculated from image analysis using an EMCCD camera. In the case of scattering a laser is coupled into the objective such that backscattered light is detected, with a fast CMOS camera. With a software feedback system, electrical fields are updated at about 100 Hz to correct the particle position, which should be sufficient to trap particles as small as 30 nm. Once a particle is trapped, properties such as its size and charge and the charge fluctuations will be investigated.

The engineering aspects of the Thesis include working with an electro-optical setup with lasers, optical detectors (camera's), voltage generators, which are synchronized and automated (LabView), fabrication of microfluidic devices with integrated electrodes (cleanroom Zwijnaarde), and advanced image analysis (Labview/Matlab). The physical aspects include the dynamics and electrophoretic properties of individual nanoparticles (Brownian motion, double layer theory), the physics of scattering nanoparticles.

This thesis proposal is linked to the following clusters of elective courses: electrical measurements (electronics), Mie-scattering (photonics), nanoparticles (materials), and is related to electrophoretic displays (Display Technology).

Locatie:

iGent

21504: Electro-optical modelling and characterization of liquid crystal displays for smart contact lens applications

Promotor(en):	Herbert De Smet, Andrés Felipe Vasquez Quintero
Begeleider(s):	
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Optische modellering; verband met vloeibare kristallen; beeldvorming op de retina

Probleemstelling:

Small liquid crystal cells in close proximity to the eye, for instance inside a contact lens, are becoming feasible with new progress in microfabrication and integration technology. These cells can be used for different applications, for instance to actively filter light or modify the visual performance of the user. The optical modeling of such devices together with the response of the eye elements (i.e. cornea, crystalline lens, iris and retina) is crucial to determine the optimal parameters for their design. Such models require a validation throughout experimentation in order to be applicable elsewhere. Currently, such models are limited in their application for eye wearable medical devices such as contact lenses.

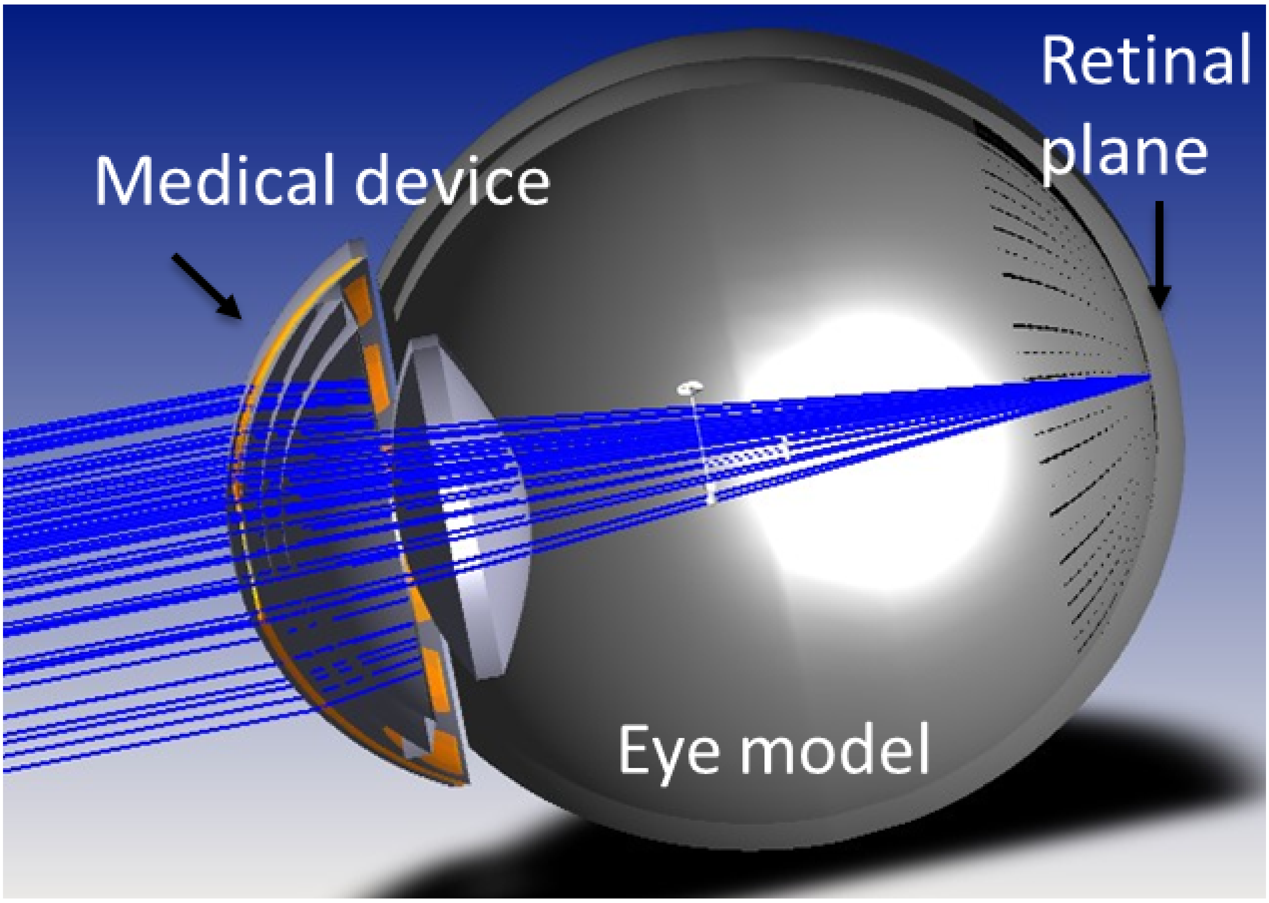


Figure 1: Eye model simulated in Zemax in order to determine the effect of a small pupil contact lens (medical device).

Doelstelling:

In this master thesis project, a literature review will be performed in order to determine the optical function of all the eye elements (ex. Cornea, crystalline lens, iris, retina, etc.) and to identify their optical models. With that information, the student will setup an optical model in combination with a wearable eye medical device (ex. Contact lens) and explore their effect in visual acuity, visual angle, contrast sensitivity, etc. The simulations can be performed in Zemax in a sequential (ray tracing) or non-sequential (retinal intensity) modes. Finally, such models will be validated by means of optical experimentation in the lab.

Locatie:

Ardoyen (iGent + optics lab in building 125)

Deze masterproef werd reeds 1-maal toegekend!

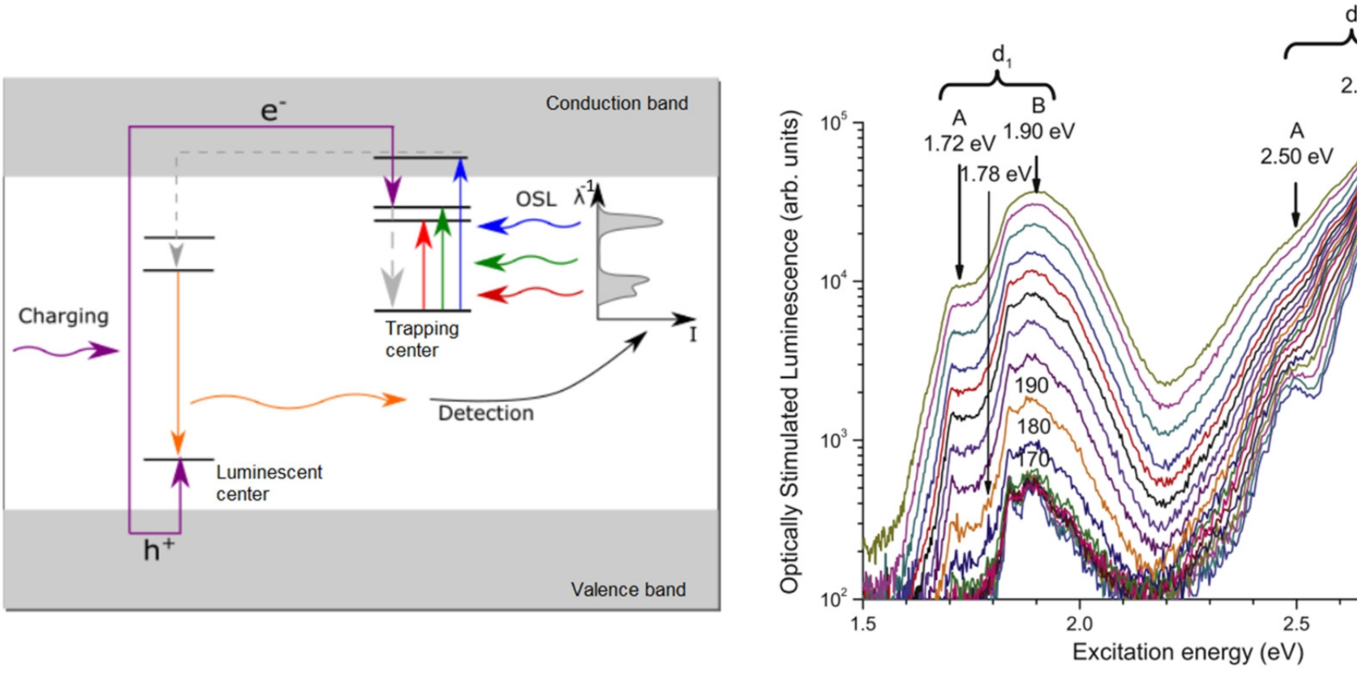
20805: Energy storage in lanthanide/s2 ion activated phosphates

Promotor(en):	Philippe Smet, Jonas Joos
Begeleider(s):	David Van der Heggen
Contactpersoon:	Philippe Smet
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist	

voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	This thesis subject is situated at the crossroads between fundamental physics, photonics and materials, with close connection to "Atomic and molecular physics". Connected elective courses include "Luminescence", "Optical Spectroscopy of Materials". The thesis aims at creating new energy storage and readout schemes in luminescent materials, opening many application possibilities.

Probleemstelling:

Photoluminescent (PL) materials or phosphors are ubiquitous in many technologies such as LEDs for lighting and information displays, medical imaging and scintillators to detect high energy radiation. These materials are typically composed of an inorganic host crystal with a large band gap that is deliberately doped with one or more impurities that activate the luminescence. These impurities can be a transition metal (e.g. Cr3+, Mn2+, Fe3+, ...), a lanthanide (Ce3+, Eu2+, Tb3+, ...) or heavy p-block ions that are also known as s2 ions (e.g. Pb2+, Bi3+, Tl+). Depending on the type of ion, **different electronic transitions give rise to the luminescence**. Typically, the luminescence process can be described by two steps, i.e. the absorption of a photon and the subsequent emission of a photon with slightly lower energy, the energy difference being dissipated as heat.



(a) Schematic overview of the relevant processes for OSL.

(b) Experimental OSL excitation spectrum for YF
[A.J.J. Bos et al. / Radiation Measurements 45 (

A special class of luminescent materials are those that can store the absorbed energy, typically by trapping photo-ionized charge carriers at intrinsic or extrinsic defects. It can be released after the application of external stresses such as pressure (mechanoluminescence, ML), temperature (thermoluminescence, TL) or the absorption of another photon (optically stimulated luminescence, OSL). Glow-in-the-dark materials are an example where the ambient temperature triggers the slow release of the stored energy. In this thesis, particular systems are investigated that are expected to show energy storage. Phosphate host crystals are selected due to their chemical tunability, offering a means to manipulate physical properties such as band gap energies, dielectric screening etc. Upon doping by lanthanide ions, in particular Ce3+, Eu2+ and Yb2+, efficient 4f*N* – 4f*N*-15d luminescence is activated. It has been shown that energy storage occurs in particular phosphate crystals without co-doping. **Here s2 ions, in particular Bi3+ and Sb3+, are introduced as a co-dopant as they are believed to behave as traps for charge carriers**. Up to now, their trapping mechanism is however not established. Furthermore, there is still disagreement on which charge states these s2 ions can take and how they behave electronically as impurity in inorganic hosts. By studying the luminescence of the lanthanide ions, it is the goal to learn about the behavior of the s2 ions in an indirect way.

Doelstelling:

Luminescent phosphates will be prepared by a solid state reaction. The nature of the materials (orthophosphates, metaphosphates, pyrophosphates, ...) will be varied by tuning the reaction parameters and precursor materials. Subsequently, lanthanide (Ce^{3+}, Eu^{2+} and Yb^{2+}), s2 (Bi^{3+} and Sb^{3+}) co-doped materials will be selected for a profound study of their charge trapping dynamics, including the measurement of charging behavior, luminescent decay, TL and OSL. For this, the student will be educated to operate the state-of-the-art **spectroscopic tools** that are available within LumiLab. The outcome of this experimental investigation will serve as the input to devise **energy level schemes** of the impurity ion in the phosphate hosts. These schemes should help to explain the trapping/detrapping behavior in the materials and validate various claims on the luminescence mechanisms involving s2 ions. Finally, the most promising phosphors will be optimized with regard to the envisioned **applications such as afterglow or storage phosphor**.

Locatie:

De Sterre

Website:

Meer informatie op: lumilab.ugent.be

Opmerkingen:

21593: Exploring the detection limit of on-chip Raman spectroscopy for real-time antibiotics monitoring

Promotor(en):	Roel Baets, Nicolas Le Thomas
Begeleider(s):	Zuyang Liu
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Biomedical Engineering
Niet behouden voor:	
Nog onbeslist voor:	Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The research of on-chip Raman spectroscopy is carried out in the photonics research group, and mainly involves knowledge in photonics. For students in this field, it is a perfect fit to their previous study and a good opportunity to practice their skills.

Probleemstelling:

Effective antimicrobial therapy for infectious diseases is threatened by increasing resistance rates and a limited supply of new antimicrobial drugs. Because of specific changes in physiology, critically ill patients are at risk for low antibiotic concentrations and subsequent treatment failure and emergence of antimicrobial resistance. The complex physiological condition associated with critically ill patients poses a question on the 'one-dose-fits-all' approach. Nowadays, β-lactam antibiotics are the most widely used antibiotics, and they have played a significant role in the front line of healthcare. However, current techniques for concentration measurement require bulk, expensive equipment and experienced lab technicians, resulting in an obstacle in personalizing the dosing. There is a need for compact, low-cost,

Raman spectroscopy is a promising technique for real-time and selective detection of antibiotics in complex environments, such as serum and interstitial fluid. The Photonics Research Group of UGent has pioneered photonics chip-based Raman spectroscopy and has demonstrated proof-of-concept demonstrations of a range or on-chip Raman sensors, including Waveguide-Enhanced Raman Spectroscopy (WERS) [1], Surface Enhanced Raman Spectroscopy (SERS) [2], and Coherent Raman Spectroscopy (CRS) [3]. The potential of the on-chip Raman technique has also been recognized imec XPand, which is a prestigious seeding investment funding. With the financial support from imec XPand, two graduates from the photonics research group are actively working on it, with the target to establish a spin-off for on-chip antibiotics TDM with on-chip Raman spectroscopy.

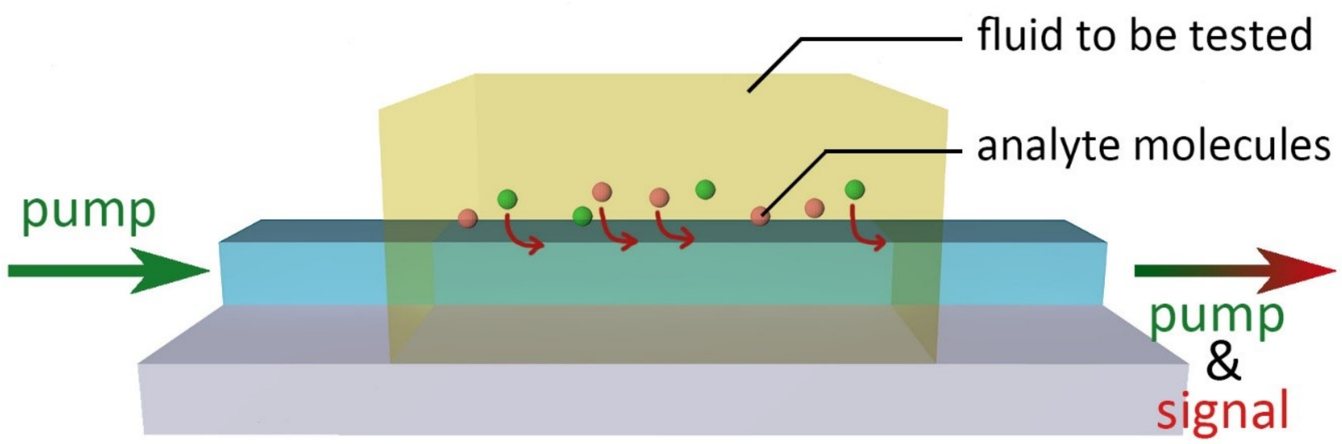
Nevertheless, the sensitivity of on-chip Raman spectroscopy has not met the requirement of continuous monitoring or antibiotics. The ongoing optimization of the waveguide sensor for antibiotic monitoring is mainly based on silicon nitride waveguide platform. Two current master students, Tom Vanackere and Emiel Dieussaert, are actively looking for methods to extend the detection limit of the silicon nitride platform. In the meanwhile, we are also looking for new material platforms beyond silicon nitride, eg tantalum pentoxide (Ta2O5) waveguides. Ta2O5 waveguides have a higher index contrast, which is capable of enhancing the Raman signal by 10-fold in preliminary simulations. In collaboration with the research group of Prof. dr. Dan Blumenthal at the University of California Santa Barbara,

Reference:

[1] Dhakal, A. et al. Optical Letters 39, 4025–4028 (2014).

[2] Wuytens, PC, Subramanian, AZ, De Vos, WH, Skirtach, AG & Baets, R. Analyst 140, 8080–8087 (24 2015).

[3] Zhao, H., Clemmen, S., Raza, A. & Baets, R. Optical Letters 43, 1403-1406 (2018).



Doelstelling:

Although WERS is a promising technique for many pharmaceutical and biomedical applications, its detection limits do not meet the requirement of these applications yet. This thesis aims to extend the detection limit of on-chip Raman spectroscopy beyond state-of-the-art and realize an on-chip Raman sensor that is capable of monitoring antibiotics in physiologically relevant concentration. We are expecting a 10 times improvement or performance by exploring the potential of tantalum pentoxide waveguides. Furthermore, the student will explore advanced signal processing methods in order to improve signal-to-noise ratio.

As a first step, the student will participate in a complete cycle of design, starting from the simulation or an extensive collection or waveguide geometries using COMSOL or Lumerical commercial software. After pinpointing the optimal geometry, the waveguide will be fabricated by UCSB.

The student is also expected to characterize the new waveguides with in-house Raman setups. The objective is to improve the detection limit of the waveguide sensor by a factor of ten, compared to silicon nitride waveguides. Successful results of new lab-on-a-chip approach can lead to scientific publication and progress in β-lactam TDM.

Locatie:

Deze masterproef werd reeds 1-maal toegekend!

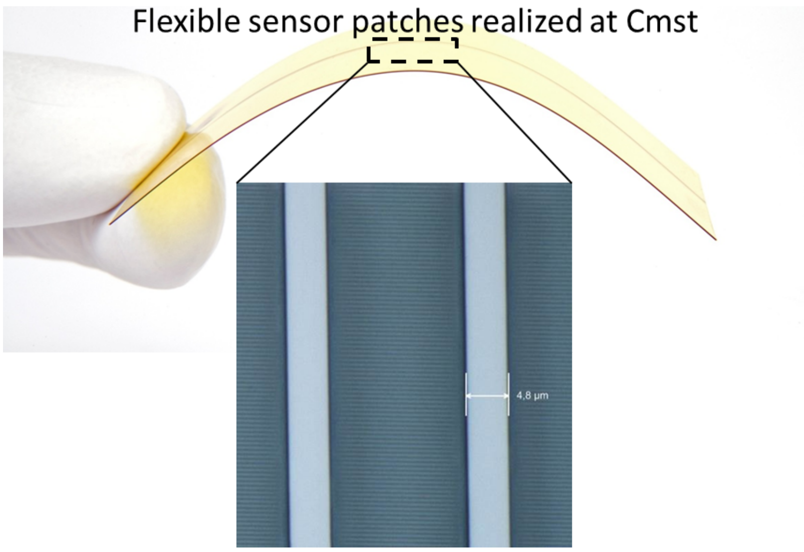
20910: Flexible optical sensor foils for wireless strain sensing

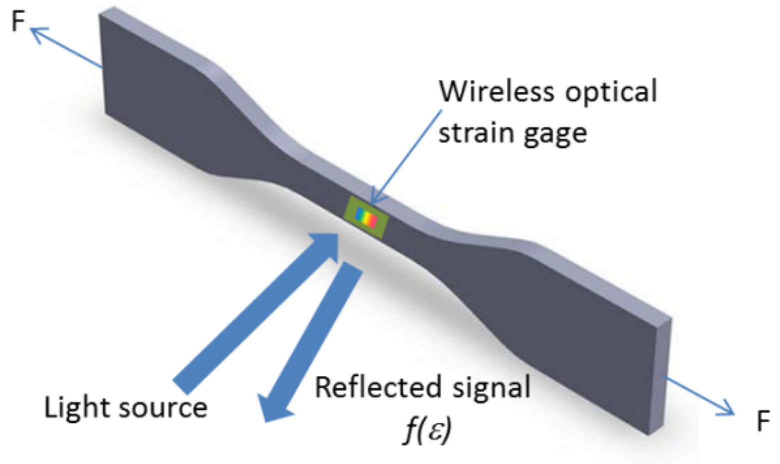
Promotor(en): Jeroen Missinne, Geert Van Steenberge

Begeleider(s):	Marie-Aline Mattelin
Contactpersoon:	Jeroen Missinne
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
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	2
Motivering voor deze opleiding:	an optical sensor on a foil will be developed which, allows strain sensing. Optical simulations, fabrication and testing is involved

Probleemstelling:

Composite materials are used in a wide array of application markets such as aviation, automotive, biomedical implants, construction materials, etc. by virtue of their strength, stiffness and lightness. Adding optical sensing intelligence to these structures enables monitoring the material integrity, which is obviously beneficial in terms of safety, but additionally may prolong their lifetime, and therefore significantly decrease the environmental impact through a reduced use of raw materials and energy savings. A particular example is the new Airbus A380, which is composed for a large part of composite materials (red, green and purple zones in the schematic below). Since large mechanical stresses and deformations act on these structures, it is vital to use sensors during the testing phase, but also during to structure's lifetime for monitoring critical events (e.g. high stress events) and monitor the integrity of the material afterwards.





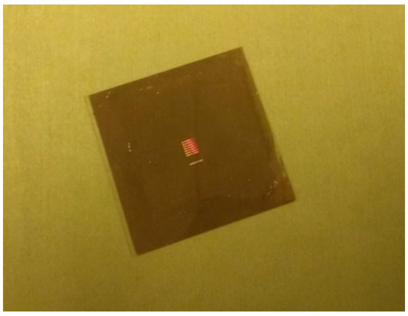
Recently, the research group Cmst (Department Elis) has developed thin polymer waveguide-based sensor foils which can be used for this. The sensing principle is comparable with already commercially-available fiber Bragg gratings, but these polymer foils have many additional advantages: they can be very thin (tens of microns), can contain many sensors for measuring strain/stress in well-defined directions and can support higher elongation values compared to silica fibers.

However, a disadvantage is that these foils need an optical fiber connection for reading out sensor data. To overcome this, the thesis will focus on a slightly different type of sensor foil (using a so-called guided-mode resonance grating) which allows reading out sensor data "wirelessly", and which will have clear advantages for use on rotating or moving structures.

A guided-mode resonance (GMR) sensor consists of a grating (for example imprinted in a polymer foil) which shows a resonance in its reflection spectrum when illuminated with a collimated light source. The wavelength of the peak in the reflection spectrum depends on the grating pitch and hence strain.

Doelstelling:

The basic principle of using GMR sensors for strain sensing has been tested at Cmst, but more developments are required to make a robust sensor. The figure shows a matrix of GMR sensors (each having a slightly different pitch) realized on a foil.



The goal of this thesis is therefore to develop such a GMR-based optical sensor that is easy to use and that can eventually be used for strain sensing on real mechanical structures. An important difference compared to what is already available is that the sensors for this master thesis will be realized on very thin glass substrates as compared to polymer foils used before, to make the sensor more robust for operation in demanding conditions.

There are several important aspects to achieve this goal which can concretely be divided as follows:

1) Based on scientific papers and based on already available sensors and results from previous research at Cmst, the most ideal sensor topology will be selected as a starting point for the sensor design.

2) Designing the optical strain sensor to make it both sensitive for strain and at the same time tolerant for misalignment of the readout system. The performance of the sensor (sensitivity, tolerances, ...) will be simulated so that it can later be compared with actual realized sensors.

3) After finalizing the design, the sensors will be fabricated and validated. All required fabrication steps can be executed in the UGent cleanrooms (Zwijnaarde, Technologiepark) which means that different designs can quickly be fabricated, tested, and if needed redesigned.

4) Testing of the sensor system in the lab and later in a real environment (e.g. tracking the deformation of a mechanical structure)

Together with the master student, the focus of the master thesis can be slightly shifted towards one of the specified parts.

Locatie:

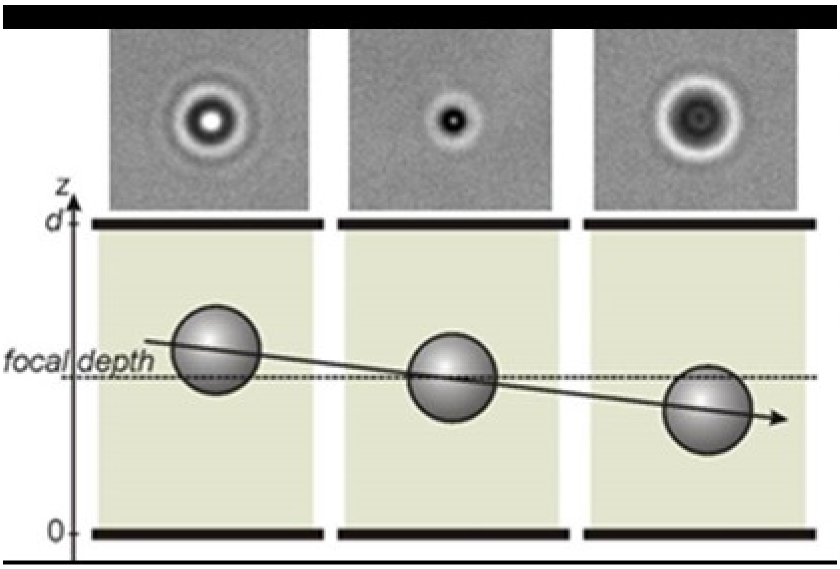
Ardoyen (clean rooms, iGent building) and at home

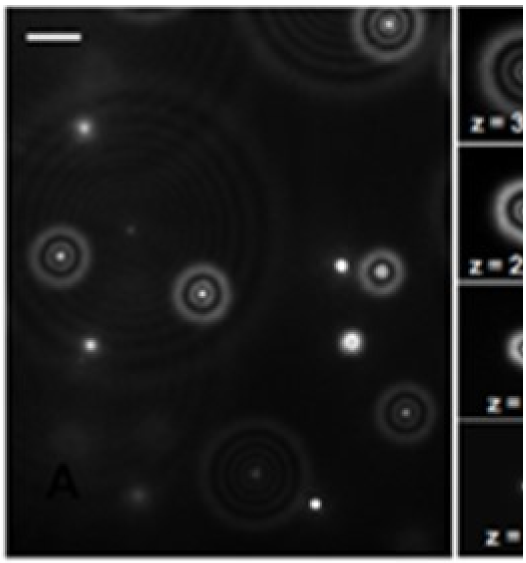
21523: Fourier-Bessel image analysis for tracking single nanoparticles

Promotor(en):	Filip Strubbe, Kristiaan Neyts
Begeleider(s):	Bavo Robben
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

Probleemstelling:

3D tracking of single nanoparticles is frequently used in biomedical and other life science applications. The z-position perpendicular to the plane of the microscope image can be determined by analysing the diffraction pattern of the particle. However, in the present literature the image analysis and algorithms used for determining the absolute z-position are based on calibration and rather arbitrarily chosen parameters (such as counting the number of diffraction rings). In our group recently a more robust algorithm is developed to determine the z-position, based on decomposition of images into a set of orthonormal modes, for example spherical Fourier-Bessel functions. This algorithm is very efficient for analysing micrometer-sized objects (larger than the wavelength of light).





Doelstelling:

The aim of this Master Thesis is to apply the existing Fourier-Bessel image analysis technique to single nanoparticles. Both fluorescent nanoparticles as scattering gold nanoparticles can be used. Firstly, movies of diffusing nanoparticles will be obtained using either fluorescence microscopy or microscopy based on scattered laser-light. Secondly, image analysis will result in the Fourier-Bessel components as a function of the particle's z-position. Algorithms to fit a smooth curve to scattered data of Fourier-Bessel coefficients will be further developed in order to extract information on the actual z-position. Finally, this method will be used to investigate the motion of nanoparticles near surface, and –when an AC electric field is applied– to measure the electrical charge of single nanoparticles.

The engineering aspects of the Thesis include developing and working with an optical setup with a laser, a fast CMOS camera or a fluorescence microscope with EM-CCD camera, automated in LabView, and advanced image analysis (LabView and Matlab). The physical aspects include the dynamics of individual nanoparticles (Brownian motion) and the theory of scattering nanoparticles.

This thesis proposal is linked to the following clusters of elective courses: electrical measurements (electronics), diffraction pattern of point particles (photonics), nanoparticles (materials), and has its application in the bio-medical engineering.

Locatie:

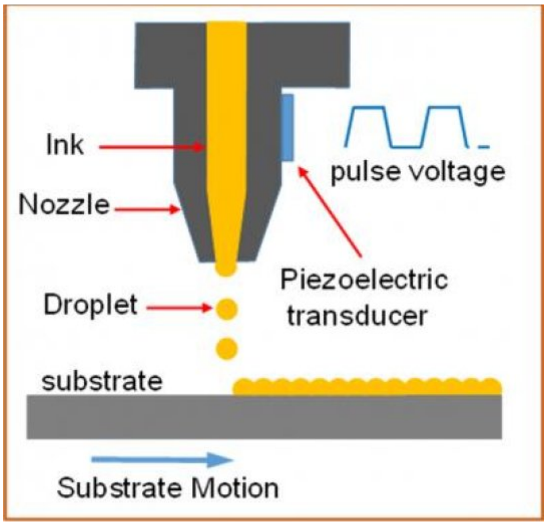
iGent

21506: Inkjet and screen printing of functional layers for smart contact lens applications

Promotor(en):	Andrés Felipe Vasquez Quintero, Herbert De Smet
Begeleider(s):	
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	band met slimme contactlenzen; vloeibare kristallen, transparante geleiders, laserablatie, microfabricage van elektro-optische systemen

Probleemstelling:

Small liquid crystal cells in close proximity to the eye, for instance inside a contact lens, are becoming feasible with new progress in microfabrication and integration technology. These cells can be used for different applications, for instance to actively filter light or modify the visual performance of the user. The patterning of pixels on such liquid crystal cells would allow to independently address them enabling interesting optical phenomenon. The electrical conductors are required to be optically transparent with low resistivity. The materials used for these layers are typically conductive polymers such as PEDOT:PSS or 1D materials such as graphene. The pixel formation has been proposed by means of laser ablation, however, this step is affecting the plastic substrate of the cell. Novel patterning methods such as inkjet and screen printing are desirable in order to reduce waste, cost and effect on the substrate.



a) b)

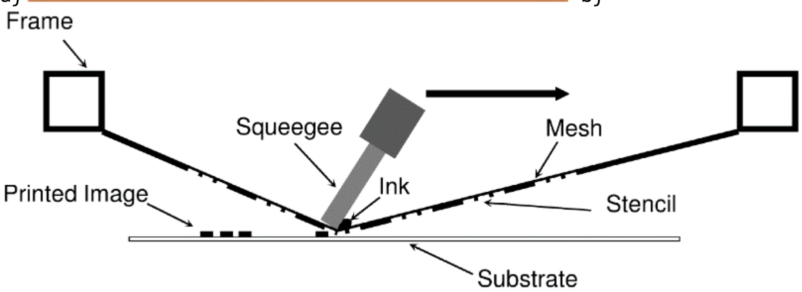


Figure 1: a) Schematic representation of inkjet printing and b) screen printing.

Doelstelling:

In this master thesis, a literature review will be performed in order to determine the electrical, optical and mechanical properties of the substrates and conductive layers for active cells based on liquid crystals. In addition, the comparison of different printing techniques to pattern conductive layers will be assessed. The student will work in the cleanroom facility at Technologiepark developing the patterning techniques and characterizing the performance of the electro-optical devices. This development will allow for the fabrication of the first generation of smart contact lenses with liquid crystal displays.

Locatie:

Ardoyen: Cleanroom + iGent

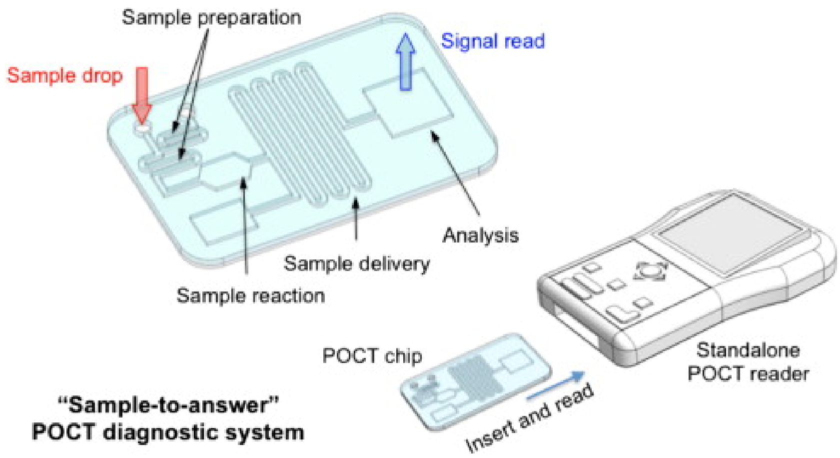
20909: Laser-written point of care optofluidic biochip in glass

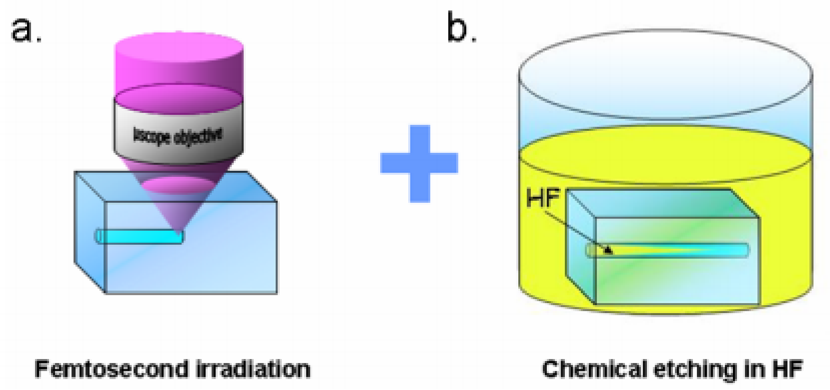
Promotor(en):	Jeroen Missinne, Geert Van Steenberge
Begeleider(s):	Andres Desmet
Contactpersoon:	Jeroen Missinne
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	2
Motivering voor	Using a laser based technology, an optical sensor chip will be developed

deze opleiding:

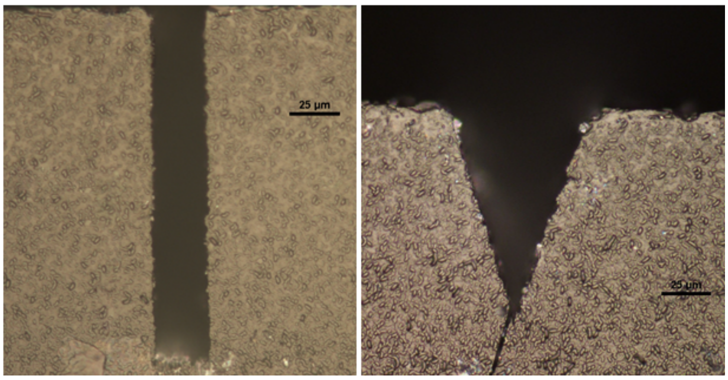
Probleemstelling:

Current advancements in medicine and biotechnology require more and more personalized or specific diagnostic tools. Specific diagnostic results in laboratory settings often require runs with time-consuming specialized equipment. Thus, there has been a growing need to provide diagnostic results at the point of care, for prompt treatment of acute diseases such as acute myocardial infarction and for home-care diagnostics such as diabetes monitoring. Point-of-care testing (POCT) diagnostic systems are instruments that can rapidly provide *in vitro* diagnostic results by non-trained personnel at a patient site in the physician's office, the field, the home, an ambulance, or a hospital.

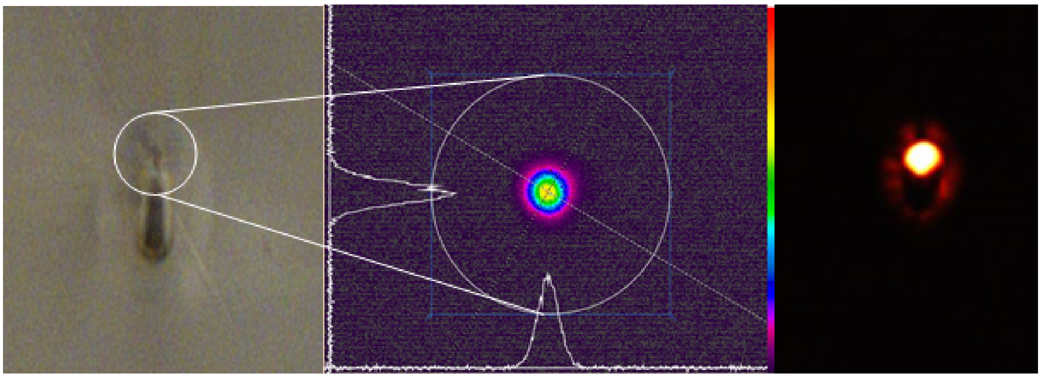




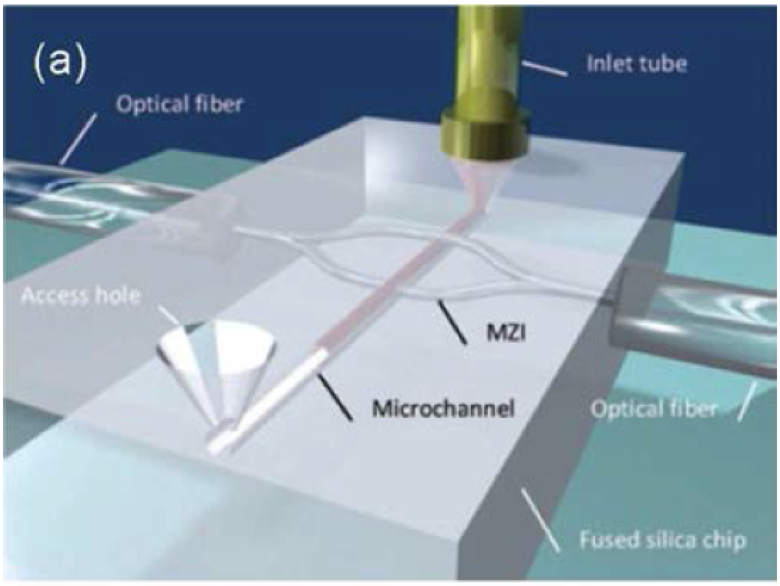
Femtosecond laser irradiation followed by chemical etching (F.L.I.C.E) is an emerging technique for the fabrication of microfluidic channels in transparent dielectrics such as glass and allows for rapid prototyping of such POCT devices, which is invaluable during development. To achieve this, a tightly focussed laser spot is scanned along a 3D path in the bulk of the glass and afterwards the regions which have been exposed to the laser light will etch (using an appropriate etchant) yielding microchannels. The next pictures show the cross-section of 2 etched channels on the surface created by FLICE.



Furthermore, with the same laser but with different parameters, optical waveguides can be inscribed opening up possibilities for combining microfluidics with optical (sensing) structures, e.g. for biological analysis. The pictures below show a microscope image of a written waveguide, its corresponding beam profile and a camera image of out-coupling light at 635nm.



Doelstelling:



During the thesis, we will develop a platform that integrates microfluidic channels together with optical waveguides in a glass biochip. For biosensing, there is a lot of interest in measuring the refractive index or optical absorption spectrum of liquids. For example, the figure shows an implementation of a biochip with a refractive index sensor based on a waveguide interferometer with 1 arm crossing a microfluidic channel, but many other configurations are possible and may yield promising biosensors. The thesis will therefore be organized as follows:

1. Literature study and discussions to define the most promising glass-based biosensor chip configuration.
2. Fabrication of the chip. Initial laser parameters are known and can be used by the student, both for etching and for writing of waveguides. However, further optimization of laser writing parameters may be required (depending on the proposed design from step (1)). Parameters that can be varied are the laser energy, repetition rate, beam polarization, writing speed.
3. Characterization of the components in terms of fabrication quality (using microscopy, etc.)
4. Characterization of the biochip (optical, spectroscopic, … measurements).

The student will use the recently installed state-of-the-art ultrafast laser system for realizing laser-induced photo-modification in glasses. He/she will work in a cleanroom environment for all the experiments related to laser and wet chemical etching. Proper training will be given to work in a cleanroom and to use all the other tools needed for characterization involved in this work. Together with the master student, the focus of the master thesis can be shifted towards one of the specified parts.

Sources:

http://www.rsc.org/suppdata/sm/c1/c1sm05813d/c1sm05813d.pdf

http://www.sciencedirect.com/science/article/pii/S0167931714004316

Femtosecond laser processing for optofluidic fabrication

Locatie:

Ardoyen, (iGent building + Cleanroom), thuis

Samenwerking met bedrijf

Bedrijf: Trinean
Samenwerking: use case

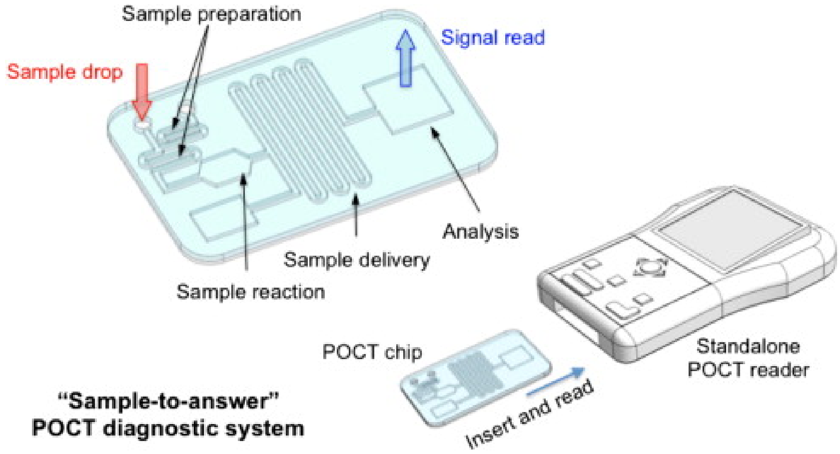
Deze masterproef werd reeds 1-maal toegekend!

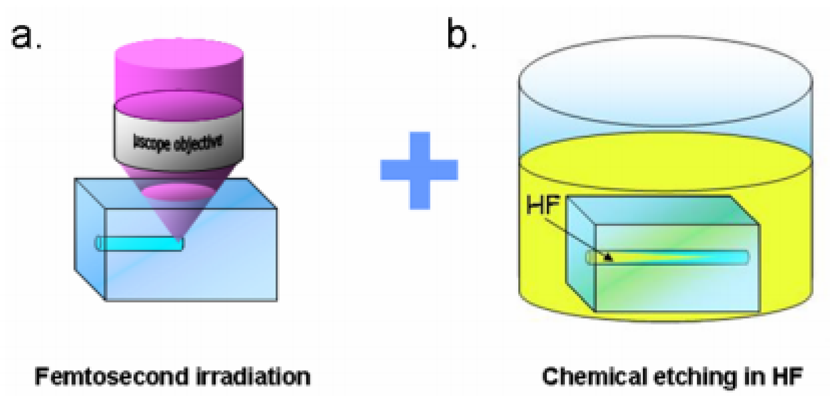
22032: Laser-written point of care optofluidic biochip in glass

Promotor(en):	Jeroen Missinne, Geert Van Steenberge
Begeleider(s):	Andres Desmet
Contactpersoon:	Jeroen Missinne
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	

Probleemstelling:

Current advancements in medicine and biotechnology require more and more personalized or specific diagnostic tools. Specific diagnostic results in laboratory settings often require runs with time-consuming specialized equipment. Thus, there has been a growing need to provide diagnostic results at the point of care, for prompt treatment of acute diseases such as acute myocardial infarction and for home-care diagnostics such as diabetes monitoring. Point-of-care testing (POCT) diagnostic systems are instruments that can rapidly provide *in vitro* diagnostic results by non-trained personnel at a patient site in the physician's office, the field, the home, an ambulance, or a hospital.





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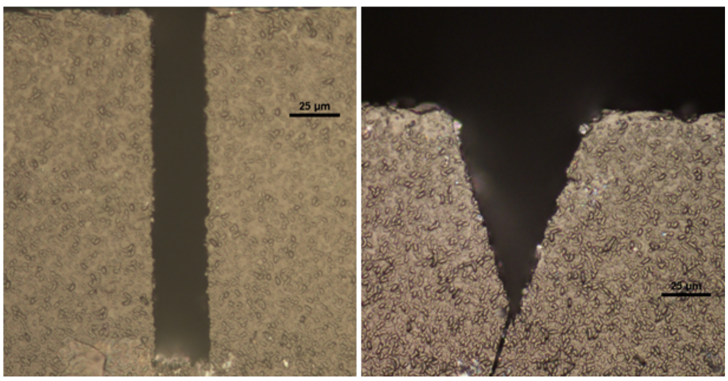
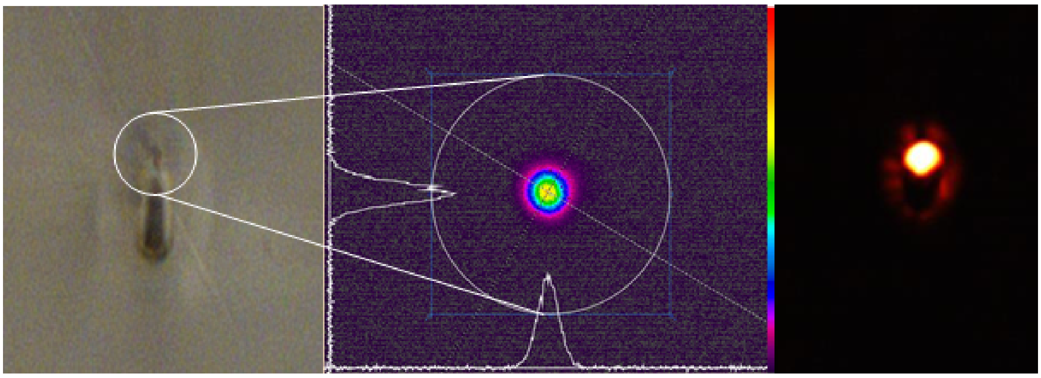
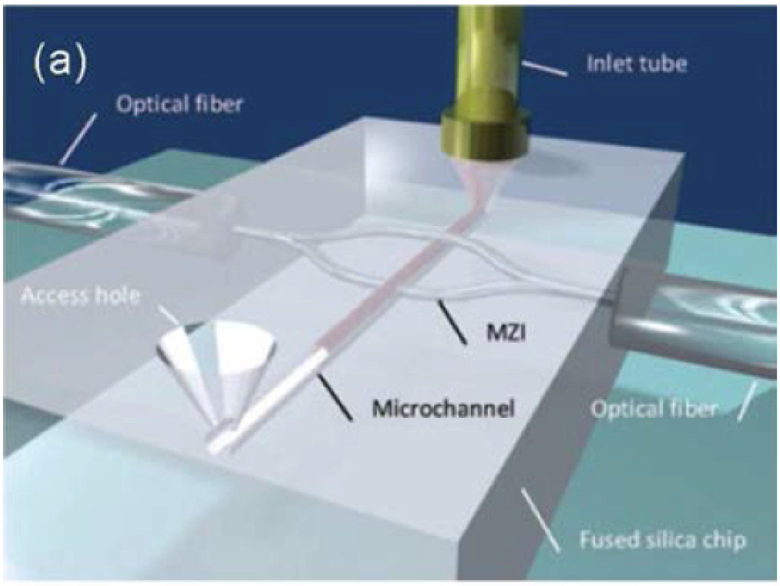


Furthermore, with the same laser but with different parameters, optical waveguides can be inscribed opening up possibilities for combining microfluidics with optical (sensing) structures, e.g. for biological analysis. The pictures below show a microscope image of a written waveguide, its corresponding beam profile and a camera image of out-coupling light at 635nm.



Doelstelling:



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2. Fabrication of the chip. Initial laser parameters are known and can be used by the student, both for etching and for writing of waveguides. However, further optimization of laser writing parameters may be required (depending on the proposed design from step (1)). Parameters that can be varied are the laser energy, repetition rate, beam polarization, writing speed.
3. Characterization of the components in terms of fabrication quality (using microscopy, etc.)
4. Characterization of the biochip (optical, spectroscopic, … measurements).

The student will use the recently installed state-of-the-art ultrafast laser system for realizing laser-induced photo-modification in glasses. He/she will work in a cleanroom environment for all the experiments related to laser and wet chemical etching. Proper training will be given to work in a cleanroom and to use all the other tools needed for characterization involved in this work. Together with the master student, the focus of the master thesis can be shifted towards one of the specified parts.

Sources:

http://www.rsc.org/suppdata/sm/c1/c1sm05813d/c1sm05813d.pdf

http://www.sciencedirect.com/science/article/pii/S0167931714004316

Femtosecond laser processing for optofluidic fabrication

Locatie:

Ardoyen, (iGent building + Cleanroom), thuis

Deze masterproef werd reeds 1-maal toegekend!

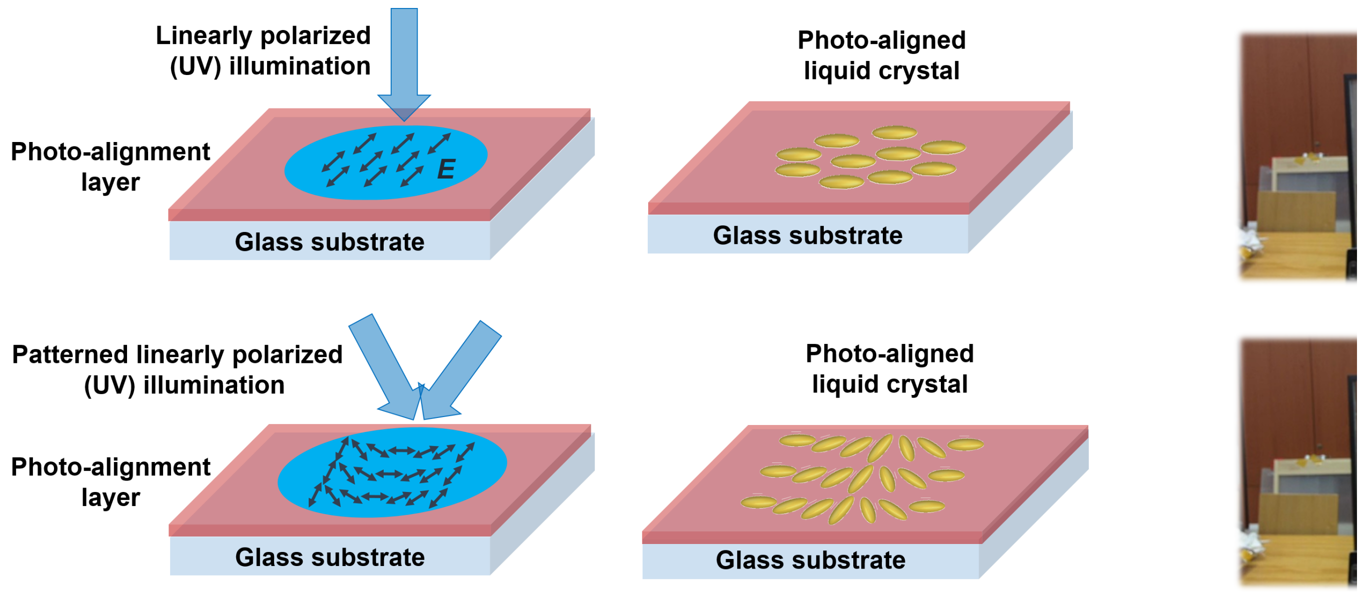
21371: Liquid crystal smart windows by photo-alignment

Promotor(en):	Kristiaan Neyts, Jeroen Beeckman
Begeleider(s):	Inge Nys
Contactpersoon:	Inge Nys
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	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 electrically tunable smart windows will be investigated (see figure). 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, etc. We want to takle these issues by using the electrical tunability and the anisotropic optical properties of liquid crystal.



Doelstelling:

The aim of this master thesis is to realize liquid crystal cells that can electrically switch between different optical states (transparent, scattering, reflective). This will be realized by optimizing the alignment pattern of the liquid crystal at the substrates. To control this 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 to orient the alignment molecules (see figure). The liquid crystal near the substrate follows this orientation of the alignment molecules. 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.

To design a liquid crystal device with the desired optical properties, different alignment patterns and different types of liquid crystals will be tested and the cell thickness will be optimized. 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 switching between the different states. To produce such a low-power device, bistablility (tristability) of the stabilized liquid crystal configurations is necessary. This should be possible by optimizing the device parameters (alignment pattern, liquid crystal material, thickness, voltage treatment).

Engineering physics aspects: liquid crystal is a kind of soft matter and the structure that is formed depends on a minimization of the free energy (combining elastic energy, electric energy and surface anchoring energy), investigation of physical properties by interaction of electrical, optical and elastic properties

This thesis proposal is linked to the following cluster(s) of (elective) courses: photonics, physics, optical materials, materials and fields

Locatie:

iGent (Zwijnaarde), thuis

21512: Liquid crystal tuning for reconfigurable photonic circuits

Promotor(en):	Jeroen Beeckman, Wim Bogaerts
Begeleider(s):	Lukas Van Iseghem
Contactpersoon:	Lukas Van Iseghem
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The thesis is linked to integrated photonics and liquid crystals.

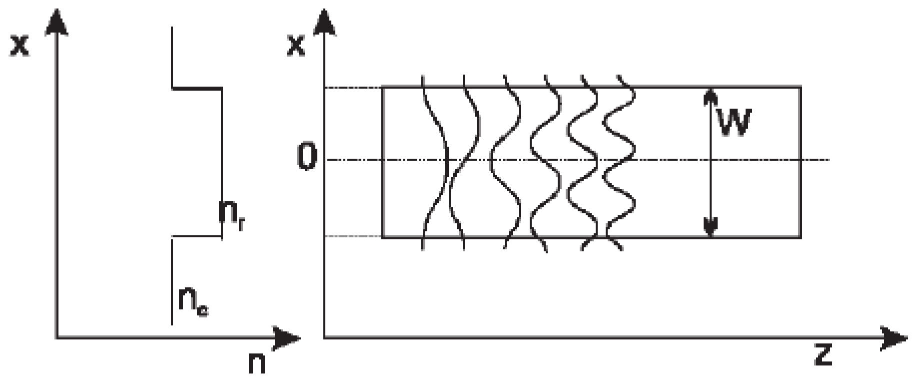
Probleemstelling:

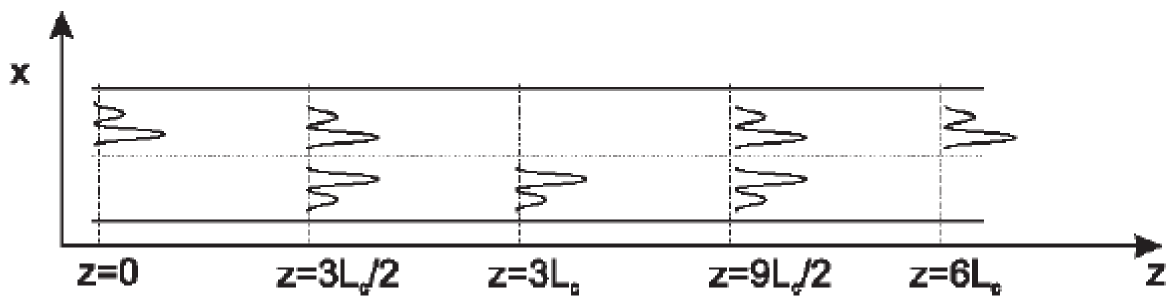
Photonic Integrated Circuits (PICs) using silicon on insulator technologies have been around for some time now. Much like the electronic integrated circuit market in the early years, the main focus of development was situated within ASICs (Application Specific Integrated Circuits), scaling down specific optical applications to schip-scale dimensions, such as spectroscopy and switching applications. Now that the silicon photonics market is maturing and a variety of specifc tasks have been demonstrated using PICs, the question arises wether it would be feasible and interesting to develop programmable PICs, much like microcontrollers and FPGAs in electronics. These devices consist of a vast number of individually controllable elements which, when configured in a certain way, result in a certain behaviour of the chip.

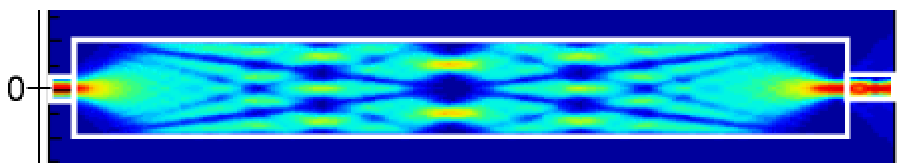
This requires several mechanisms. First, one has to enable local tuning of the optical properties of materials changing the behaviour of light locally on a photonic chip. This translates towards the ability to tune the refractive index of materials locally with an applied voltage (electric field). One known way to achieve this is using liquid crystal materials as a cladding (top layer) on silicon. Because the liquid crystal reorients as a function of applied voltage, a local change in the refractive index can be achieved with moderate voltages. Once the local tuning is possible, the second part consists of figuring out how these individual elements should cooperate to achieve a desired behaviour or functionality. Different control approaches and driving schemes can be used to realise different functionalities.

Doelstelling:

The goal of this thesis is to influence behaviour of a well known and widely used component in the field of microphotonics, the multimode interferometer (MMI). Localised liquid crystal tuning will be used to achieve tunable behaviour of a component with a larger scale, The MMI is actually a very broad waveguide. Different dimensions result in different behaviours, because the width determines the optical modes traveling at different speeds. As a result, the inference pattern of these modes change along the length of the component. By carefully choosing a certain length, one can localise or concentrate the light in a certain output or distribute the power evenly among several outputs (power splitter).







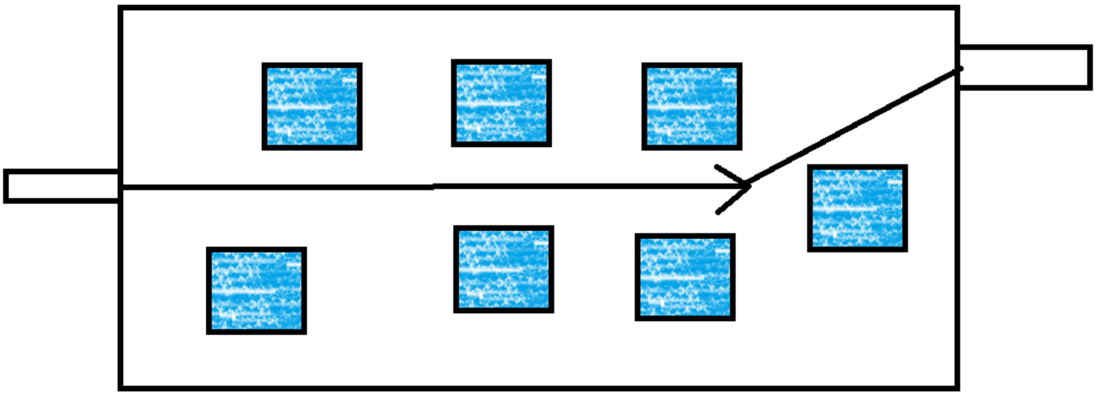
The alternative is to start from fixed dimensions of the MMI, and try to achieve different functionalities using localised liquid crystal tuning. Several MMIs are available to experiment on, and earlier work involving liquid crystal cladding and tuning has been done, so the challenges are situated within other aspects of this research. The first task of this thesis would be to investigate the configuration of the liquid crystal cells consisting of metal pads and guiding materials to guide the electrical field lines locally (simulation). Once a tunable liquid crystal cell is designed and verified via simulation, different spatial configurations/distributions of these control elements could be investigated, simulating how the liquid crystal reacts on the applied voltages. Then the behaviour of the light in the MMI has to be simulated with these local variations, demonstrating an adaptive functionality via liquid crystal tuning.

Another degree of freedom, apart from the spatial distribution of these elements on the MMI, is how to drive these elements (voltage patterns) to achieve a certain functionality. In this final phase, the device could perform functions like modulation and switching, where the functionality/behaviour of the MMI changes in time (for example, a 1x4 multiplexer where the power is sequentially focussed in 4 output waveguides rather then simultainously distributed as would be the case with power splitting). This thesis evolves from a very physics intensive component:

- simulation of electrical field distribution
- simulation of liquid crystal orientation and how this affects the optical properties locally
- simulation of how light reacts on the reorientation of these liquid crystal

But it also contains an important engineering component:

- how does the funcionality of the MMI change as a function of certain spatially distributed local changes
- which driving schemes can be used to achieve a certain functionality if the distribution is spatially fixed, and can this function be evolving in time? (response rates etc)
- demonstration of certain functionalities



Locatie:

Zwijnaarde (iGent)

20991: Making finite state machines with tunable analog components

Promotor(en):	Joni Dambre, Peter Bienstman
Begeleider(s):	Matthias Freiberger
Contactpersoon:	Joni Dambre
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	2
Motivering voor deze opleiding:	This project uses techniques from machine learning to design building blocks with a given behaviour such that an abstraction (FSM) from the physical properties can be made. A photonics student would

focus on doing this with integrated photonic reservoirs.

Probleemstelling:

Digital computing systems build upon the digital abstraction: all information is encoded into a binary representation, and processed using digital operations. Very often, this information is the result of measuring the physical world. In this case, analog signals are encoded and processed digitally and in many cases, the results are transformed back into analog signals. Clearly, since digital building blocks are essentially made out of analog components, this creates a huge overhead. The popularity of this approach largely depends on one fundamental assumption: the (almost) error-free operation of the fundamental digital building blocks (logic gates, flipflops). If this assumption is fulfilled, the very well-established digital design methodology can be used blindly to design computers with guaranteed behaviour. Software can be written and compiled to program these computers without the need to know much about the physical properties of the underlying hardware. However, under extreme scaling, which is driven by the search for lower power and higher speed, the fundamental assumption of error-free operation breaks down. In addition, the power-benefits of using CMOS also fade away under extreme scaling. Under these conditions, it becomes very questionable whether the digital abstraction is still the most (power and speed) efficient solution to computing. This is particularly true for situations where the inputs and outputs are (or represent) analog values and small absolute or relative errors on the desired output can be tolerated, i.e. for almost all signal processing tasks.

An alternative approach is to leverage techniques from machine learning and artificial neural networks to build analog computing systems. One particular approach is to use physical reservoir computing to build analog computing modules. Over the past decade, this has yielded an approach to create **tuneable analog modules** (TAM) in various technologies using a machine learning based technique called *physical reservoir computing*. Each such block can approximate a continuous range of relatively 'simple' input-output relations with reasonable precision (and a much wider range with poor precision). The next challenge is to develop a design methodology for building larger computing systems with these blocks. Multiple Master Thesis subjects relate to this general context.

The aim of this specific master thesis is to realise finite state machines with TAMs. Finite state machines are one of the core computational paradigms used to build computer systems. They allow the input-output relation that is realised by a system to depend on the current inputs, as well as the input history. If finite state machines can be realised, then a large fraction of existing computer design methodology that builds upon FSMs can again be reused. In finite state machines, all required information about the past is encoded in a discrete 'state', part of a finite set of possible states. If the required input event for a given state transition does not occur, a realisation of finite state machine must be able to maintain its state indefinitely. However, in our TAMs, the information about past inputs can only be remembered for a short amount of time. In this project you will use them to construct FSMs by 'learning' appropriate feedback connections. Two approaches can be followed: states can be encoded as constant values or as periodic attractors. Obviously a mechanism for triggering the right state transitions must also be provided. You can build upon previous experience and initial results.

Doelstelling:

In this master thesis, you will study how and how well finite state machine behaviour can be achieved by adding 'learned' feedback connections to reservoirs. Many questions still need to be addressed: How many states can you encode? What is the best way to trigger state transitions? Can you make trigger transition between all states? Are some FSM 'harder' to realise than others? Are there stability issues, i.e., if small perturbations occur, will the system go back to its state? To study these questions, you can either work on a specific use case (task), a specific TAM technology (e.g. photonic reservoirs) or specific optimisation techniques (e.g. gradient-descent, genetic algorithms, ...).

From a computer science perspective, you will approach this as a machine learning problem. A possible approach, that was invistigated in a previous student project, is to use brain-inspired self-organising learning to find 'oscillation' states that are natural to the TAM. A proof of concept exists, but it remains to be investigated how far you can go.

From a physics perspective, the goal of this thesis boils down to changing the state space such that it contains a predefined number of well separable static or periodic attractors. In addition, a mechanism for controlled switching between these attractors must be found. Physics students will approach the problem from this angle, with a focus on analysing what actually happens in state space and linking this to the physical properties of the devices used (delays, bandwidth, internal degrees of freedom,...).

Electronics and photonics students can focus on either perspective, but will focus on applying this to photonic or electronic TAMs.

This master thesis is very challenging and addresses a highly innovative/speculative research direction. However, good results will inevitably lead to the co-autorship of a publication in a scientific journal or conference.

Locatie:

21737: Mid-infrared metamaterials for optical gas sensing

Promotor(en):	Günther Roelkens, Joris Roels
Begeleider(s):	Xiaoning Jia
Contactpersoon:	Günther Roelkens
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Topic draait rond optische gassensoren die geminiaturizeerd moeten worden

Probleemstelling:

Gas sensing & spectroscopy is an attractive and growing market, especially driven by increasing concerns on air quality. Most common molecules have unique absorption band at the Mid-IR spectral region, thus it provides a nearly universal means for their detection. In particular, Non-Dispersive InfraRed (NDIR) optical sensors have gained a lot of traction and attention the latest years due to their low cost, low power consumption and long durability. In a typical NDIR sensor, a wide band thermal infrared detector chip is used in combination with a discrete optical filter. These filters must be narrow band pass (<200nm FWHM) and have central wavelengths in the mid-infrared (MIR) range (e.g. 4.3um for CO2).

Figure 1. (a) NDIR working principle: Beer-Lambert law. (b) Typical NDIR sensor layout. (c) Absorption spectrum of common molecules in mid-IR region. (d) Passband of optical filters used in CO2 detection.

Moreover these characteristics are required over a broad angle spectrum. State-of-the-art transmission filters require a dielectric layer stack, consisting of multiple tens of separate layers. Not surprisingly such approach results in high cost filters, sensitive for fabrication tolerances and difficult to scale to mass production. Melexis is a Flemish high tech sensor IC company and world leader in designing and fabricating wide band infrared detectors. It is reaching out for the Photonics Research Group to find a disruptive optical filter solution which could be integrated directly on its thermopile based infrared detector chips.

Doelstelling:

The goal of the thesis is to investigate and demonstrate the feasibility of metamaterials as narrow band absorption filter in the MIR range. In contrast with the classical approach a metalic component will be used and the number of layers will be limited to 2 to 3 layers. This exciting and promising approach would allow integration of the filter directly on the detector chip and potentially allow low cost wafer scale mass production.

Figure 2. Concept of metamaterial emitter light source[1]

In a first phase literature study and decision on the right simulation approach (the PRG has a wide range of simulation tools available e.g. Finite-element or RCWA). The first phase has to lead to a deep and thorough understanding of the physics behind meta materials. In a second phase the obtained insights and optimized simulation approach can be used to propose and test totally new metamaterial designs, potentially superior to the existing literature[1] and potentially within the boundaries (dimensions and materials) as applicable in a real CMOS compatible fabrication process as used by Melexis. In the final phase fabrication of the simulated metamaterial concept in the PRG cleanrooms and thorough characterization in the measurement lab will take place in order to verify the obtained insights and simulation results.

References:

[1] Lochbaum A, Fedoryshyn Y, Dorodnyy A, et al. On-chip narrowband thermal emitter for mid-IR optical gas sensing[J]. ACS photonics, 2017, 4(6): 1371-1380.

Locatie:

iGent, UGent cleanrooms

Samenwerking met bedrijf

Bedrijf: Melexis
Samenwerking: promotor

21131: Near field levitated optomechanics using silicon nano-photonics

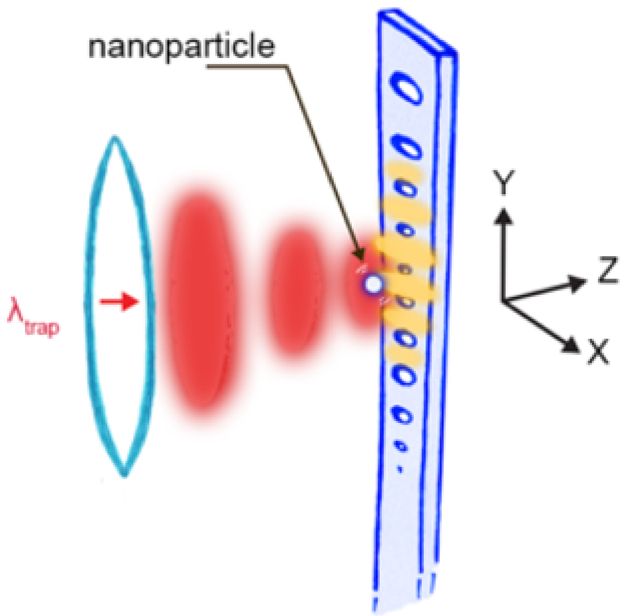
Promotor(en):	Dries Van Thourhout, Filip Beunis
Begeleider(s):	Khannan Rajendran
Contactpersoon:	Khannan Rajendran
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics
Niet behouden voor:	

Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Thesis contains considerable fraction of photonics

Probleemstelling:

Optomechanics is the study of the interaction between electromagnetic radiation and mechanical motion mediated by radiation pressure. It explains the underlying principles of natural phenomena like comet tails as well as optical lasers or LIGO detectors. The latter were awarded the Nobel Prize in Physics for the Year 2017 and 2018 respectively.
Optomechanics is the study of the interaction between radiation and the medial radiation. It explains the underlying principles of natural phenomena like comet tails as well as optical lasers or LIGO detectors. The latter were awarded the Nobel prize in physics for the years 2017 and 2018 respectively.

Traditional levitated optomechanics relies on optical trapping or nanoparticles. The optical trap is an intensity gradient where dielectric particles or higher refractive index are attracted towards the region of maximum optical intensity.
The attractiveness of levitating particles is that it eliminates phonon dissipation and thermal disturbances resulting from mechanical clamping, thus enabling much higher mechanical Q factor. But also weaknesses such as weak optomechanical interaction, scattering losses and back-action noise.



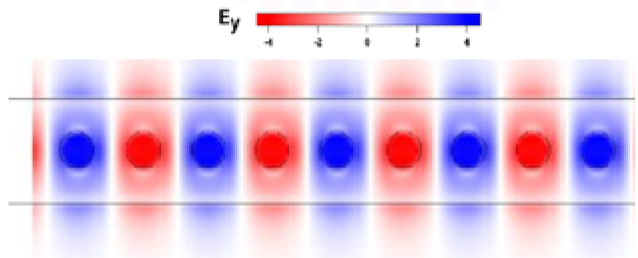


Figure 2: 1D photonic crystal with air-band edge

Figure 1: Schematic of trapping a nanoparticle using an optical tweezer and photonic crystal nanobeam.

Nano-photonic devices like photonic crystal cavities, ring resonators and whispering galleries have a small mode volume, high quality factor and can be fiber coupled. Photonic crystals are periodic dielectric structures that have a band gap that forbids propagation of a certain frequency range of light. This makes them particularly interesting as they can be tailored to the electric field intensity in their cavities (see fig.2). This allows for 3-dimensional trapping or particles in the near field (see fig.1), while enhancing the strength of the optomechanical interaction while eliminating clamping and scattering losses.

The thesis will be a collaborative project between the PRG (Photonics research group - https://www.photonics.intec.ugent.be) and LCP (Liquid crystal and photonic - http://lcp.elis.ugent.be). The PRG has a tremendous experience in designing, fabricating and measuring such photonic crystals devices. While the LCP wants to provide expertise on optical trapping and manipulation.

Doelstelling:

The thesis will be split into simulation and experimental design. The first goal is to simulate the optical gradient forces in a 1-D photonic crystal cavity and estimating the optomechanical coupling strength with respect to a nanoparticle. This will be done by the construction of an optical tweezer to manipulate and trap the dielectric particle. Finally, the student will perform the characterization of the optomechanical response of the photonic crystal nanobeam.

Locatie:

IGent (Technologiepark Zwijnaarde)

Opmerkingen:

References: L. Magrini, R. Norte, R. Riedinger, I. Marinković, D. Grass, U. Delić, S. Gröblacher, S. Hong, and M. Aspelmeyer, "Near-field coupling of a levitated nanoparticle to a photonic crystal cavity," Optica 5, 1597-1602 (2018).

20730: Near-infrared emitting luminescent materials for medical imaging applications

Promotor(en):	Dirk Poelman
Begeleider(s):	
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Promoter D. Poelman is member of the NB-photonics consortium and lecturer in this Photonics Master program. The subject is directly related to a range of photonics subjects.

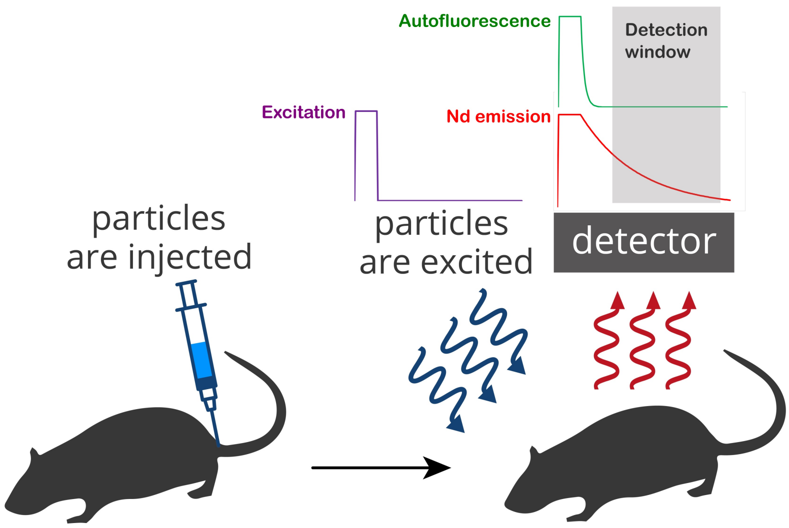
Probleemstelling:

Many of the current imaging techniques in the medical world (CT, PET, SPECT) use ionizing radiation that is potentially dangerous to the patient. Therefore, a number of optical imaging techniques have been developed that use fluorescent 'tracers' that emit light in the near infrared, in a wavelength range for which tissues are largely transparent. Such techniques have a limited applicability, because during the exposure autofluorescence of the tissues themselves occurs, which makes accurate detection difficult.

In the thesis project you will investigate luminescent materials that can be excited in the near infrared and also emit in the near infrared (at slightly longer wavelength). Such luminescent materials have a much longer decay time (order 100 µs) compared to the decay time of the autofluorescence and the classical fluorescent tracers (order ns), which makes it possible to measure the emission during the time that the autofluorescence has already expired, but the luminescence of the particles is not yet decayed (see figure). This technique offers enormous potential as a sensitive, inexpensive, and safe technique for tracking blood flows, labelled cells, medicines, ...

Doelstelling:

In the master thesis you will investigate Nd (neodymium) doped oxides, which are excited with a diode laser around 808 nm. You will fine-tune the excitation wavelength by controlling the temperature of this laser, for which you build a



temperature regulator with a microcontroller. To measure the emission spectra and the decay times, you work with infrared-sensitive InGaAs detectors and cameras. You also use electron microscopy to investigate the particle properties: size, shape, composition and light emission on a microscopic scale.

This research is executed in close collaboration with pharmacy, where the nanoparticles are functionalized for in vitro and - ultimately - in vivo tests.

The proposed research fits within the scope of the clusters Nanoscale Sciences, Materials, Energy and Electronics of Engineering Physics/Toegepaste Natuurkunde, and combines exploratory and implementation aspects (engineering component) with a fundamental study of materials (scientific component).

Locatie:

Sterre Campus S12 / S1

21218: Numerical and experimental study of micro-plasma electrodes on a photonic chip

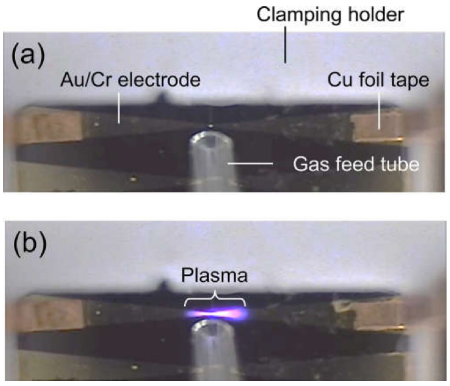
Promotor(en):	Nicolas Le Thomas, Christophe Leys
Begeleider(s):	Anton Nikiforov, Chupao Lin
Contactpersoon:	Nicolas Le Thomas
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	A large part of the project focuses on photonics and takes place in the Photonic Research Group

Probleemstelling:

Controlling the light generated by a plasma with a photonic chip is foreseen to enable a large amount of applications in the fields of medicine, biotechnology and pharmacology. The Photonic Research Group (PRG) and the Research Unit Plasma Technology (RUPT) have recently combined their expertise to develop original light sources with unprecedented properties. PRG is a worldwide leading lab in the field of integrated photonics with a strong expertise in the design, fabrication and characterisation of photonic chips. For fifteen years, RUPT has built up an internationally recognized expertise in the field of cold atmospheric pressure plasmas.

Doelstelling:

The proposed master thesis project aims at investigating novel designs of electrodes to generate plasma on photonic chips. The main target of the design and simulation methodology is to produce specific shapes of micro-plasmas in order to maximize their spatial confinement, to engineer their shape and to optimize the on-chip breakdown voltage of the plasma gas. The numerical simulations will be carried out with the Comsol software at RUPT. The electrical and optical properties of the plasma will be experimentally studied at PRG with an advanced optical set-up.



T. Okada et al. / Archives of Biochemistry and Biophysics 605 (2016) 11–18

Fig.1: Typical example of an on-chip plasma

Locatie:

Technicum and Ardoyen zwijnaarde (iGent Tower)

Website:

Meer informatie op: https://www.photonics.intec.ugent.be

20816: On-chip realization of an active mmWave phased antenna array with optical beamforming for the next-generation wireless applications

Promotor(en):	Hendrik Rogier, Bart Kuyken
Begeleider(s):	Sam Lemey, Quinten Van den Brande, Dries Vande Ginste
Contactpersoon:	Sam Lemey
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
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal bachelorproeven:	1
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, and to students of both the Electronic Circuits and Systems and the Communication and Information Technology subject areas.

Probleemstelling:

Current-generation wireless communication systems all populate the frequency spectrum below 6 GHz making the spectrum overcrowded. As a consequence, the limits of this band are reached. Moreover, the available bandwidths are too small to accommodate for the data rates envisioned by next-gen applications. On top, the long associated wavelengths complicate compact integration of the RF front-end. To overcome these limitations, academia and industry are shifting their attention to techniques and strategies that enable broadband wireless communication at much higher frequencies allowing for high bandwidths and shorter wavelengths, thereby addressing the stringent demands of automotive, space, 5G, and the Internet-of-Things applications.

A very promising strategy consists of combining beamforming techniques with mm-wave technology. The very short wavelengths (< 1 cm) make it possible to combine a large number of broadband antenna elements in a compact, and low-profile antenna array configuration. Beamforming techniques can then be used to focus the beam of the array in the wanted direction and hence improve link quality enormously. The application domain is vast: watching Netflix in HD quality with zero-latency on your next transatlantic flight will become possible, low-latency robotized industrial processes will improve efficiency and reduce waste, high-resolution radar will lead to self-driving cars, and so on.

In theory, this concept looks good. Unfortunately, in practice, it proves to be very challenging to steer antenna arrays consisting of several hundreds of antenna elements in an all-electronic approach. A result is usually a complex, narrowband and inefficient feeding network, not capable of serving an array of adequate size due to electromagnetic compatibility issues and high losses. So we need to rethink and leave the classic approach behind.

Recent advances in microwave and mm-wave photonics have shown a great potential in diminishing issues related to such an all-electronic approach. Optical fiber has some very interesting advantages over classic transmission lines and waveguides (small & light, low losses, easy to route, no EMI issues,...) that can be used to greatly reduce the complexity of the array feed system. In addition, beam steering of broadband signals, without beam squint errors, is possible by relying on photonic true-time-delay technology.

Silicon V

Doelstelling:

In this master thesis, an active on-chip multi-antenna system with optical beamforming will be designed and implemented at mmWave frequencies. Special attention will be paid to combine the key benefits of silicon photonic integrated circuits, active electronics and the potential of substrate-integrated-waveguide antenna elements.

As a starting point, the opportunities related to an opto-electric antenna array feed will be investigated. Next, a stand-alone active opto-electronic antenna element will be designed and co-optimized to guarantee peak performance. Based on this antenna element, a low-complexity proof-of-principle antenna array (i.e. a uniform linear array based on substrate-integrated-waveguide antenna elements, transimpedance amplifiers and photodetectors) will be designed, fabricated and tested to optimally interface with a cutting-edge beamforming circuit implemented in silicon photonic integrated circuit technology (available at our research group). In a final step, the student(s) will set up a high-data rate mmWave communication link, thereby demonstrating the benefits of combining photonic integration technology and phased array technology.

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 in Flanders, 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 (High frequency design, antenna design, co-optimization) 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)

Deze masterproef werd reeds 1-maal toegekend!

20698: 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
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

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 beam; 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.

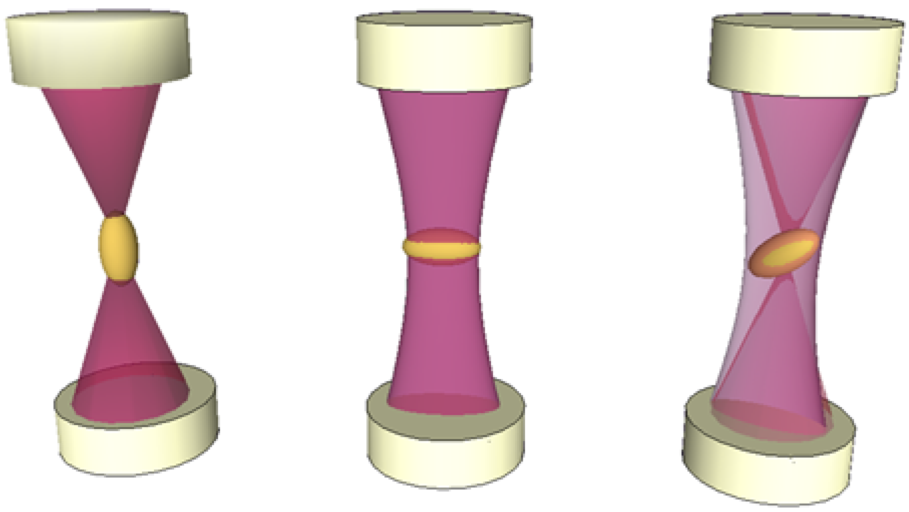


Figure: Different kinds of laser beams allow control, not only over the particles position, but also over its orientation.

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/

20699: Optical trapping in complex media

Promotor(en):	Filip Beunis, Kristiaan Neyts
Begeleider(s):	Bavo Robben
Contactpersoon:	Filip Beunis
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

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 nanotechnolo
particle in place and manipulate its position by using a laser beam tightly focused by a microscope setup. Moreover, they allow f
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.

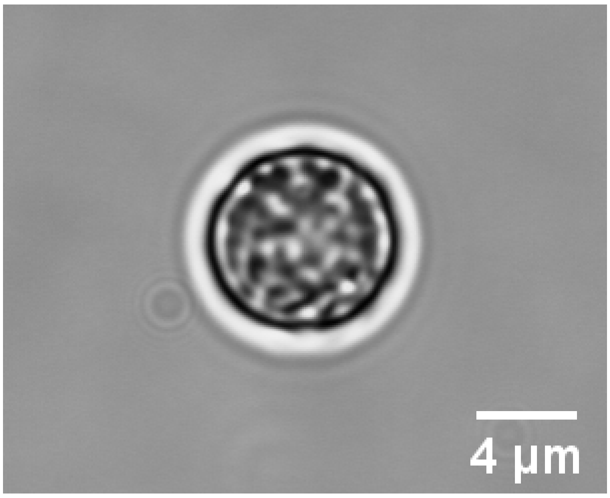


Figure: Trapped double water-in-oil-in-water particle.

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.

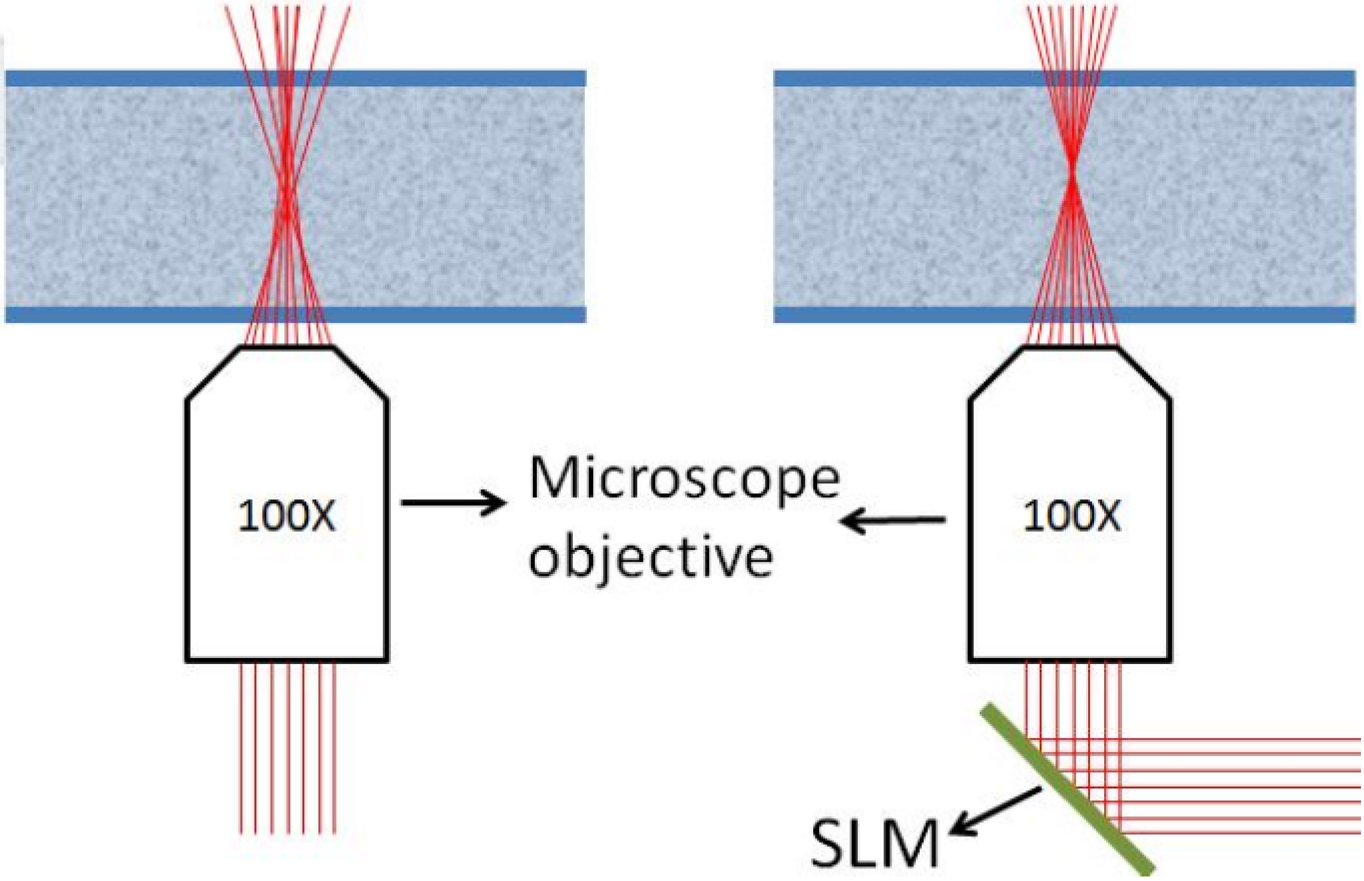


Figure: Aberrations introduced by a suspending fluid deteriorate the performance of optical tweezers (left). This master thesis uses a spatial light modulator (SLM) to compensate for these aberrations and create optical landscapes to trap complex structures.

Locatie:

iGent, Zwijnaarde

Website:

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

21413: Optical trapping microrheology of living cells

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

Probleemstelling:

Optical tweezers are a powerful tool in the study of biological systems, where they are used to manipulate objects such as living cells at the microscale. The principle behind optical tweezers is that an object with a higher refractive index than the surrounding liquid is attracted towards the focus of a tightly focused laser beam. By using two laser beams, a living cell (e.g. a red blood cell) can be 'grabbed' at two different places to move, rotate or even stretch it. In optical trapping microrheology, this principle is used to study the visco-elastic properties of living cells, which provides important insights about cell structure and which can be used for diagnostics. The correlation between the movement of two optically trapped points of the cell is measured at different frequencies, either by looking at random variations due to Brownian motion (passive microrheology) or by moving one of the laser beams (active microrheology).

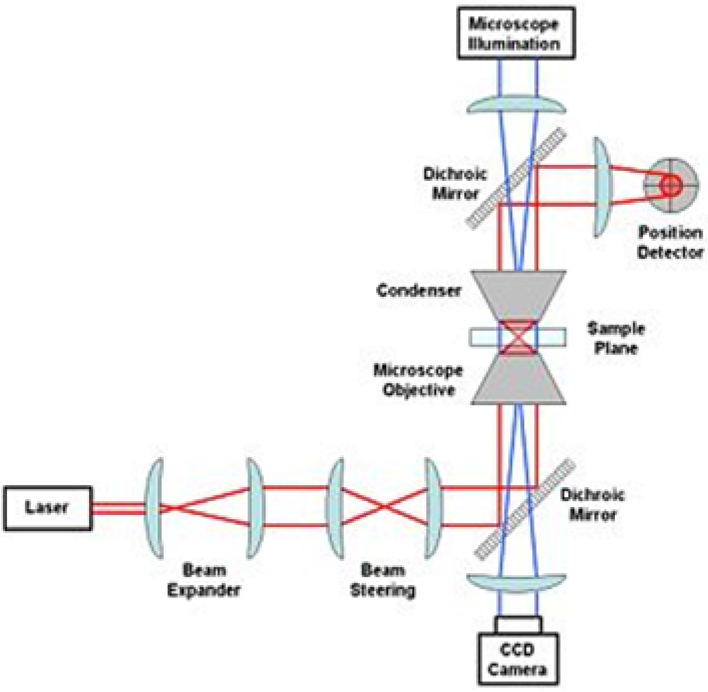


Figure: Schematic representation of an optical tweezers setup, artist impression of optical manipulation of a red blood cell, and an actual experiment in which a red blood cell is "stretched".

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:

The "Liquid Crystals and Photonics" (LCP) Group has built a double optical tweezers and accurate position detection setup, around a state-of-the-art confocal fluorescence microscope. We recently demonstrated that we can use this setup to precisely manipulate (move, rotate, stretch, ...) single red blood cells (see figure). In this master thesis project, we want to extend the possibilities of our setup to perform optical trapping microrheology. Your goal will be to implement and compare the different variations of microrheology described above, and use them to study the visco-elastic properties of a number of different systems, with an emphasis on living cells. The project includes technological, experimental and theoretical work, and is of a particular interdisciplinary nature, with aspects of engineering, physics and biology.

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.

Locatie:

iGent, Zwijnaarde

Website:

Meer informatie op: lcp.elis.ugent.be

21331: Phase matching of second-order nonlinear optical processes using auxiliary nanophotonic structures.

Promotor(en):	Stéphane Clemmen
Begeleider(s):	
Contactpersoon:	Stéphane Clemmen
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	the topics covers nonlinear optics, analytical study and numerical simulations

Probleemstelling:

Nonlinear optics allow to change the color of light. The recent development of nanophonic waveguides presenting a large second order nonlinearity promisses record high nonlnear nteractions and applications for quantum information processing. The recent work has been focused on fabricating waveguides with higher nonlinearty and lower loss to increase the overall interaction. However, there are applications for which a length increase doesn't translate in a stronger interaction unless improvement are simultaneously made to the refractive properties of the waveguides. More specifically, the waveguide must be engineered to allow phase matching. Phase matching in second order nonlinear processing is particularly challengingbecause the wavelength of photons imnvolved in the process differ widely. It is usually obtained by playing on the birefringence of the maerial or by reversing periodically the sign of its nonlinearity. Within this master project, we want to explore phase matching strategies exploiting auxiliary photonic structrure to alter the refractive properties of a nonlinear waveguide [1].

[1] S. V. Rao, K. Moutzouris, and M. Ebrahimzadeh, "Nonlinear frequency conversion in semiconductor optical waveguides using birefringent, modal and quasi-phase-matching techniques," J. Opt. Pure Appl. Opt., vol. 6, no. 6, pp. 569–584, Apr. 2004.

Doelstelling:

Two auxiliary structures can be explored numerically during this master thesis. The first one is a so-called semi-nonlinear waveguide[2]and is a form of modal phase matching. The second one consists in using a Bragg grating to slow down one of the wave. Bragg gratings have been used in interactions [3]Bragg but not yet in ones.

The main goal of this master thesis is to explore theoretically those possibilities. This implies analytical and numerical work using simulation software such as Lumerical. Depending on the progress made, experimental work can be envisaged in collaboration with a PhD student of the group.

[2] R. Luo, Y. He, H. Liang, M. Li, and Q. Lin, "Semi-Nonlinear Nanophotonic Waveguides for Highly Efficient Second-Harmonic Generation," Laser Photonics Rev., vol. 0, no. 0, p. 1800288.

[3] B. J. Eggleton, R. E. Slusher, C. M. de Sterke, P. A. Krug, and J. E. Sipe, "Bragg Grating Solitons," Phys. Rev. Lett., vol. 76, no. 10, pp. 1627–1630, Mar. 1996.

Locatie:

iGnt, Tech Lane Ghent Science Park - Campus A, Zwijnaarde

Website:

Meer informatie op: photonics.intec.ugent.be

21511: Photoacoustic spectroscopy with a laser Doppler microphone for noninvasive glucose sensing

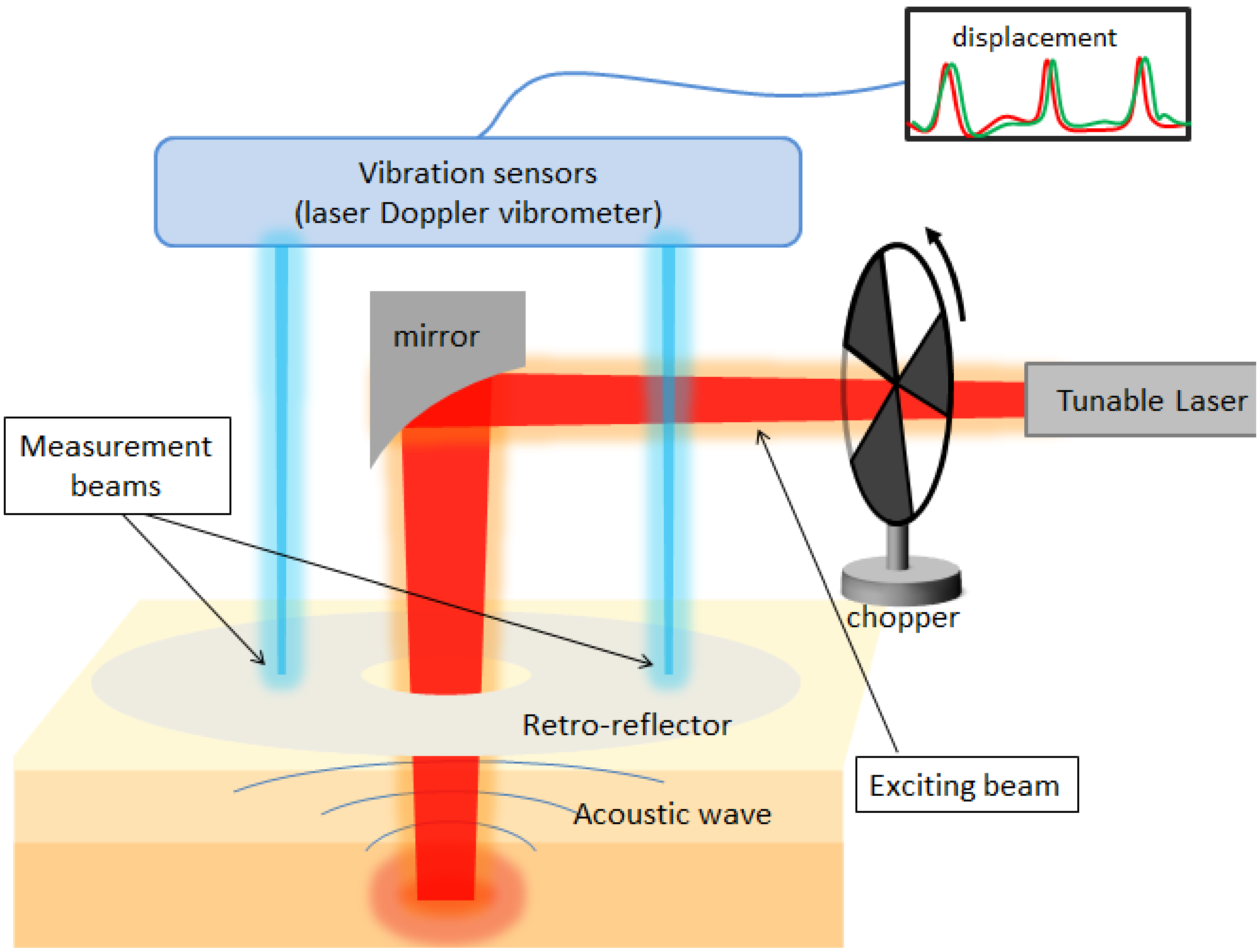
Promotor(en):	Roel Baets
Begeleider(s):	Yanlu Li
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical Engineering, Master of Science in Biomedical Engineering, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Silicon photonics, photo-acoustic spectroscopy

Probleemstelling:

Can we detect the concentration of trace amounts of molecules in the body (e.g. glucose) in a non-invasive way (without pricking)? We will accept this challenge and try to build a non-invasive molecule concentration monitor in this master thesis, based on two powerful optical measurement techniques: photoacoustic spectroscopy and laser Doppler Vibrometer. The working principle of the device is explained as follows:

The device recognizes molecules by measuring their unique absorption spectra. In order to measure these spectra accurately in a strongly scattering material, such as the tissue, the intensity of the laser beam (exciting beam in the figure) is modulated. Since light absorption creates a local heating which then leads to local pressure change, an acoustic wave can be generated in the absorbing material when the exciting light beam is modulated. The strength of the sound wave is proportional to pressure change caused the light absorption. Therefore one can tell the absorption coefficient of the material at the measurement wavelength. The whole absorption spectrum of the material will be obtained by tuning the wavelength of the exciting beam and recording the corresponding sound pressure. This spectrum is then used for telling the concentration of molecules which have absorption lines in the scanned spectrum.

The sound pressure is usually recorded by a normal microphone. To increase the sensitivity of our device, we will use a home-made on-chip multi-beam vibration sensor instead of the microphone. This vibration sensor, usually called a laser Doppler Vibrometer (LDV), measures the movement of the surface (skin here) induced by the acoustic wave using a highly sensitive interferometric technique. Besides, our LDV device also has several measurement beams to provide more information of the acoustic waves (e.g. the Doppler shift of the acoustics in different directions), which may help to further increase the sensitivity.



Doelstelling:

In this thesis, the student needs to build the measurement setup including the modulated tunable laser and the home-made on-chip LDV. The student will measure and study the relation between the power of the exciting laser beam and the displacement amplitude caused by the excited acoustic wave for various absorbing molecules with various concentrations. If all goes well you can measure your own glucose level at the end.

Locatie:

Opmerkingen:

The topic is related to the photonics cluster of elective courses. For students in engineering physics: • physics aspects of this topic: acoustics, optics and interaction between both • engineering aspects of this topic: construct proof-of-concept system • this thesis subject is closely related to the following clusters of elective courses: PHOTONICS, BIOMEDICAL

Deze masterproef werd reeds 1-maal toegekend!

22036: Photoacoustic spectroscopy with a laser Doppler microphone for noninvasive glucose sensing - modality 2

Promotor(en):	Roel Baets
Begeleider(s):	Yanlu Li
Contactpersoon:	
Goedgekeurd voor:	European Master of Science in Photonics, International Master of Science in Biomedical

	Engineering, Master of Science in Biomedical Engineering
Niet behouden voor:	
Nog onbeslist voor:	Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems, Master of Science in Engineering Physics
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Silicon photonics, photo-acoustic spectroscopy

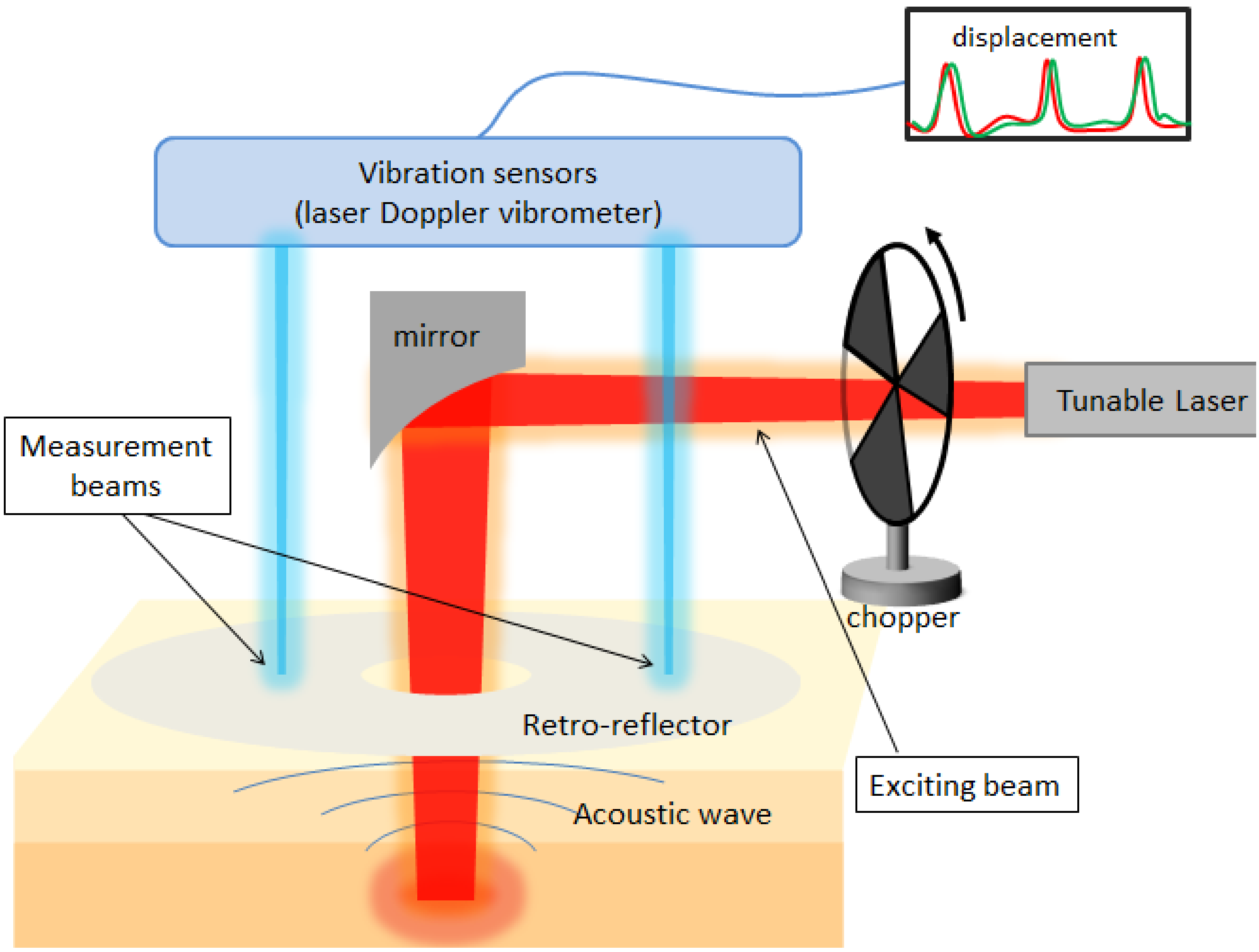
Probleemstelling:

Can we detect the concentration of trace amounts of molecules in the body (e.g. glucose) in a non-invasive way (without pricking)? We will accept this challenge and try to build a non-invasive molecule concentration monitor in this master thesis, based on two powerful optical measurement techniques: photoacoustic spectroscopy and laser Doppler Vibrometer. The working principle of the device is explained as follows:

The device recognizes molecules by measuring their unique absorption spectra. In order to measure these spectra accurately in a strongly scattering material, such as the tissue, the intensity of the laser beam (exciting beam in the figure) is modulated. Since light absorption creates a local heating which then leads to local pressure change, an acoustic wave can be generated in the absorbing material when the exciting light beam is modulated. The strength of the sound wave is proportional to pressure change caused the light absorption. Therefore one can tell the absorption coefficient of the material at the measurement wavelength. The whole absorption spectrum of the material will be obtained by tuning the wavelength of the exciting beam and recording the corresponding sound pressure. This spectrum is then used for telling the concentration of molecules which have absorption lines in the scanned spectrum.

The sound pressure is usually recorded by a normal microphone. To increase the sensitivity of our device, we will use a home-made on-chip multi-beam vibration sensor instead of the microphone. This vibration sensor, usually called a laser Doppler Vibrometer (LDV), measures the movement of the surface (skin here) induced by the acoustic wave using a highly sensitive interferometric technique. Besides, our LDV device also has several measurement beams to provide more information of the acoustic waves (e.g. the Doppler shift of the acoustics in different directions), which may help to further increase the sensitivity.

In the modality proposed in this thesis the spectrum will not be obtained by tuning the exciting laser source but by spatially mapping the spectral components of a broadband source onto the target/analyte. The LDV array will then capture the PA response from different positions and hence from different spectral components.



Doelstelling:

In this thesis, the student needs to build the measurement setup including the spatially dispersed broadband source and the home-made on-chip LDV. The student will measure and study the relation between the power of the exciting beam and the displacement amplitude caused by the excited acoustic wave for various absorbing molecules with various concentrations. If all goes well you can measure your own glucose level at the end.

Locatie:

Opmerkingen:

The topic is related to the photonics cluster of elective courses. For students in engineering physics: • physics aspects of this topic: acoustics, optics and interaction between both • engineering aspects of this topic: construct proof-of-concept system • this thesis subject is closely related to the following clusters of elective courses: PHOTONICS, BIOMEDICAL

Deze masterproef werd reeds 1-maal toegekend!

21313: Photonic reservoir computing for telecommunication applications

Promotor(en):	Peter Bienstman, Joni Dambre
Begeleider(s):	Stijn Sackesyn
Contactpersoon:	Stijn Sackesyn
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology

Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	photonics related

Probleemstelling:

Reservoir computing is a machine learning technique in which a nonlinear dynamical system is used for computation. It was originally implemented as an efficient way to train a neural network but it has grown to a more versatile machine learning method nowadays, for example to solve classification and regression tasks. The dynamical system - the reservoir - is held unchanged during the procedure and during training. Only the weights used to linearly combine the reservoir states are optimized. Keeping the recurrent network unchanged and thus only training on the level of the reservoir states makes reservoir computing a computationally cheap method.

Although reservoir computing was originally invented in computer science as a software solution to bypass the computational cost of optimizing a neural network, it is perfectly suited to be implemented in various hardware platforms. These implementations do not suffer from classical digital computer bottlenecks and are by nature more convenient to operate neuromorphic computing schemes. One such hardware implementation that is especially suited for reservoir computing is silicon photonics.

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.

One of the domains of application where photonic reservoir computing fits in naturally is optical telecommunication. Nowadays, digital to analog converters (DACs) are still used a lot within telecommunication networks, converting signals from the optical domain to the electrical domain and back. Reservoir computing could be an elegant solution to reduce the number of DACs to enhance speed, latency and power consumption.

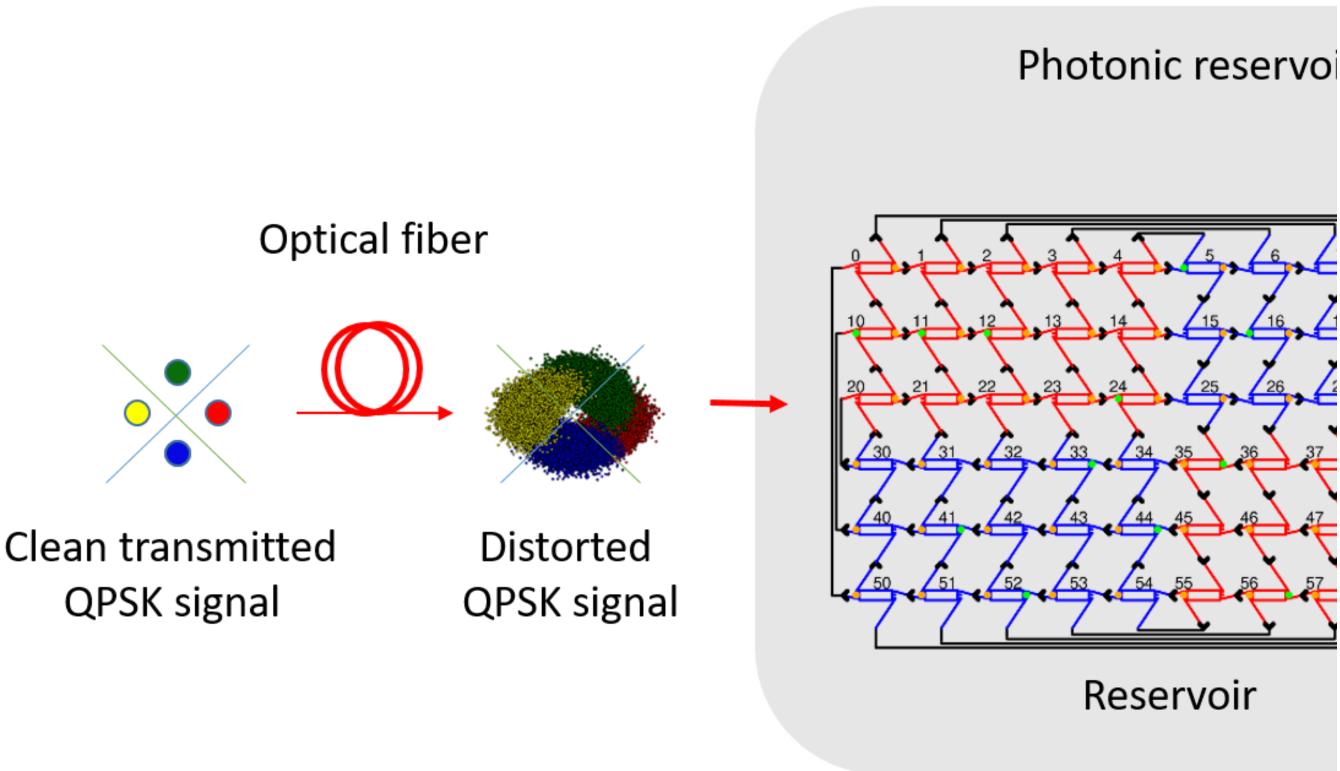


Figure 1. Application: Photonic reservoir computing for equalization

Doelstelling:

The goal of the dissertation is to use photonic reservoir computing to solve telecommunication-oriented tasks as fiber equalization, package switching, header recognizing, ...

Instead of using the more classical incoherent modulation techniques (NRZ, PAM4), the student will focus on implementing coherent modulation schemes (BPSK,QPSK,16QAM) for photonic reservoir computing as there is general consensus that this is the next step forward in the ever-growing field of telecommunications.

The thesis will mainly exist of simulation work using existing as well as self-written software. Depending on the interests of the student, there is also a possibility to test the simulation outcomes in high-speed measurements.

Locatie:

iGent toren (campus Ardoyen), thuis

Deze masterproef werd reeds 1-maal toegekend!

21129: Photonic Switches for addresssing Magneto-Optical memories

Promotor(en):	Dries Van Thourhout
Begeleider(s):	Clemens Krückel
Contactpersoon:	Clemens Krückel
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
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The thesis contains an important photonics component (optical switching network), optical addressing tunnel junctions

Probleemstelling:

Within the SPICE project [1], UGent is part of an international research consortium that works towards the next generation of efficient data storage. In SPICE, we specifically explore optical writing of magnetic tunnel junctions (MTJs) with the help of short optical pulses. The primary goal is to bring together novel magneto-optic materials and silicon photonic technology with the ambition to target memory writing with ultra-low energy consumption. The specific role of the photonic research group in SPICE is the development of a photonics routing layer. This routing layer allows to spatially distribute optical pulses and address individual magnetic memory elements. As a first prototype we fabricated [2] a 1:8 distribution network that is shown in Fig 1a. For the network we use MZI-switches (Fig.1b) with carrier-injection technology [2] because of its bandwidth, low-loss and efficiency that allows a 1:8 network with low footprint of ~2mm2.

Doelstelling:

The efficiency of the carrier-injection technology offers low energy consumption. However, further reduction of the energy consumed in the network is required. For this reason, we pursue a wavelength-division multiplexing (WDM) approach were broadband MZI-switches (Fig.1b) are combined with ring-switches (Fig.1c) [3]. While the MZI-switches can switch several optical channels at same time (energy distribution per channel decreases), the following demultiplexer stage consists of energy-efficient ring-switches. This new switching network is being fabricated at the moment.

Your task is to explore the devices theoretically and experimentally. You will expand an existing simulation framework (Lumerical, Matlab/Simulink, Mathematica, ipkiss) in order to understand and optimize the device performance. Furthermore, you will carry out device characterization in the laboratory covering basic measurement techniques as well as high-speed characterization.

[1] www.spice-fetopen.eu

[2] www.europractice-ic.com/SiPhotonics_technology_imec_ISIPP50G.php

[3] J. Van Campenhout et. al, "Design of a digital, ultra-broadband ...," Op. Exp. 23, 23793-23808 (2009)

[4] Q. Xu et. al, "12.5 Gbit/s carrier-injection-based silicon micro-ring ...," Op. Exp. 15, 430-436 (2007)

Locatie:

ardoyen

Website:

Meer informatie op: www.spice-fetopen.eu

20526: Photonics and machine learning solutions for fast cell sorting applications

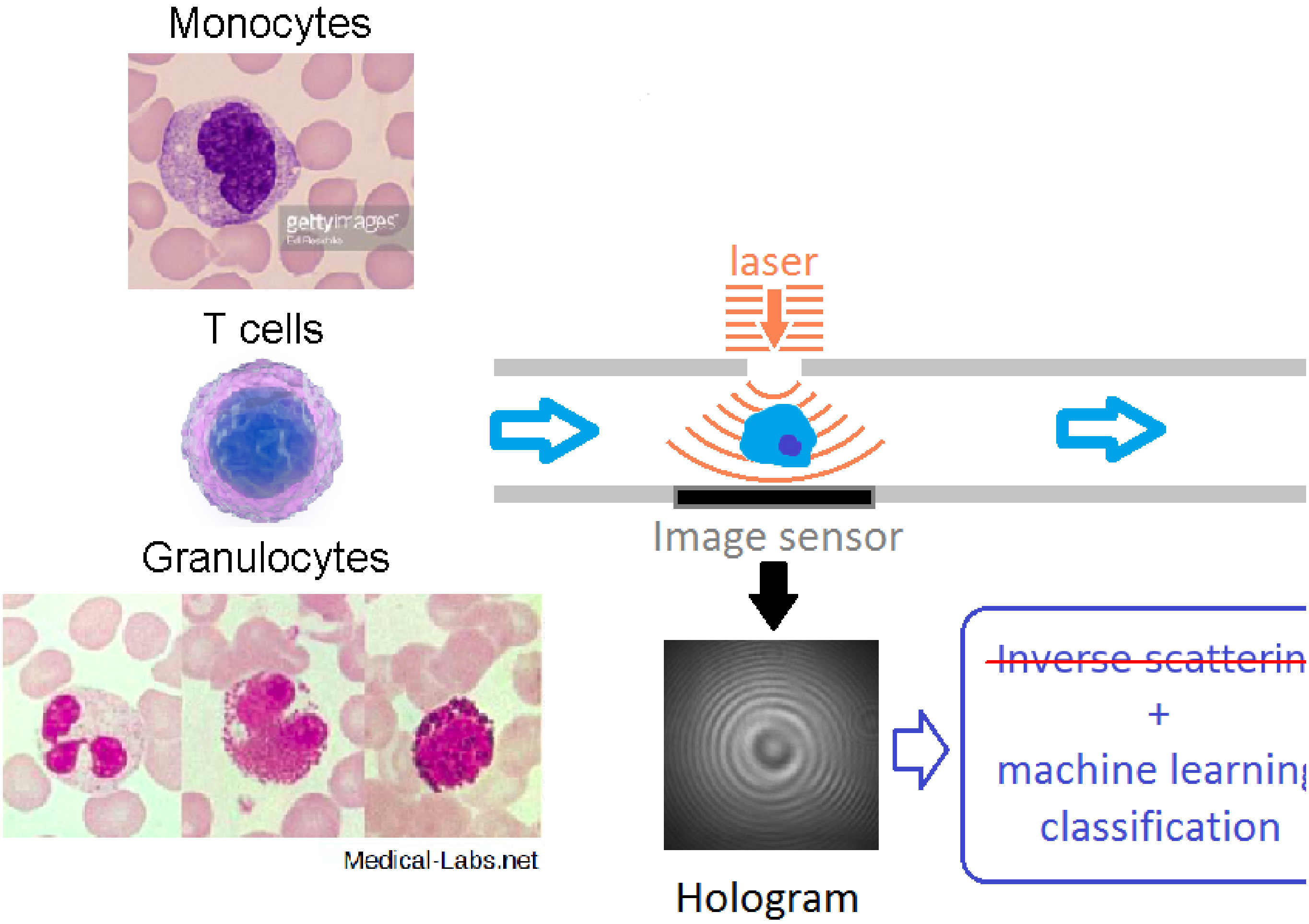
Promotor(en):	Peter Bienstman, Joni Dambre
Begeleider(s):	Alessio Lugnan
Contactpersoon:	Alessio Lugnan
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Computer Science Engineering
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The project is centered on the use and optimization of optical experimental and simulation setups to acquire and classify interference pattern of microparticles or cells

Probleemstelling:

The analysis and the classification of biological cells (and of microparticles in general) is of great importance in medicine (e.g. human cells analysis for clinical diagnostics), in biology and in many other areas. Traditionally, it has been carried out by scientists employing a microscope. Nowadays, automated techniques for cell analysis and sorting can decrease the costs and times by orders of magnitudes. However, these techniques often require the labelling of the cells under study (e.g. by adding a fluorescent tag to them) which usually leads to significant changes in their morphology or in their biological functions. This often kills the cells, so that they cannot be used for subsequent biological analysis.

A successful label-free technique is digital holographic microscopy, in which the interference pattern projected by monochromatic light passing through the cell is acquired by an image sensor. This hologram is then digitally reconstructed (using inverse Maxwell equations) and analyzed (using machine learning algorithms). The relatively large computational time for the image reconstruction, however, precludes high speed applications on cell sorting.

A promising solution is to drop the struggle for reconstructing the image which is familiar to microscopists and let a computer learn how to directly analyze raw interference patterns through high-speed machine learning implementations. In that context, photonics combined with electronics has been proven to provide a suitable platform for fast, compact and low-cost integrated hardware learning computers.



Doelstelling:

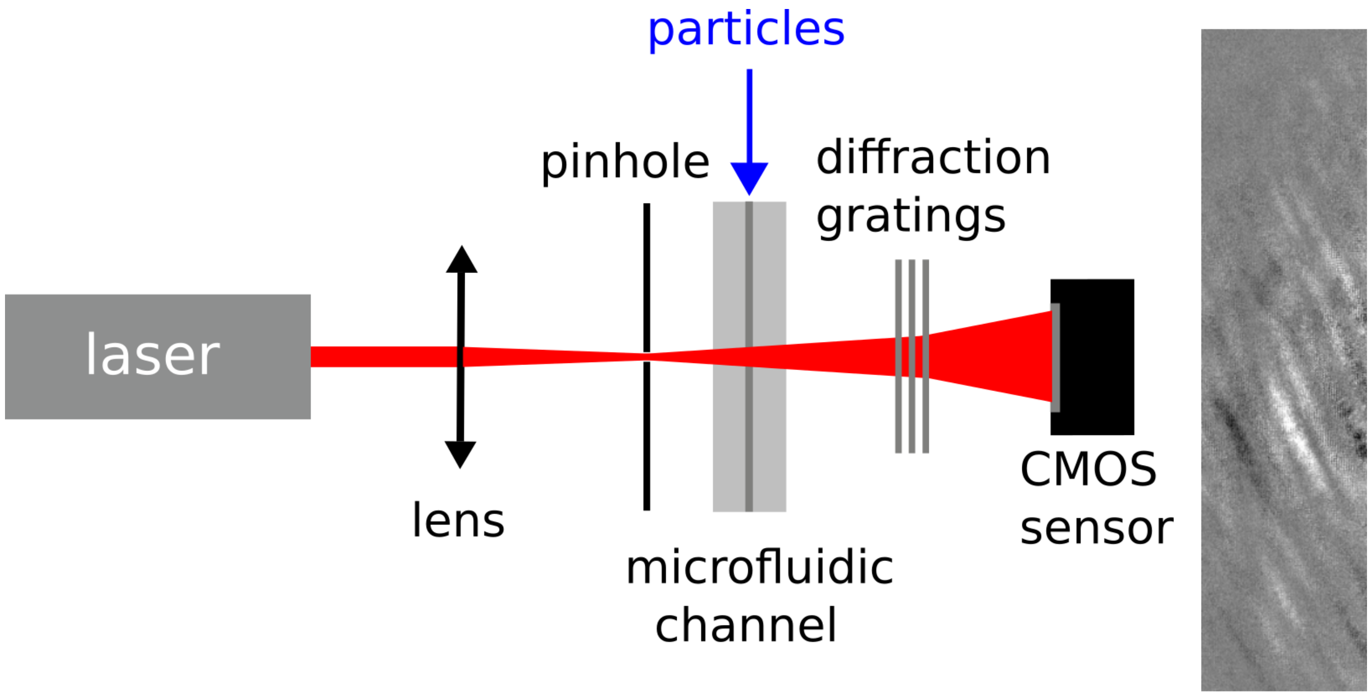
Your aim will be to get acquainted with and contribute to the development of techniques for fast machine learning analysis of cells or microparticles through digital holographic microscopy.

In particular, the following objectives (you can choose one or both) are proposed:

1) Employ and improve the existing experimental setup to acquire and classify microparticle holograms. Devise and test new combinations of mixing optical elements (e.g. lenses, diffraction gratings, diffusers...) to obtain interference patterns that are better employable in the machine learning classification of microparticles.

2) Familiarize with and improve the existing 2D FDTD simulation setup of an integrated microscatterers-based white blood cells classifier. Design and test a computationally efficient 3D approximation of these simulations, in which temporal dynamics might play an interesting role in cell classification.

Requirements: basics of photonics and/or machine learning, willingness to tackle challenges coming from combining photonics and machine learning to understand and design new techniques.



Locatie:

Campus Ardoyen, iGent building.

Samenwerking met bedrijf

Bedrijf: Imec
Samenwerking: begeleider

Opmerkingen:

The student can choose to focus more on the photonics-related or on the machine learning-related aspects. Also, the student can choose to work more on the experimental or simulation setup.

20700: Planar cavity with organic materials for lasing

Promotor(en):	Kristiaan Neyts, Jeroen Beeckman
Begeleider(s):	Frederik Van Acker
Contactpersoon:	Kristiaan Neyts
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

Probleemstelling:

A laser is made of a material with optical gain placed between two reflectors. Liquid crystals consist of organic molecules that self-organize and obtain interesting macroscopic properties. The most common property is optical birefringence, because light propagation is slower when the electric field is parallel to the long axes of the molecules. When the molecules are chiral (not identical to their mirror image), the liquid crystal can spontaneously form a periodic grating, which can act as a mirror when the periodicity is similar to the wavelength of light. Light emitting organic molecules can effectively provide gain when the material is excited with a short laser pulse. Layers with gain and layers which effectively reflect light can be combined to realize lasing in an organic stack.

In the literature there are many reports of liquid crystal lasers based on chiral liquid crystal doped with photoluminescent dye molecules. The threshold can be below one microjoule and the slope efficiency above 30%.

Doelstelling:

The aim of this thesis is the development and analysis of planar lasers based on organic materials. By changing the structure and by using different materials for gain and mirrors, you will try to further reduce the threshold and increase the slope efficiency.

For the gain we can use dye-doped liquid crystal layers or thin organic layers that are deposited in vacuum. For the mirrors we can use chiral liquid crystal layers with high reflectivity and low absorption. By changing the thicknesses of the layers, the lasing wavelength can be chosen. Organic layers can be deposited on liquid crystal when the liquid crystal layer is first made solid by polymerization. Another aim is the realization of a laser with a particular structure that emits light at an angle with the substrate normal.

The work will have a technological part (depositing the different layers on top of each other), an experimental part (evaluating the transmission, reflection, photoluminescence, gain and lasing properties), and an analysis part (comparing the results with numerical simulations of lasing).

The engineering aspects include: the deposition of structures and layers; building the setup to measure the photoluminescence and lasing.

The physical aspects include the principle of photoluminescence, spontaneous emission, gain and stimulated emission and lasing.

This thesis proposal is linked to the following clusters of elective courses: photonics (materials, lasing, non-linearities)

Locatie:

iGent (technologiepark Zwijnaarde), thuis

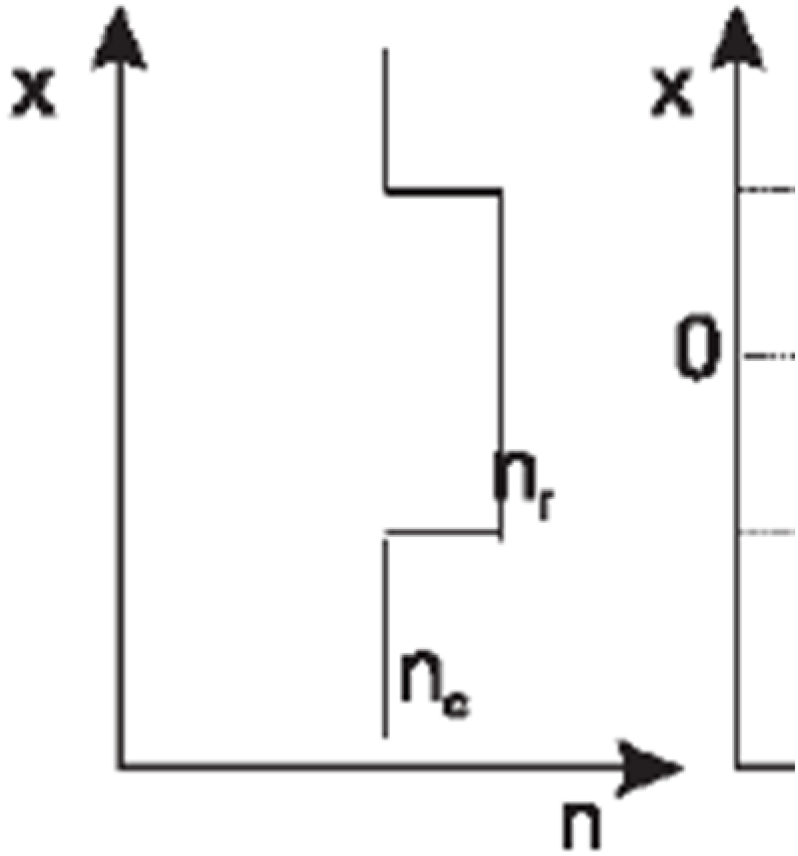
21552: Programmable multimode interferometers (MMIs) using liquid crystals

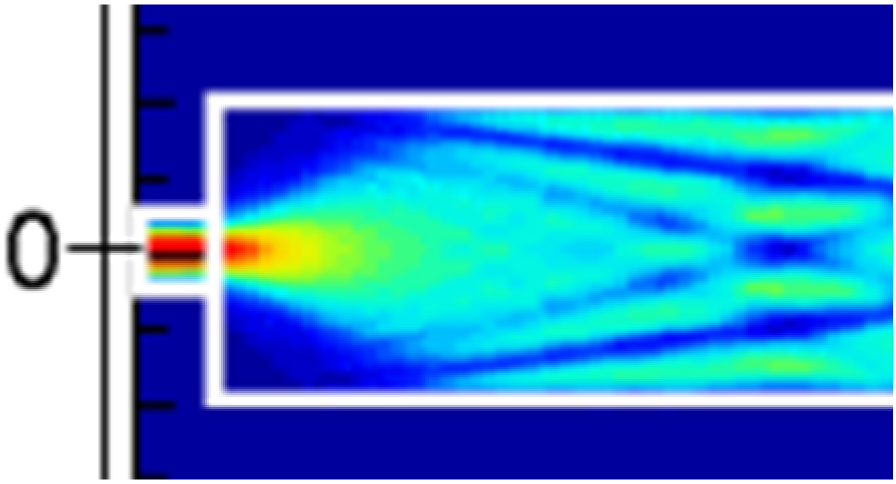
Promotor(en):	Wim Bogaerts, Jeroen Beeckman
Begeleider(s):	Lukas Van Iseghem
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	This thesis focuses on adaptive photonic integrated circuit elements, a fairly new topic in the world of photonics

Probleemstelling:

Photonic Integrated Circuits (PICs) using silicon on insulator technologies have been around for some time now. Much like the electronic integrated circuit market in the early years, the main focus of development was situated within ASICs (Application Specific Integrated Circuits), scaling down specific optical applications to schip-scale dimensions, such as spectroscopy and switching applications. Now that the silicon photonics market is maturing and a variety of specifc tasks have been demonstrated using PICs, the question arises wether it would be feasible and interesting to develop programmable PICs, much like microcontrollers and FPGAs in electronics. These devices consist of a vast number of individually controllable elements which, when configured in a certain way, result in a certain behaviour of the chip.

This requires several mechanisms. First, one has to enable local tuning of the optical properties of materials changing the behaviour of light locally on a photonic chip. This translates towards the ability to tune the refractive index of materials locally with an applied voltage (electric field). One known way to achieve this is using liquid crystal materials as a cladding (top layer) on silicon. Because the liquid crystal reorients as a function of applied voltage, a local change in the refractive index can be achieved with moderate voltages. Once the local tuning is possible, the second part consists of figuring out how these individual elements should cooperate to achieve a desired behaviour or functionality. Different control approaches and driving schemes can be used to realise different functionalities.





Doelstelling:

The goal of this thesis is to influence behaviour of a well known and widely used component in the field of microphotonics, the multimode interferometer (MMI). Localised liquid crystal tuning will be used to achieve tunable behaviour of a component with a larger scale, The MMI is actually a very broad waveguide. Different dimensions result in different behaviours, because the width determines the optical modes traveling at different speeds. As a result, the inference pattern of these modes change along the length of the component. By carefully choosing a certain length, one can localise or concentrate the light in a certain output or distribute the power evenly among several outputs (power splitter).

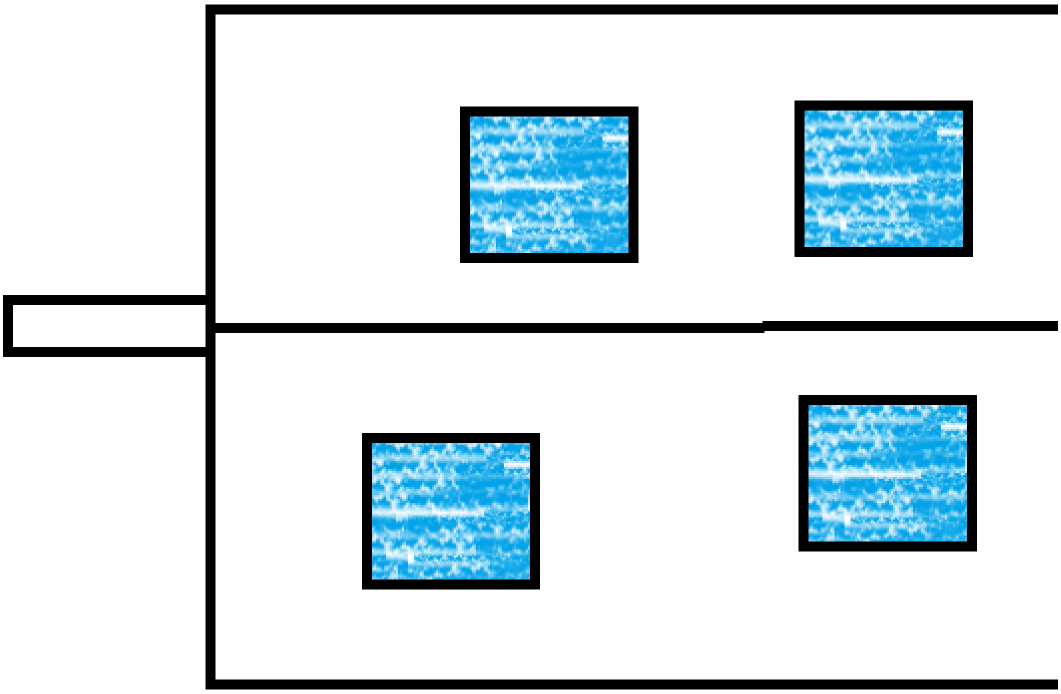
The alternative is to start from fixed dimensions of the MMI, and try to achieve different functionalities using localised liquid crystal tuning. Several MMIs are available to experiment on, and earlier work involving liquid crystal cladding and tuning has been done, so the challenges are situated within other aspects of this research. The first task of this thesis would be to investigate the configuration of the liquid crystal cells consisting of metal pads and guiding materials to guide the electrical field lines locally (simulation). Once a tunable liquid crystal cell is designed and verified via simulation, different spatial configurations/distributions of these control elements could be investigated, simulating how the liquid crystal reacts on the applied voltages. Then the behaviour of the light in the MMI has to be simulated with these local variations, demonstrating an adaptive functionality via liquid crystal tuning.

Another degree of freedom, apart from the spatial distribution of these elements on the MMI, is how to drive these elements (voltage patterns) to achieve a certain functionality. In this final phase, the device could perform functions like modulation and switching, where the functionality/behaviour of the MMI changes in time (for example, a 1x4 multiplexer where the power is sequentially focussed in 4 output waveguides rather then simultainously distributed as would be the case with power splitting). This thesis evolves from a very physics intensive component:

- simulation of electrical field distribution
- simulation of liquid crystal orientation and how this affects the optical properties locally
- simulation of how light reacts on the reorientation of these liquid crystal

But it also contains an important engineering component:

- how does the funcionality of the MMI change as a function of certain spatially distributed local changes
- which driving schemes can be used to achieve a certain functionality if the distribution is spatially fixed, and can this function be evolving in time? (response rates etc)
- demonstration of certain functionalities



Locatie:

iGent, Technologiepark-Zwijnaarde

20701: Routing and switching of liquid crystal waveguides

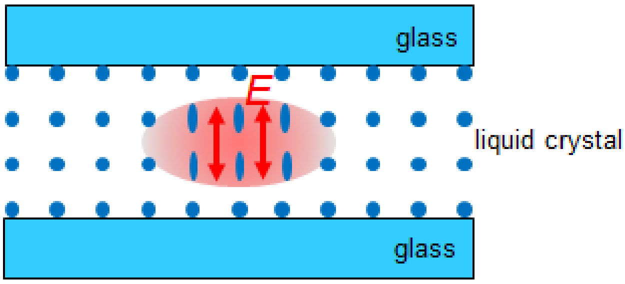
Promotor(en):	Jeroen Beeckman, Kristiaan Neyts
Begeleider(s):	Inge Nys, Brecht Berteloot
Contactpersoon:	Inge Nys
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics

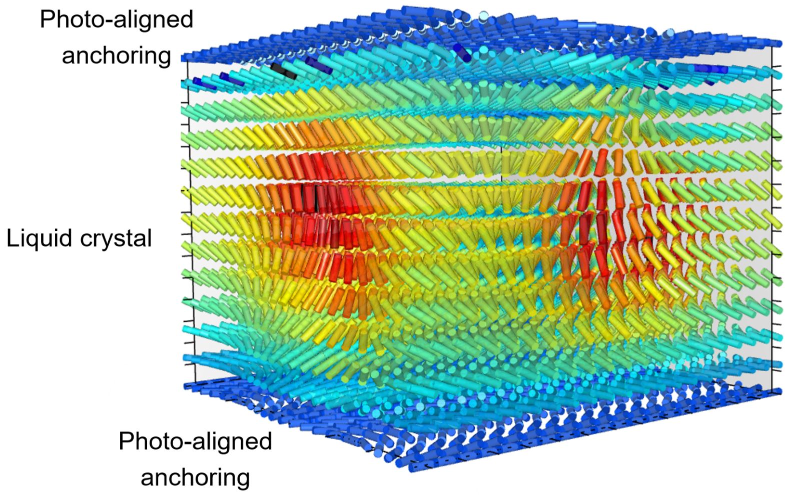
Niet behouden voor:
Nog onbeslist voor:
Aantal studenten: 1
Aantal bachelorproeven: 1
Motivering voor deze opleiding: link with photonics, microphotonics, optical materials, waveguides

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 orientation of the liquid crystal molecules can be varied by the application of a voltage or by the electric field of a laser beam. Because the elastic energy in liquid crystals is extremely small, small voltages and low power laser beams are sufficient to modify light propagation. In the past the non-linear optical effects have been used to make ‘optical transistors’ where light propagation is determined by the laser beam that is supplied to the structure.





Doelstelling:

The aim of the thesis is the realization and electrical and optical manipulation of optical waveguides in liquid crystals. Recently the LCP group has obtained expertise in the realization of photo-alignment. This is the alignment of liquid crystal near the surface of a substrate by illuminating a photo-sensitive layer with polarized UV light. After this procedure, the liquid crystal aligns near the substrate in the direction perpendicular to the polarization of the UV light. By varying the polarization direction of the UV light as a function of x and y, complex patterns can be created near the surface, and because liquid crystals are a kind of soft matter, the orientation is also modified in the entire layer (see figure). The aim is to use this novel approach to make straight and curved waveguides parallel to the glass substrates.

The second part of the thesis is the characterization of the waveguides. Light coupling to the waveguides can be realized through a window at the side or by exciting photoluminescent dye molecules that are dissolved in the liquid crystal. The light propagation path can be observed in the microscope. By applying a voltage or by changing the power of the beam, changes in the light path will be observed.

Engineering physics aspects: liquid crystal is a kind of soft matter (combining elasticity, electric fields and light), design of waveguides, investigation of physical properties by interaction of electrical, optical and elastic properties

This thesis proposal is linked to the following cluster(s) of elective courses: photonics

Locatie:

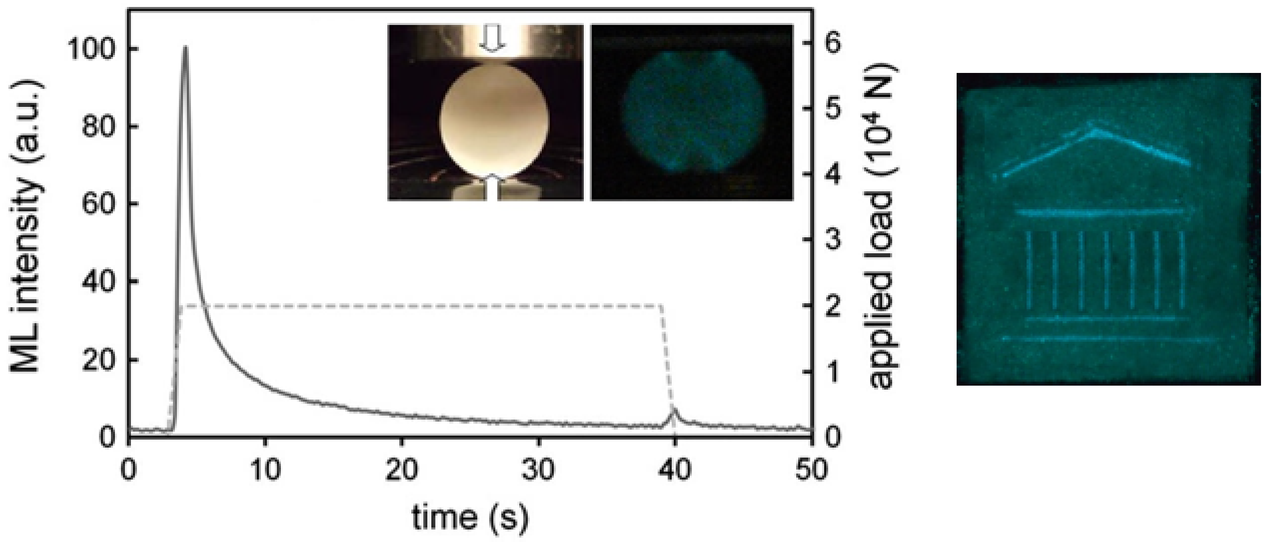
iGent (Technologiepark), thuis

20809: See the pressure - Mechanoluminescentie als sensor in composieten

Promotor(en):	Philippe Smet, Mathias Kersemans
Begeleider(s):	Simon Michels
Contactpersoon:	Philippe Smet
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Electromechanical Engineering
Niet behouden voor:	Master of Science in Engineering Physics
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Non-destructive testing, Elastic waves, Stress/strain, Novel materials, Luminescent processes, nonlinear phenomena, signal processing & analysis

Probleemstelling:

Vele organische en anorganische materialen vertonen een lichtemissie wanneer ze gebroken of vermalen worden, wat men triboluminescentie noemt. Materialen die licht uitzenden bij een elastische vervorming zijn zeldzamer, maar hebben een groter potentieel aan toepassingen gezien het niet-destructieve karakter. Deze piëzo-luminescente materialen kunnen immers ingezet worden als contactloze druksensoren, op voorwaarde dat de lichtemissie voldoende sterk is en schaalt in functie van de uitgeoefende druk. De tot nu toe gekende materialen zijn meestal efficiënte persistente of glow-in-the-dark fosforen, wat een verzamelnaam is voor materialen die minuten tot uren lang licht blijven emitteren nadat de excitatie gestopt werd. Dit betekent dat ze in staat zijn om een hoeveelheid energie – tijdelijk – op te slaan, die onder invloed van warmte (persistente luminescentie) of druk (mechanoluminescentie) weer vrijgegeven kan worden. Over het mechanisme achter dit drukafhankelijke fenomeen is er nog weinig geweten, hoewel er een sterke link met piëzoelektrisch gedrag, en dus de kristalstructuur, verondersteld wordt.



Links: Lichtoutput van de fosfor $BaSi_2O_2N_2$:Eu bij belasting. Rechts: het effect van het 'schrijven' op hetzelfde poeder met een puntig voorwerp.

Daarnaast beginnen vezelversterkte kunststoffen (zogenaamde composieten) alsmaar meer toepassingen te krijgen in het dagdagelijkse leven. Deze materialen zijn ideaal voor structurele applicaties waar een hoge stijfheid-gewichtsverhouding en/of sterkte-gewichtsverhouding nodig is, zoals bij windturbines, vliegtuigonderdelen of fietskaders. Onder zware, repetitieve belasting kan schade voorkomen onder de vorm van microscheurtjes en -gaatjes, wat gewoonlijk leidt tot macroscopisch verlies van sterkte en stijfheid. Het detecteren van deze schade is echter niet zo evident bij composieten, aangezien deze meestal niet of slechts gedeeltelijk aan het oppervlakte zichtbaar is.

Doelstelling:

Het doel van deze masterproef is het experimenteel onderzoeken van het gedrag van een recent aan LumiLab ontwikkelde mechanoluminescente fosfor, nl. europium-gedopeerd BaSi2O2N2. Er is nog weinig geweten over het mechanisme achter dit fenomeen, en om tot praktische toepassingen te komen moet de rol van verschillende parameters van de aangelegde spanning (totale grootte, aanlegsnelheid, frequentie in geval van dynamische belasting, ...) nauwkeurig onderzocht worden. Als hierover meer bekend is, kan duidelijk worden of dit materiaal toepasbaar is in composietmaterialen, enerzijds voor het opsporen van zwaar belaste zones (spanningsconcentraties), anderzijds voor het detecteren van schade in het composietmateriaal. Naargelang de interesse van de student kan de nadruk van dit afstudeerwerk liggen op volgende facetten:

- Synthese en karakterisering van het mechanoluminescente materiaal, waarbij getracht wordt het mechanoluminescente gedrag te koppelen aan de structurele en luminescente eigenschappen van het materiaal en de eigenschappen van de aangelegde spanning. Hiervoor zijn opstellingen gebouwd die reproduceerbare kras-belasting of geluidsgolven kunnen toedienen aan een sample. De relatie tussen de afterglow en de mechanoluminescentie wordt bestudeerd.
- De drukafhankelijkheid van de mechanoluminescentie wordt bekeken wanneer het ingebed zit in een composiet of een epoxy, door het op- en ontlaadgedag en de lineariteit te bekijken bij belasting. Voor deze toepassing als druksensor wordt een servo-hydraulische trekbank van de vakgroep Toegepaste Materiaalwetenschappen (Technologiepark, Zwijnaarde) gebruikt.
- Het maken van composietplaten en het inbrengen van het poeder op strategische plaatsen. Daarna kan gekeken worden of de zeer lokale spanningsconcentraties, als gevolg van de weefselstructuur van de versterkingsvezels, gevisualiseerd kan worden. De invloed van de belasting (trek, vermoeiing, impact) op het lichtbeeld, alsook de evolutie van dit lichtbeeld ten gevolge van schade zal worden bestudeerd en gemodelleerd.

Locatie:

Website:

Meer informatie op: lumilab.ugent.be

Opmerkingen:

Dit onderzoeksproject kadert in een lopende samenwerking tussen LumiLab en de onderzoeksgroep Mechanics of Materials and Structures (MMS, Technologiepark).

21967: Silicon Photonics Wavelength Filters for Multiplexed Ultrasound Sensor Readout

Promotor(en):	Wim Bogaerts, Wouter Westerveld
Begeleider(s):	
Contactpersoon:	Wim Bogaerts
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Ontwerp en karakterisatie van photonic IC

Probleemstelling:

Silicon photonics provides an attractive platform to implement sensors: silicon waveguides are extremely sensitive to a multitude of effects. A new type of sensors to make use of silicon waveguides is ultrasound sensors. By creating freestanding waveguide membranes, sound waves will distrot the wavegudie, causing a change in optical path length, which can be measured by an interferometric device, such as a Mach-Zehnder interferometer (MZI) or a microring resonator (MRR). This will result in a shift of resonance wavelength, which can be measured with a spectrometer. In IMEC, such ultraound sensors are being developed in a custom silicon photonics platform. Together with these sensors, an optical readout circuit needs to be designed and fabricated, consisting og a combination of ring resonators and arrayed wavegudie gratings (AWG). These latter circuits are very powerful for wavelength sensing, but are not trivial to design.

Doelstelling:

In this master thesis, the objective is to implement a read-out circuit for the ultrasound sensors. As this will be done in a customized silicon photonics platform, the student will have to go through all the steps for creating an AWG-based spectroemeter circuit

- Using mode solvers to calculate the optical properties of the layers and the waveguides.
- Estimating the sensitivity of the new platform to fabrication variations (e.g. line width of the waveguides, thickness of the silicon layer).
- Building a rudimentary design kit for the new platform, consisting of a few basic building blocks (e.g. directional coupelrs, wavegudie apertures, grating couplers)...
- Designing and simulating AWG wavelength filters to obtain the specification for the ultrasound sensor readout. This involved a number of trade-offs in the design parameters which are not trivial.

This should result in one or more designs for a circuit that will be taped out in January 2020, and fabricated in IMEC. The resulting devices should be ready by April for characterization, which will allow the student to match the experimental results to the original design. This involves parameter fitting, and ultimately updating the design kit with the new technology information.

Locatie:

iGent, IMEC-Leuven

Deze masterproef werd reeds 1-maal toegekend!

21001: Theoretical and numerical study of the scattering loss in heterogeneously integrated DFB lasers

Promotor(en):	Geert Morthier
Begeleider(s):	Javad Rahimi Vaskasi
Contactpersoon:	Geert Morthier
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	European Master of Science in Nuclear Fusion and Engineering Physics
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	De thesis gaat in essentie over verstrooiing van optische golven aan oppervlakteruwheden

Probleemstelling:

The photonics research group has been working for many years on InP laser diodes, which are heterogeneously integrated on silicon-on-insulator.

The efficiency of a laser diode is determined by the ratio of mirror loss over internal loss. For the laser diodes which are integrated on silicon-on-insulator, that internal loss is mainly due to scattering at sidewall roughnesses of the InP mesa. Hence, in order to increase the efficiency of the InP-on-Si lasers, we want to reduce the scattering loss by modifying the designs of the lasers. The aim of this master thesis is to optimize the laser designs for minimal scattering using numerical simulations.

In a later stage, a limited number of new designs can be fabricated and the internal losses can be measured to confirm (or not) the numerical outcomes.

Doelstelling:

The student is expected to first study the literature on scattering loss and if possible find some analytical approximations for this loss which can be applied to the typical structure of InP-on-Si lasers. He/she will then have to make a script/program to use the outcome of waveguide mode analysis software for the calculation of the scattering loss.

A next step is to calculate the scattering loss for different laser cross section geometries and optimise parameters like mesa width, silicon waveguide width, ... to minimize the scattering loss.

Once a structure with sufficiently optimum scattering loss is designed, it can be fabricated by PhD students and then measurements of the internal loss can be done by the master student and experimental results can be compared with numerical results.

Locatie:

iGent

21114: Thin film polarizers for application in smart contact lenses

Promotor(en):	Kristiaan Neyts, Herbert De Smet
Begeleider(s):	Boxuan Gao, Brecht Berteloot, Rik Verplancke
Contactpersoon:	
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
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	link with photonics, microphotonics, optical materials

Probleemstelling:

Most liquid crystal displays (LCDs) operate with polarized light and therefore the polarizer is an essential component. Often polarizers are made by stretching a polymer film containing absorbing dye molecules. For applications such as contact lenses, it is essential that the polarizer is only a few mm thick and the stretching method cannot be used. Therefore, the first artificial iris demonstrators employ liquid crystal modes without polarizers, such as 'guest host LCD', which suffer from a relatively low contrast. The availability of thin film polarizers could dramatically improve the quality of such devices. Thin film polarizers can be realized by mixing liquid crystal with anisotropic dye molecules, aligning the mixture between two glass plates that are for example 10 mm apart, and polymerizing the layer.

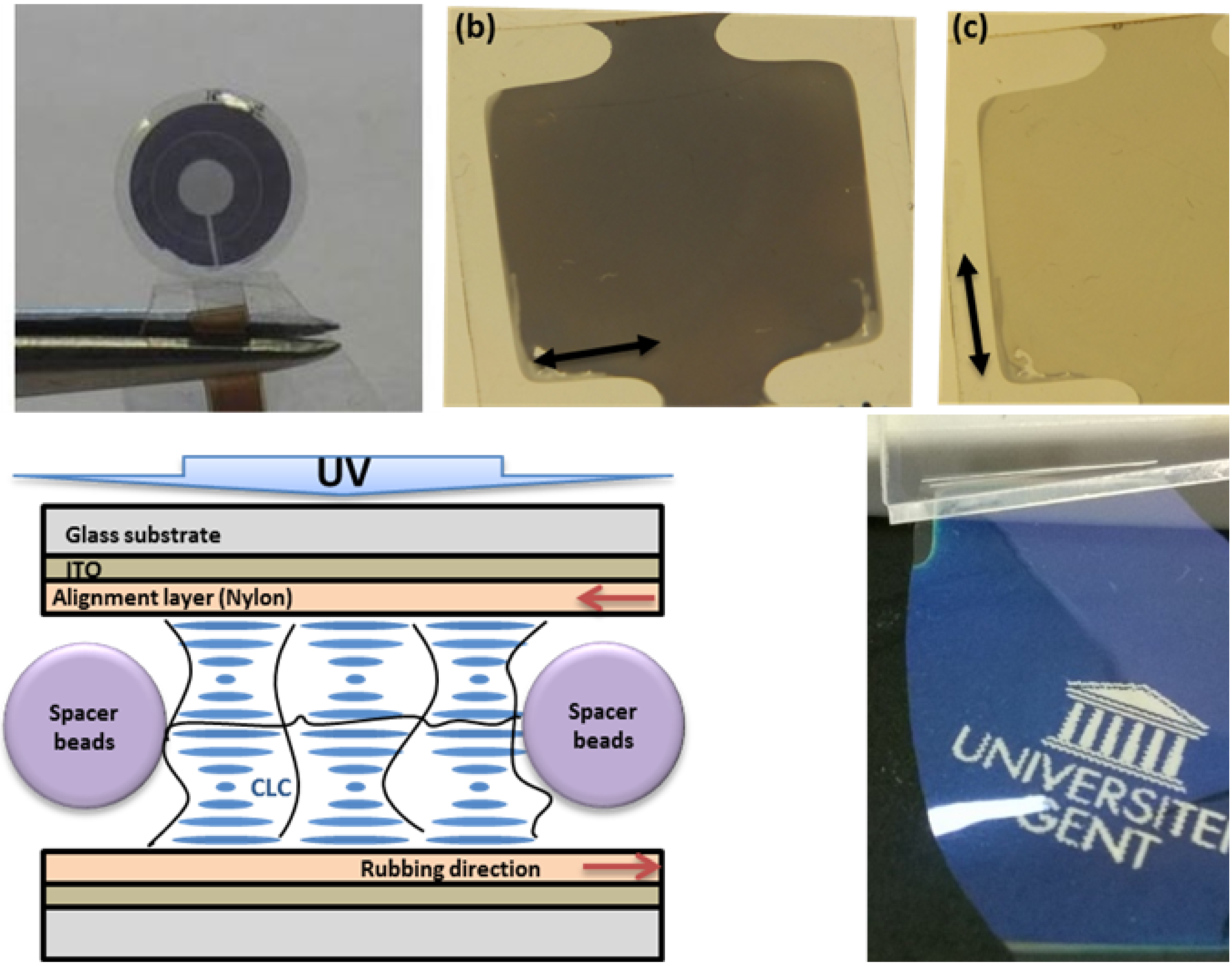


Figure 1. top left: Artificial IRIS made by CMST; top right: thin film polarizer made by LCP;

bottom left: structure of a polymerized film; bottom right: free-standing polymerized film.

Doelstelling:

The plan is to realize thin polarizing films on flexible substrates that may be used in contact lenses. The material will be a mixture of absorbing dyes and liquid crystal.

- The first step will be to realize a thin film polarizing layer between two glass plates. The polarization direction may be homogeneous, but also patterned polarizers will be made, with the plane of polarization depending on the location: j(x,y). The orientation of the liquid crystal will be determined by photo-alignment (illumination with polarized UV light).
- The second step is to make a thin film polarizer by spin-coating on flat or curved, glass or plastic substrates. After deposition of the polarizing liquid crystal layer, it will be polymerized. Here the alignment of the liquid crystal can be done with either photo-alignment, or oblique evaporation of SiO2.
- Finally twisted nematic liquid crystal cells with be made with the produced polarizers. This cell can be switched between dark and bright when a voltage is applied.

Locatie:

Ardoyen (iGent), thuis

Website:

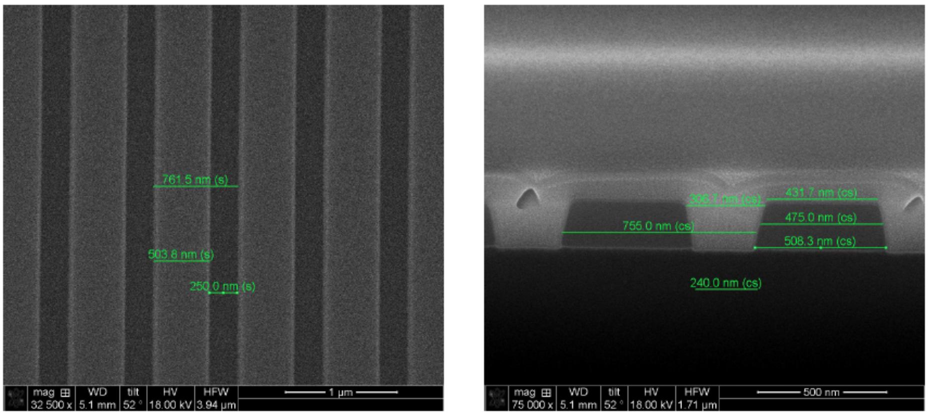
21513: Tunable high-contrast reflectors

Promotor(en):	Jeroen Beeckman, Johan Lauwaert
Begeleider(s):	Sheng Yang, John Puthenparampil George
Contactpersoon:	Jeroen Beeckman
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The subject deals with photonic components: theoretical understanding of the optical behaviour, simulation and optical measurements using an infrared microscope

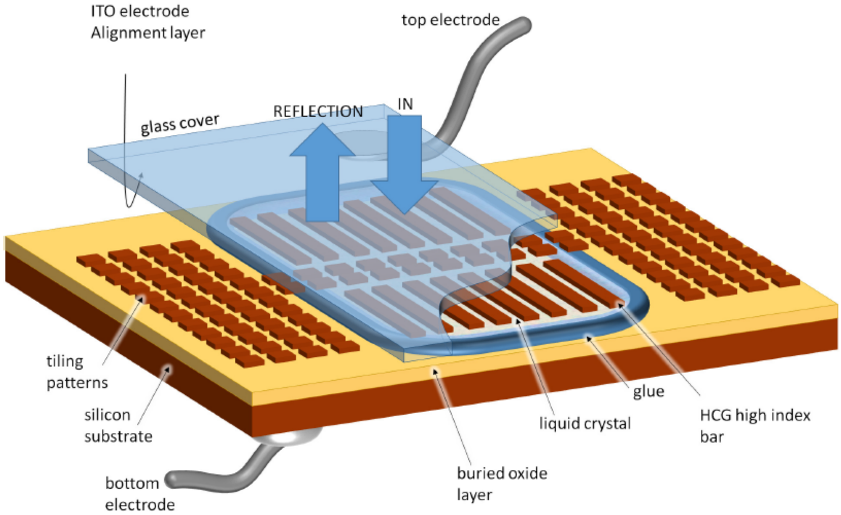
Probleemstelling:

Traditional ways to achieve very high relectivity (>99%) of light involve Bragg reflectors. Such reflectors consist periodic layers with low and high refractive index. In order to achieve high reflectivity, a large number of periods are necessary. Recently, another way to achieve very high reflection coefficients is the use of High Contrast Gratings (HCGs). Instead of periodic layers, the HCG consists of a single layer with a periodicity in the plane. Only when there is a very high refractive index contrast with the surrounding material, very high reflectivity can be achieved. In practice, silicon (n = 3.5) can be used in combination with SiO2 (n = 1.45). The figure below shows a picture of a HCG grating that was fabricated using DUV lithography. The HCGs can be designed to have a very high reflection over a wide wavelength range. But they can also be designed to have very sharp peaks with high reflectivity. Usally, these gratings are fixed, and once fabricated, the properties cannot be changed anymore.

Liquid crystals (n = 1.5 to 1.7) are materials than can be used to tune the reflection peaks thanks to the large electro-optic effect. Tunable HCGs have not be demonstrated before, although several applications could benefit from having widely tunable reflection peaks: e.g. in hyperspectral imaging, tunable laser cavities or fast shutters.



(a) Top view (b) Cross section



In this thesis, the aim is to demonstrated for the first time that wide tuning of HCGs is possible.

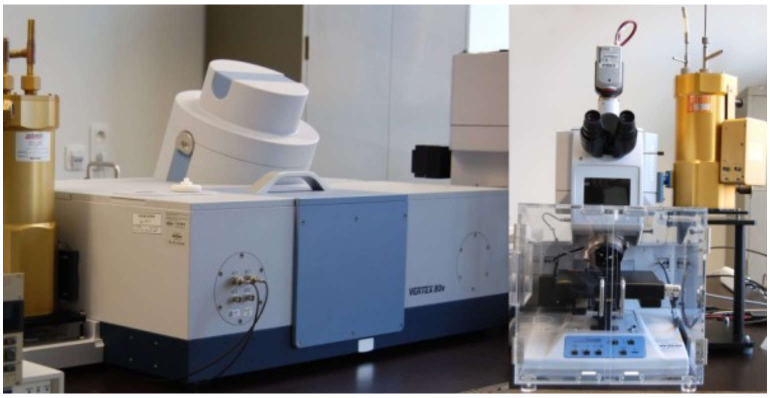
Doelstelling:

This thesis will involve a combination of theoretical work, numerical simulations, clean room fabrication and measurements. We not only aim at experimental demonstration of HCG tuning. It is also expected to match these results with theoretical and numerical calculations.

The thesis will involve:

- Theoretical and numerical calculations: the tuning of the reflection peaks using liquid crystals will be simulated using in-house software for liquid crystal calculations and Comsol calculations for the optical properties.
- The silicon chips with the HCGs are readily available thanks to a previous Multi-Project Wafer run. First they will be characterized without liquid crystal (in air). The characterization will be performed using an infrared microscope (see figure below).
- In the UGent cleanroom, the silicon chips will be assembled with a glass plate with electrodes to make a liquid crystal device out of it. The electrodes are used to control the liquid crystal behavior.
- Further characterization will examine the possibility of liquid crystal based tuning.

An important question that will be addressed during the thesis work is how the liquid crystal material needs to be driven in order to achieve strong and reliable tuning. Different contacting schemes are possible. Simulations are required to understand the liquid crystal behavior and the resulting tuning effects.



Locatie:

iGent

Website:

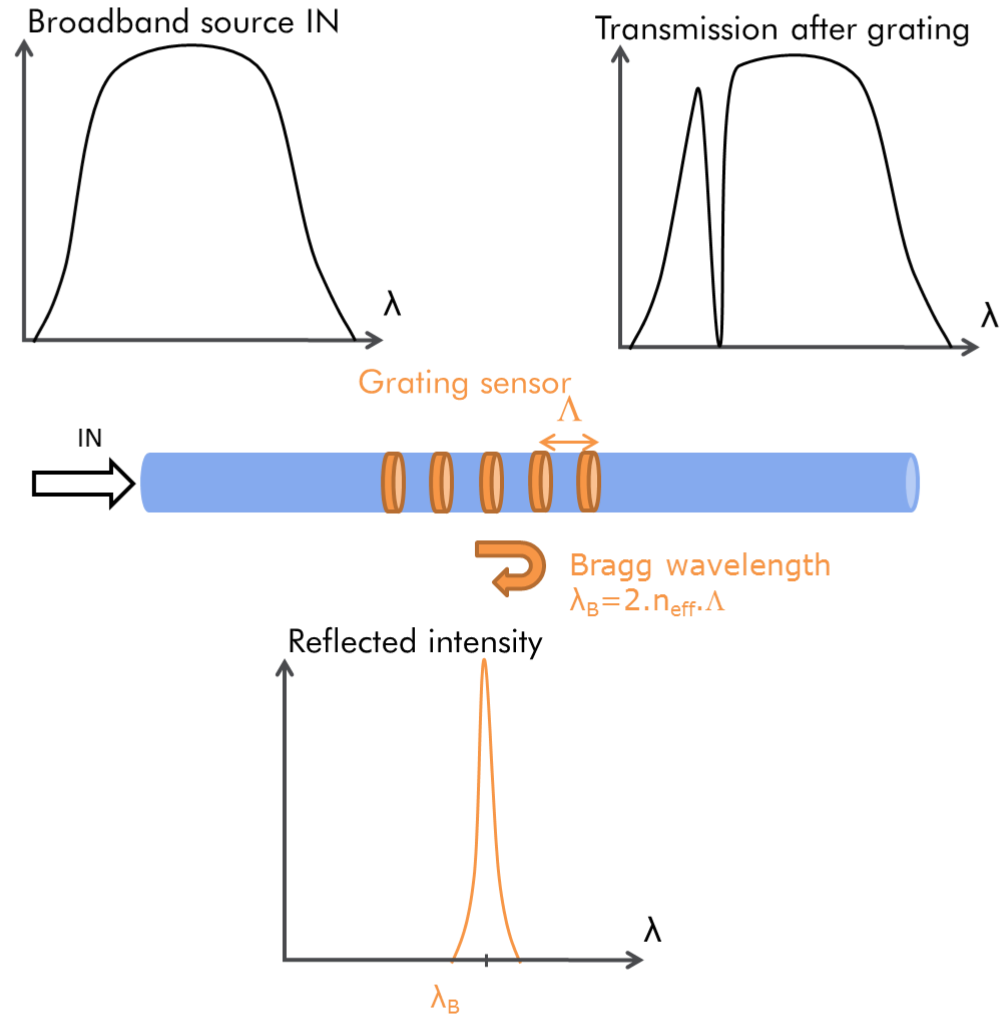
Meer informatie op: lcp.elis.ugent.be

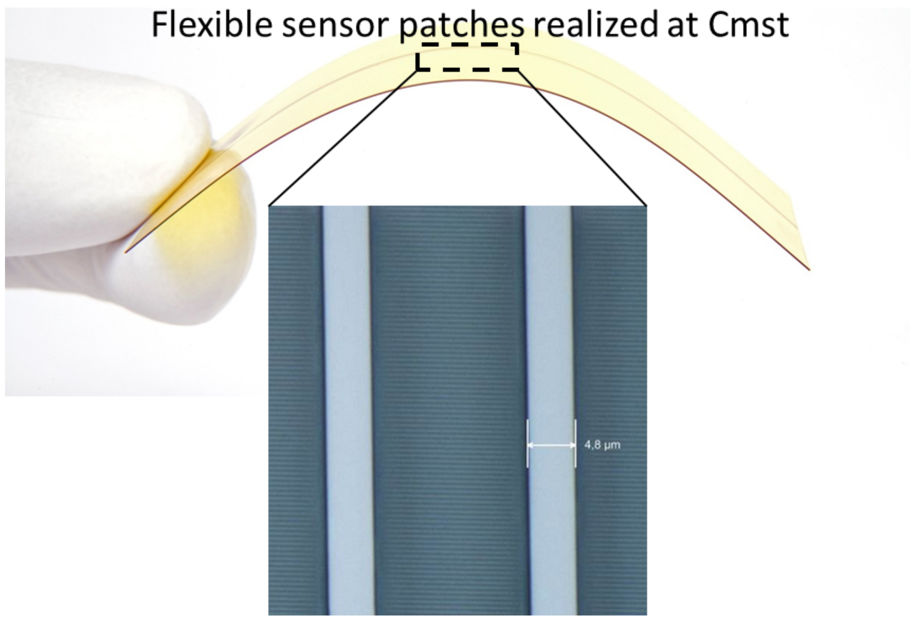
20637: Ultra-sensitive, compact, non-contact reader system for optical strain sensors

Promotor(en):	Jeroen Missinne, Xin Yin
Begeleider(s):	Marie-Aline Mattelin, Cédric Bruynsteen
Contactpersoon:	Jeroen Missinne
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Kortrijk, Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Schoonmeersen, Master of Science in Electrical Engineering - afstudeerrichting Communication and Information Technology, Master of Science in Electrical Engineering - afstudeerrichting Electronic Circuits and Systems
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1 of 2
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	Readout electronics will be developed to interface optical sensors

Probleemstelling:

Optical Bragg grating sensors are used in a wide array of high-end applications such as aircrafts, wind turbines, mechanical constructions, gas and oil industry, … The general principle of such a sensor is explained in the figure: a Bragg grating reflects a certain wavelength of light, called "Bragg wavelength (lambda_B)". This Bragg wavelength is sensitive to temperature or mechanical strain (a.o. because of the elongation of the grating caused by these external parameters) making it very suitable as a sensor. Compared to conventional electrical sensors, these optical strain sensors are very reliable, but they are mainly used in these high-end applications due to the total system cost. The reason is that although sensors themselves are relatively affordable, the traditional platform (called the "interrogator") to readout the sensor information (= a peak or dip in the spectral domain) consists of an optical spectrometer which is relatively expensive and not very compact. Furthermore, the sensor needs to be physically connected to read out the signal, which is a disadvantage, especially when used on moving parts such as wind turbine blades.





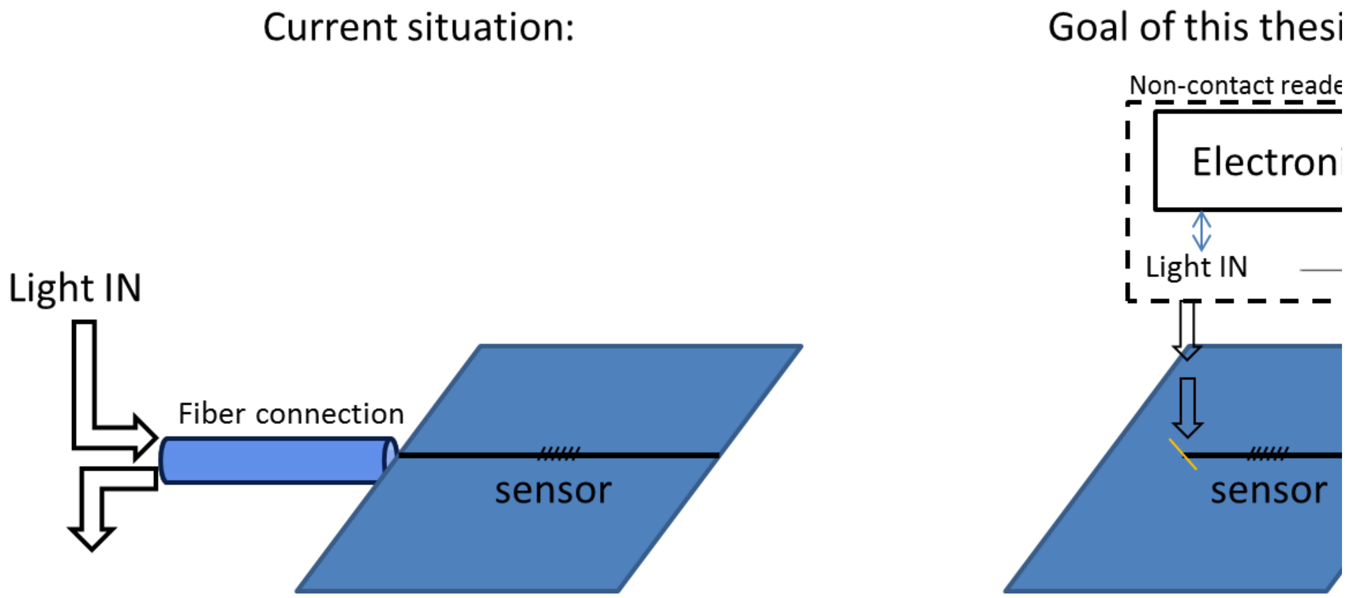
In this master thesis, we will therefore tackle these issues by developing a new concept for a non-contact electronic system to readout Bragg grating sensors based on a light source (laser or LED) and a photodiode connected with an ultra-sensitive read-out subsystem (including sensor front-end, signal conditioning, ADC and digital processing). If this concept can successfully be demonstrated, you can think of implementing it in a smartphone-like “scanner” or even in a drone to readout sensors which are difficult to reach.

Doelstelling:

Within the research lab CMST (department Elis), such Bragg grating sensors have been developed in polymer waveguides (see figure above). The advantage compared to making Bragg gratings in fibers is that we have a lot of design freedom: we can choose the waveguide materials, dimensions, orientation, grating design and also make compact optical sensor circuits for example on a flexible foil.

The IDLab Design group (department INTEC) has extensive experience in developing advanced electronic ICs, sub-systems and demonstrators for various applications, esp. in cutting-edge data-/tele-communications and high-end sensing/instrumentations areas.

The goal of the thesis is to combine the experience of both research labs to obtain a compact reader.



In this thesis, the non-contact readout principle, which is illustrated in the figure above will be studied. Instead of glueing an optical fiber to such a sensor, a light beam will be launched from above onto the sensor, and a photodiode will capture either the transmitted or reflected light. The light can be deflected over 90 degrees using micromirrors integrated on the sensor. This principle has been tested in the lab, but the current setup employs bulky and expensive components, such as a tunable laser. The wavelength of this laser is scanned in fine steps, and by monitoring the photocurrent at each wavelength, the spectrum can be reconstructed and the location of the Bragg wavelength can be determined.

A first task will be to study the already available system and investigate how it can be improved and miniaturized. For example, there exist compact tunable lasers which are used for telecom applications and eventually the use of low-cost LEDs could be investigated. Related to this taks, the required electronic subsystems will be developed to drive the laser/LED, to readout the photodiodes and to study the performance (alignment tolerance, sensor signal quality, etc.)

Finally, the best solution will be selected and a demonstrator will be built proving that a changing sensor signal (e.g. a sensor subject to elongation) can be tracked.

The thesis will mainly focus on implementing the electrical part of the sensor system, making use of sensors which are already available at Cmst. Of course, depending on the student's preferences, some optical aspects can optionally also be studied and further optimized.

The work is divided in the following parts:

- Designing and testing of the non-contact readout concept making use of already available lab equipment (laser, LEDs, sensor foils, photodiodes, ...)

- Developing a dedicated, electronic circuit which will lead to the non-contact, compact readout system. This includes driver circuits for the light source, transimpedance amplifiers (TIA) to readout photocurrents, signal conditioning, control electronics or a microcontroller to trigger the different building blocks and collect the sensor data.

- Testing of the full sensing system in the lab and later in a real environment.

Together with the master student, the focus of the master thesis can be slightly shifted towards one of the specified parts.

Locatie:

Ardoyen, (iGent building + Cleanroom), thuis

Samenwerking met bedrijf

Bedrijf: Com&Sens
Samenwerking: use case

21103: Ultrabright and Integrated Single Photon Sources

Promotor(en):	Pieter Geiregat, Dries Van Thourhout
Begeleider(s):	Jorick Maes, Ivo Tanghe
Contactpersoon:	Pieter Geiregat
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The development of integrated quantum light sources is a key area of research for Photonics engineers.

Probleemstelling:

The first quantum revolution brought us optical fiber communication, LEDs and micro-electronics. Using the quantum nature of light, in particular the properties of a single 'photon', we can now enter the 2nd quantum revolution which promises unhackable cryptography and non-classical computing. Heavily investigated by major industrial players (IBM, Intel, Google, ...), a key question in using photons for quantum information science is an obvious one: how do we generate these single photons ? Moreover, the ideal single photon source is demanding as we aim for high emission rate ('brigthness') and single photon purity, room temperature operation and compatibility with existing technology, such as CMOS fabrication used in micro-electronics.

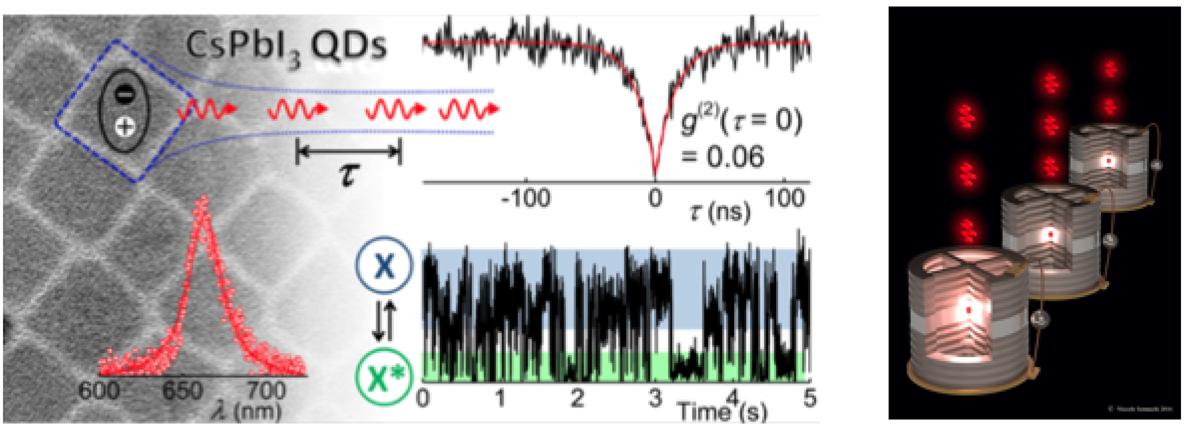


Figure: (left) Single photon emission from CsPbI3 perovskite quantum dots (10 nm size), evidenced by single photon spectroscopy showing strong anti-bunching at time zero. (right) Array of single photon sources for multiplexed quantum optics.

Doelstelling:

In a joint effort between the Physics and Chemistry of Nanostructures Group (Prof. Hens, Prof. Moreels) and the Photonics Research group (Van Thourhout), we are developing integrated single photon sources based on colloidal nanomaterials. These solution-processable pieces of semiconductor are only 5 to 10 nanometer in size, giving rise to peculiar quantum confinement effects. A special class of these materials, called perovskite quantum dots, has shown great promise as single photon emitter due to fast radiative lifetimes (down to 200 picoseconds) and high yield of photo-emission. Your goal will be to (a) characterize single photon emission at room temperature from quantum confined perovskite nanocrystals and (b) develop a strategy to incorporate these emitters onto a standardized integrated optics platform. As such, the project will consist of both fundamental material characterization , using state-of-the-art single photon microscopy, and (photonics) engineering, using the advanced cleanroom facilities at UGent to embed single photon emitters in silicon photonics circuitry.

For students in engineering physics:

- physics aspects of this topic: The connection between quantum confinement and the fundamental optical properties of "single" light emitting QDs, such as single photon purity and lifetime.
- engineering aspects of this topic: Using and optimizing advanced microscopy techniques to characterize single photon emitters and developing protocols to embed these emitters with silicon photonics circuitry (cleanroom work).
- this thesis subject is closely related to the following clusters of elective courses: PHOTONICS, MATERIALS and NANO

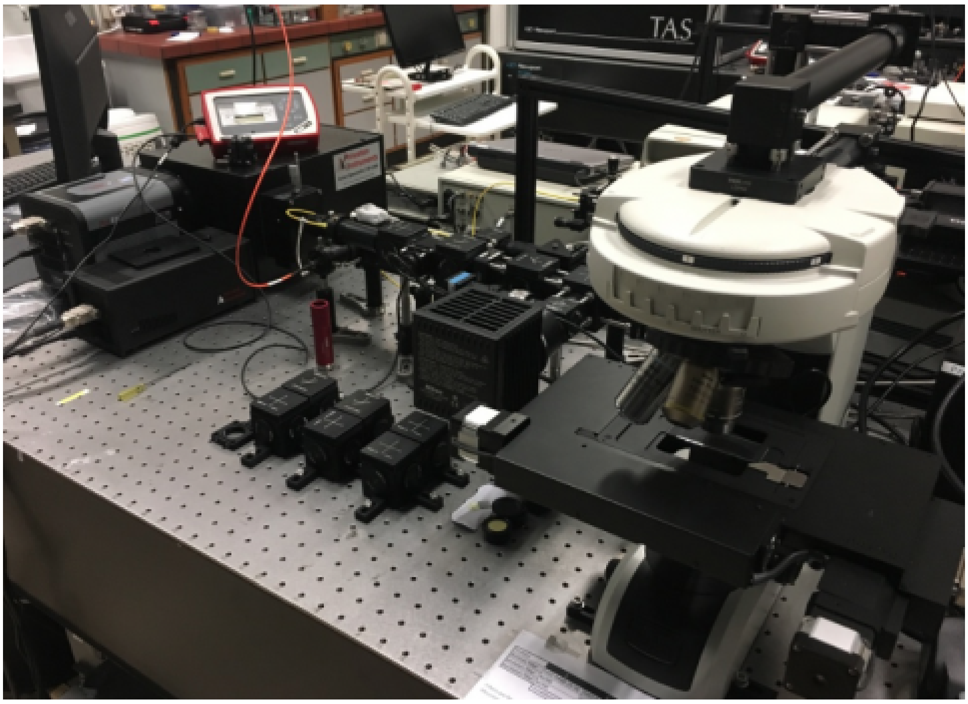


Figure: Single photon microscope at UGent (Campus Sterre), capable of detecting single photons emitted by e.g. a perovskite quantum dot and resolving their fundamental properties (energy, polarization, ...).

References:

1. "Genesis, challenges and opportunities for colloidal lead halide perovskite nanocrystals", Nature Materials (2018), doi:10.1038/s41563-018-0018-4
2. "Properties and potential optoelectronic applications of lead halide perovskite nanocrystals", Science (2017) , 358 (6364)
3. "Solid-State Single Photon Emitters", Nature Photonics (2015), 10

Locatie:

De Sterre, Ardoyen

Website:

Meer informatie op: www.nano.ugent.be

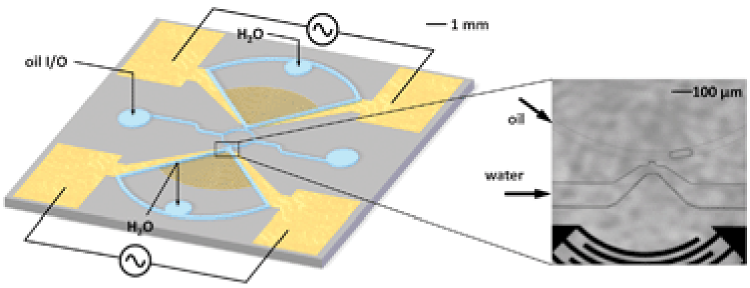
21514: Ultrasonic waves for particle manipulation

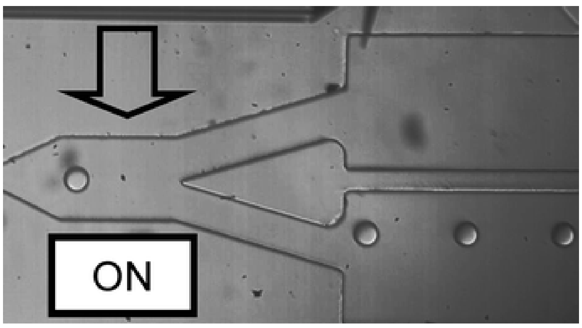
Promotor(en):	Jeroen Beeckman, Filip Beunis
Begeleider(s):	John Puthenparampil George, Tessa Van de Veire
Contactpersoon:	Jeroen Beeckman
Goedgekeurd voor:	European Master of Science in Photonics, Master of Science in Engineering Physics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The visualization of trapped particles under the microscope and the optical simulation of light diffraction on particles.

Probleemstelling:

Piezo-electric materials are materials that deform when an electric field is applied. These materials are widely used in electronic components. In the latest smartphones (IPhone or Samsung Galaxy) these materials are used in so-called Bulk Acoustic Wave resonators (BAWs) for filtering in- and outgoing 4G signals. In other telecommunication techniques often Surface Acoustic Wave (SAW) resonators are used. In BAW resonators the waves travel perpendicular to the surfaces, in SAWs the waves travel along the surface. More info can be found on wikipedia.

In the Liquid Crystals & Photonics research group a novel way to deposit high-quality thin films with extraordinarily high piezoelectric coefficients was developed (and patented). The deposition is optimized for optical applications, but this patented method could also be used for the fabrication of high quality SAW devices. One particular advantage of our method is that the thin films can be deposited on large substrates such as window glasses, glass surfaces in displays or glasses for microfluidic devices. In this thesis, the purpose is to integrate SAWs in microfluidic devices. One of the possibilities of the suface acoustic waves is the manipulation of micrometer sized objects (such as particles, water droplet or living cells). In a first stage the device will be simulated using finite element methods. Then devices will be fabricated and ultrasonic surface waves will be generated. The effect on different types of particles will be tested. Depending on the interest of the student these particles can be replaced by living cells such as blood cells. The image below shows a picture of how picoliter droplets can be generated using piezoelectric materials or how particles can be moved from one microfluidic channel to other. Some articles on this topic: 1 & 2.





Doelstelling:

Depending on the interest and background of the student, this thesis will focus more on physical effects (surface acoustic wave simulations) or on applications (microfluidics, particle manipulation). The basic scheme will be the same:

- getting acquainted with piezoelectric materials: properties, measurements, deposition, ...
- simulations using finite element methods (e.g. Comsol)
- mask design: electrode design for the surface acoustic wave generators
- electrical measurements of the test samples
- using the samples to manipulate different types of objects: water droplets, silica beads, blood cells, ...

Locatie:

iGent Ardoyen, home

Website:

Meer informatie op: lcp.elis.ugent.be

22031: Wavelength division multiplexing in photonic reservoir computing

Promotor(en):	Peter Bienstman, Joni Dambre
Begeleider(s):	Emmanuel Gooskens
Contactpersoon:	Emmanuel Gooskens
Goedgekeurd voor:	European Master of Science in Photonics
Niet behouden voor:	
Nog onbeslist voor:	
Aantal studenten:	1
Aantal bachelorproeven:	1
Motivering voor deze opleiding:	The dissertation focuses on the wavelength division multiplexing aspect of an in photonic hardware implemented information processing system.

Probleemstelling:

Reservoir computing is a machine learning technique in which a nonlinear dynamical system is used for computation. It was originally implemented as an efficient way to train a neural network but it has grown to a more versatile machine learning method nowadays, for example to solve classification and regression tasks. The dynamical system - the reservoir - is held unchanged during the procedure and during training. Only the weights used to linearly combine the reservoir states are optimized. Keeping the recurrent network unchanged and thus only training on the level of the reservoir states makes reservoir computing a computationally efficient method.

Although reservoir computing was originally invented in computer science as a software solution to bypass the computational cost of optimizing a neural network, it is perfectly suited to be implemented in various hardware platforms. These implementations do not suffer from classical digital computer bottlenecks and are by nature more convenient to operate neuromorphic computing schemes. One such hardware implementation that is especially suited for reservoir computing is silicon photonics.

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, can exploit many nonlinear processes, for instance by wavelength coupling, and has inherent parallelism through use of wavelength multiplexing.

Examples of specific challenges are investigating the wavelength dependence of the reservoirs and exploring creative solutions for achieving nonlinear wavelength coupling.

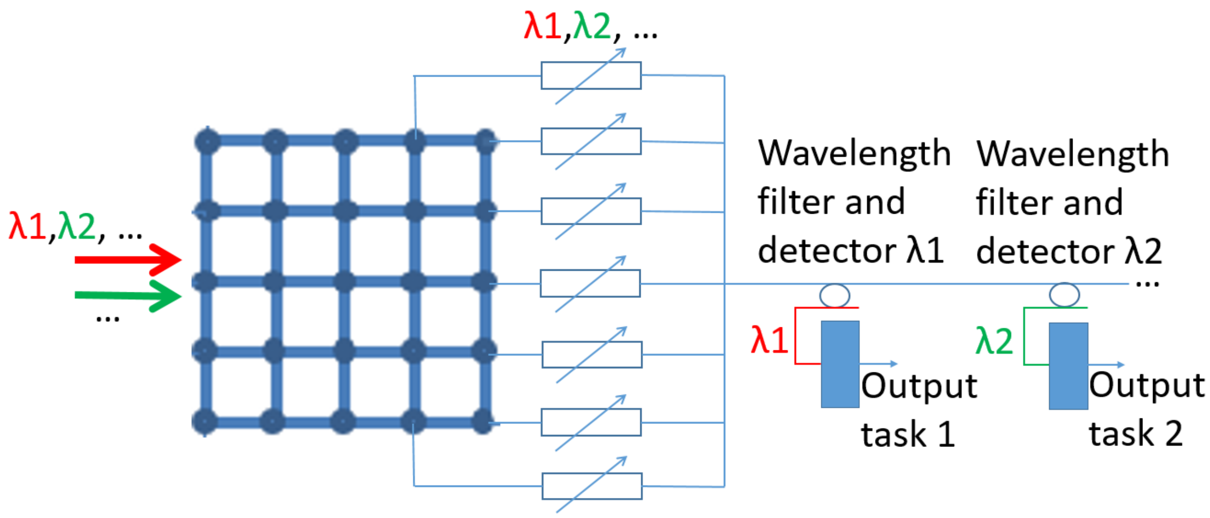


Figure 1: Example of how wavelength multiplexing in a photonic reservoir system can be used to achieve parallelism. Here a single reservoir (displayed as a grid of interconnected nodes) and a single set of readout weights is used to solve (identical) tasks in parallel. The tasks could for instance consist of signal equalization. Different signals multiplexed on different wavelengths could thus be processed in parallel without increasing the footprint of the device. The challenge is to find a set of readout weights suitable for all wavelengths. The difficulty of this challenge depends on the wavelength dependence of the reservoir.

Doelstelling:

The purpose of this master dissertation is to apply a photonic reservoir system making use of multiple wavelengths to a telecommunication or benchmark task such as signal equalization, header recognition or time series prediction and compare the results to a single wavelength photonic reservoir.

The thesis will mainly consist of simulation work using existing as well as self-written software. Depending on the interests of the student, there is also a possibility to test the simulation outcomes in high-speed measurements.

Locatie:

iGent toren (campus Ardoyen), thuis (home)

Deze masterproef werd reeds 1-maal toegekend!