- 15292 Nanorod alignment in a liquid for polarized light emission
  Promotoren: prof. dr. ir. Kristiaan Neyts en prof. dr. Zeger Hens
  Begeleider(s): dr. ir. Filip Strubbe
  Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

  Probleemstelling:

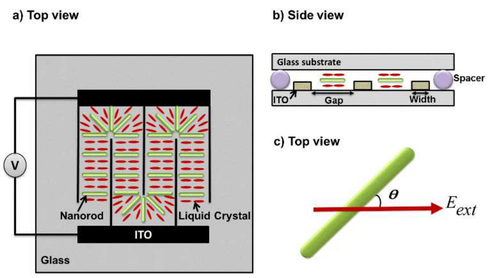
  Almost all light sources (LEDs, phosphorescent lamps, sun) emit unpolarized light, but for some applications (displays, microscopy, car headlights) the emission of polarized light would offer many benefits. The origin of polarized emission lies in the electrical dipole transitions that take place on the nano-scale. It is known that some long-shaped organic dye molecules and semiconductor nanorods emit photons that have an electric field component that is mainly along the long axis. We have shown that it is possible to align dye molecules or nanorods on a substrate along the same axis, and that the emission from that substrate has a high degree of polarization. Nanorods with a small (5 nm) CdSe dot in the core and a 50 nm long CdS shell are produced in the Physical Chemistry research group in the faculty of Sciences. These nanorods can be dispersed in a liquid and have a permanent electrical dipole moment. When an electric field is present in the liquid, the dipole moment (and the nanorod with it) tries to align with the field. This phenomenon can be used to align the nanords and obtain a polarized emitter. Polarized emitters have to potential to dramatically increase the efficiecny of a liquid crystal backlight, when the polarization direction is aligned with the polarizer of the liquid crystal display.

  Doelstelling:

  The goal of this thesis is to align nanorods by applying a voltage between electrodes. The amplitude of the voltage should be sufficiently high to overcome the rotation due to the thermal (Brownian) motion. In the past, we have demonstrated that this is possible, by dispersing the nanords in a non-polar liquid. Now we would like to expand the possibilities.

  One question we want to address is origin of the alignment: is it by the permanent dipole moment of the quantum rod or by the induced dipole moment (a pure dielectric effect). To answer this question, we want to study the motion of quantum rods between four electrodes that have ac voltages that are out of phase. A permanent dipole should always point towards the lowest potential, whereas an induced dipole should align along the field (parallel or antiparallel is equivalent). With a polarization microscope we can visualize the orientation by measuring the polarization of absorbed (or fluorescently emitted) light.

  A second approach is to obtain a thin polymer film with aligned quantum rods. There are different possibilities to fix the orientiation: by evaporation of the liquid, by (UV induced) polymerization of the (monomer containing) liquid or liquid crystal. The electrodes may be on one substrate, on two different substrates or on a probe. Testing the alignment can be done by observing the polarization of the photoluminescence. The plan is to try out different experimental setups and to try to obtain homogeneous regions with aligned nanorods that emit polarized light.

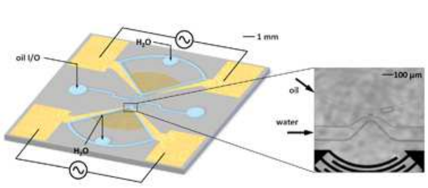
  

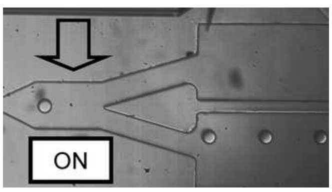
- 15595 Ultrasonic waves for particle manipulation and droplet generation
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Filip Beunis
  Begeleider(s): John Puthenparampil George
  Richtingen: Master of Science in Biomedical Engineering, International Master of Science in Biomedical Engineering, Master of Science in de ingenieurswetenschappen: biomedische ingenieurstechnieken

  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:

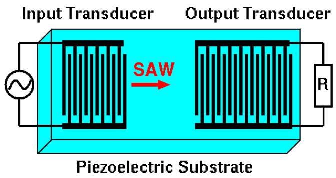
  Depending on the interest and background of the student, this thesis will focus more on physical effects (surface acoustic wave simulations) or on applications (microfluidics, particle manipulation). The basic scheme will be the same:

  - 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, ...
- 15502 Ultrasonic waves for sensing, filtering and data transmission
  Promotor: prof. dr. ir. Jeroen Beeckman
  Begeleider(s): John Puthenparampil George

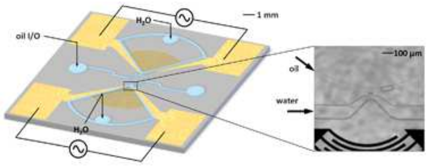
Richtingen: Master of Science in Electrical Engineering, Master of Science in Engineering Physics

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 very large substrates such as window glasses or glass surfaces in displays. In this thesis, SAWs will be integrated on glass substrates of about 10 to 20 cm. In a first stage the device will be simulated using finite element methods. Then devices will be fabricated and ultrasonic waves will be generated by an input transducer and detected by an output transducer. Depending on the interest of the student, the subject can be geared towards electronic applications or towards applications in bio-sciences. One of the possibilities of the suface acoustic waves is the manipulation of micrometer sized objects (such as particles, water droplet or living cells). The image below shows a picture of how picoliter droplets can be generated using piezoelectric materials. 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 (diffraction & losses of the ultrasonic waves) or on applications (data transmission, sensors, microfluidics, ...). 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 input/output SAWs
- electrical measurements of the first tests samples
- second design which will focus on either further study of the physical effects or the demonstration of an application

- 15535 Advanced electrical characterization of Kesterite thin film solar cells with different zinc and tin contents
Promotoren: prof. dr. Johan Lauwaert en prof. dr. ir. Kristiaan Neyts
Begeleider(s): dr. ir. Samira Khelifi
Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, European Master of Science in Photonics

Probleemstelling:

In thin film solar cells technology, the absorber is the layer where the majority of light is absorbed and converted to electricity. This is the reason why a large part of research is directed to the optimization of the absorber properties. Kesterite compounds (Cu2ZnSnS4 or Cu2ZnSnSe4) (CZTS) are good candidates to replace Cu(In,Ga)Se2 (CIGSe) layer in thin film solar cells. The absorber layer of Kesterite thin film contains tin and zinc instead of indium and gallium, which are abundant, low cost and non toxic elements.

The ratio between zinc and tin (Zn/Sn) has a big influence on the CZTS absorber layer properties and hence on the solar cell performance.

Doelstelling:

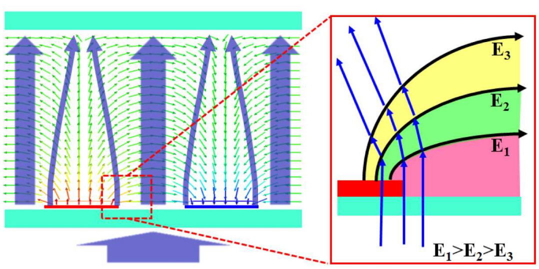
The aim of this thesis is to characterize CZTS thin film solar cells with different Zn/Sn ratio using advanced electrical characterization techniques to investigate the effect of Zn and Sn on the absorber physical properties.

- 15293 Anisotropic ray tracer for display simulations
Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Kristiaan Neyts
Begeleider(s): Xiaoning Jia
Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Computer Aided Design (CAD) involves, among other things, the modelling and simulation of the functioning of a device for its respective field. These modelling and simulation tools also exist in the field of photonics (e.g. Zemax, COMSOL) and allow one to simulate the propagation of light in various geometries that represent the actual devices.

The techniques used in these simulations can be categorized according to the discretization of the simulation domein (finite differences or finite elements) or according to the underlying physical model (beam propagation, time domain simulations, etc.). Each has its own advantages and disadvantages. In our research group, we mostly work with the finite element method (FEM), because it allows one to increase the accuracy of a calculation in a region where one could expect the optical field to change drastically. It is therefore a computationally efficient method and relatively fast. But for three dimensional simulations the method becomes quite demanding in terms of memory usage and computation time. For quite a number of configurations, it is not necessary to use such an accurate method and less computationally demanding methods can be a good alternative.



Above is a figure taken from D. Xu et al., Optics Express 2013 in which an optical model is described to calculate light transmission through an anisotropic blue phase liquid crystal display.

Doelstelling:

In this master dissertation, you will create a computer program that simulates the propagation of light in anisotropic media, such as liquid crystals. The method will be similar to a ray tracer, but now applied for anisotropic media. Afterwards, you will verify the functioning of your simulation program by fabricating some liquid crystal cells (minor cleanroom work) and building a setup to measure the optical properties, such as deviation angle. Additionally you will be able to verify the validity of the method by comparing the result with some of the advanced finite element tools that are available in the research group. The final goal is to obtain a reliable method to design and optimize liquid crystal devices that can be used in displays, beam steerers and tunable lenses.

- 14455 Beeldverwerkingsalgoritmen als methode om pijnbeleving waar te nemen
Promotoren: prof. dr. ir. Peter Veelaert en prof. dr. Johan Lauwaert
Begeleider(s): Francis Deboeverie en prof. dr. Tine Vervoort
Richtingen: 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 Computer Science Engineering

Probleemstelling:

De schaal van een bepaalde pijn en de ervaring of reactie op bepaalde omgevingen is moeilijk te vatten. Zeker voor kinderen is het moeilijk om hun ervaring te verwoorden of hun ervaring te vergelijken met voor volwassen welbekende prikkels. Daarom worden bij gezondheidspsychologisch onderzoek vaak verschillende methoden gebruikt om het effect van de pijn of de beleving van pijn te registreren. Enerzijds wordt de gelaatsexpressie van de kinderen opgenomen en zorgvuldig geanalyseerd volgens een vast protocol. Anderzijds worden de ervaringen zo goed mogelijk gerapporteerd door het kind, en wordt de ouder ondervraagd over hoe hij of zij de beleving van het kind zou interpreteren. Deze data wordt daarna zorgvuldig vergeleken.
Omdat het decoderen van het beeldmateriaal een zeer tijdintensieve en moeilijke bezigheid is biedt numerieke beeldverwerking hiervoor een mogelijke oplossing. Bovendien zal met numerieke verwerking de interpretatie die steeds persoonsafhankelijk blijft vermeden worden.

Figuur 1: Twee voorbeelden van emotieherkenning met een beeldverwerkingsalgoritme.

Doelstelling:

Het doel is om een beeldverwerkingsalgoritme te implementeren dat dit intensieve werk vervangt en dat instaat is om op een onafhankelijke manier de beelden te interpreteren. Daarna zullen in samenwerking met het Laboratorium voor gezondheidspsychologie de resultaten van de interpretatie door het nieuwe algoritme vergeleken worden met de resultaten van het manuele scoren van de beelden en de bevragingen.

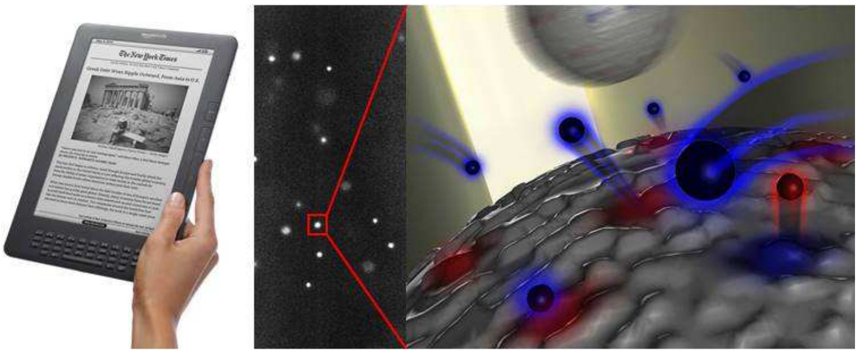
- 14497 Charge measurements on nanoparticles in liquid
Promotoren: dr. ir. Filip Strubbe en prof. dr. ir. Kristiaan Neyts
Begeleider(s): ir. Caspar Schreuer
Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

In Millikan’s famous oil drop experiment the electrical charge of single oil droplets in air is measured with precision higher than the elementary charge. In the Liquid Crystal and Photonics Group we are able to repeat Millikan’s oil drop experiment, but on particles in a liquid instead of on air. Then, the electrical charge of a colloidal particles is measured with such precision that discrete steps can be observed whenever the particle charge changes. Over the last few years the technique has been refined, using micron-sized beads in a nonpolar liquid and using optical tweezing electrophoresis.

Doelstelling:

The aim of this Master thesis is to measure discrete electrical charges on nanoparticles in liquids. Two types of experiments can be envisaged, depending on the preference of the student. In a first experiment, fluorescent nanobeads (~100 nm) in nonpolar liquids are measured. This experiment is similar to the measurement on micron-sized particles that are carried out on a regular basis, but with two advantages: the charging events occur less frequently due to the small particle surface area and the precision of the charge measurement is higher for smaller particles. In a second experiment, the charge of gold nanoparticles (20-60 nm) in water is analysed using capillary electrophoresis. Here, single nanoparticles can be visualized using laser scattering. The goal is to detect single events at the solid-liquid interface of a gold nanoparticle leading to an increase or decrease of the particle charge can be detected. Such a method would open up promising ways to study chemical reactions at solid-liquid interfaces on a quantum level rather than using classical chemistry.



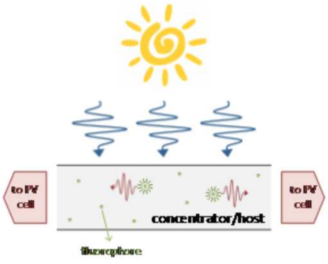
- 15474 Design of anisotropic emitters for solar concentrators

Promotoren: prof. dr. ir. Kristiaan Neyts en prof. dr. ir. Jeroen Beeckman
Begeleider(s): ir. Inge Nys en ir. Karel Dumon
Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

A solar concentrator is a semitranparent plate that absorbs incident sunlight and transforms it into light with a longer wavelength by photoluminescence. Because the plate has a larger refractive index than air, most of the photoluminescent light is wave-guided in the plate. The result is a high concentration of (longer wavelength) light in the plate. The energy of the waveguided light can be harvested at the edge of the plate by solar cells that that are glued to the sides. Solar concentrators can be used as decorative elements or as energy producing windows in architecture.

The photoluminescent agent can be a single organic molecule or a semiconductor nanoparticle. Both of them are much smaller than the wavelength of light and may be anisotropic. The anisotropy can be used to optimize our goals, which are to absorb light that is incident from air (and not the light that is waveguided in the plate) and the emit light in the directions that are waveguided by the plate (and not into air). We are particularly interested in nanoparticles that consist of two materials: a shell with a larger band gap which absorbs light and a core with a smaller band-gap which emits light. The photoluminescence of the core (with the smaller band-gap) is not absorbed by the shell (with the larger band gap) and is traveling unhindered by waveguiding to the edges of the plate.



Doelstelling:

The aim of the thesis is to find a design and an orientation for the nanoparticle that maximizes the absorption for incident light; maximizes the emission that is waveguided in the solar concentrator plate and minimizes the emission that exits from the substrate. The approach is to use numerical simulations to estimate the absorption and emission for a number of nanoparticles and to find how these parameters depend on the dimension and shape of the nanoparticle.

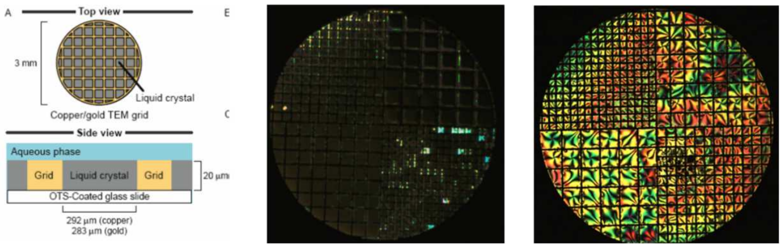
Because the nanoparticles are much smaller than the wavelength of light we do not have to consider the wave equations, instead we will find the field in the particle when it is placed in a homogeneous field. To find the emission pattern of a nanoparticle we have to estimate the dipole moment of the nanoparticle for a given dipole moment in the core of the particle. The results of the calculations can be compared with experimental results for cigar-shaped nanorods. The calculations should be able to provide guidelines for the optimal design with respect to the emission.

The simulations can be done in Mathlab or be based on another tool for 3D field finite element calculations. An important task will be to define the 3D mesh for the different structures.

- 15118 Detection of molecules in water with liquid crystal lasers
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): ir. Inge Nys
  Richtingen: Master of Science in Biomedical Engineering, International Master of Science in Biomedical Engineering, Master of Science in de ingenieurswetenschappen: biomedische ingenieurstechnieken, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

  Probleemstelling:

  Liquid crystals are materials that combine the properties of liquids and solid crystals.The molecules exhibit a certain degree of ordering while the material is still fluid. It is know since the pioneering work of Abbot and coworkers that the orientation of the liquid crystal at the interface with water can change when adding surfactant to the water. The figures below show a microscope image of a metallic grid used in TEM measurements. The squares of the grid are filled with liquid crystal. Depending on the presence (and concentration) of surfactant in the water, the image under the microscope changes from almost black to colorful. This is due to the fact that the liquid crystel changes its orientation at the interface. But due to the elastic nature of liquid crystals also the liquid crystal orientation in the rest of the volume changes. The liquid crystal can thus be used as an 'ampflifier' of reactions at the interface. Recently (January 2015) it was shown (again by Abbott and coworkers) that the reaction of the liquid crystal can be made specific for certain types of proteins.

  Doelstelling:

  In this thesis the aim is to use a TEM grid filled with liquid crystals to detect the presence of surfactant molecules in water, similar to the experiments described above. But instead of using a microscope to detect reactions at the interface, we will use a different type of liquid crystal which is chiral. Due to the chirality, there is an inherent periodicity in the material. When the periodicity is matched to optical wavelengths the liquid crystal layer can be easily transformed into a laser. The properties of the lasing signal can then be used to acquire information about the presence of biological entities in the water, thus avoiding the need for an expensive microscope setup.

  The thesis work is divided into two parts:

  - The behavior of chiral liquid crystal in a TEM grid will be studied using a polarization microscope. The influence of surfactant in the water will be investigated.
  - Once the behavior of chiral liquid crystals in this configuration is well understood, the liquid crystal in the TEM grid will be optically pumped with a pulsed laser source. The laser signal from the liquid crystal will be investigated. The aim is to find a shift in the lasing properties when surfactant is dissolved into the water.
- 15583 Een gevoelige elektrische screening methode van absorberlagen voor dunnefilmzonnecellen
  Promotoren: prof. dr. Johan Lauwaert en dr. ir. Samira Khelifi
  Begeleider(s): dr. ir. Samira Khelifi en prof. dr. Johan Lauwaert
  Richtingen: Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Kortrijk, Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Schoonmeersen

  Probleemstelling:

De markt van de zonnecellen wordt nog steeds overheerst door mono- en multikristallijne siliciumzonnecellen. De kostprijs van deze types cellen wordt voor ongeveer 50% bepaald door de dikke (>200µm) siliciumlaag. Dunnefilmzonnecellen, die als absorber een laag van slechts enkele µm van een directe halfgeleider gebruiken, vormen een goedkoper alternatief. Een bijkomend voordeel is dat ze op flexibele dragers kunnen worden afgezet.

Als individuele zonnecel behaalt Cu(In1-xGax)Se2 (CIGS) de hoogste efficiëntie met recordwaarden van 28,3%, zelfs hoger dan het record met multikristallijn silicium. Daarnaast wordt op basis van deze technologie getracht om een tandem zonnecel te maken in combinatie met silicium. Ook organische zonnecellen zijn gebaseerd op dunnefilmen.

Daarom gaat de zoektocht naar materialen die bruikbaar zijn in zonneceltoepassingen als een sneltrein voort. Dit gebeurt heel vaak met "trial and error", waarbij men bepaalde lagen in de huidige technologie aanpast en daarna hun bruikbaarheid evalueert op basis van de impact op de zonnecelefficiëntie. Dit is vaak de enige methode omdat de elektronische parameters die nodig zijn om de bruikbaarheid van deze laag te evalueren via simulatie niet bekend zijn. Parameters die in het verleden jaren '40 en '50 voor silicium zeer zorgvuldig werden bepaald met toegewijde experimenten op grote (cm's) kristallen, die speciaal voor dit experiment voorbereid werden. Jammer genoeg zijn deze experimenten niet zomaar eenvoudig toe te passen op de gebruikte dunnefilmen omdat deze lagen niet de juiste afmetingen hebben, het vaak niet makkelijk is om goede elektrische contacten op het oppervlak te fabriceren en men typische mobiliteiten van ladingsdragers verwacht die 100 tot 1000 keer kleiner zijn.

Om deze zoektocht op een efficiënte manier te kunnen verderzetten is er dus nood aan een goede screening methode voor de concentratie en de mobiliteit van de ladingsdragers in de verschillende halfgeleidende dunnefilmen.

Doelstelling:

Het finale doel van deze thesis is om een gevoelige en praktische meetopstelling te bouwen die toelaat om snel de concentratie en de mobiliteit van de ladingsdragers van dunne filmen te bepalen.

De concentratie en de mobiliteit van ladingsdragers worden vandaag de dag typisch met een Hall-Vanderpauw opstelling gemeten. Als men deze techniek toepast op de geproduceerde dunnefilmen dan lijkt dat door de lage mobiliteit in combinatie met een hoge ladingsdragersconcentraties de Hall-spanning zelfs bij magneetvelden tot 1T niet meetbaar is. Dit zou bijvoorbeeld gedurende dit thesisonderwerp kunnen verholpen worden door de stroom door de film of het magneetveld te moduleren (rotatie van het specimen) en zodoende met Lock-in detectie deze Hall-spanning te versterken.

Anderzijds kan de minoritaire ladingsdragers levensduur en mobiliteit gemeten worden met behulp van het Haynes-Schockley experiment. Dit experiment wordt typisch uitgevoerd op toegewijde specimens met welbepaalde vorm en grootte het doel is om deze techniek te miniaturiseren zodat dit makkelijk kan toegepast worden op dunne filmen.

- 14495 Elektrische X-stralen detectoren met behulp van organische halfgeleidende Ã©Ã©nkristallen
  Promotoren: prof. dr. Johan Lauwaert en prof. dr. ir. Henk Vrielinck
  Begeleider(s): dr. ir. Samira Khelifi en dr. Evelien Bogaert [Universitair Ziekenhuis Gent, dienst radiotherapie-oncologie]
  Richtingen: Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Kortrijk, Master of Science in de industriële wetenschappen: chemie, Master of Science in de industriële wetenschappen: elektronica-ICT - Campus Schoonmeersen

Probleemstelling:

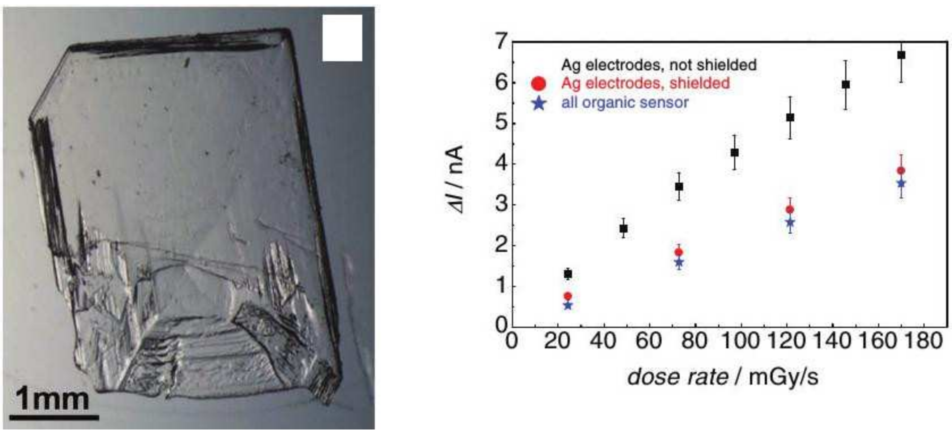
Ioniserende straling kan waargenomen worden als een elektrisch signaal als de absorptie in een materiaal zorgt voor de creatie van elektron gat paren die kunnen gescheiden worden. Dit elektrisch signaal zorgt dat een onmiddellijk uitlezing van de dosis mogelijk wordt, wat een grote meerwaarde is ten opzichte van de klassiek draagbare dosimetrische technieken zoals filmdosimetrie en thermoluminescente detectoren. Jammer genoeg zijn er slechts een beperkt aantal dure halfgeleidende materialen (SiC, CdTe, CZT) die de ladingsdragers gegenereerd door de ioniserende straling meetbaar maken bij kamertemperatuur.

Het onderzoek naar organische halfgeleiders heeft recent al voor vele mooie doorbraken in de micro-elektronica en fotonica gezorgd: Organische LEDs, dunnefilmtransistoren, organische zonnecellen en heel gevoelige organische fotodetectoren.

Als stralingsdetector zijn deze organische halfgeleiders eveneens veelbelovend. Naast hun lage kostprijs verwacht men door zijn hoge conversie efficiëntie van X-stralen naar ladingsdragers een dosimeter te kunnen maken die slechts een geringe fractie van de straling absorbeert en eveneens optisch transparant is. Hierdoor kan deze dosimeter breed inzetbaar zijn als dosimeter in omgevingen met gevaar voor ioniserende straling maar ook in vele medische toepassingen.

Het gebruik van organische halfgeleiders voor de detectie van ioniserende straling is nog veel minder onderzocht dan de anorganische halfgeleidende detectoren maar kan op twee manieren. Een eerste manier is de energie van de ioniserende straling omzetten in zichtbaar of Ultraviolet licht in een organische scintillator en dit licht wordt op zijn beurt gedetecteerd door een organische fotodetector. Een tweede recent gedemonstreerde manier [1] (zie figuur) is de ioniserende straling rechtstreeks omzetten in een elektrisch signaal in een organisch éénkristal. Hierdoor wordt de opbouw van de detector heel wat eenvoudiger en krijgt men een betere signaal ruis verhouding. De laatste methode zal verder onderzocht worden in dit thesisonderwerp.

[1] B. Fraboni, A. Ciavatti, F. Merlo, L. Pasquini, A. Cavallini, A. Quaranta, A. Bonfiglio, A. Fraleoni-Morgera, Organic semiconducting single crystals as next generation of low-cost, room-temperature electrical x-ray detectors.: Advanced Materials, 2012



Figuur 1: Een uit oplossing gegroeid 4HCB-kristal (links) en zijn response bij aangelegde spanning 500V op verschillende dosistempo's bij 35keV straling met verschillende contacten (rechts) [figuur samengesteld uit Ref[1]]

Doelstelling:

Het doel van deze masterproef is om een systematische studie te maken van verschillende organische éénkristallen die zullen gegroeid worden uit een oplossing in samenwerking met de vakgroep vastestofwetenschappen (WE04, prof. H. Vrielinck). Een methode die binnen deze onderzoeksgroep momenteel gebruikt wordt voor het groeien van alanine- en sucrosekristallen voor EPR-dosimeters. De structurele eigenschappen en elektronische eigenschappen zullen onderzocht worden.

Op de éénkristallen met bruikbare grootte en de beste elektrische en structurele eigenschappen zullen dan verschillende metallische of organische contacten opgedampt worden. De elektrische eigenschappen van deze contacten zullen onderzocht worden aan de hand van zijn stroom-spannings en capaciteits-spannings verloop.

Afhankelijk van de interesse en de afstudeerrichting van de student (Elektronica, Chemie) kan de focus van dit thesisproject meer liggen op de elektronische eigenschappen en werking van deze detector of de kristalgroei en spectroscopische karakterisering (FTIR/EPR) van de organische kristallen.

Finaal kan de efficiëntie van de gemaakte stralingsdetectoren getest worden in samenwerking met de dienst radiotherapie-oncologie van het universitair ziekenhuis (dr. E. Bogaert en prof. C. De Wagter).

- 15215 Galliumnitride onder de loep
Promotoren: prof. dr. Benoit Bakeroot en prof. dr. Johan Lauwaert
Begeleider(s): prof. dr. Benoit Bakeroot en prof. dr. Johan Lauwaert
Richtingen: Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Men gaat er van uit dat meer dan 60% van alle elektrische energie door één of meerdere elektronische vermogenscomponenten stroomt. De efficiëntie waarmee elektronische componenten (diodes en schakelaars of transistoren) elektrische energie omzetten heeft een enorme impact op het wereldwijde verbruik van elektriciteit. Deze componenten worden tot op heden quasi allemaal vervaardigd uit één enkel materiaal: silicium. Zolang silicium gebruikt wordt als halfgeleidermateriaal, zal een radicale verbetering in de efficiëntie van deze schakelcomponenten uitblijven. Vanuit theoretisch oogpunt zijn halfgeleiders met een brede bandkloof (wide band gap) hét alternatief voor vermogenscomponenten. Zowel siliciumcarbide (SiC) als galliumnitride (GaN) lijken over de beste papieren te beschikken: beide hebben een bandkloof van meer dan 3.0 eV, halen een kritisch elektrisch veld dat meer dan een tienvoud is dan dat van silicium, hebben een hoge mobiliteit en saturatiesnelheid, en een relatief hoge thermische geleidbaarheid. Daarbij komt nog dat deze materialen in principe geschikt zijn om bij hogere temperaturen te werken dan silicium, een voordeel dat wel eens van primordiaal belang zou kunnen zijn in bijvoorbeeld elektrische motoren in auto's. GaN lijkt een zeer geschikte kandidaat voor het maken van elektrische schakelaars, niet alleen omdat het mogelijk is in dit materiaal hoge elektronmobiliteiten te halen (tot 2000 cm2/Vs) in combinatie met hoge elektrondichtheden aan bepaalde heterojuncties, maar ook omdat het mogelijk is dit materiaal te groeien op siliciumplakken (wafers) - een belangrijke economische troef. Jammer genoeg blijft één van de belangrijkste uitdagingen voor deze technologie het vervaardigen van GaN van voldoende hoge kwaliteit, d.w.z. met zo weinig mogelijk defecten.

Doelstelling:

Na een kennismaking met de wondere wereld van galliumnitride, is het de bedoeling verder inzicht te verwerven door bv. 1D-structuren te bestuderen aan de hand van numerieke simulaties in een commercieel softwarepakket (Synopsys' "Technology Computer Aided Design" of TCAD waarin onder meer de Poisson- en de drift-diffusievergelijkingen worden opgelost m.b.v. de eindige-elementenmethode). De vakgroep ELIS (zowel CMST als LCP) heeft een ruime ervaring in het simuleren van halfgeleidercomponenten en begeleidt dan ook dit deel van de thesis. Een ander luik van dit thesiswerk bestaat uit luminescentiemetingen, zowel fotoluminescentie als cathodoluminescentie in een elektronenmicroscoop. De samples worden ter beschikking gesteld vanuit imec, waar het CMST-labo aan geassocieerd is. De metingen gebeuren hoofdzakelijk in De Sterre (S1), in de onderzoeksgroep LumiLab (Prof. D. Poelman, Faculteit Wetenschappen). Uit deze metingen volgt een karakterisering van bepaalde onzuiverheden of defecten. Een derde en finale stap bestaat uit het terugkoppelen van deze meetresultaten in de TCAD-simulaties teneinde een verbeterd inzicht te verkrijgen van de werking van GaN-componenten.

- 15294 Holographic Optical Trapping Electrophoresis for non-Spherical Particles
Promotoren: prof. dr. ir. Filip Beunis en prof. dr. ir. Kristiaan Neyts
Begeleider(s): ir. Caspar Schreuer
Richtingen: Master of Science in Electrical Engineering, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

The electrokinetic properties of colloidal particles in nonpolar liquids are relevant for applications such as E-ink displays and liquid toner printing. The electrokinetic behavior is determined by the particle's surface charge, size and shape, and the ionic strength of the liquid.

For non-spherical particles, there is not only an (electrical) force, but also a torque. Currently there is no commercial system that can measure the anisotropy of the electrokinetic behavior of such particles. The goal of this thesis is to employ Holographic Optical Tweezers (HOT) to control the particles orientation and measure the three-dimensional diffusion and electrokinetic mobility tensors.

Doelstelling:

An Optical Trap (or Tweezers) consists of a tightly focused laser beam. Particles with high refractive index are attracted to the focus and are trapped in this position. The source of this 'classical' trap is the intensity gradient of the beamÍ¾ the particle is attracted towards the region with the highest optical density. HOT is an extension of Optical Trapping, where a single trapping beam can be converted into an array of multiple beams, non-Gaussian beams or even a line trap as depicted in the figure below.

With HOT, one can obtain control over a particles position and its orientation. This enables the study of the particles' anisotropy. This project involves calculating the required SLM pattern with a (partially) selfwritten program and performing the electrokinetic measurements with the beam patterns you designed.

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.

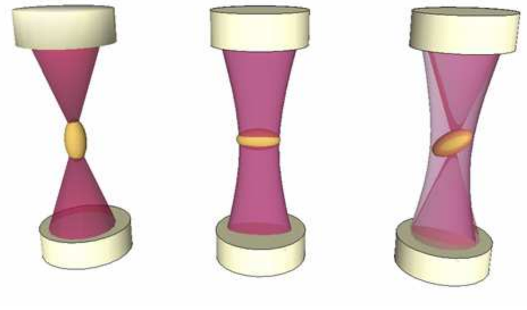


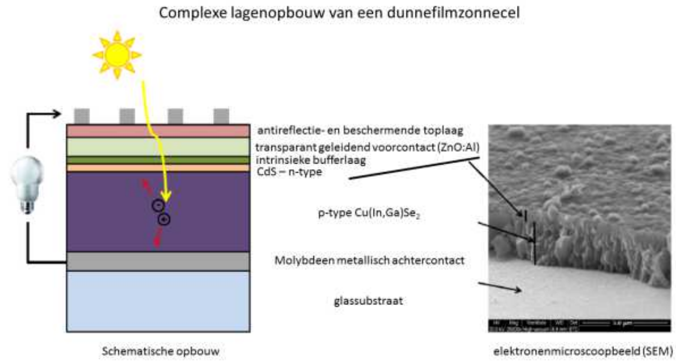
Figure: A point trap, a line trap and a superposition of both traps allows control, not only over the particles position, but also over its orientation.

- 14438 Karakterisering van de kinetiek van ladingsdragers in een dunne-film zonnecel via capaciteits-spectroscopische meettechnieken
Promotoren: prof. dr. ir. Henk Vrielinck en prof. dr. Johan Lauwaert
Begeleider(s): prof. dr. ir. Henk Vrielinck en prof. dr. Johan Lauwaert
Richtingen: Master of Science in Engineering Physics

Probleemstelling:

De markt van de zonnecellen wordt nog steeds overheerst door mono- en multikirstallijne siliciumzonnecellen. De kostprijs van deze types cellen wordt voor ongeveer 50% bepaald door de dikke (>200µm) siliciumlaag. Dunne-film zonnecellen, die als absorber een laag van slechts enkele µm van een directe halfgeleider gebruiken, vormen een goedkoper alternatief. Cu(In1-xGax)Se2 (CIGS) zonnecellen behalen onder de dunne-film cellen de hoogste efficiëntie met recordwaarden van meer dan 21%. Dit is zelfs hoger dan het record met polykristallijn silicium. Een bijkomend voordeel is dat CIGS zonnecelstructuren ook op flexibele dragers kunnen worden afgezet.

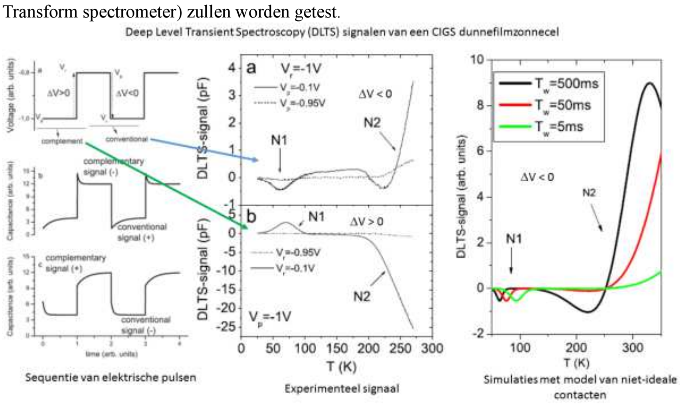
Elektrisch actieve defecten in de absorberlaag, die energieniveaus diep in de bandgap genereren, leiden tot een verkorting van de levensduur van de ladingsdragers die door optische absorptie worden gegenereerd, en zo ook tot een lagere zonnecelefficiëntie. Het is dan ook heel belangrijk om de concentratie en de eigenschappen van dergelijke defecten nauwkeurig te kunnen bepalen. Capaciteitsspectroscopie is hier in principe bijzonder goed voor geschikt: vangst en emissie van ladingsdragers door defecten laat zich immers zien in de frequentie-afhankelijkheid van de capaciteit (admittantiespectroscopie = AS) of in een trage transiënt in de capaciteit na een spanningspuls (deep-level transient spectroscopy = DLTS). Deze spectroscopische technieken bieden een schat aan informatie over defecten in eenvoudige halfgeleidercomponenten zoals p-n of Schottky diodes van mono- of multikristallijne halfgeleiders. Dunne-film zonnecellen hebben echter een veel ingewikkeldere structuur: ze zijn opgebouwd uit meerdere lagen van minder goed bestudeerde halfgeleiders. Niet-ideale contacten tussen de lagen en gehinderd transport in de lagen kunnen eveneens aanleiding geven tot signalen in de capaciteitsspectra, wat de analyse bemoeilijkt. Bijgevolg lijkt het aangewezen om de structuur van de samples te vereenvoudigen en een grotere parameterruimte te scannen in de experimenten (temperatuurbereik, variatie in pulsparameters,…).



Dit onderzoek past binnen de clusters Materials en Electronics van de opleiding Engineering Physics/Toegepaste Natuurkunde. Het sluit onder andere aan bij de keuzevakken Quantum physics of solids en Photovoltaic energy conversion and sustainable energy. Het bouwt voort op kennis uit de vakken Vastestoffysica en halfgeleiders I en II en Fysica van halfgeleidercomponenten.

Doelstelling:

Het doel van dit thesisonderzoek is te achterhalen wat capaciteitsspectra ons kunnen leren over defecten en/of andere niet-idealiteiten in de absorber van CIGS zonnecellen. Hiertoe zullen metingen worden uitgevoerd op volledige zonnecellen, maar ook op vereenvoudigde structuren: absorbermateriaal afgezet op een Ohms geleidend contact met een metaal Schottkyvoorcontact, of zonnecellen waarvan verscheidene lagen aan het voorcontact zijn weggeëtst en vervangen door een metaalcontact. Simulaties op basis van in de groep reeds ontwikkelde circuitmodellen voor de zonnecelstructuur zullen worden gebruikt om de parameters van de experimenten optimaal te kiezen, zodat de verschillende oorzaken voor signalen zo goed mogelijk kunnen worden onderscheiden. Daarnaast zullen de klassieke DLTS paden wat worden verlaten: op vereenvoudigde structuren kan het temperatuurbereik worden uitgebreid tot boven kamertemperatuur en alternatieve DLTS technieken (meting van stroomtransiënten na optische pulsen, en DLTS onder infrarood belichting in een Fourier-Transform spectrometer) zullen worden getest.



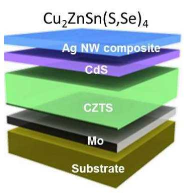
Afhankelijk van de concrete interesses van de student, kan modelleren en ontwikkelen en verfijnen van modellen een meer prominente rol innemen.

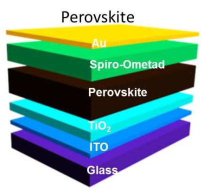
In dit onderwerp spreekt de wisselwerking tussen experimenteren en modelleren heel duidelijk de ingenieursvaardigheden aan. De basis van de meet- en modelleringstechnieken ligt in vastestof- en halfgeleiderfysica.

- 14975 Kesterite thin film solar cells for tandem application
  Promotoren: dr. ir. Samira Khelifi en prof. dr. Johan Lauwaert
  Begeleider(s): dr. ir. Samira Khelifi en prof. dr. Johan Lauwaert
  Richtingen: Master of Science in Electrical Engineering, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

  Probleemstelling:

  In thin film solar cell technology, materials with Kesterite structure are very promising, with efficiency up to 12.6 %. In the case of Si containing S or Se based kesterite, the band gap could theoretically be adjusted between 1.6-2.1 eV as confirmed by first principle calculations and optical measurements on single crystals. This will help to pave the way for this technology to become a suitable top cell candidate for tandem devices (e.g., based on already available high-efficiency crystalline silicon (c-Si) bottom cells).





The subject is related to the recently accepted European Project SWInG-project (Development of thin film **S**olar cells based on **WI**de band **G**ap kesterite absorbers), in which UGent is partner, together with IMEC and different other partners from The Netherlands, Germany and Sweden.

Doelstelling:

The aim of this thesis is to characterize CZTSe thin film solar cells with different bandgaps for tandem application, using advanced electrical characterization techniques (mainly admittance spectroscopy AS, capacitance-voltage C-V, current-voltage J-V and external quantum efficiency EQE measurements).

Modelling and simulation of the physical and electronic operation of these cells will be performed using the software Scaps (Solar Cell Capacitance Simulator 1-D) developed at ELIS. The software Scaps will be used to develop a reliable device model which will be able to properly interpret the measurements results and allow to define and understand the effect of interface properties (band alignements), defect states,…etc, on the device performance. The development of such model will establish the design rules for device improvement.

- 14549 Kinetiek van ladingsdragers in een dunne-film zonnecel: modellering versus experiment
  Promotoren: prof. dr. Johan Lauwaert en prof. dr. ir. Joris Thybaut
  Begeleider(s): prof. dr. Johan Lauwaert en Kenneth Toch
  Richtingen: Master of Science in Engineering Physics

  Probleemstelling:

  De markt van de zonnecellen wordt nog steeds overheerst door mono- en multikirstallijne siliciumzonnecellen. De kostprijs van deze types cellen wordt voor ongeveer 50% bepaald door de dikke (>200µm) siliciumlaag. Dunne-film zonnecellen, die als absorber een laag van slechts enkele µm van een directe halfgeleider gebruiken, vormen een goedkoper alternatief. Cu(In1-xGax)Se2 (CIGS) zonnecellen behalen onder de dunne-film cellen de hoogste efficiëntie met recordwaarden van 22.3%, zelfs hoger dan het record met multikristallijn silicium. Een bijkomend voordeel is dat ze op flexibele dragers kunnen worden afgezet (metaaltape, polymeren).

  Elektrisch actieve defecten in de absorberlaag, die energieniveaus diep in diens bandgap genereren, leiden tot een verkorting van de levensduur van de ladingsdragers die door optische absorptie worden gegenereerd, en zo ook tot een lagere zonnecelefficiëntie. Het is dan ook heel belangrijk om de concentratie en de eigenschappen van dergelijke defecten nauwkeurig te kunnen bepalen. Capaciteitsspectroscopie is hier in principe bijzonder goed voor geschikt: vangst en emissie van ladingsdragers door defecten laat zich immers zien in de frequentie-afhankelijkheid van de capaciteit (admittantiespectroscopie) of in een trage transiënt in de capaciteit na een spanningspuls (deep-level transient spectroscopy). Deze spectroscopische technieken bieden een schat aan informatie over defecten in eenvoudige halfgeleidercomponenten zoals p-n of Schottky diodes van mono- of multikristallijne halfgeleiders. Dunne-film zonnecellen hebben echter een veel ingewikkeldere structuur: ze zijn opgebouwd uit meerdere lagen van minder goed bestudeerde halfgeleiders. Niet-ideale contacten tussen de lagen en gehinderd transport in de lagen kunnen eveneens aanleiding geven tot signalen in de capaciteitsspectra, wat de analyse bemoeilijkt.

  Doelstelling:

  Het doel van de masterproef bestaat er in de capaciteitsspectra als gevolg van de kinetiek van de ladingsdragers in de absorberlaag van CIGS zonnecellen nauwkeurig te modelleren. Verschillende mechanismen zullen worden gemodelleerd: voor elk hiervan kan een stel optimale parameters worden af geschat via niet-lineaire regressieanalyse op experimentele spectra. Vergelijking van deze modellen zal dan toelaten het mechanisme dat de experimenten het best beschrijft te selecteren. Bovendien kan op basis van simulaties worden gezocht naar de experimentele omstandigheden (meetparameters) die verschillen tussen de modellen het best tot uiting laten komen (maximum contrast). Verder kan, om bepaalde hypotheses te testen, de lagenstructuur van de dunne-film zonnecel vereenvoudigd worden, bij voorbeeld door lagen aan het voorcontact weg te etsen en te vervangen door een metaalcontact. Tenslotte kan met behulp van zonnecelsimulatiesprogramma's het effect van de gedetecteerde defecten, niet-ideale contacten of transportparameters, op de efficiëntie van de zonnecel worden geëvalueerd.

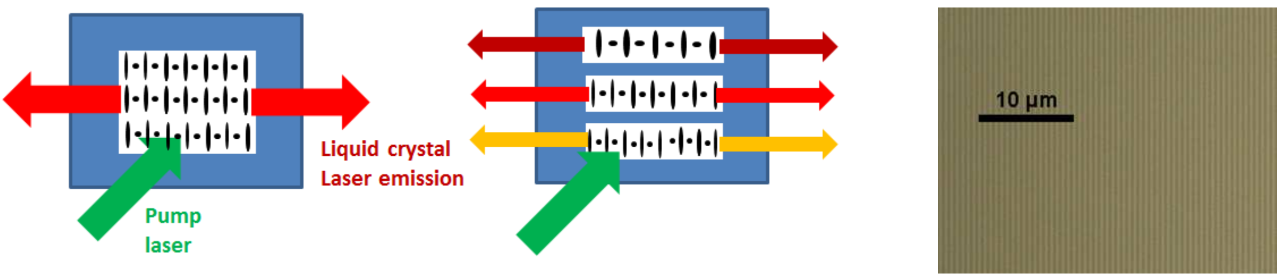
  Het onderwerp kan, afhankelijk van de concrete interesses van de student, meer gericht worden op experimenteel werk of op modelleren.

- 15354 Liquid crystal alignment in polymeric structures
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Jeroen Missinne
  Begeleider(s): ir. Inge Nys
  Richtingen: Master of Science in Engineering Physics

  Probleemstelling:

  Liquid crystal is a material that exhibits orientational ordering of elongated molecules (as in solid crystals), while still exhibiting fluidic properties (as in the liquid phase). Thanks to the ordering of the molecules the elastic, optical and electrical properties are anisotropic. This makes liquid crystals interesting materials for all kinds of display and non-display related applications.

  The orientation of the liquid crystal molecules can be controlled by external fields (electric, magnetic) or by surfaces. In this thesis subject, we want to align liquid crystal molecules in small polymeric structures such as containers and periodic channels. We are mainly interested in the alignment of chiral nematic liquid crystals in these kind of structures, since they offer interesting possibilities for lasing applications. These lasers have the potential to achieve low threshold lasing and integrating the liquid crystal in a polymeric structure can open the way to integration in a lab-on-chip environment.



  The right and middle picture show the alignment of liquid crystal in different types of containers, being either a square container or a long container. Different container can contain liquid crystal with different periodicity, leading to the generation of laser light with different wavelength. The right picture shows a grating with very small pitch made of liquid crystal made in the Liquid Crystals & Photonics research group. The periodicity in the liquid crystal was written with a powerful UV laser.

  Doelstelling:

  The goal of this thesis is to obtain a better understanding and control over the alignment of liquid crystal molecules in small polymeric structures.

  Alignment containers and channels based on polymer materials (such as SU-8, a type of epoxy) will be fabricated in the UGent clean rooms. Depending on the required dimensions, different fabrication technologies can be investigated. For dimensions not much smaller than a micrometer, a laser-based direct write lithography (LDW) technology is available and for smaller dimensions nanoimprint lithography (NIL) can be used. If needed, both technologies can even be combined. Afterwards, these structures will be filled with liquid crystal and the interaction between both will be studied.

  The alignment of liquid crystal molecules can not only be studied experimentally but also by numerical simulations. In our research group, a finite element simulation tool is available to simulate the liquid crystal configuration in two- and three-dimensional structures. This simulation tool will help us to understand and optimize the liquid crystal alignment inside the small containers and channels.Depending on the interest of the student, the focus can be shifted between the experimental part and the simulations.

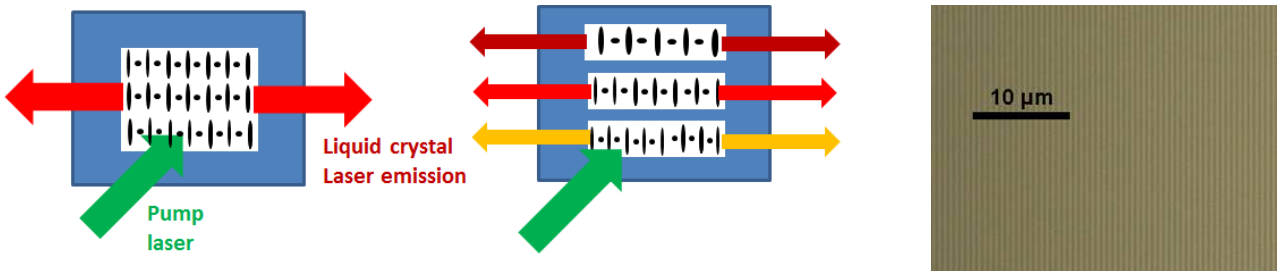
  The processing will be done in the clean room in Zwijnaarde. The fabricated cells will be characterized in the labs at the iGent building (Zwijnaarde).

- 15353 Liquid crystal alignment in polymeric structures
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Jeroen Missinne
  Begeleider(s): ir. Inge Nys
  Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, European Master of Science in Photonics

Probleemstelling:

Liquid crystal is a material that exhibits orientational ordering of elongated molecules (as in solid crystals), while still exhibiting fluidic properties (as in the liquid phase). Thanks to the ordering of the molecules the elastic, optical and electrical properties are anisotropic. This makes liquid crystals interesting materials for all kinds of display and non-display related applications.

The orientation of the liquid crystal molecules can be controlled by external fields (electric, magnetic) or by surfaces. In this thesis subject, we want to align liquid crystal molecules in small polymeric structures such as containers and periodic channels. We are mainly interested in the alignment of chiral nematic liquid crystals in these kind of structures, since they offer interesting possibilities for lasing applications. These lasers have the potential to achieve low threshold lasing and integrating the liquid crystal in a polymeric structure can open the way to integration in a lab-on-chip environment. Studying the lasing behaviour will be part of this thesis subject.



The right and middle picture show the alignment of liquid crystal in different types of containers, being either a square container or a long container. Different container can contain liquid crystal with different periodicity, leading to the generation of laser light with different wavelength. The right picture shows a grating with very small pitch made of liquid crystal made in the Liquid Crystals & Photonics research group. The periodicity in the liquid crystal was written with a powerful UV laser.

Doelstelling:

The goal of this thesis is to obtain a better understanding and control over the alignment of liquid crystal molecules in small structures and channels.

Alignment containers and channels based on polymer materials (such as SU-8, a type of epoxy) will be fabricated in the UGent clean rooms. Depending on the required dimensions, different fabrication technologies can be investigated. For dimensions not much smaller than a micrometer, a laser-based direct write lithography (LDW) technology is available and for smaller dimensions nanoimprint lithography (NIL) can be used. If needed, both technologies can even be combined. Afterwards, these structures will be filled with liquid crystal and their properties regarding lasing will be studied.

We will focus on the use of chiral nematic liquid crystal and try to obtain lasing in different configurations. The emission spectrum, beam shape, laser threshold and output power will be characterized.

The processing will be done in the cleanroom in Zwijnaarde. The fabricated cells will be characterized in the labs at the iGent building (Zwijnaarde).

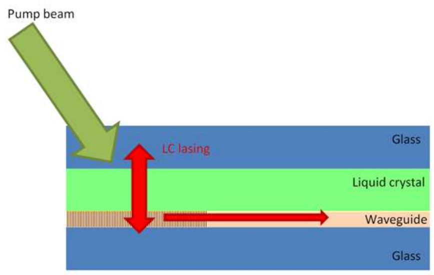
- 15117 Liquid crystal laser with waveguide coupling
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): ir. Inge Nys
  Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Lasing in liquid crystals is quite easy to achieve because of two reasons:

  - Liquid crystals can have optical gain by mixing appropriate laser dyes into the material
  - Building and designing a cavity for optical feedback is not necessary, because the optical feedback can occur inside the material itself. The liquid crystal is doped with a chiral dopant which introduces a periodic pattern in the liquid crystal: the liquid crystal molecules twist and form a helix. This gives a reflection band for certain wavelengths

When the gain spectrum of the dye is matched with the reflection band of the liquid crystal, the material can start lasing when it is sufficiently pumped. In the last couple of years, different master thesis students and PhD students have been working on the improvement of the efficiency and the threshold of such liquid crystal lasers.



Doelstelling:

In this thesis, we want to investigate the possibility to couple the laser light efficiently into a waveguide structure. Currently, most of the research is focused on the use of these lasers for free-space applications (e.g. for cheap tunable laser sources, for use in projection systems, etc.), but we think that these lasers have a lot of potential when the light can be efficiently coupled into a waveguide structure. This could for example be interesting for lab-on-chip biosensing applications. The aim of this thesis is to fabricate a coupling structure to couple the light into the waveguide. Most probably this will be done by writing a grating into a polymer waveguide with the holographic UV laser setup which is available in the research group. Then the liquid crystal laser has to be put onto this coupling structure and the lasing and coupling will be tested experimentally. A small optical setup will be built for the experiment.

- 15465 Microfluidics for Optical Trapping Electrophoresis
  Promotoren: prof. dr. ir. Filip Beunis en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): ir. Caspar Schreuer
  Richtingen: Master of Science in Electrical Engineering, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Most lab-on-a-chip systems have a microfluidic channel to study dispersed particles. Optical trapping electrophoresis allows to accurately measure the surface charge of a microparticle, by combining optical tweezers with an AC electric field. The measured amplitude of the oscillatory motion is directly related to the particle charge.

A common issue in microfluidics is electro-osmotic flow. The origin of this flow lies at the finite surface charge of the channel, which attracts free moving ions of the opposite polarity. By applying an electric field, this layer of ions starts moving and it drags the fluid in the bulk along. Therefore, the measured particle movement is a superposition of the electrokinetic motion and the flow. This effect limits the accuracy in aqueous media of all commercially available charge measurement systems.

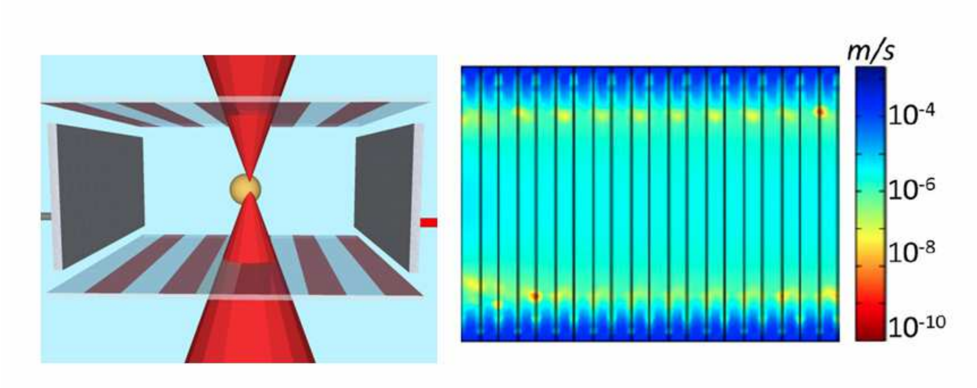


Figure: A 3D impression of a patterned OTE measurement cell and a corresponding 2D simulation of the flow.

Doelstelling:

A novel approach to counter electro-osmotic flow is to design the surface of the channel to have an alternating pattern of strips with positive and negative surface charge. Each two neighboring strips direct a flow in the opposite direction, effectively cancelling each other out. As a result, the bulk of the channel is flow free. Preliminary simulation results, as shown in the figure above, reveal that this method can reduce the flow velocity by a factor of 150.

This thesis includes simulating a microfluidic channel, has a technological aspect in manufacturing the designed microfluidic device and has a hands on part in which you will perform your own experiments with the optical trapping electrophoresis setup. It fits best within the Photonics and Electronics clusters of Engineering Physics. This thesis fits in a bigger project, in which the LCP group develops a new technique to study charging mechanisms of particles in water.

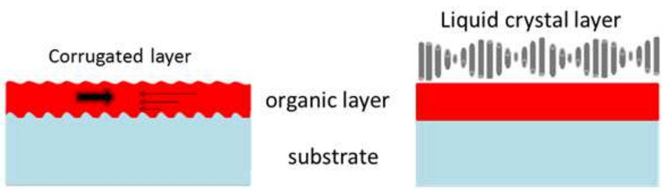
The staff of the LCP group will provide you with all the necessary help and know-how, but we also encourage you to take the initiative to come up with your own ideas to tackle the project. Where feasible and within the scope of the project, we'll support you to develop these ideas.

- 15307 OLED and LC technology: enemies or friends?
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): ir. Inge Nys en ir. Michiel Callens
  Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Liquid crystal lasers have great potential as small-size, low-cost, widely-tunable lasers. A big advantage of liquid crystal lasers, is that it is not necessary to build and design a cavity for optical feedback because the feedback can occur inside the material itself. The liquid crystal is doped with a chiral dopant which introduces a periodic pattern that gives rise to a reflection band for certain wavelengths.

In the common type of liquid crystal laser, a dye is doped inside the liquid crystal material to provide optical gain. In this thesis we want to combine an organic layer as gain material with a non dye-doped liquid crystal for optical feedback. By using a liquid crystal the difficult and time-consuming processing to obtain a corrugated layer with submicrometer periodicity can be eliminated.



Doelstelling:

The project consists of a fabrication part and an experimental part. In the first part of the process, an organic layer will be deposited on a glass substrate.
Afterwards a cell will be assembled and filled with liquid crystal. Both the thickness of the organic layer and the alignment of the liquid crystal layer will have to be optimized.

The processing will be done in our process bays in the clean room in Zwijnaarde. The fabricated cells will be characterized in the labs at the Technicum.
The emission spectrum, beam shape, laser threshold and output power will be characterized.

- 14439 Ontwikkeling van hoge gevoeligheidstechnieken in Fourier-transform infraroodspectroscopie van defecten in halfgeleiders
  Promotoren: prof. dr. ir. Henk Vrielinck en prof. dr. Johan Lauwaert
  Begeleider(s): prof. dr. ir. Henk Vrielinck en prof. dr. Johan Lauwaert
  Richtingen: Master of Science in Engineering Physics

Probleemstelling:

Recombinatie van ladingsdragers in halfgeleiders wordt in belangrijke mate beïnvloed door slechts kleine concentraties aan defecten, die diepe niveaus introduceren in de bandgap van de halfgeleider. Dit heeft zijn weerslag op de levensduur van de vrije ladingsdragers en zo ook op lekstromen in elektronische componenten of de efficiëntie van zonnecellen. In ternaire en quaternaire halfgeleiders die vaak gebruikt worden als absorber in dunnefilmzonnecellen, zijn de ondiepe donoren en acceptoren vaak ook intrinsieke defecten, maar hun structuur en de precieze ligging van hun defectniveaus zijn dikwijls nog onbekend.

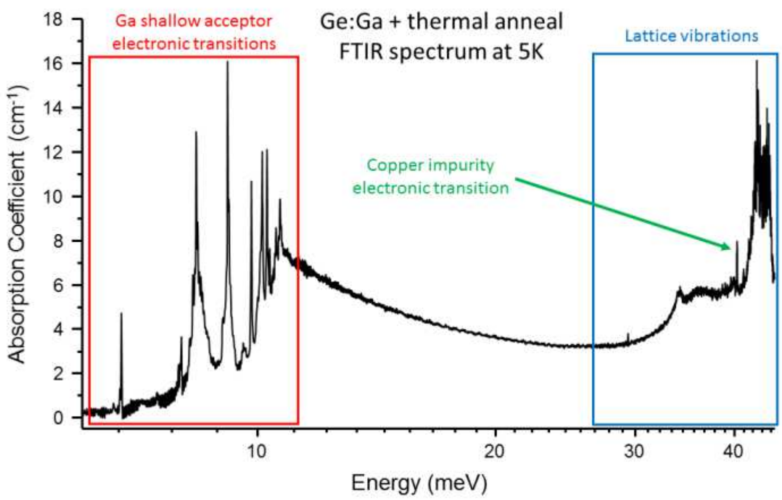
Experimenteel vaststellen welke concentraties (kwantificering) van welke types defecten (identificatie) er in halfgeleiders aanwezig zijn, is een belangrijk maar ook heel uitdagend probleem, zeker als defectconcentraties zeer laag zijn. Absorptiespectroscopie in het infrarood, waarmee karakteristieke vibraties van defecten in het midden-infrarood, en overgangen tussen de waterstofachtige energieniveaus van neutrale donoren en acceptoren in het verre infrarood kunnen worden gedetecteerd, is in principe uitermate geschikt voor identificatie en kwantificering van defecten in halfgeleiders, maar heeft slechts een beperkte gevoeligheid. Als lichtabsorptie in de halfgeleider waargenomen wordt via de veranderingen die ze teweegbrengt in een elektrische parameter, zoals de geleidbaarheid, capaciteit of fotovoltaische spanning, kan de gevoeligheid van de metingen aanzienlijk worden opgedreven. In dit thesisproject worden de gevoeligheidslimieten van "klassieke" optische transmissiemetingen met de modernste onderzoeksapparatuur onderzocht en daarnaast ook de mogelijkheden van elektrische detectietechnieken, die de gevoeligheid nog aanzienlijk zouden moeten verhogen.

Het voorgestelde onderzoek past binnen de clusters Materials en Electronics van de opleiding Engineering Physics/Toegepaste Natuurkunde. Het sluit onder andere aan bij de keuzevakken Quantum physics of solids en Photovoltaic energy conversion and sustainable energy. Het bouwt voort op kennis uit de vakken Vastestoffysica en halfgeleiders I en II en Fysica van halfgeleidercomponenten.

Doelstelling:

Een eerste doelstelling van dit onderzoek is, via ver-infraroodmetingen in transmissie op Si en Ge, ondiepe defectconcentraties in deze materialen te kwantificeren en zo een schatting te verkrijgen van de gevoeligheidslimieten van deze techniek. Hierbij zal gebruik gemaakt worden van een recent geïnstalleerde Fourier-transform infraroodspectrometer die metingen in een heel breed frequentiebereik (15000-10 cm-1) toelaat en ook is uitgerust met een microscoop (FT-IMAGER). De metingen zullen verder ook bij zeer lage temperatuur moeten gebeuren om vrije ladingsdragers op ondiepe defectniveaus in te vriezen.

Vervolgens zullen op dezelfde samples de mogelijkheden van elektrische detectietechnieken voor optische absorptie worden onderzocht. De aandacht zal in de eerste plaats uitgaan naar metingen van fotogeleidbaarheid (Photothermal Ionization Spectroscopy, PTIS) wat een bijzonder hoge gevoeligheid oplevert voor defecten met ondiepe donor of acceptorniveaus. Uiteindelijk zullen de mogelijkheden van PTIS en eventueel ook andere elektrische detectietechnieken voor infraroodabsorptie worden onderzocht bij de studie van defecten in Cu(In,Ga)Se2, een absorbermateriaal voor zeer efficiënte dunnefilmzonnecellen.

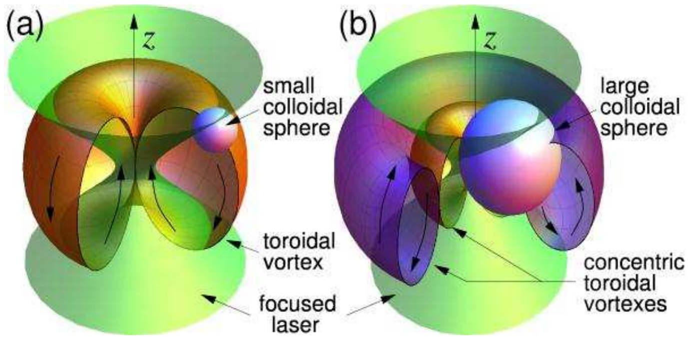


Dit onderzoek combineert explorative en implementatieaspecten (ingenieurscomponent) met een fundamentele studie van de eigenschappen van defecten in halfgeleiders (fysicacomponent). De onderzocht materialen kennen bovendien directe toepassingen in de elektronica en/of fotovoltaïsche industrie.

- 15466 Optical manipulation and detection of microparticles with non-Gaussian beams
  Promotoren: prof. dr. ir. Filip Beunis en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): ir. Caspar Schreuer
  Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Optical tweezers are used for characterizing micrometer sized particles in fluids. A focused laser beam holds particles in a fixed position in its focus within the liquid, allowing for very accurate measurements. Particles with high refractive index are attracted to the focus and trapped at this position. The source of this ‘classical’ trap is the intensity gradient of the beamÍ¾ 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 nonGaussian. 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 LaguerreGaussians, Bessel beams, optical solenoid beams, phasegradient line traps, etc… These traps increase the accuracy of the technique and extend it to a new class of experiments.



Doelstelling:

Non-Gaussian beams have complex phase profiles and intensity distributions. These tailored traps offer stronger traps and more accurate detection beams. The extra degrees of freedom allow to exert a torque on colloidal particles, to trap low index materials or even to apply a force that is directed opposite the beam propagation. Using the existing setup, you will address the spatial light modulator (SLM) and generate the desired optical trap. This project involves calculating the required SLM pattern with (partially) self-written program and performing the measurements with beam patterns you designed.

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.

- 15469 Optical trapping in complex media
  Promotoren: prof. dr. ir. Filip Beunis en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): ir. Caspar Schreuer

Richtingen: Master of Science in Biomedical Engineering, International Master of Science in Biomedical Engineering, Master of Science in de ingenieurswetenschappen: biomedische ingenieurstechnieken, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

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

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

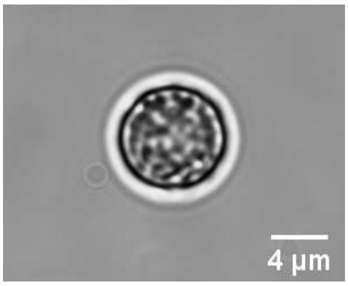


Figure: Trapped double water-in-oil-in-water particle.

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 and of the PaInT 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.

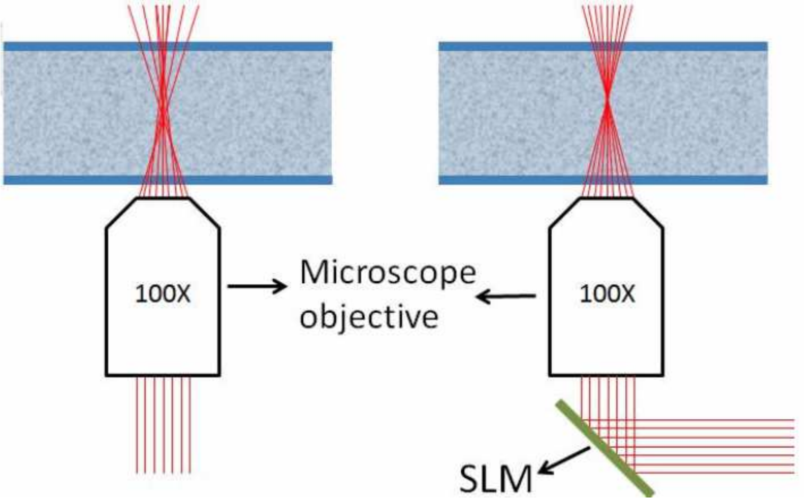


Figure: Aberrations introduced by a suspending fluid deteriorate the performance of optical tweezers (left). This master thesis uses a spatial light modulator (SLM) to compensate for these aberrations and create optical landscapes to trap complex structures.

- 15520 Optical trapping microrheology of living cells
Promotor: prof. dr. ir. Filip Beunis
Begeleider(s): ir. Caspar Schreuer
Richtingen: Master of Science in Biomedical Engineering, International Master of Science in Biomedical Engineering, Master of Science in de ingenieurswetenschappen: biomedische ingenieurstechnieken, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

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).

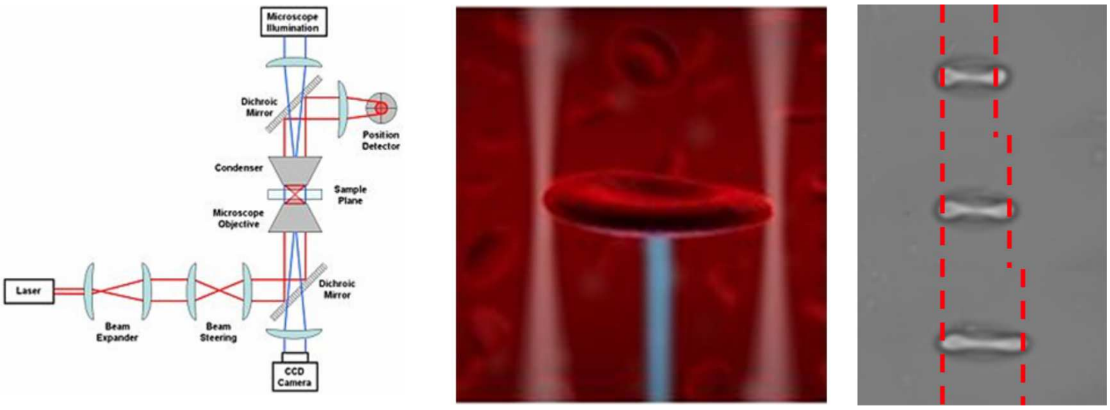


Figure: Schematic representation of an optical tweezers setup, artist impression of optical manipulation of a red blood cell, and an actual experiment in which a red blood cell is "stretched".

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.

- 15628 Polarization-independent beam steering with blue phase liquid crystals
  Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Kristiaan Neyts
  Begeleider(s): Xiaoning Jia
  Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Beam steering devices are widely used in many optical systems such as fiber-optical switches, free space communications and 3D-displays. Conventional beam steering devices are implemented with mechanically controlled optical elements(mirrors, prisms and lenses), these technologies suffer from disadvantages such as mechanical complexity, high cost, and limited steering speed. Due to these drawbacks non-mechanical approaches have been investigated among which beam steering modules based on liquid crystals show great promises and various configurations have been reported.

In general, the working principle of these devices relies on the electro-optically controlled refractive index of liquid crystals, writing a linearly changed refractive index profile in LC leads to a linear phase retardation (phase arrays) of light such that incident light can be diffracted into discrete angles. The problem of this kind of technique is that the induced phase profile of the light by means of molecule reorientation between the electrodes is not linear which severely limits the steering efficiency. Our solution to this problem is by depositing a highly dielectric or resistive layer on the bottom substrate such that the voltage profile can be smoothed out, so as the phase profile of the incident light, as shown in Figure 1.

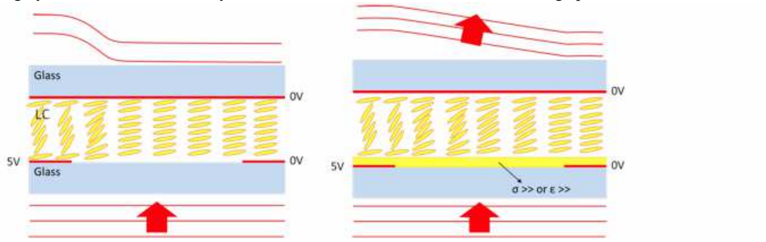


Figure 1. Liquid crystal layer between two glass plates (top glass: uniform electrode, bottom glass: patterned electrodes) without (left) and with (right) resistive or dielectric layer.

Doelstelling:

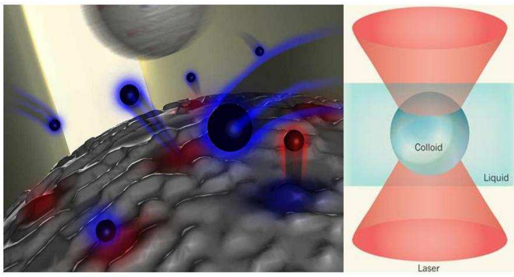
In this master dissertation, the student will design liquid crystal cells with special electrodes and verify the designs by doing simulations with matlab and FDTD solutions, with the results in mind the student will fabricate some LC cells in the clean room and build the setup for characterization, the idea is to introduce blue phase liquid crystal in the cell so that the device can achieve polarization-indenpent beam steering and a fast switching time due to excellent properties of blue phase liquid crystals.

The final goal is to create LC devices which can steer incident light by ~5 deg without lossing too much light, and the switching should be polarization independent.

- 15470 Quantized charge measurement of colloidal particles
  Promotoren: prof. dr. ir. Filip Beunis en dr. ir. Filip Strubbe
  Begeleider(s): ir. Caspar Schreuer
  Richtingen: Master of Science in Electrical Engineering, Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

In the Liquid Crystals and Photonics group a technique has been developed to study molecular reactions on particles in nonpolar liquids with unprecedented accuracy. In this technique, colloidal particles are held in an optical trap using focused laser light. The charge of the particles can be measured with accuracy better than the elementary charge, such that the exact number of electrical charges of the particles is known. Therefore even a single chemical event at the solid/liquid interface of the particle leading to an increase or decrease of the particle charge can be detected. This opens up promising ways to study chemical reactions at solid/liquid interfaces on a quantum level rather than using classical chemistry.



Doelstelling:

The aim of this Master thesis is to measure the charging dynamics of different types of particles such as polystyrene, PMMA and silica. Each measurement produces the statistics of the electrical charge, as well as the characteristic speed of charge variations. To achieve this goal, optical trapping will be used to keep a single particle fixed between two electrodes. At the same time an oscillating electric field is applied. The particle movement in response to this field is measured with subnanometer precision and results in the quantized charge.

- 15598 Smart windows based on liquid crystals
Promotoren: prof. dr. ir. Jeroen Beeckman en prof. dr. ir. Kristiaan Neyts
Begeleider(s): ir. Karel Dumon
Richtingen: Master of Science in de ingenieurswetenschappen: fotonica, Master of Science in Photonics Engineering, Master of Science in Engineering Physics, European Master of Science in Photonics

Probleemstelling:

Liquid crystals (LC) are materials that are widely used in displays. Displays make use of different LC switching modes depending on the type of display (in a mobile phone, television, etc.). Each of these modes have their own advantages in terms of complexity, price, contrast or viewing angle of the display. For many other applications, the switching modes that are highly optimized for displays are not ideal. Other types of switching modes need to be developed which can fulfill the specific requirements of these applications. Smart windows for example require very high transmission of light in one state to allow daylight entering the building when for example it is cloudy outside. All displays use modes that are based on the use of crossed polarizers. Such polarizers block a lot of light which means that only due to these polarizers the maximum transmission is limited to about 30 percent. In the Liquid Crystals and Photonics group, switching modes are investigated that offer distinct advantages for a number of non-display applications. The idea is to do this by looking at modes in which the generation, annihilation and/or movement of defects and disclination lines are utilized.â??

Doelstelling:

There is a lot of interest in smart windows, as they have the potential to become a new green sustainable technology (by e.g. replacing airconditioning systems), but a lot of interdisciplinary research questions remain open until today. Next to the LC switching modes itself, new suitable electrode patterns have to be designed to upscale the usage of LC to large surfaces. Also, one could have a look at the integration of a light harvesting mechanism (e.g. organic solar cells, to realize autonomy of the window) or sensors (to automatically adapt the smart window to environmental circumstances).

Depending on the interest of the student, the thesis can focus on simulations or a more experimental approach. The Liquid Crystals & Photonics group has been collaborating with the company Merck Window Technologies (in Eindhoven, The Netherlands). If the student is interested, this thesis can also be carried out in the company Merck Window Technologies.

- 15463 voids in germanium wafers : shape prediction and shape determination
Promotoren: prof. dr. Stefaan Cottenier en prof. dr. Johan Lauwaert
Begeleider(s): ir. Michael Sluydts en dr. ir. Samira Khelifi
Richtingen: Master of Science in Sustainable Materials Engineering, Master of Science in Engineering Physics

Probleemstelling:

High-purity and high-quality germanium single crystals are an essential part of crucial devices, such as solar panels for space applications. One of the unsolved problems in the production process of these crystals, is the appearance of micrometer sized voids. When wafers are cut from the crystal, and the wafer contains a void at the surface, the device built on top of it might either be less efficient or not working at all. If the atomistic mechanisms that lead to the growth of voids would be understood, it would be easier to design strategies that can suppress or control their appearance. Important information in that respect might be hiding in the shape of the voids, and in the relation between the shape and the crystal faces that form the inner walls. Experimental information about this can be compared to first principles prediction of the void shape. Such a comparison can learn whether or not the voids have a thermodynamic equilibrium shape or not.

Improved understanding of the issue is valuable information for the semiconductor industry. This research topic will be conducted in the framework of a strong international network and if possible the student will be actively involved in work discussions with collaborative partners.

Doelstelling:

This work has an experimental and a computational aspect. It depends on the preference of the candidate whether emphasis will be on the experimental part, the computational part, or on the dialogue between both. The goal of the experimental part is to improve the visualization of the form of the voids. Nowadays the largest voids can be observed as pits on the surface of a polished wafer (see fig.) from which an estimate of their form is not so straightforward. These surface pits can be enlarged using novel preferential etchants allowing a systematic study via optical microscopy. In the computational part, surface energies of several high-index surfaces of germanium will be calculated. These energies are used in a so-called Wulff-construction, in order to obtain the thermodynamical equilibrium shape of a nano-particle (fig) or – in this case – a void. If temperature-dependent surface energies are computed, then the shape of the void can even be predicted as a function of temperature.