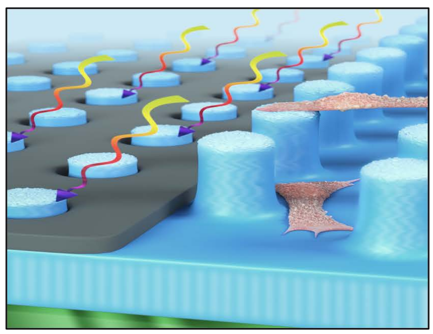
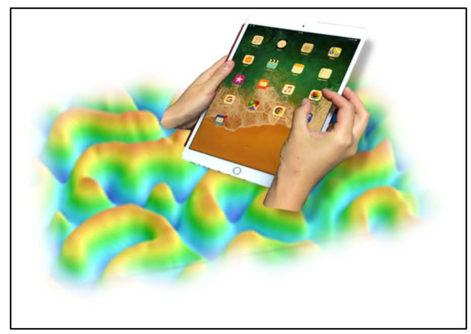
EINDHOVEN UNIVERSITY OF TECHNOLOGY





Department of Chemical Engineering and Chemistry

Stimuli-responsive Functional Materials and Devices (SFD)

Welcome to Stimuli-responsive Functional Materials & Devices

In our group we develop polymers with stimuli-responsive functionalities and integrate them into devices to meet industrial and societal challenges in the fields of sustainable energy, healthcare & personal comfort. Our group follows the complete chains of knowledge; from organic synthesis to prototypes (molecule --> device). The integration of these new polymers in devices is what distinguishes our group from many other research groups. So called top-down and bottom-up methods are employed for the preparation of hierarchically structured materials. The group operates at the nexus between the basic sciences, applied sciences, and engineering, inspiring a variety of multidisciplinary projects and interactions. SFD collaborates with multinationals, small- and medium size enterprises, and facilitates start-ups.

Color changing luminescent materials

Michael Debije

Introduction

The luminescent solar concentrator (LSC) consists of fluorescent dyes applied as a thin layer to the top of a transparent plastic lightguide. Incident sunlight is absorbed and re-emitted by the dye at longer wavelengths, trapped in the lightguide, and directed towards the edges. By embedding the dyes in liquid crystals (LCs), it becomes possible to align the dye molecules and achieve directed light emission. We have started direct ink writing of LC oligomers containing fluorescent dyes, gaining localized control over dye orientation, and generating dramatic visual effects.

Project summary

While 3D printing LSC devices, we made a startling discovery: several samples underwent dramatic color changes upon polymerization. In some, there was a red shift in color, but in others there was a heretofore unknown blue shift in both absorbance and emission spectra. This color shift is sometimes reversible, suggesting using this unique effect as a sensor. The exact source of this dramatic color change is not yet known.

The goal is to understand the processes, and, if possible, gain control over them in order to develop an LSC that can change color and emission properties, and act as a reversible sensor to, for example, ultraviolet light. You will work on the development of these LC oligomer/ fluorescent dye inks, studying the effect of using different photoinitiators and irradiation conditions to see if we can identify the cause of the color change, and see if it can be controlled. You synthesize new materials and perform in-depth characterization. You will then make coatings of these materials and characterize their absorptive/emissive characteristics as a function of temperature and polymerization conditions.

Project goals

- Synthesis and characterization of the liquid-crystal host material
- Production and study of the dye-doped luminescent coatings
- Comparing results between chemicals and processing conditions to control system

Contact information

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Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

4D Printing of Stimuli-Responsive Materials

Michael Debije

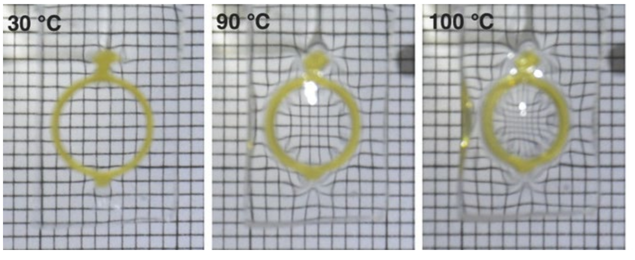
Introduction

Additive manufacturing techniques – known colloquially as 3D printing – allow for the design and production of intricate three-dimensional designs. We aim to move additive manufacturing and its possibilities to the next level by using novel and stimuli-responsive building blocks based on, for instance, liquid crystalline matter.

Project summary

Liquid crystalline (LC) materials have been investigated intensively the last couple of decades – and for good reason. From thermal response to humidity sensing, and from light-responsiveness to nanoporosity; anything seems possible with these unique, anisotropic organic molecules. Lots of novel functions have been, and are being developed – with one caveat: the form factor of these materials has so far been limited to (mostly) thin films with thicknesses in the micrometer range.

In this project, the aim is to build objects with more “tangible” dimensions, as demonstrated by López et al., among others. The first step is to successfully print a 3D object capable of autonomous response, after which more functionalities can be considered.



Example of a thermally-responsive 3D-printed lens as demonstrated in M. López-Valdeolivas, D. Liu, D. J. Broer, C. Sánchez-Somolinos, *Macromol. Rapid Commun.* **2018**, *39*, 1700710.

Project goals

- Development of stimuli-responsive mixtures as 4D-printable material or as dopants for 3D-printing filaments
- Design and fabrication of stimuli-responsive 3D objects through additive manufacturing
- Full characterization of actuation or response of a 4D-printed material

Contact information

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Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

A new class of smart materials for 4D printing

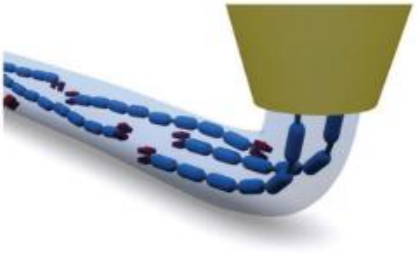
Sean J. D. Lugger, Albert P. H. J. Schenning

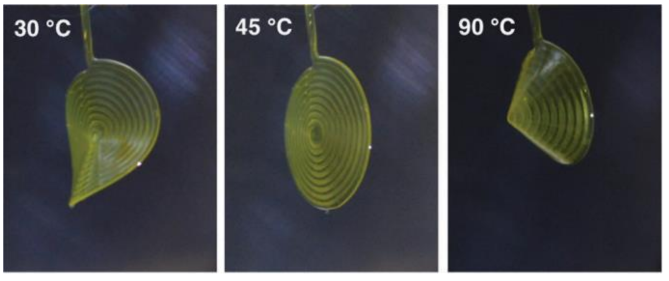
Introduction

Smart materials that reversibly deform in a programmed manner upon exposure to an external stimulus (*e.g.*, heat, humidity, or light) are potential elements in many applications such as soft robotics. 3D printing of stimuli-responsive materials allows for realizing complex designs and highly controlled shape changes in response to an external stimulus (*i.e.*, 4D printing).

Project summary

Currently, 3D printed actuators are often based on permanently crosslinked polymers which generally are fixed after fabrication. In this project, our goal is to develop and expand on a new class of materials for 4D printing allowing for deformable and recyclable objects with highly tunable properties. We want to investigate the stimuli-response and recyclability of the actuators and explore their full potential to realize new and intriguing applications. Additionally, other manufacturing techniques and applications that are interested can be investigated as well.





[Macromol. Rapid Commun. **2018**, 39, 1700710.]

Project goals

- ✓ Development and characterization of stimuli-responsive materials
- ✓ Design and fabrication of 3D structures with complex deformations
- ✓ Study the reconfigurable and recyclable properties of the materials

Contact information

If you are interested and want to know more, do not hesitate to contact us!

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CHEMICAL ENGINEERING AND CHEMISTRY

Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Photonic actuators: Towards self-sensing soft robots

Pei Zhang and Albert P. H. J. Schenning

Introduction

Sensing and reacting are survival traits for natural organisms. For example, an octopus is able to sense its environment and reacts by changing its shape and color to disguise itself.[1] By mimicking its surroundings, octopus appears almost invisible (Figure 1A). Such organisms have inspired scientists to develop soft robotics that could resemble the sensing and reactions of these creatures.

Project summary

Cholesteric liquid crystals (CLCs) are good candidate to make actuators that can change shape and structural color simultaneously. We recently reported a cholesteric liquid crystal elastomer (CLCE) film that can reversibly change their shape and color when exposed to temperature changes (Figure 1B).[2] The CLCE films are fabricated by making partially crosslinked cholesteric liquid crystal elastomer (CLCE) films, stretching them, then fully crosslinking them. Using a molding process, 3D shaped photonic actuators can also be made. However, the photonic actuators are not able to move.

In this project, we will explore how to transfer photonic actuators into self-sensing robots capable of moving and sensing the environment.

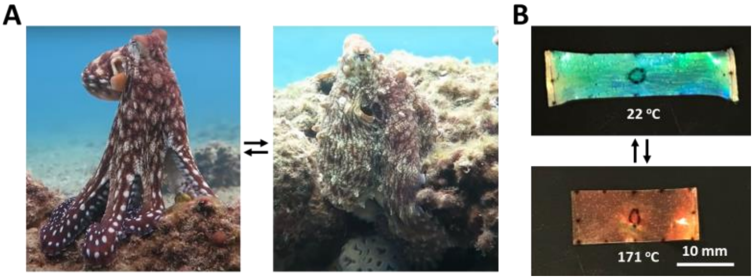

Figure 1.

Project goals

Make photonic soft robots that are capable of sensing the environment and reacting accordingly by changing its appearance (shape/color) and motion.

References

[1] R. Hanlon, Curr. Biol. 2007, 17, R400.
[2] P. Zhang, G. Zhou, L. T. de Haan, A. P. H. J. Schenning, Adv. Funct. Mater. 2020, 2007887, 1.

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Stimuli-responsive Functional Materials and Devices (SFD)

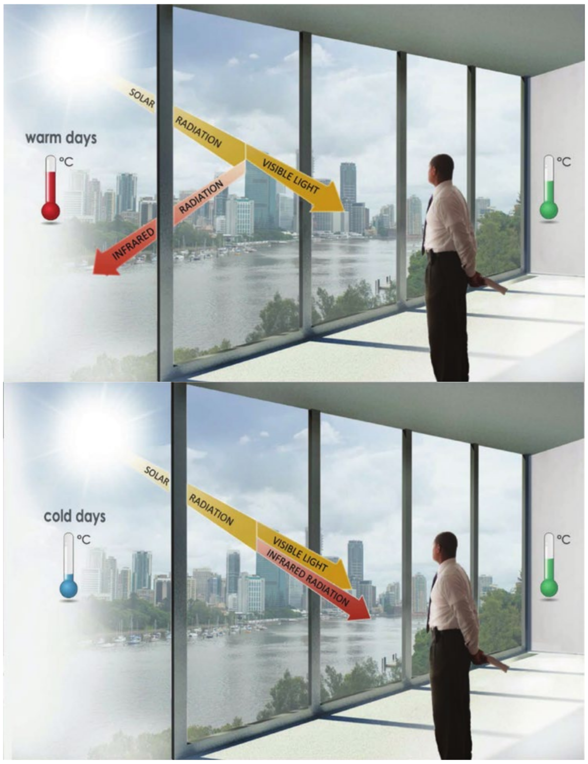
Energy saving window foils

Henk Sentjens, Stijn Kragt, Albert Schenning

Introduction

Up to 40% of the energy use in buildings and cars is spent on cooling. This is mainly a result of interior overheating caused by the passage of infrared sunlight (heat) through windows. If we are able to develop a window which is able to control the amount of solar heat entering an indoor space, we can save this energy and contribute to an energy efficient society.

Project summary



In this project, we aim for the development of infrared reflecting foils, which are transparent for the visible light. These foils can be adhered to window panes to save energy without affecting the positive effects of sunlight on the health, productivity and safety of building and car occupants. The foils are based on liquid crystal inks coated on flexible substrates using techniques which are compatible with large scale roll-to-roll production.

Especially interesting is the development of adaptive foils, which reflect more infrared on warm days (summer) compared to cold days (winter). Such a foil will autonomously control the passage of solar heat through windows, which will aid to the overall energy savings.

Project goals

I am looking for motivated students to help me with the development and application of the ink formulations as well as with the development of adaptive window foils. Your work will directly relate to the development of a scalable and societal relevant product.

Contact information

If you are interested or want to know more, feel free to contact me: ***h.sentjens@tue.nl***

Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Light-responsive Surfaces for Cell-Material Interactions

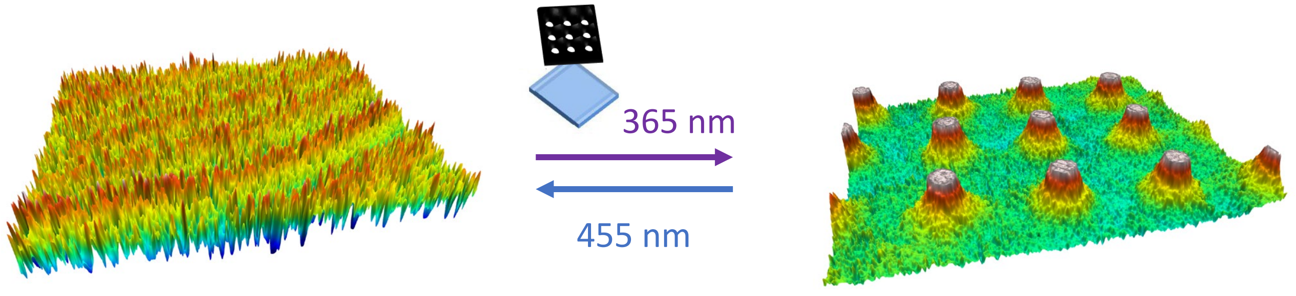
Ruth M. C. Verbroekken, Albert P. H. J. Schenning, and Burçu Gemuscu

Introduction

Even though cells are known to respond to patterned surfaces, many studies discuss static material-surfaces that do not correspond well to the continuously-changing body environment. Therefore, cell-material interactions with dynamic material surface topographies can increase our understanding of cell behavior. Light-responsive liquid crystal polymers are promising to study cell responses to dynamic surface patterns.

Project summary

In this project, we utilize light-triggered actuating and interactive polymer network platforms for cell manipulation. The topographical deformation of polymer films is known to have effect on cell adhesion and migration yet must be biocompatible. Photo-switchable liquid crystal polymers are suitable materials for such light-responsive polymer films and enable stimuli-induced mechanical and topographical surface changes. Therefore, incorporation of these light-responsive polymers in organ-on-chip devices allows for light-triggered cell-material interactions to study cell behavior.



Project goals

- ✓ Develop synthetic interactive polymer actuators for ambient conditions
- ✓ Adapt polymer actuators for biocompatibility
- ✓ Integration of the responsive polymers into microfluidic settings to study cell-material interactions

Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Recyclable photonic actuators

Lansong Yue, Sean J. D. Lugger, Albert P. H. J. Schenning

Introduction

Photonic actuators can reversibly change both shape and color in response to environmental changes (Figure 1). Cholesteric liquid crystal elastomers (CLCEs) have great potential as photonic actuators. However, recyclable CLCEs with adaptive structural color and actuation properties have never been reported. Such materials would lead to applications ranging from reusable smart sensors to sustainable soft robotic devices.

Project summary

In this project, we aim to prepare recyclable supramolecular cross-linked cholesteric liquid crystal elastomers based on thiourethane hard segments and liquid crystal soft segments via a one-pot synthesis.

We will investigate the responsive and recyclable properties, study the response mechanism, and explore the potential applications of the photonic actuators.

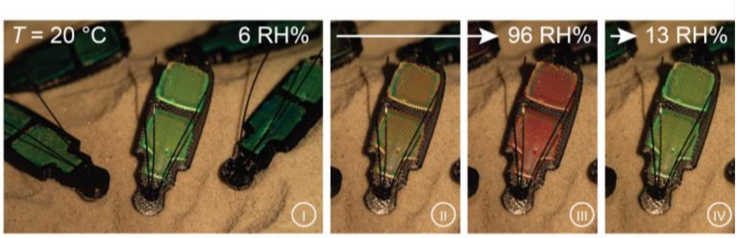

Figure 1. An artificial 3D printed longhorn beetle. This photonic actuator changes its color to atmospheric humidity The photographs show a colony of 3D printed water-responsive beetles at increasing, and then decreasing, relative humidity. (Picture taken from: Adv. Funct. Mater. 2022, 32, 2201766.)

Project goals

- Design of light responsive photonic actuators.
- Fabrication of recyclable, and reconfigurable cholesteric liquid crystal actuators.
- Characterization of the color and actuation properties of the photonic actuators.

Contact information

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Liquid Crystalline Materials Discovery

Dr. Johan Lub, Dr. Ghislaine Vantomme, Dr. Francesca Grisoni

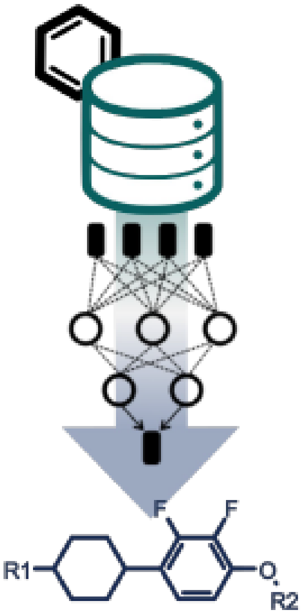
Introduction

Machine learning is one of the most exciting tools to accelerate fundamental and applied research. In the field of drug discovery, machine learning (ML) has found multiple applications, while it remains sparsely used in material science. This makes the discovery of new materials frustratingly slow, especially given the vast chemical space of possibilities available in the synthesis of new organic molecules. How great would it be to develop a tool that predicts the structures and the properties of the next socially relevant materials, such as liquid crystals, with a wide range of applications in energy, health, and soft robotics? This is exactly what we propose to do with this new project.

Project summary

During the last decades, Dr. Johan Lub and his team at Philips Research have synthesized and studied a library of over 500 liquid crystalline molecules. Also, recently several of these molecules have appeared in the literature. Some of these molecules have become essential components of today's LCD screens in TVs and computers and new applications are found for these materials everyday.

This valuable molecular repository can be used as the starting point to develop novel structure-property relationship models leveraging modern ML methodologies. Such models will allow us to (a) understand the molecular features that drive the assembly and the properties of these materials, and (b) design improved compounds for various applications.



Project goals

In this project, you will work at the interface of artificial intelligence and material science and learn not only the properties of liquid crystals, but also the development of machine learning techniques.

✓ Interact at the interface of artificial intelligence and material science
✓ Basics of Python and molecular machine learning for property prediction

Contact information

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Human Interactive Materials (HIM)

STORM-BOTS

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Miniaturized self-regulation in liquid crystal oligomer network actuators

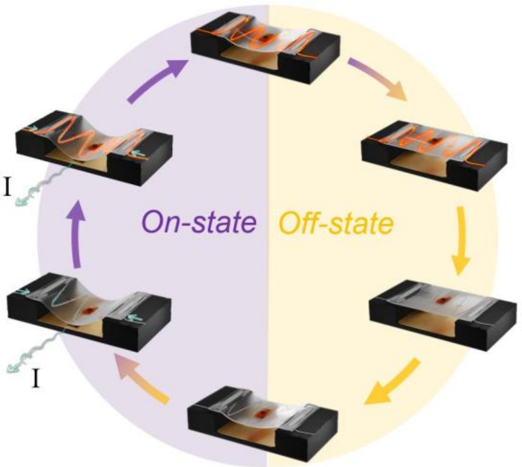
Mert Orhan Astam, Danqing Liu, Dirk J. Broer

Introduction

Soft robots stand to revolutionize our interaction with our devices and machines, or even transform how machines communicate with each other. Applications that require advanced material handling or communication with the user or machine, such as virtual reality devices, can benefit greatly from soft robotics. Liquid crystal oligomer networks (LCONs) show promise in such applications, especially in terms of its actuation programmability and self-regulating properties.

Project summary

LCONs have proven self-regulating capacities, acting as a sensor and an actuator within a specialized set-up to keep the parameters, such as temperature, of its dynamic environment constant. The next step is for this proof-of-concept to be optimized for application as a soft robotic device. This entails device miniaturization, aiming to induce advanced functions such as precise material transport. The complex LCON device needed to achieve this may include series or arrays of self-regulating systems.
Moreover, this system must be suited for conventional electrically-powered robotic infrastructure. Therefore, electric stimuli is required, yet preferably wirelessly-powered to further expand the versatility of our LCON systems.



Project goals

- To develop compact, electrically-responsive LCON actuators that can be activated wirelessly.
- To demonstrate the self-regulating function of a miniaturized LCON system.
- To use the miniaturized self-regulating systems in series and arrays to produce advanced soft robots capable of controlled material transport.

Contact information

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Human Interactive Materials (HIM).

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Optimization of self-assembly process for solitonic defect in CLCs coatings

Jacques Peixoto, Danqing Liu & Dirk J. Broer

Introduction

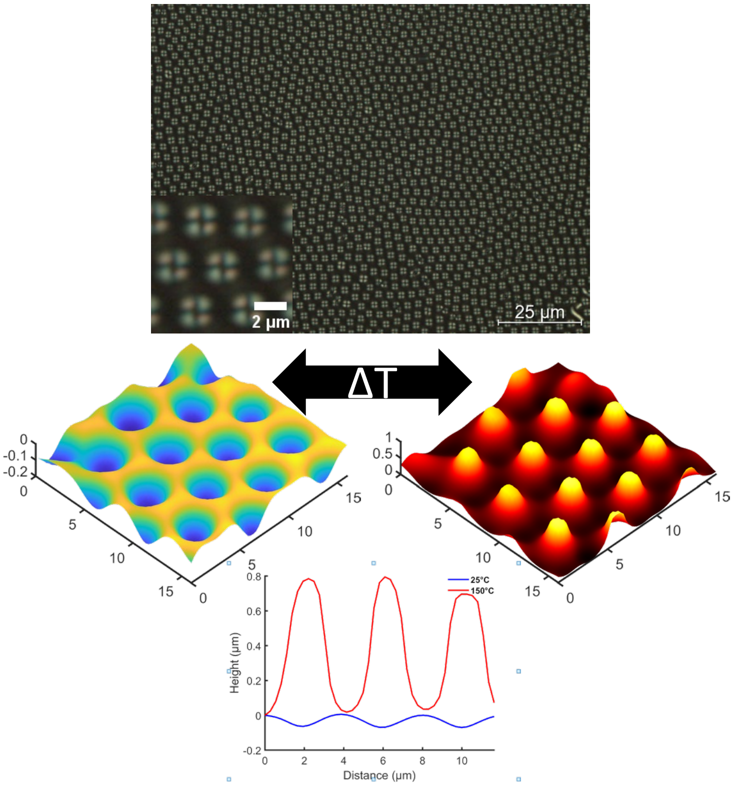
Cholesteric Liquid Crystals (LC) are well known and currently under investigation for their versatility in large scale of applications. One of the most common texture is the fingerprint one. Moreover, this isn't the only powerful metastable state of it. Solitonic defects as Toron for example can be generated in specific conditions which enhance the possible applications

Project summary

The project will be based on tuning the spin coating process by playing with different liquid crystal or/and using surfactant.

The control of the self-assembly process before polymerization could help to get coating populated by those defect which we will define the surface topography and actuation.

The applications are broad. Going from biomimetics (Gecko's feet) to optoelectronic devices (Photonic Crystal).



Project goals

- Control the self-assembly process by tuning :
  - The coating thickness over the pitch size
  - The air/coating interface (Liquid crystal nature & surfactant)
- Study of the dynamic of the coating after polymerization upon light or temperature

Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

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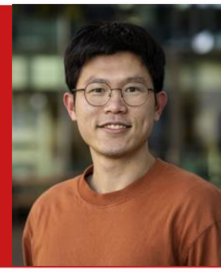
Developing (semi-) conductive liquid crystal elastomer toward an autonomous robot

Pengrong Lyu, Danqing Liu



Introduction

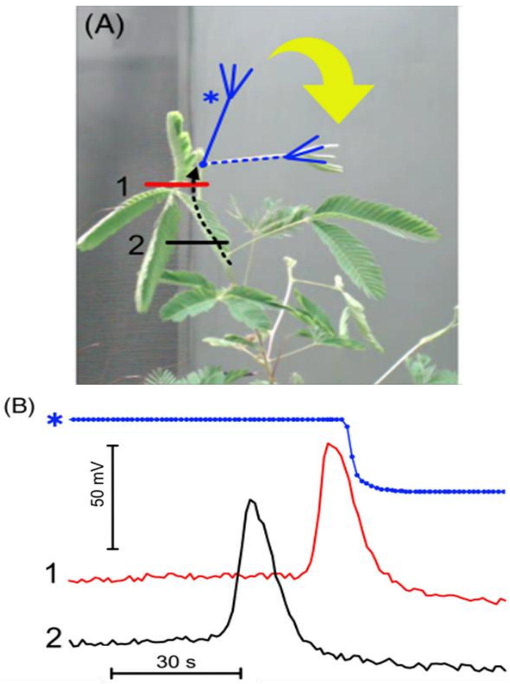
In nature, the generation, transmission, and processing of electrical signals are common forms to control the action of plants and animals, such as the reflex arc in the human body, the sequential actuation of mimosa, and so on. The feedback system, consisting of the sensing, processing, and actuating unit, endows the animals and plants with autonomous behaviors.

Project summary

In this project, we plan to develop the **(semi-) conductive liquid crystal elastomer**, which can be used as both an actuating element and sensing element. It will be activated by electricity. Its deformation will be monitored simultaneously. Figures on the right show this concept. Currently, we use the ionic liquid as a medium for conducting electricity.

The next step is to use **new conducting liquid crystal polymers** to assemble devices with specific functions, such as grasping objects.

[1] Stolarz,et al. *Physiologia Plantarum* 173.4 (2021): 1882-1888.



Mimosa generates and transmits action potentials after being stimulated[1].

Project goals

- Develop (semi-) conductive (liquid crystal) materials
- Integrate the materials into an autonomous soft robot
- Analyze robotic functions

Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

STORM-BOTS

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Dual modulus actuators for snap-through instability

Duygu Sezen Polat, Dirk Jan Mulder, Dirk J. Broer and Danqing Liu

Introduction

Design paradigms that enable the fast and rapid responses can unlock the true potential of soft-materials as they suffer from slow responses and small forces. Nature is a great source of inspiration where its elegant machineries can put instabilities into work to respond in a rapid manner. Venus flytrap, for example, can close its leaves to catch a prey in less then 100 milliseconds by employing snap-through instability.

Project summary

We have previously demonstrated the potential of snap-through instability in liquid crystalline networks (LCNs) with snappers that can actuate in less than 70 milliseconds, propel big and small objects from its surface (Figure 1). In this work we aim to intensify the performance of snap-through by developing dual modulus actuators. The first step is going to be the development of chemistry and fabrication of the LCNs with dual modulus, after which its integration into a device can follow.

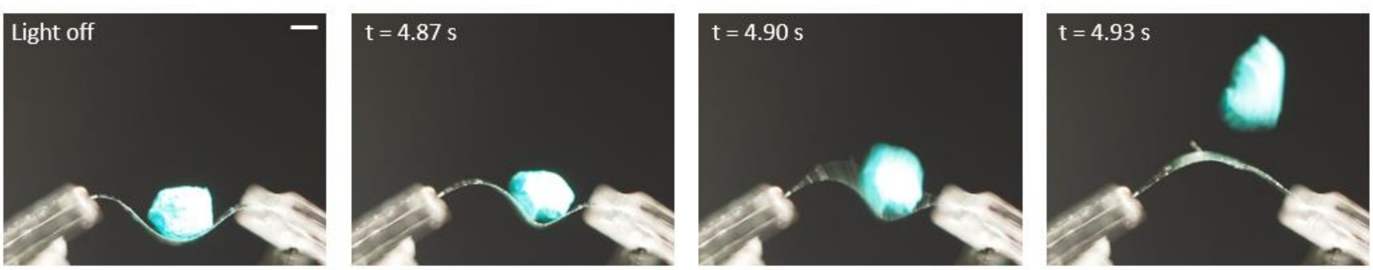


Figure 1: Snap-through of LCN. Snapper is 1 mg, ball is 2 mg and scale bar corresponds to 2 mm.

Project goals

I am looking for motivated students to help me with the fabrication of dual modulus actuators. Work is going to include the optimization of the fabrication procedure and characterization of the actuators.

Contact information

If you have questions and would like to learn more about the project, feel free to contact me: d.s.polat@tue.nl

CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

Liquid secretion on demand

Dongyu Zhang, Dirk J. Broer, and Danqing Liu

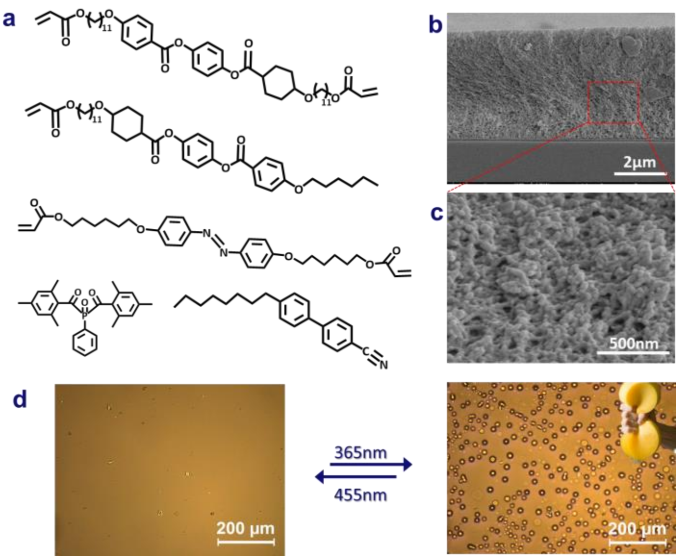
Introduction

Liquid Secretion is ubiquitous in all forms of life as it can drastically change properties between surfaces. For example, fishes secrete a protective layer of mucus not only to against the pathogenic microbes, but also to reduce friction between their skin and water to speed up swimming. Synthetic surfaces releasing lubricants are promising in the application of self-cleaning surfaces, adhesion control, anti-icing, reactant release and drug release.

Project summary

We are aiming to develop smart sponge-like coatings that can release and re-absorb functional liquids upon external stimulus such as light and electricity. Using different stimulus, different principle is employed. Light triggered liquid secretion is taken as an example. Initially, the liquid is stored within porous liquid crystal network. Upon UV light illumination, the network is deformed, and the liquid is squeezed out and secreted at the surface in the form of droplets.

We have been working on secreting various liquids and localizing the secretion at a desired location at the surface by using different techniques.



Project goals

Our goal is to develop on-demand liquid secretion using different triggers, to secrete different types of liquids, and to fabricate flexible skin-like surfaces. Thinking further, it is also possible to integrate these self-lubricating polymer skins within microfluidics and robotics.

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Human Interactive Materials (HIM)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Nano-PDLC for 5G communication

Eliza Sopubekova, Dirk. J. Broer, Danqing Liu

Introduction

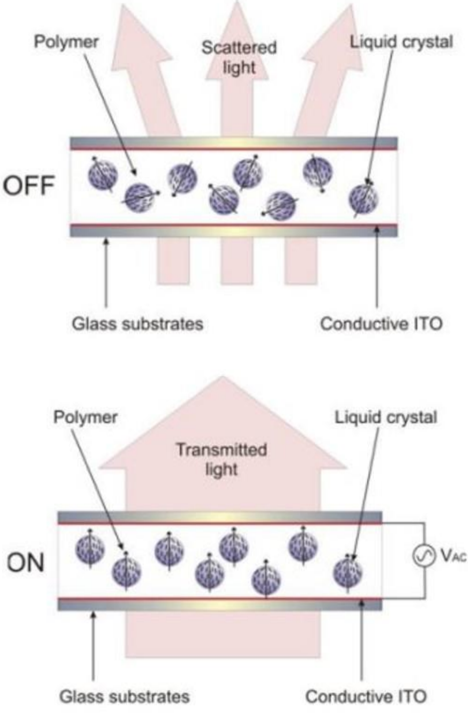
Smart responsive materials have the potential to provide new functionalities and push the limit of current or new applications. In a similar way as liquid crystals are used for their adjustable optical properties in liquid crystal displays, upon application of an electric field, the dielectric properties of the LC can be tuned to adjust the interaction of the substrate with radio frequency waves. This project will focus on the assessment, development and processing of polymer dispersed liquid crystals for 5G applications

Project summary

Polymer Dispersed Liquid Crystals (PDLCs) are composite materials in which liquid crystals (LCs) are dispersed as droplets in a polymer matrix. In an absence of external field, droplet director of LCs are randomly oriented which leads to refractive index mismatch between LCs and polymer and the material is in optically scattering state. When the material is subjected to electric field, the reorientation of droplet directors occurs and the sample becomes transparent.

In nanosized PDLC systems, LC orientation and thus, it's dielectric properties can be tuned without any dependence on light polarization.

The objective of this project is to develop nano-PDLC systems with tunable dielectric properties towards their application as next generation mm-wave communication systems.



Project goals

- Development of electrically responsive nano-PDLCs with tunable dielectric properties
- Characterization of the response performance of the prepared materials
- Investigation ofthe parameters affecting the droplet formation, its size and shape
- Testing the materials for 5G antenna application

Contact information

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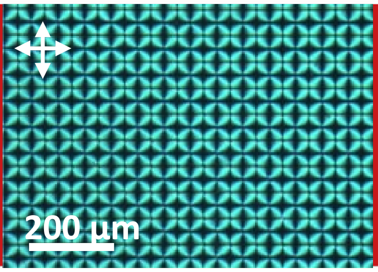
CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Programmable dynamic surface topographies

Yuxin You and Danqing Liu



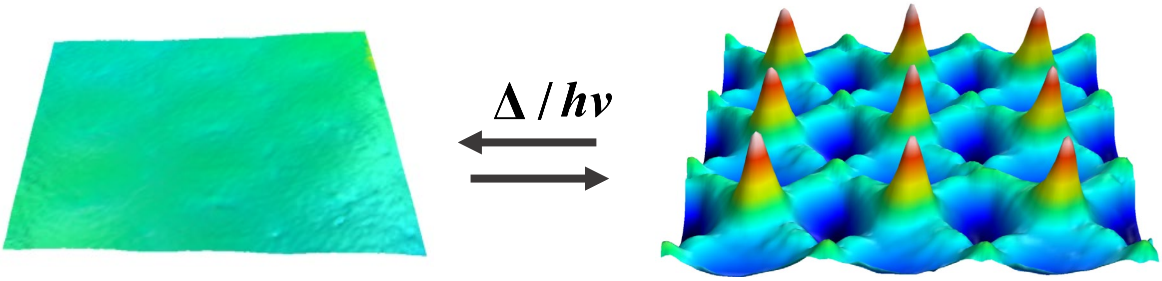
Patterned LCON characterized by Polarized optical microscope

Introduction

Surface topographies play a vital role in nature. For instance, goosebumps on mammals' skin can conserve heat. Cuttlefishes generate textures on their skin for camouflage. The ingenuity of these creatures lies in regulating the functionality of their surface by switching their topographies to interact with the surrounding environment. Here, we would like to develop smart coatings with dynamic surface topographies which are anticipated to benefit many new functions in the fields of haptics and robotics.

Project summary

Liquid crystal oligomer networks (LCONs), combine the elastic properties of rubber and the anisotropic properties of liquid crystals, are among the most promising materials to prepare surface topographies. In this project, we will fabricate LCON coatings on the substrates with pre-programmable patterned defect information which is established by photoalignment technology. The prepared coating can be reversibly actuated by heat, light, or electricity to form various surface topographies you like. Next, we will apply them for certain functions, an example is the formation of cilia to mimic the natural archetypes-hair structure on gecko feet for super adherence.



3D image of the surface topogeaphies

Project goals

Some of goals can include：

- Design the defect pattern for certain topographies.
- Characterize and study the actuation for dynamic surfaces.
- Explore more applications, for example in the fields of haptics and robotics.

Contact information

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Stimuli-responsive Functional Materials & Devices

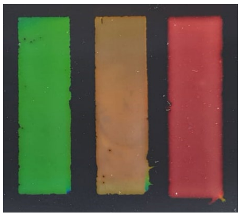
EINDHOVEN UNIVERSITY OF TECHNOLOGY

Optical indicators for food packaging

Yari Foelen

Introduction

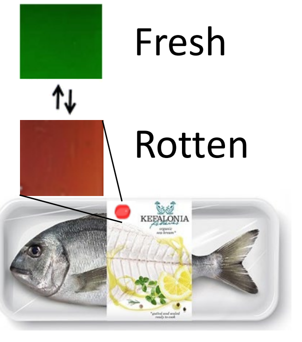
In support of growing food consumption, a great need arises to decrease food waste through a more conscious resource management. Battery-free optical indicators form a key element for the sustainable food packaging of the future to impact food waste and food safety to a large extent. We design responsive colored coatings, as a dynamic and more accurate alternative for old-fashioned static expiration dates.



Project summary

The technology applied to produce these indicators is based on cholesteric liquid crystals to obtain responsive structural color. Our solution presents a tunable ink of which the color changing behavior can be programmed through the chemical composition. This optical response to the environment can be closely correlated to the expiration process of perishable consumables.

The goal is to develop current technology for real world applications to make indicators for a variety of products. Therefore, a range of tunability in the indicator response needs to be further established and optimized.
You will explore different aspects of research and evaluate scientific results with a reference to industrial feasibility.



This project is part of the Faculty of Impact which gives the opportunity to further develop an exciting new technology from lab scale to market. Details of the specific project are open for discussion and will depend on the progress of the overall research.

Project goals

- Work on the development of novel optical indicators.
- Study the different influences on coating properties in order to control them.
- Investigate compositional influences on polymer properties and macroscopic response.
- Substrate screening and development of printing procedures for coating optimization.

Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Faculty of Impact

PHOTOSYNTHETIC

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

STIMULI-RESPONSIVE FUNCTIONAL MATERIALS & DEVICES

Fluorescence Probes for in situ Reaction Monitoring in Volumetric Lithography

Dirk Jan Mulder, Albert Schenning

Introduction

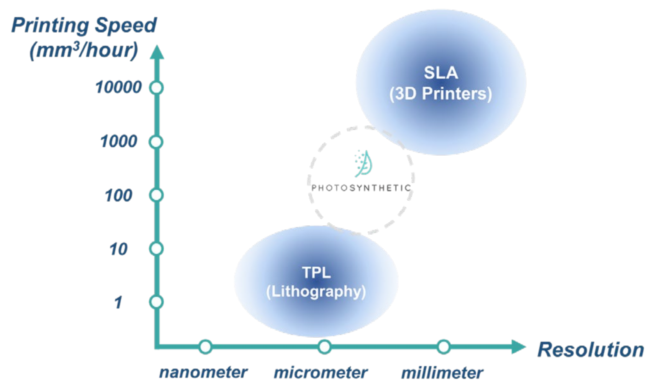
Photosynthetic is a deep-tech startup (spin-off of CWI, Amsterdam) developing a novel micro- and nanoscale 3D printing method that is flexible enough for prototyping but also fast enough for production applications. We believe that this combination, made possible by our novel and patented approach, provides a never-before-seen solution for a wide range of applications: from custom but reproducible membranes for medical instruments to MEMS-devices to 3D light paths inside of logic chips. Although only three years old, Photosynthetic has already created a proof-of-concept phase device and is now getting ready for the next steps.

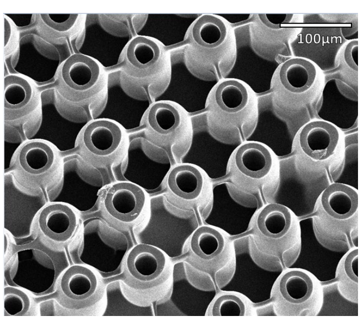
Project summary

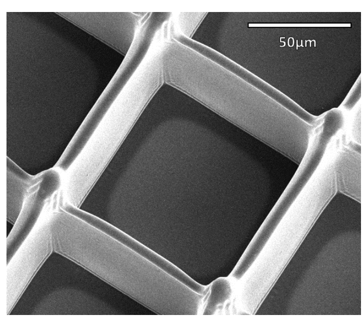
The scope of this project on the development and investigation of stimulus-responsive fluorescence probes that will enable in-situ reaction monitoring and imaging without interfering with our unique two-wavelength photocuring system.

Overall, this project is a unique opportunity for an organic chemist with a strong interest in real-life (optical) applications. The whole chain from design to application will be covered and you will be given the flexibility/freedom to follow your chemical interest and express your creativity to achieve the final goal.

Bridging the gap







Project goals

You will design novel chromophores with desired spectral requirements and viscosity response and conduct various characterizations on the synthesized dyes to assess their performance in terms of absorbance/emission, (cross-)responsiveness (monomer type, temperature, viscosity), polymerization interference, and stability (*e.g.* photobleaching). After designing, synthesizing, and characterizing the fluorescence probes, you will be responsible for the development of a method to measure *in situ* kinetics in the lab. Together with our engineers, you will implement your solution into the printing process.

Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

PHOTOSYNTHETIC

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

STIMULI-RESPONSIVE FUNCTIONAL MATERIALS & DEVICES

Photoinduced ring-opening polymerization in Volumetric Lithography

Dirk Jan Mulder, Albert Schenning

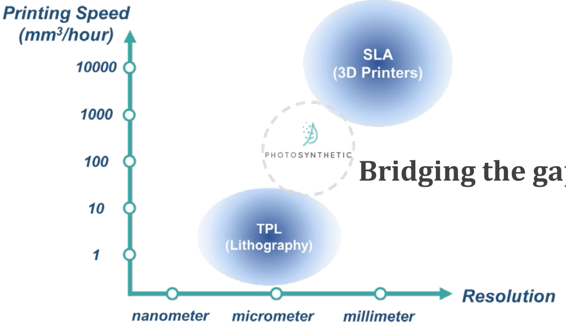
Introduction

Photosynthetic is a deep-tech startup (spin-off of CWI, Amsterdam) developing a novel micro- and nanoscale 3D printing method that is flexible enough for prototyping but also fast enough for production applications. We believe that this combination, made possible by our novel and patented approach, provides a never-before-seen solution for a wide range of applications: from custom but reproducible membranes for medical instruments to MEMS-devices to 3D light paths inside of logic chips. Although only three years old, Photosynthetic has already created a proof-of-concept phase device and is now getting ready for the next steps.

Project summary

As of today, to fabricate micro sized 3D structures, our focus has mainly been on light-controlled free radical polymerizations. To extend the chemical library of suitable monomers, we are aiming to enable our equipment to perform ring opening polymerizations (ROP).

The scope of this project will be focusing on the design and investigation of new initiator systems that can both initiate and inhibit/terminate ROP reactions using two different wavelengths. You will select the right reagents and monomers to formulate resins. If necessary, you will synthesize new reagents to achieve this goal. You will investigate the photopolymerization kinetics and evaluate the performance. Once general requirements are met, you will optimize the resin further using our state-of-the-art equipment.



Bridging the gap

Project goals

Overall, this project is a unique opportunity for a polymer chemist with a strong interest towards high-tech applications. The whole chain from design to application will be covered and you will be given the flexibility/freedom to express your creativity to achieve the final goal. As you will be working with our equipment which is capable of printing micrometer-sized objects within seconds, it would be preferred that you have some basic programming experience (or the willingness to learn) to write your own test scripts.

Contact information

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PHOTOSYNTHETIC

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

STIMULI-RESPONSIVE FUNCTIONAL MATERIALS & DEVICES

Polymer Reaction Kinetics in Volumetric Lithography

Dirk Jan Mulder, Albert Schenning

Introduction

Photosynthetic is a deep-tech startup (spin-off of CWI, Amsterdam) developing a novel micro- and nanoscale 3D printing method that is flexible enough for prototyping but also fast enough for production applications. We believe that this combination, made possible by our novel and patented approach, provides a never-before-seen solution for a wide range of applications: from custom but reproducible membranes for medical instruments to MEMS-devices to 3D light paths inside of logic chips. Although only three years old, Photosynthetic has already created a proof-of-concept phase device and is now getting ready for the next steps.

Project summary

Being able to predict the polymerization reaction kinetics under predetermined conditions is a key requirement for our 3D printing process to work. The polymerization kinetics profile will change as the resin's composition and illumination conditions change throughout the 3D printing process; hence it should be accounted for.

The scope of this project will be focusing on the investigation of polymerization kinetics during our printing process. You will develop characterization methods in which you can measure the monomer conversion and depletion of other reagents while mimicking our printer's illumination conditions. Overall, this challenging project is a unique opportunity for a polymer chemist with a strong interest towards high-tech applications. You will be diving deep into advanced photopolymerization kinetics, and you will be given the flexibility/freedom to express your creativity to achieve the final goal. However, as you will be working with our equipment which is capable of printing micrometer-sized objects within seconds, it would be preferred that you have some modeling and programming experience to write your own scripts (or the willingness to learn).

Project goals

Depending on your competencies and research interest, you can focus on various topics. For example, (1) unraveling the impact of changes in chemical and environmental conditions on various chemical reactions taking place during the printing process or (2) develop a robust kinetic model that can describe the monomer conversion in a simple and very fast way. The latter is of great interest for us as we need to calculate the monomer conversion for each point in space and time before we can print. Here, both accuracy and speed play an important role!

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