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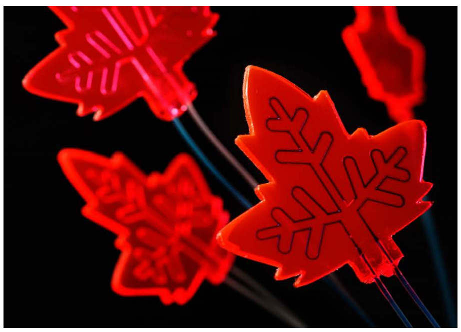
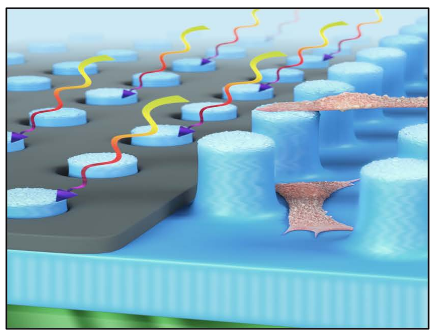
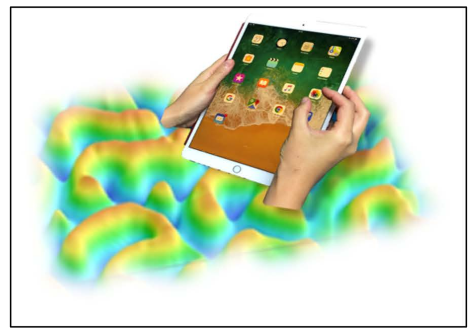
EINDHOVEN UNIVERSITY OF TECHNOLOGY







Department of Chemical Engineering and Chemistry

# Stimuli-responsive Functional Materials and Devices (SFD) & Human Interactive Materials (HIM)

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 as 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.

Human Interactive Materials

The Human Interactive Materials research group is embedded within the department of Chemical Engineering and Chemistry at the Eindhoven University of Technology.

Our research explores the potential of functionalizing the inherent intelligence within materials with interactive capacity, such as in silicones, hydrogels and liquid crystal networks or elastomers. Our specialized materials are capable of communicating information between man and machine or between machines optically or through haptics, displaying great promise for intelligent soft robotic systems. We envision our materials becoming intelligent devices within themselves, with the capacity to sense its environment and adapt desirably to any changes. Looking to the future, we foresee the development of self-learning soft robotics capable of artificial neurogenesis, following nature's approach to intelligent soft machines.

## Research department

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# Luminescent solar concentrators


# Michael Debije

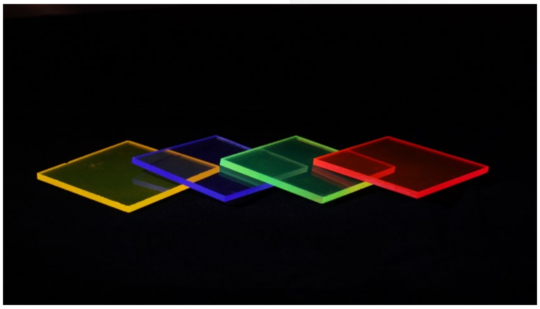

## Introduction

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

There are a wide variety of possible topics in this field to be worked on. One major area of research is application of the device in horticulture. Plants have specific growth conditions for optimal production, taste and appearance of their fruit, for example. By manipulating the intensity and color of light reaching the plant on demand, one can create a responsive growth environment for the plant.

Another topic area to address are ways to ease implementation of LSC devices into the urban setting. Through both simulation and experiment-ation, we can design new forms of the device with the goal of enhancing light transport and edge emission and their appearance as well.



## Project goals

- Switchable colors, transparency
- Inkjet, 3D printing of devices
- Novel lightguide designs

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CHEMICAL ENGINEERING AND CHEMISTRY


Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# 4D Printing of Stimuli-Responsive Materials

Michael Debije

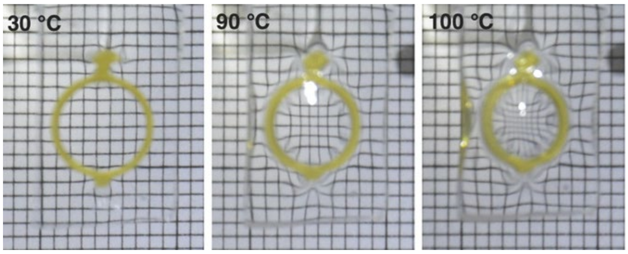
## Introduction

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)

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# Light-responsive Surfaces for Cell-Material Interactions

Ruth M. C. Verbroekken, Albert P. H. J. Schenning, and Burcu Gumuscu-Sefunc

## Introduction

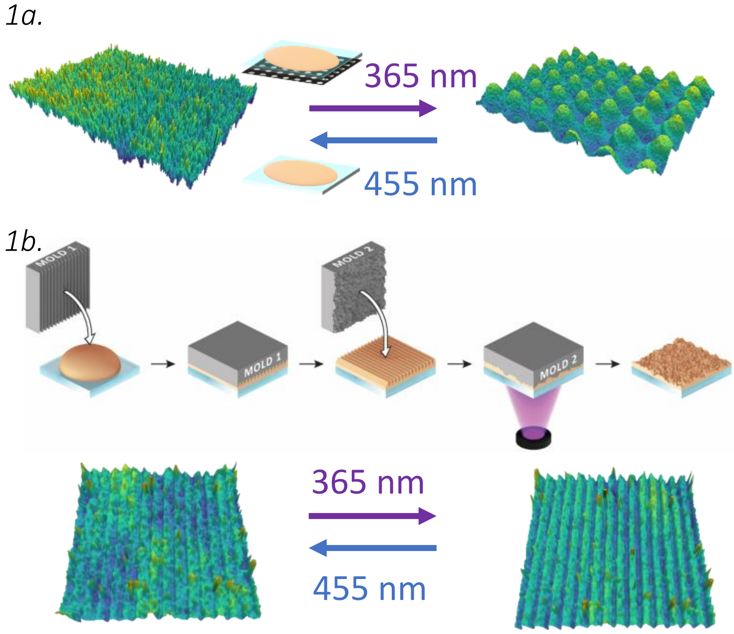
Even though cells are known to respond to patterned surfaces, many studies focus on static material surfaces that do not correspond well to the continuously-changing body environment. Therefore, cell-material interactions with dynamic material surface topographies can increase our understanding of cell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

## Project summary

Using varying patterning techniques *e.g.* mask illumination[1a] and mold imprinting[1b], in this project we fabricate light-responsive liquid crystal surfaces that allow for dynamic switching of surface topographies. Since cells are known to respond to such surface topographical changes, we focus on cell steering based on light-induced surface topographies. After establishing precise control of this reversible surface patterning, we will apply the LC films to biological studies to study on demand cell-manipulation.

*Fig 1a. Mask-patterned photoisomerization, 1b. Light responsive actuation of two-step imprint*P. Zhang 2023*

*1a.*




## Project goals

- ✓ Fabricate dynamic switching topographies
- ✓ Optimize the actuators for physiological compatibility
- ✓ Adapt polymer actuators for biocompatibility
- ✓ Study cell-material interactions

## Contact information

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Albert Schenning: **a.p.h.j.schenning@tue.nl**, and Burcu Gemuscu-Sefunc: **b.gumuscu@tue.nl**

## Stimuli-responsive Functional Materials and Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Energy saving window foils

**Henk Sentjens, Stijn Kragt, Albert Schenning**

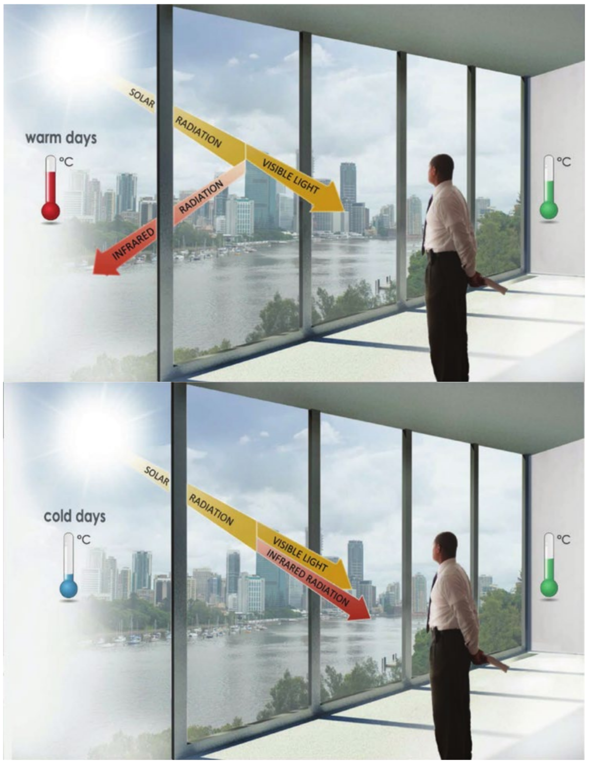
## Introduction

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***

CHEMICAL ENGINEERING AND CHEMISTRY

Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Recyclable photonic actuators

Lansong Yue, Michael G. Debije, 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.

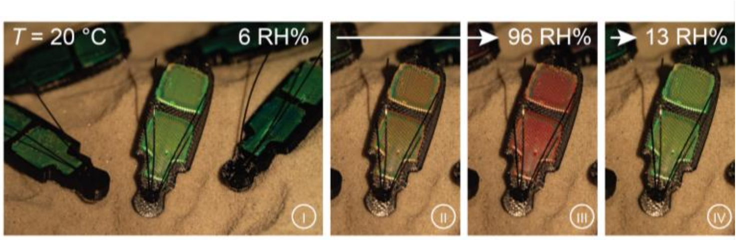



**Figure 1.** An artificial 3D printed longhorn beetle. This photonic actuator changes its color to atmospheric humidity The photographs show a colony of 3D printed water-responsive beetles at increasing, and then decreasing, relative humidity. (Picture taken from: Adv. Funct. Mater. 2022, 32, 2201766.)

## 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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CHEMICAL ENGINEERING AND CHEMISTRY

Stimuli-responsive Functional Materials & Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Melt-Extruded Photo/Thermo Dual-responsive Thermoplastic Liquid Crystal Fiber Actuators

Lansong Yue, Xue Wan, Michael Debije, Albert Schenning

## Introduction

Fiber actuators with multi-stimuli response can dynamically interact with the environment for potential application in soft robotics, smart textiles, and bionic systems. Thermoplastic liquid crystal elastomers are attractive candidates for fabricating fiber actuators as they show large and reversible deformations and have excellent self-healing and recyclable properties.

## Project summary

In this project, we aim to prepare photo/thermo dual-responsive fiber actuators through melt-extrusion and drawing of a thermoplastic liquid crystal elastomer. The fibers contain dynamic hydrogen-bonding segments as physical crosslinks and dual-responsive liquid crystal soft segments as actuation units, allowing reversible photo- and thermo-responsive actuation of the liquid crystal elastomer. The fiber can be easily recycled and reprogrammed into different shapes to show a variety of actuation motions.

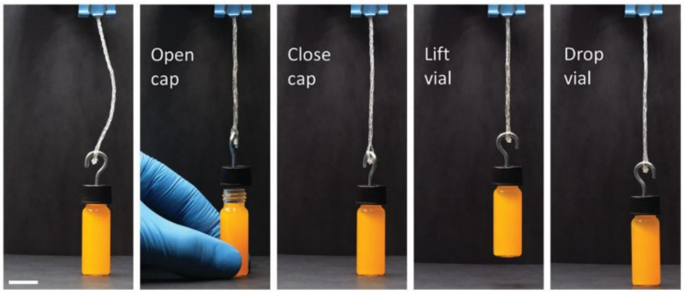


**Figure1** Example of thermal actuation of a liquid crystal elastomer rope opening and closing a screw cap and subsequently lifting the closed vial (scale bar = 15 mm). (Picture taken from Adv. Funct. Mater. 2023, 2306853)

## Project goals

- Synthesize dual-responsive thermoplastic liquid crystal polymers.
- Build a melt-extruding and drawing system.
- Characterize thermo- and photo-response of the liquid crystal fibers.

## Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Stimuli-responsive Functional Materials and Devices (SFD)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Swimming Soft Robots

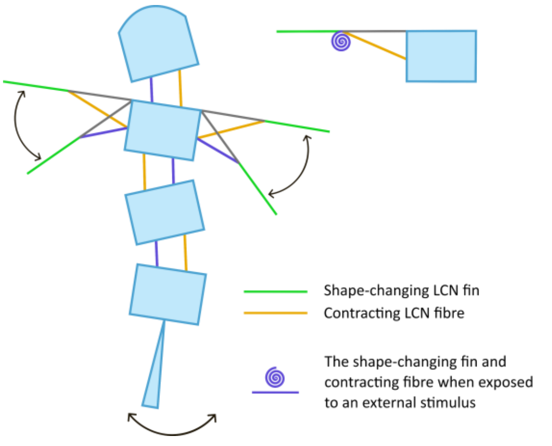
**Alexandra Gruzdenko, Michael Debije, Albert Schenning, Jaap den Toonder**

## Introduction

All 14 classes of the animal kingdom as well as the protista and monera kingdoms have organisms capable of swimming. Their propulsion mechanisms are as diverse as the creatures themselves. However, the majority of commercially available swimming robots still employ only human-designed propellers. Therefore, the aim of this project is to develop artificial swimmers with nature-inspired locomotion. To achieve this goal, liquid crystal polymer networks (LCNs), soft materials which can unidirectionally contract upon exposure to various stimuli, will be used.

## Project summary

In this project, we design mechanisms to produce asymmetric strokes and body deformations which are essential for any nature-inspired locomotion. For that, LCNs are used to make fins that can change their shape during the power and recovery strokes upon exposure to an external stimulus (e.g. light). The fin motion and body undulations can be achieved with the help of LCN fibres capable of contraction.
Both macro- and microrobots are of interest, however, for simplicity, we first focus on large scale prototypes. Therefore, the developed designs will be used to construct either a large-scale swimmer or a macromodel of a potential microswimmer with the purpose of testing its swimming ability prior microfabrication.




## Project goals

- Optimization of an LCN composition to achieve sufficiently fast actuation in water
- Design and fabrication of a shape-changing fin
- Construction of a swimmer with moving caudal/pectoral fins or capable of body deformations using LCE fibers

## Contact information

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Laboratory of Stimuli-responsive Functional materials & Devices (SFD)

# Structurally colored waterborne and biobased coatings

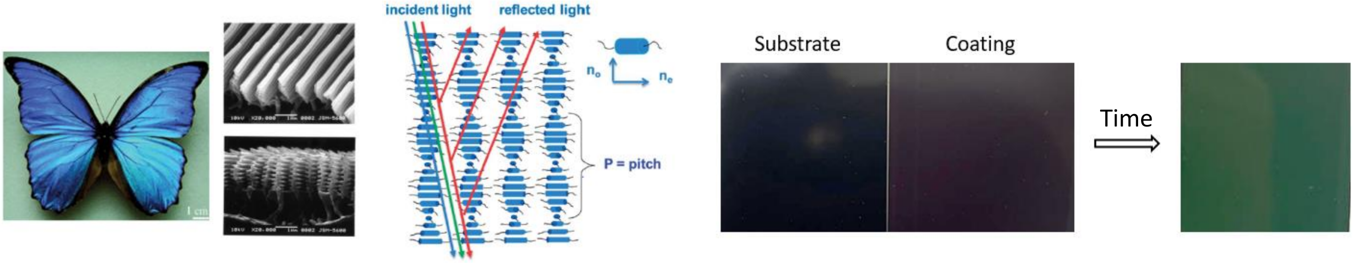
Ryno van Niekerk, Jitte Flapper, Albert Schenning & Catarina Esteves

## Introduction

Color in coatings is typically achieved with pigments of inorganic or organic nature. Many of these pigments can be non-degradable, heat-sensitive, reactive, very expensive, or have a high carbon footprint. Structural color, which is widely found in nature, is regarded as an ideal alternative to pigments since it can produce colors of greater brightness, greater saturation and provides resistance to photobleaching.

## Project summary

Structural color arises from specific interactions of light with micro/nanostructures such as interference and reflection. An example of structural color in nature can be found in the blue morpho butterfly. In this project, we want to make use of biobased cholesteric liquid crystals (CLCs) to incorporate both structural color and smart functionality in waterborne coatings. An example of such a coating is a coating that undergoes a structural color shift with time.




CLCs are rod-shaped molecules organized in a helical fashion. The length of helical periodicity, known as the helical pitch (P), and the average refractive index of the CLC determine the wavelength of light that is reflected. If you are passionate about experimental work, microscopy, spectroscopy, and sustainable chemistry, please contact us!

## Project goals

- Develop structurally colored waterborne coatings based on biobased liquid crystals
- Develop structurally colored coatings with smart functionality (e.g., responsivity towards temperature, humidity, pressure, organic vapors, etc.)
- Study of the film formation process of various liquid crystal/binder systems

## Contact information

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Stimuli-responsive Functional Materials & Devices

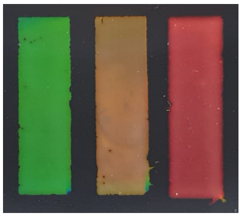
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Autonomous temperature indicators

Yari Foelen


## Introduction

Battery-free optical indicators can form a probe or warning instrument to detect improper temperature exposure over time. You will support the development of temperature responsive colored coatings, based on liquid crystal polymers. This technology has the potential to create temperature indicators for a range of applications.

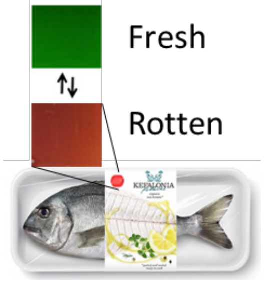


## Project summary

Indicators based on cholesteric liquid crystals are applied to obtain responsive structural color. The indicators are coated or printed with 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 temperature degradation for products such as 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, the 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 color response.
- Substrate screening and development of printing procedures for coating optimization.

## Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Faculty of Impact

## Chemical Engineering & Chemistry

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Liquid Crystalline Materials Discovery

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

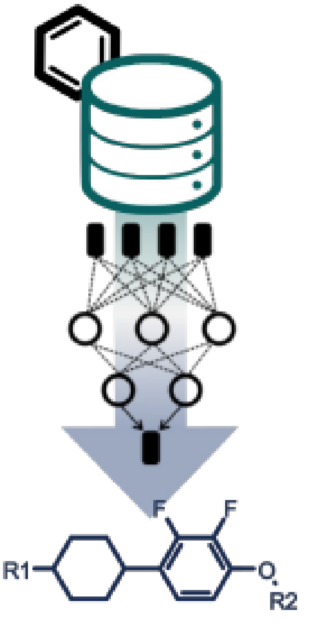
## Introduction

**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)
## Soft Robotic Matter

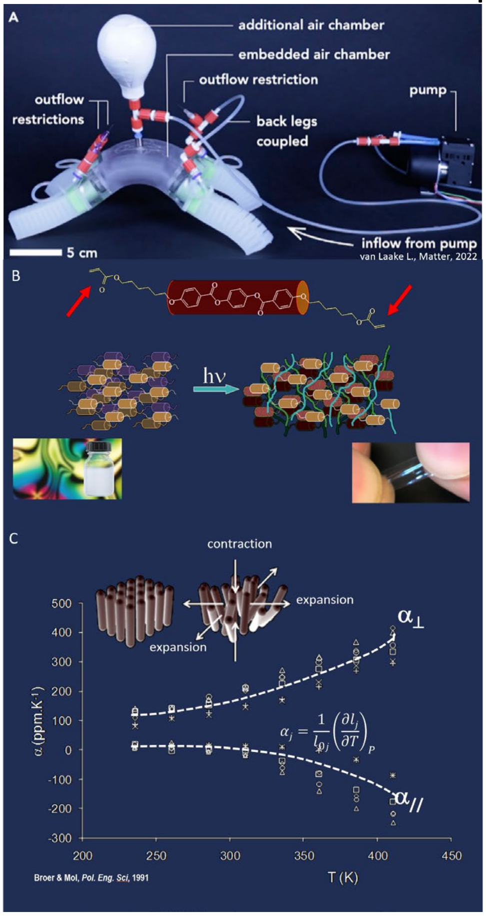
EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Embodying intelligence in LCE mechanical metamaterials by harnessing geometrical non-linearities

Elif Kurt, Danqing Liu and Bas Overvelde

## Introduction

Soft robotics is one of the new subtopics of robotics that facilitates developing designs and robotic functions from compliant materials which enables flexibility and safety for sophisticated and safe human-machine interactions. With new fabrication techniques, autonomous devices with three-dimensional shapes, coatings and actuators can be developed.




## Project summary

In this project, we aim to combine active and inactive components to obtain a hybrid design to enhance mechanical properties and have stimuli-responsive actuation which can be used for soft robotic applications. By taking the advantages of both the mesostructures of metamaterials and capability of liquid crystals to produce anisotropic mechanical response by changing the ordering with respect to a stimuli (heat, light, electricity, etc.) , we can develop intelligent soft robotic devices in macro/micro scales.

## Project goals

I would like to work with a motivated student on a challenging project about developing new design structures and actuation strategies by using hybrid inactive and active/tunable materials with stimuli-responsive sites.

## Contact information

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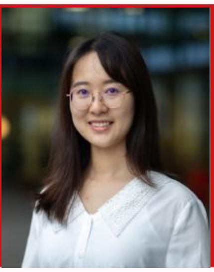
Danqing Liu, d.liu1@tue.nl; Bas Overvelde, j.t.b.overvelde@tue.nl

EINDHOVEN UNIVERSITY OF TECHNOLOGY

## Human Interactive Materials (HIM)

# Electrically active surface topographies

Yuxin You and Danqing Liu



## Introduction

Surface topographies in nature, such as mammalian goosebumps for heat conservation and cuttlefish textures on their skin for camouflage, have inspired functional surface innovations in research. Previously, we have proposed a design that generates dynamic surface protrusions by using the stimulus of heat and light (Figure 1). In modern applications, such as haptic feedback systems for touch input and the advancements in soft robotics, electricity is the preferred trigger for integrating artificial surfaces into devices.

## Project summary

In this project, we aim to develop dynamic surface topographies in thin liquid crystal polymer coatings under an electric field. To achieve this, we will design and fabricate coatings that are responsive to electric stimuli. By applying the electric field, we can precisely control and manipulate the surface structures of these coatings. Furthermore, we will conduct a thorough analysis of the dynamics to gain insights into how they behave under various electric field conditions. This will enable us to optimize the system for enhanced performance and further explore the applications.

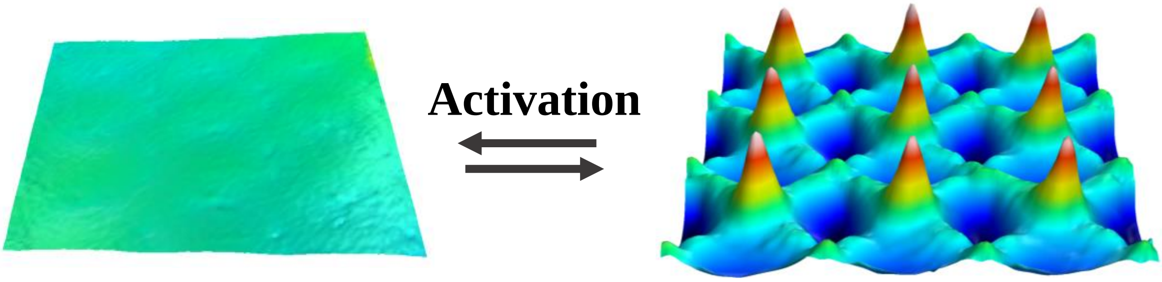



Figure 1: 3D image of the surface topographies

## Project goals

Some of goals can include：

- Create dynamic surface topographies by an electric field.
- Characterization of the actuation properties.

## Contact information

Feel free to contact me: Yuxin You - y.you1@tue.nl - STO 0.27

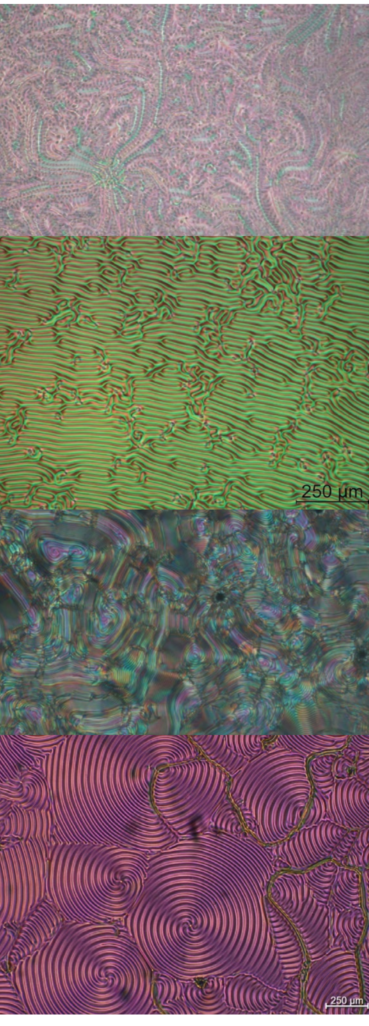
Human Interactive Materials (HIM).

# Freezing dynamic motion in liquid crystal network

Jacques Peixoto

## Introduction

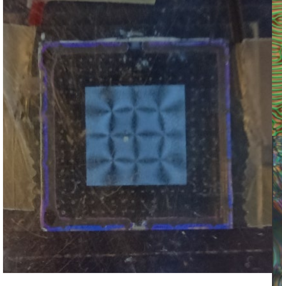
Electro Hydro Dynamic Instabilities (EHDI) has been widely studied in the past to create smart windows. Here we use the cohesive motion to control the molecular orientation of the liquid crystal before photopolymerization. Due to the variety of the textures observed, a library of coatings will be characterized.




## Project summary

The project will be based on playing with different electric signal with different parameters (Frequency / Voltage)

In that way a library of texture could be obtained. After photopolymerization those structures will be studied for their morphological change upon thermal or light stimulus.



Regarding the properties of the change application will be defined.

## Project goals

- Control the molecular orientation by tuning :
  - Electric signal
  - The composition of the liquid crystals
- Analysis of the surface upon light or temperature

## Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

# Human Interactive Materials (HIM).

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Faraday wave as bottom to top approach to pattern liquid crystal network

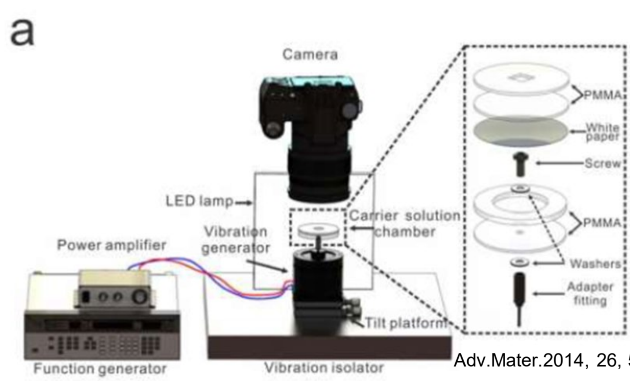
**Jacques Peixoto**

## Introduction

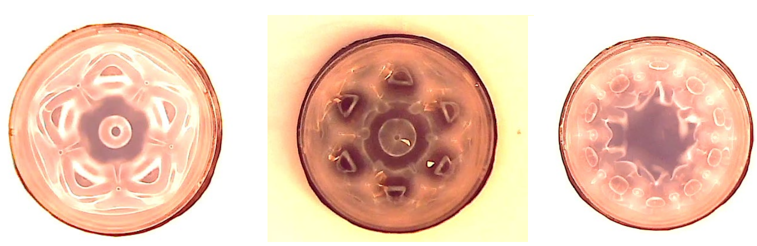
The anisotropic response of liquid crystal is one of the main features to achieve a broad range of applications. Multiple approaches exist to obtain controllable patterns. Unfortunately, the scaling up or the lack of reproducibility makes the further step complex to reach. Following this idea, a simple bottom-to-top approach could be an interesting candidate to overcome that problem.

## Project summary

Study the non-linear behavior of liquid crystal upon mechanical vibration. Distinguish different phases and the range of stability. The chemistry of the mixture combined with the nature of the wave will be studied in order to optimize the overall system. Post photopolymerization the system will be studied for its mechanical properties.




Adv.Mater.2014, 26, 5936–5941



## Project goals

- Obtention of 2D standing waves. (Variables: Frequency, Amplitude, Viscosity, Container geometry)
- Freezing the dynamic system by photopolymerization.
- Study of the dynamic of the coating after polymerization upon stimulus.

## Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM) TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Liquid Crystal Fibers

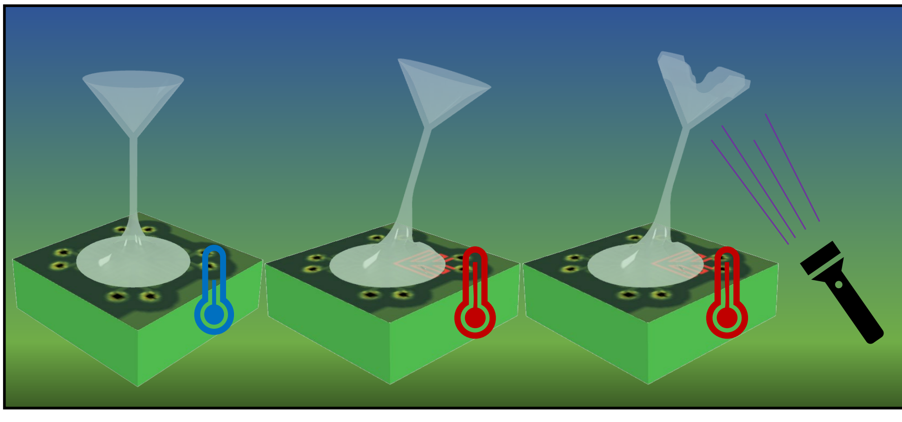
## Sam Weima

## Introduction

Soft robots are interesting since they can perform mechanical tasks without the need for joints. Instead, actuation is enabled by material properties. One class of materials for soft robots are liquid crystal elastomers, which can reversibly deform when their molecular alignment (as induced during fabrication) is disturbed. This disturbance is usually achieved by locally applying heat or light.

## Project summary

Previously, we have made liquid crystal fibers that can bend when locally heated. Recently, a new method has allowed for the creation of liquid crystal fibers with conical heads. When heated, these cones deform in a complex way, which allows for their use as switchable suction cups



While the fibers can be controllably bent via computer-controlled contact heating, an elegant way to deform the cones does not yet exist. One option is to include a dye in the fiber to allow for photothermal actuation, while another option is to change the liquid crystals used to allow for photomechanical actuation. Finally, it will be necessary to integrate the light source and -control with the fibers to create a functional device.

## Project goals

- Learn to fabricate liquid crystal fibers.
- Develop fibers from new material for combined heat- and light-based actuation.
- Develop a device for controlled actuation of the fibers using both stimuli.
- Use the fibers to perform some useful task.

## Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

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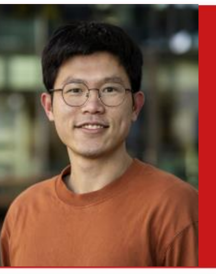
# Developing (semi-) conductive liquid crystal elastomer toward an autonomous robot

Pengrong Lyu, Danqing Liu



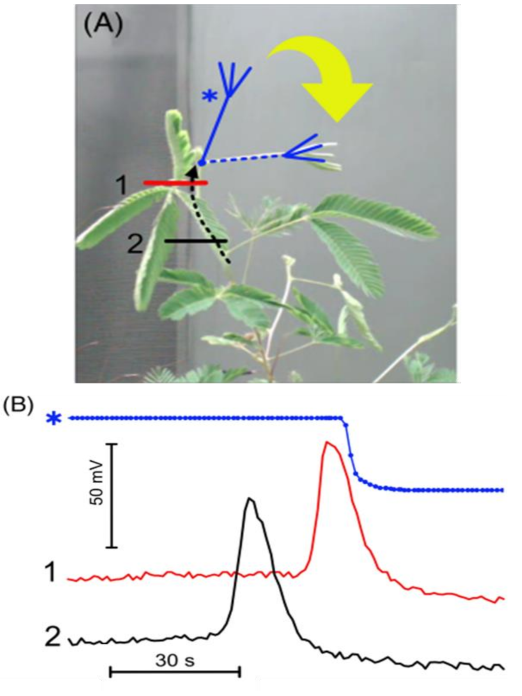
## Introduction

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.




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

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

## 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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STORM-BOTS

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# 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.

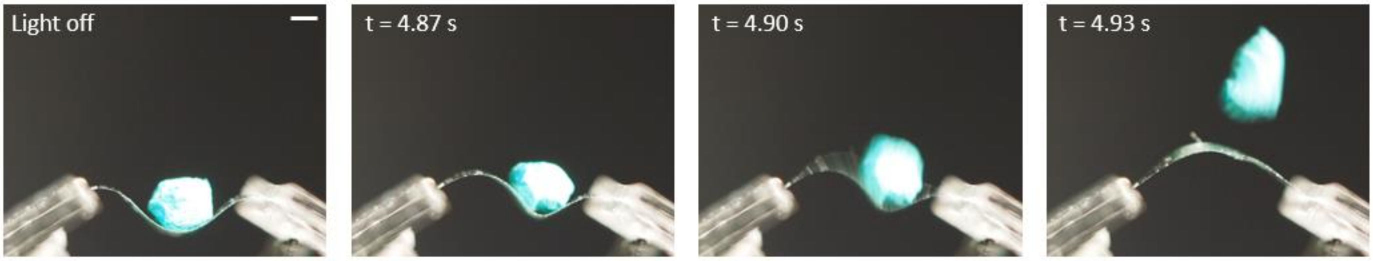



Figure 1: Snap-through of LCN. Snapper is 1 mg, ball is 2 mg and scale bar corresponds to 2 mm.

## 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](mailto:d.s.polat@tue.nl)

CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Liquid secretion on demand

Dongyu Zhang, Dirk J. Broer, and Danqing Liu

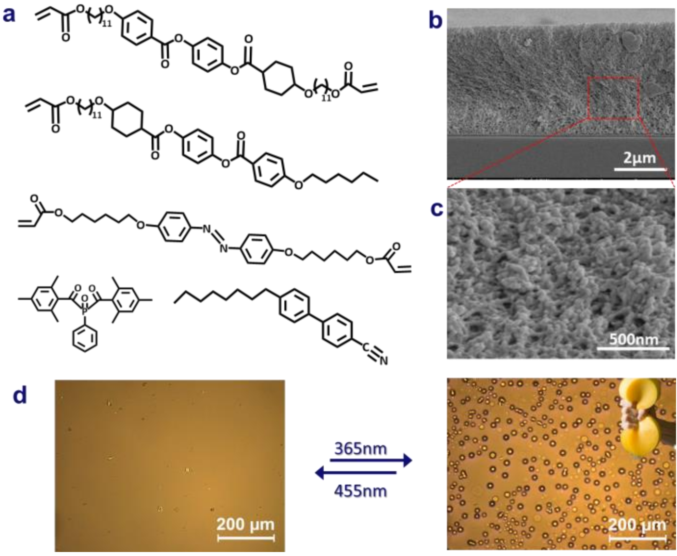
## Introduction

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.

## Contact information

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CHEMICAL ENGINEERING AND CHEMISTRY

Human Interactive Materials (HIM)

# Communicating polymer skin for haptic feedback

Tom Bruining, Danqing Liu

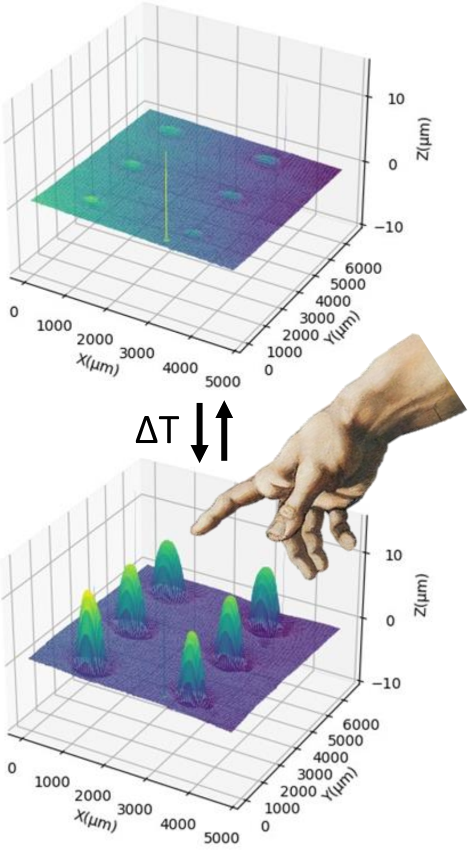
## Introduction

Most information we receive from modern day technology is either visual or auditory. Haptic feedback, or information we receive by our sense of touch, is very limited. Using responsive liquid crystal materials, haptic feedback can be created by changing the surface texture of a device. Applications for these materials range from virtual reality to technology for visually impaired people.

## Project summary

This project involves creating liquid crystal elastomer films that can change their surface structure in a range that is perceivable by human touch. Heat is currently used to trigger deformation, but we would like to expand to other stimuli such as electricity or light.

When new materials are created, they can be integrated into a device like a braille display or tactile display. We are cooperating with the Human-Technology Interaction group in the IE&IS faculty to investigate the effectiveness of the materials and devices we create in user tests.




## Project goals

- Develop liquid crystal networks for haptic feedback purposes
    - Achieve response to different stimuli
    - Increase the deformation amplitude and the rate of deformation
- Integrate the developed material into a prototype device

## Contact information

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