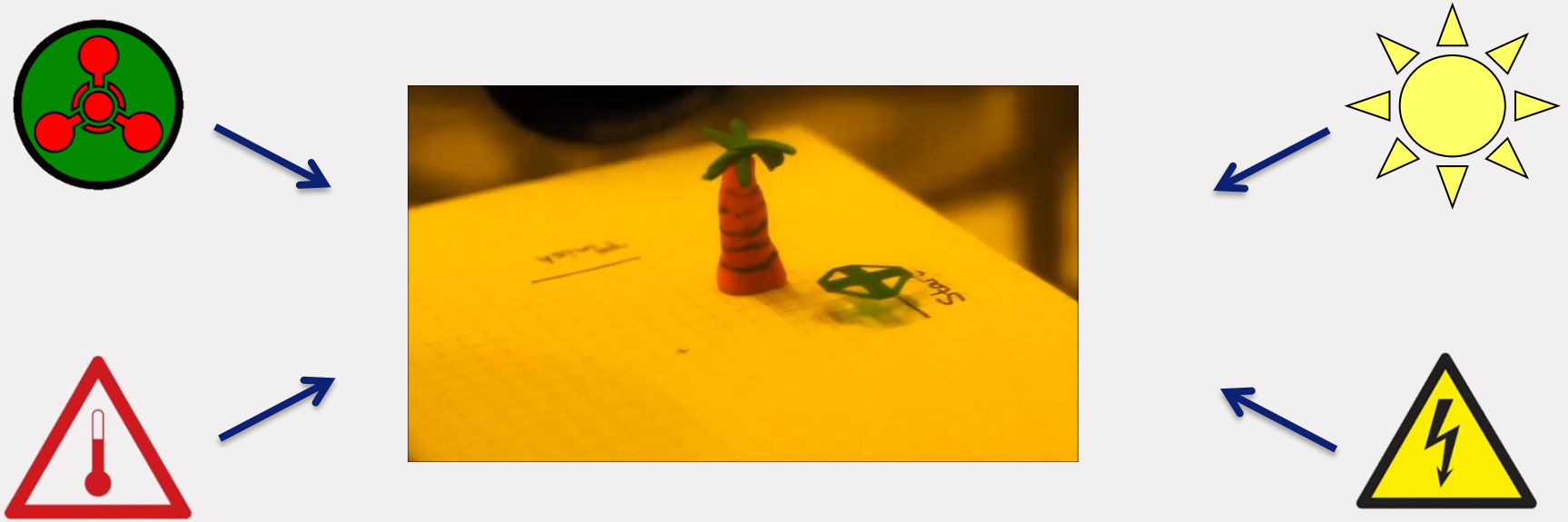
Dynamic Coatings

Webinar #3
Antimicrobial coatings novel technical approaches

Albert Schenning

June 16, 2021

Stimuli-responsive Functional materials and Devices



- Focus on polymer materials that change shape, color and/or porosity
- External triggers: chemicals, temperature, (sun)light, electricity, etc.
- Adjustment autonomously depending on user needs or upon environmental changes

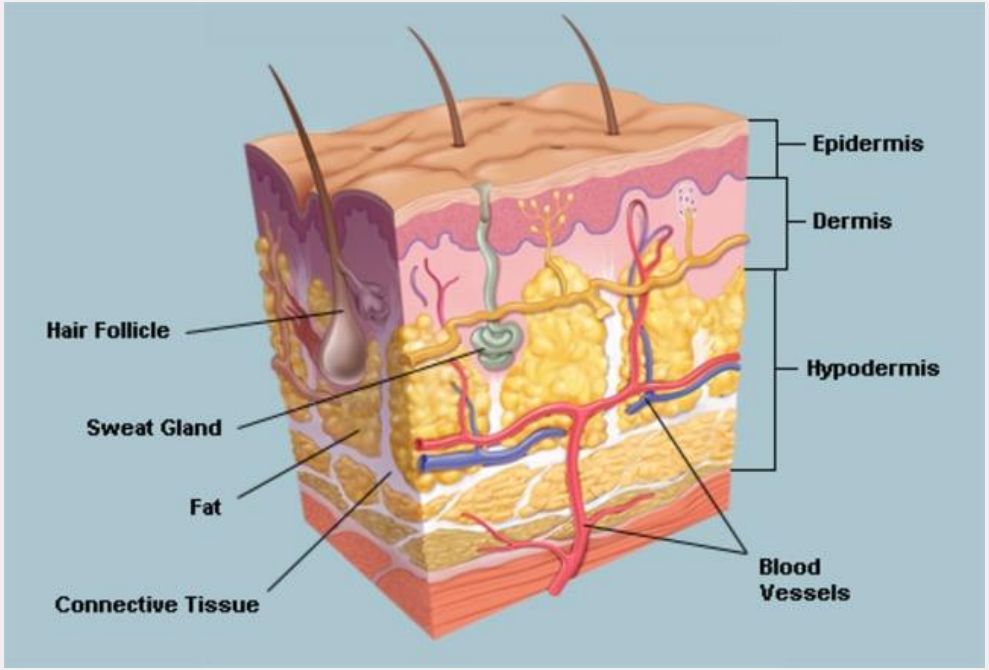
Nature – a source of inspiration

Videos from YouTube

for growth, reproduction, survival, protection, etc.

TU/e

Nature – a source of inspiration



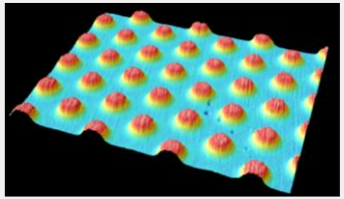
for growth, reproduction, survival, protection, etc.

TU/e

Laboratory of Stimuli-Responsive Functional Materials & Devices

Sustainable Energy

Smart coatings for self-cleaning and antifouling

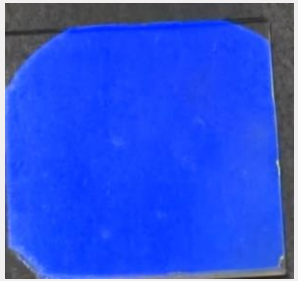


Smart windows
Luminescent solar concentrators

Health

Nanoporous materials for clean water

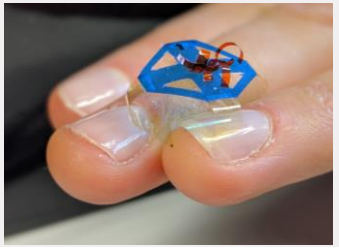
Optical sensors for health, food and safety



Personal Comfort

Smart Textiles

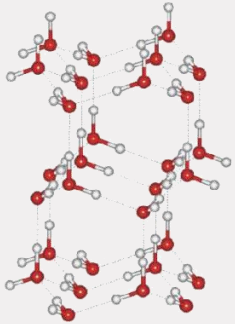
Soft Robotics, Haptics



Stimuli-responsive materials based on liquid crystals (LCs)

Liquid Crystals

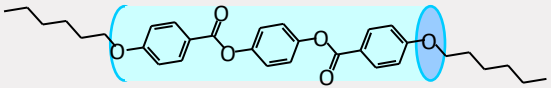
3 phases: solid, liquid and gas

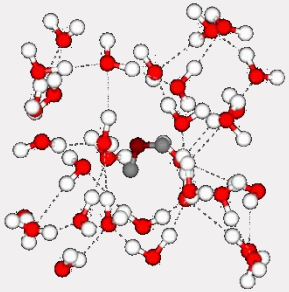


Solid (Anisotropic)

Heat

Liquid Crystal





Liquid (Isotropic)

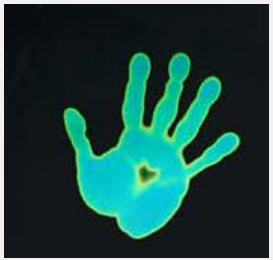
driving force for mesophase formation:

- steric repulsion by form anisotropy
- anisotropic dispersive interactions

Anisotropic materials:
properties depend on orientation

TU/e

Liquid crystals in our daily life



Thermometers

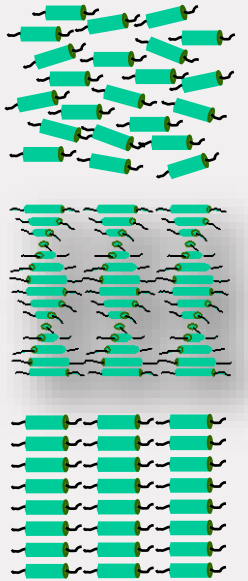
Displays

Beauty cares

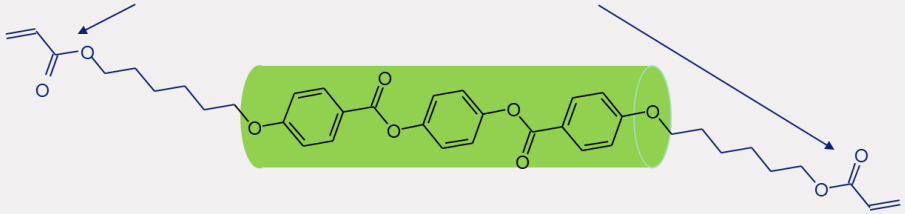
Security logo's

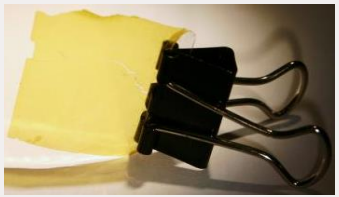
TU/e

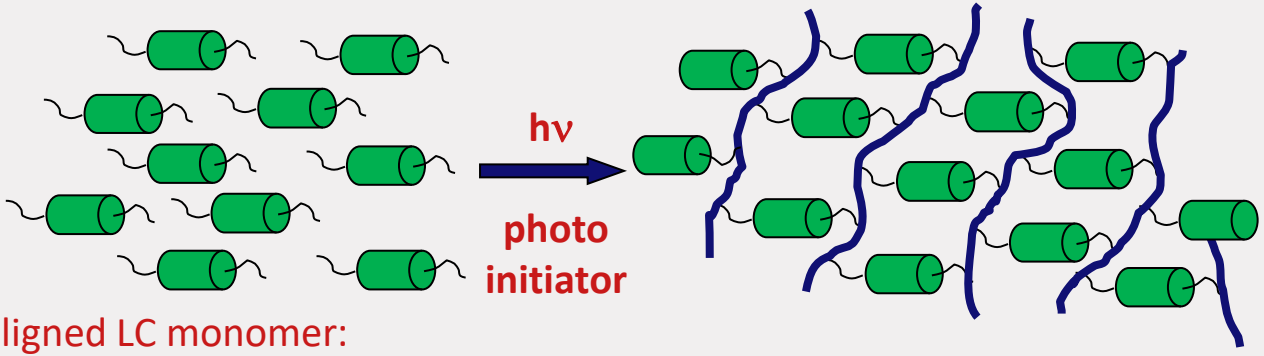
Stimuli-responsive materials based on LCs



liquid crystal with reactive end groups



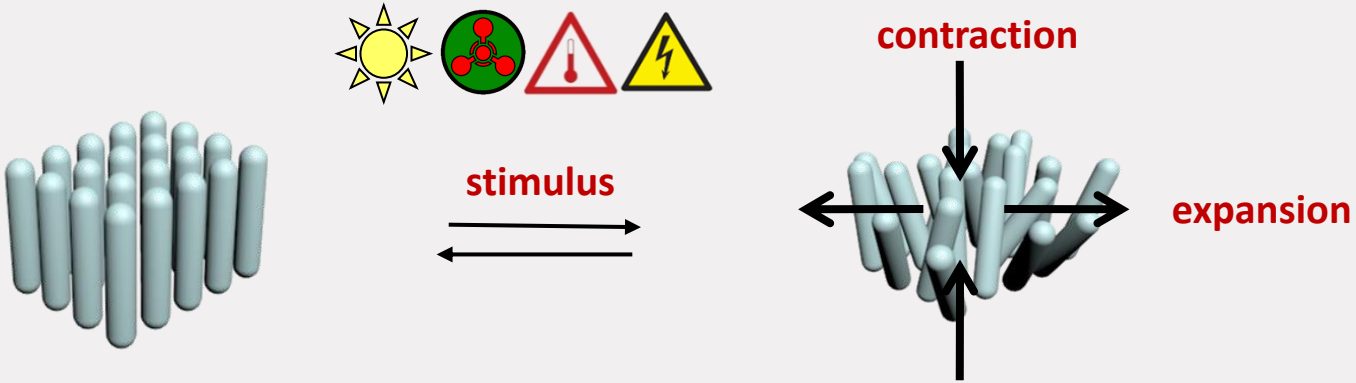




aligned LC monomer:
alignment layers
electric/magnetic field
shear, flow

often glassy polymers

Stimuli-responsive materials based on LCs



- Response is caused by a small reversible change of the local molecular order, solvents are not needed
- Disorder is induced by triggering molecules that respond to temperature, humidity, light, and/or chemicals (among others)

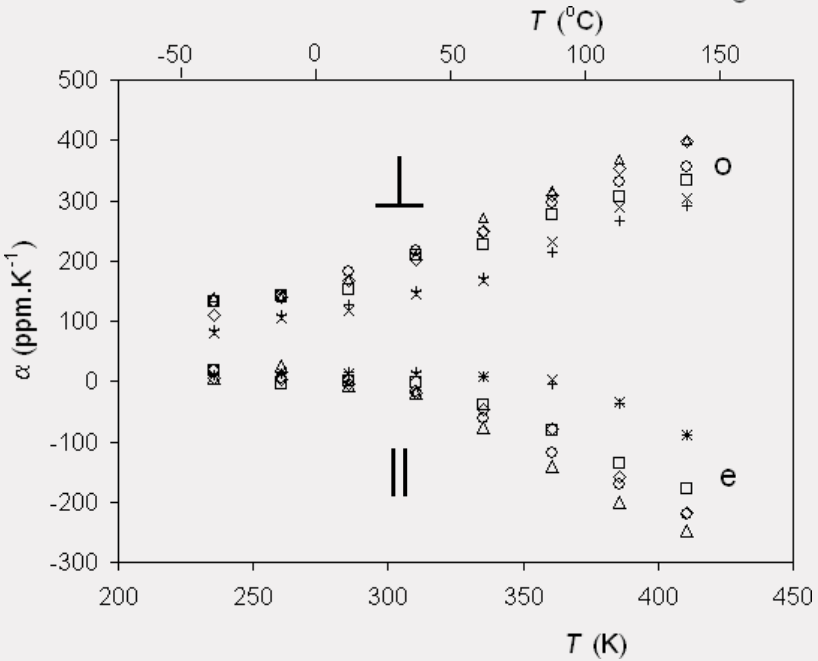
TU/e

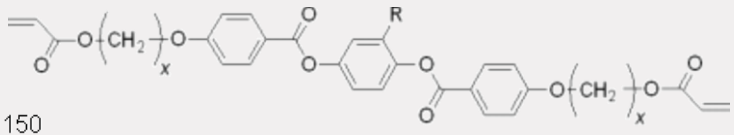
Soft actuators, Shape changing polymers

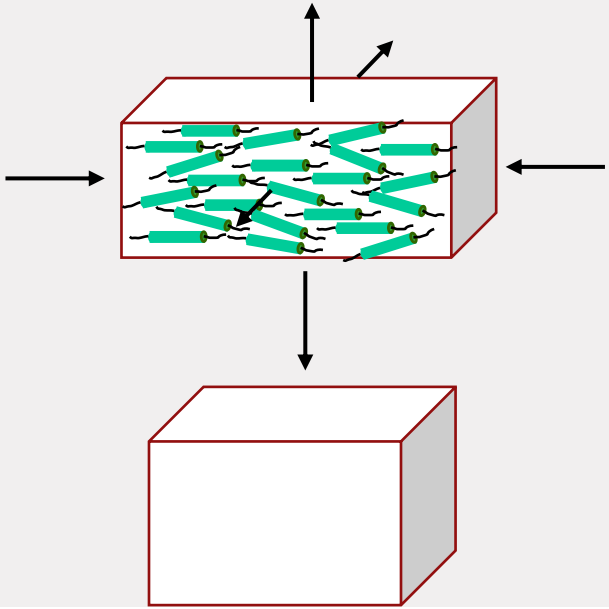
Like living organisms
Increased flexibility & adaptability for accomplishing tasks
Improved safety

Soft actuators based on LCs

Thermal Expansion Coefficient





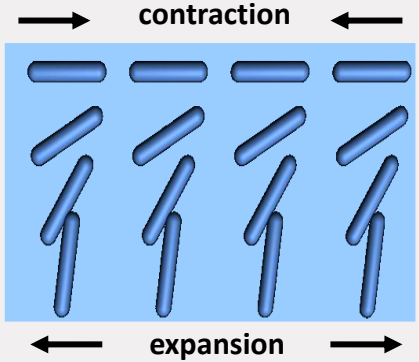


Adv. Funct. Mater. 2005, 15, 1155 - 1159

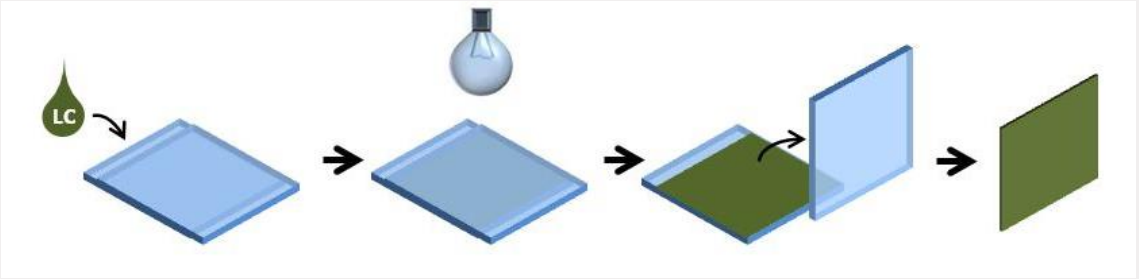
TU/e

Liquid crystal based soft actuator (bending)

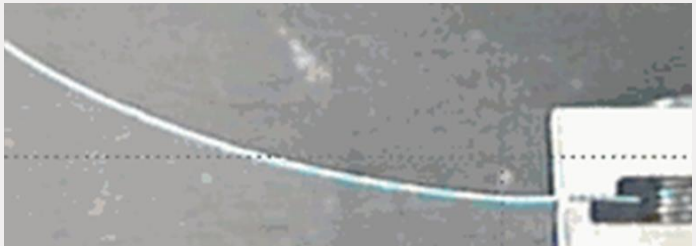
Bending: Splay network

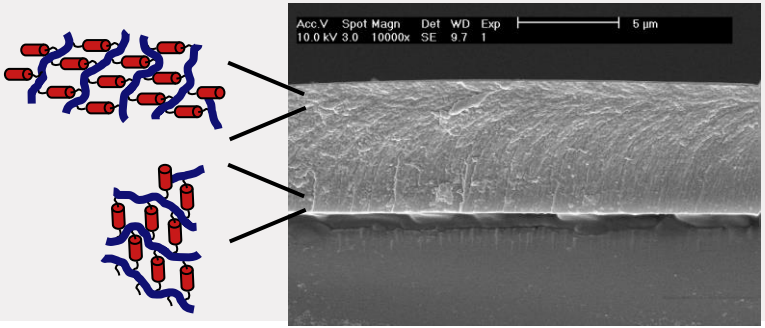


Preparation of the polymer film

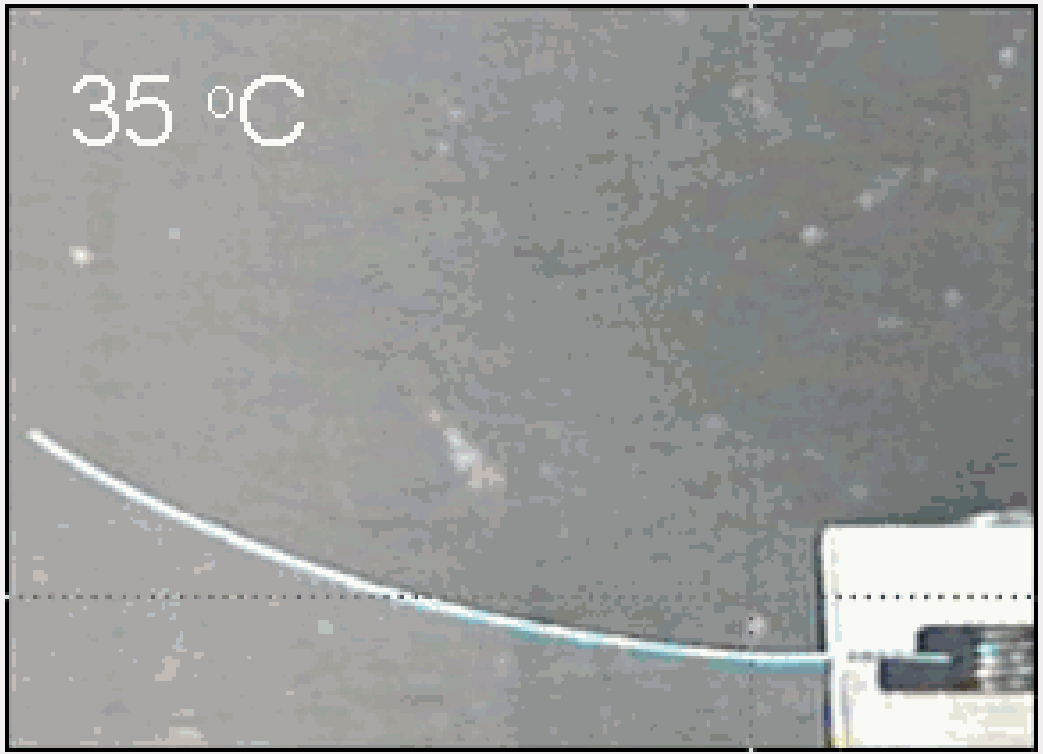


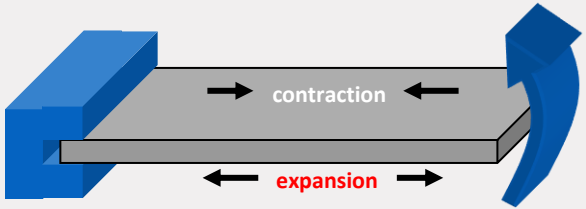
Polymer film





Thermal induced bending

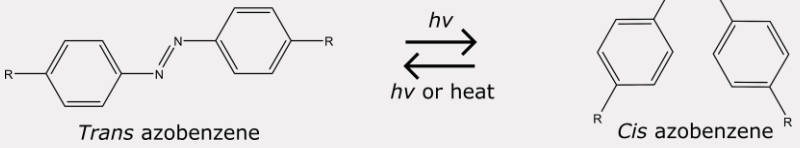




Adv. Funct. Mater. 2005, 15, 1155-1159

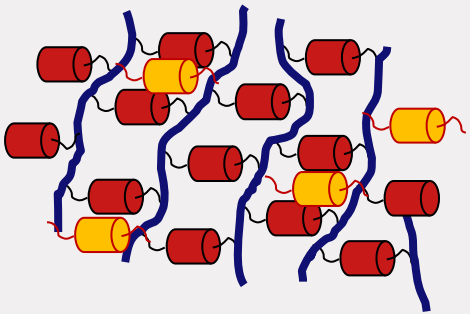
Titie Mol, Dick Broer

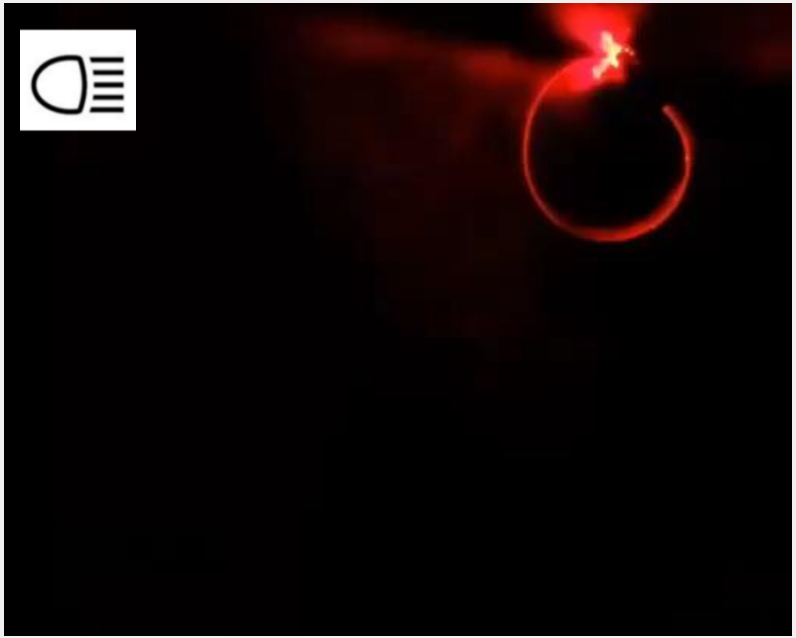
Light responsive actuators



Trans azobenzene

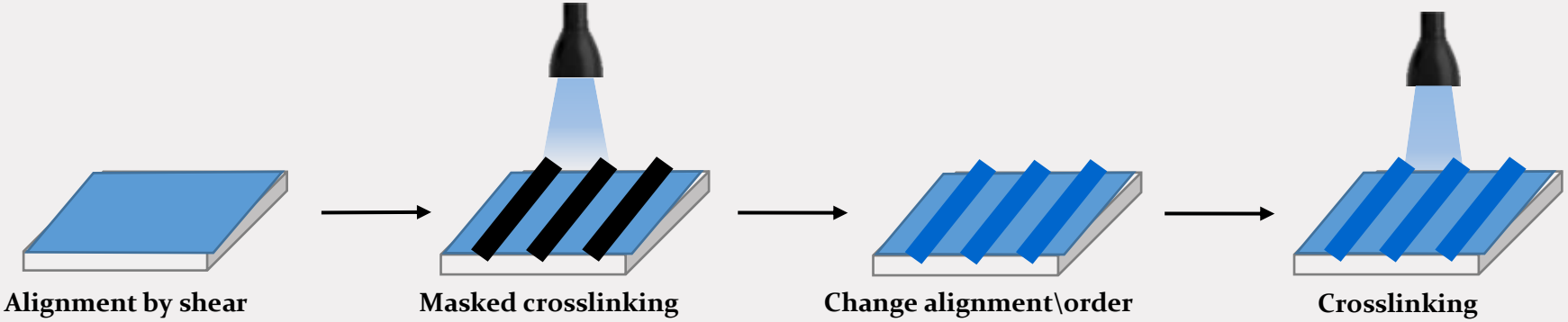
Cis azobenzene



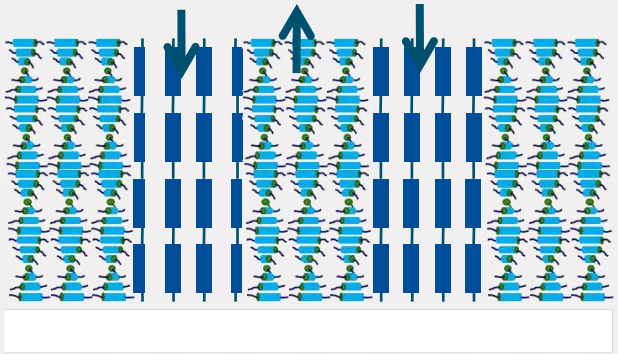


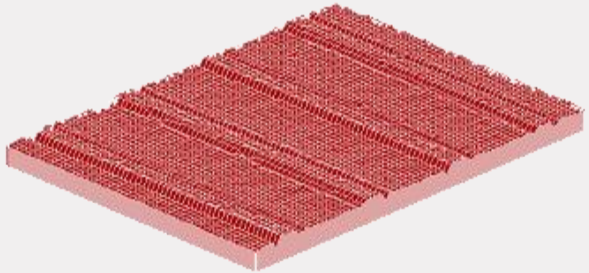
Splay network

How to prepare (patterned) LC coatings

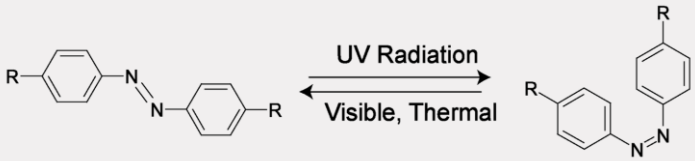


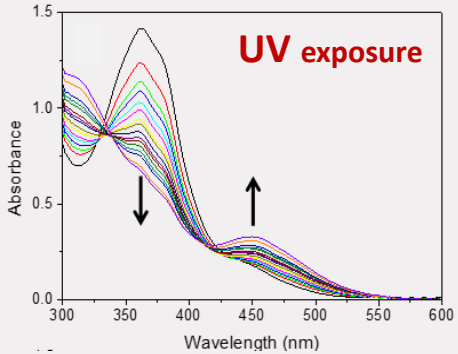
Light Responsive Surface Topographies

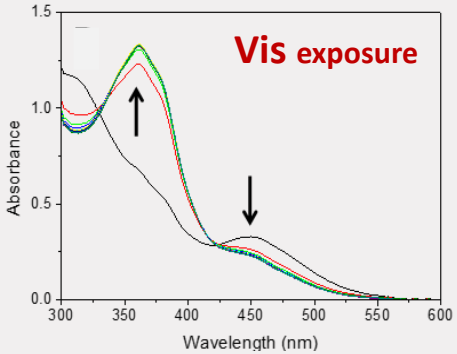




Danqing Liu, Dick Broer



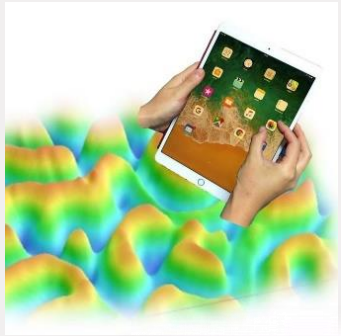


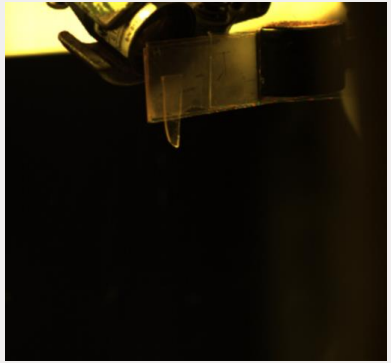


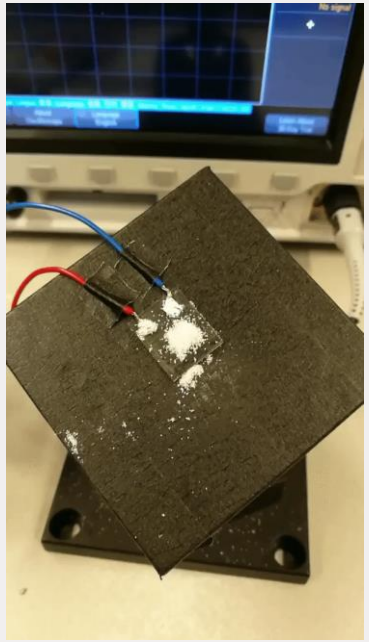
TU/e

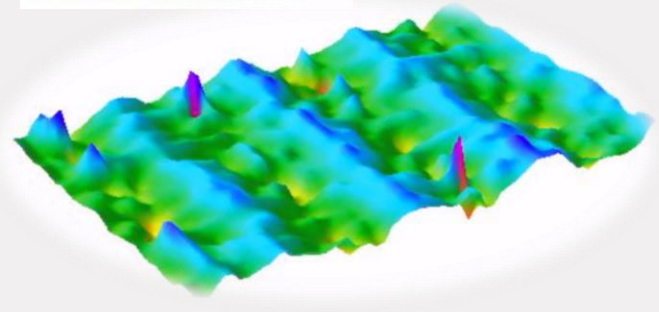
Stimuli-Responsive Surface Topographies, Applications

antifouling, self-cleaning, haptics









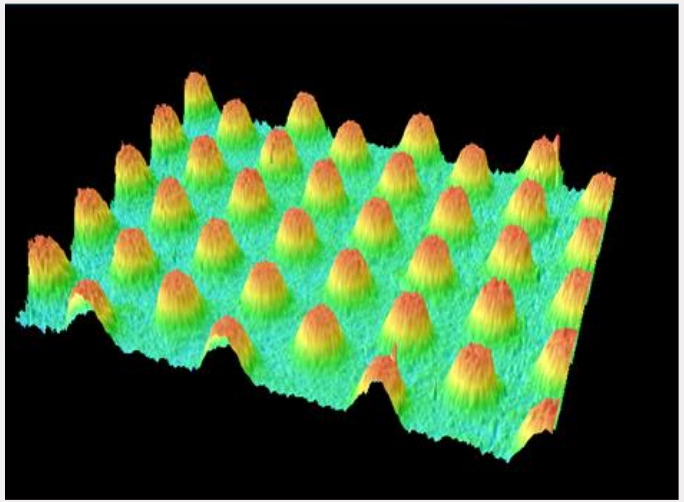
Danqing Liu, Dick Broer

TU/e

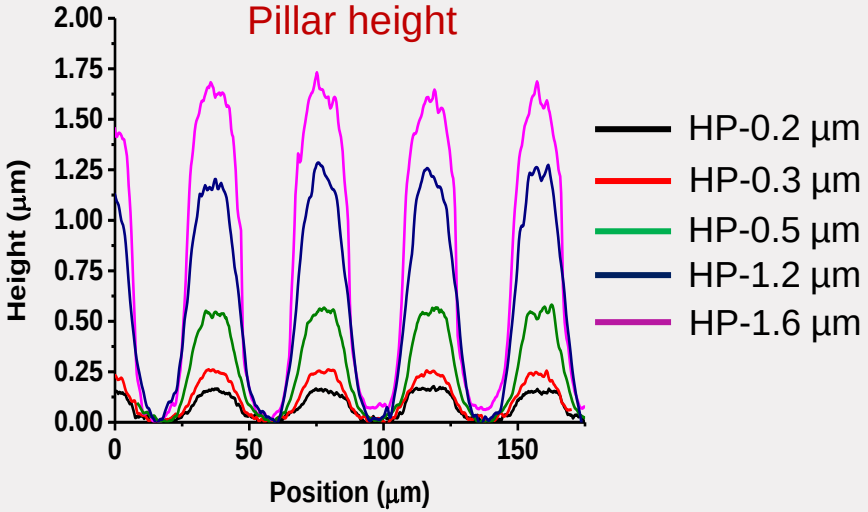
Self-cleaning solar panels

Other applications:
Regenerative medicine
to direct (stem) cell adhesion,
spreading, migration and differentiation and tissue organization

Pillars made by Light for Cells



Jeroen ter Schiphorst



Height depends on illumination intensity, sample thickness

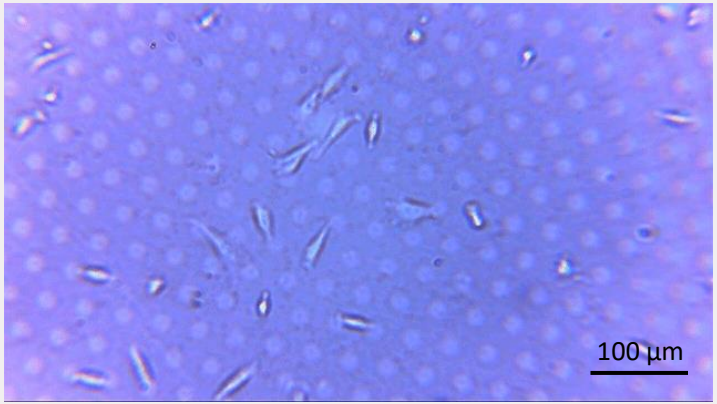
Adv. Mater. 2017, 29, 1606407

TU/e

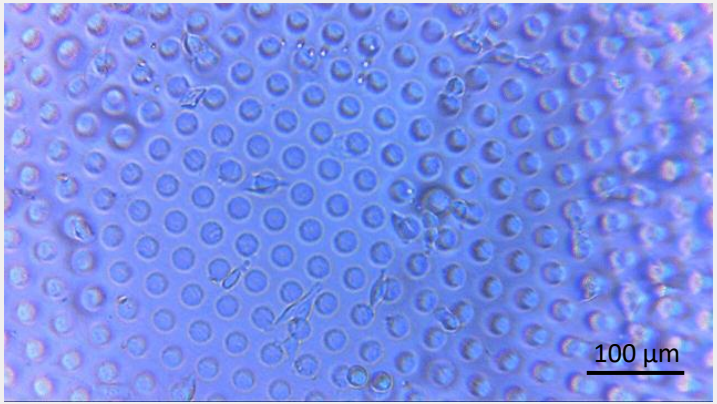
Cells on Pillared Structures

Used cells: NIH-3T3 Fibroblast (connective tissue cells)

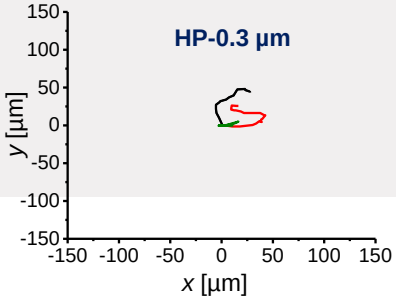
0.3 µm pillars



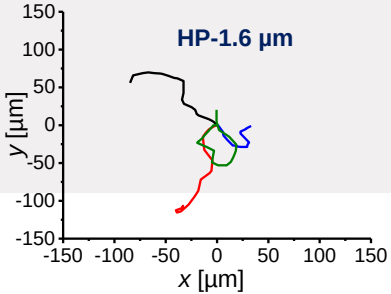
1.6 µm pillars



Cells on pillars



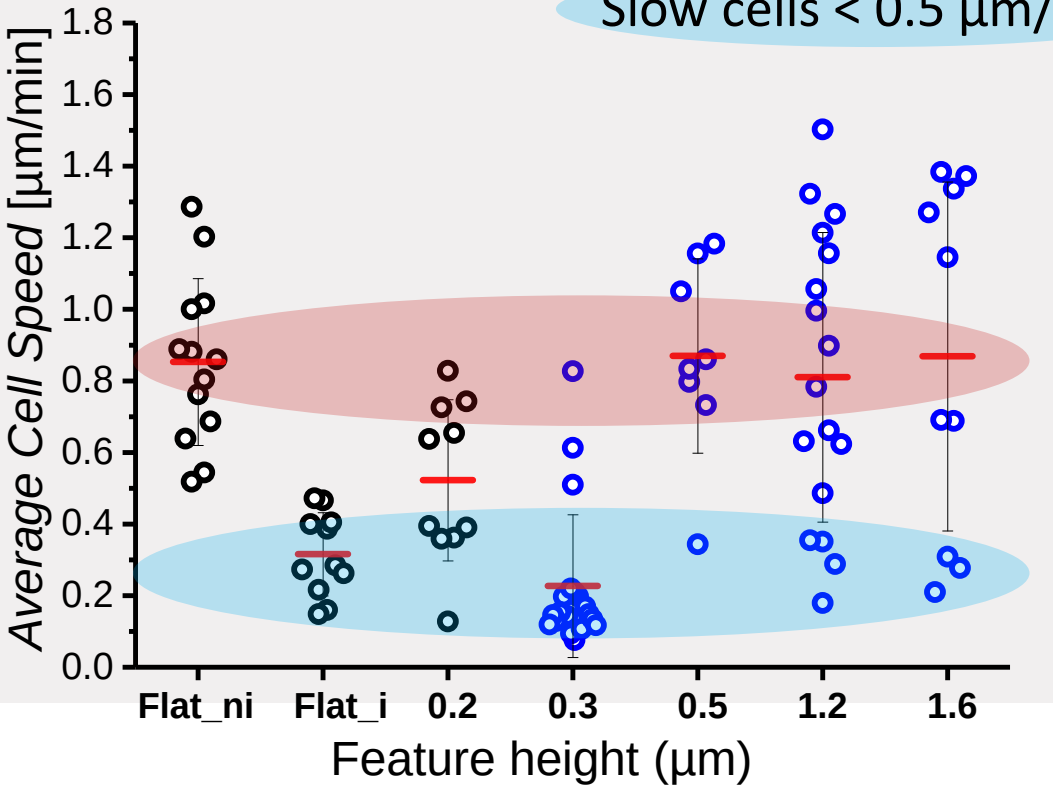
Cells have no preference



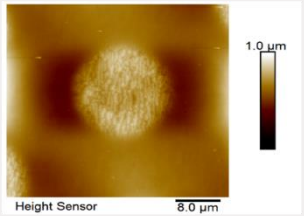
Understanding the migration

Fast cells > 0.5 µm/min

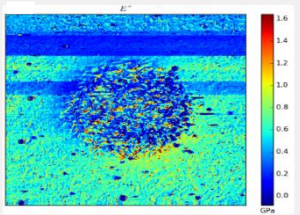
Slow cells < 0.5 µm/min



Roughness pillar: 55 nm vs 10 nm

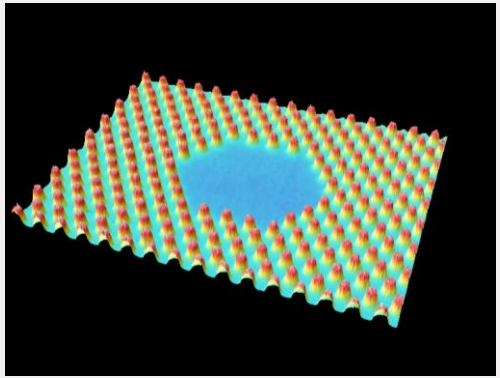


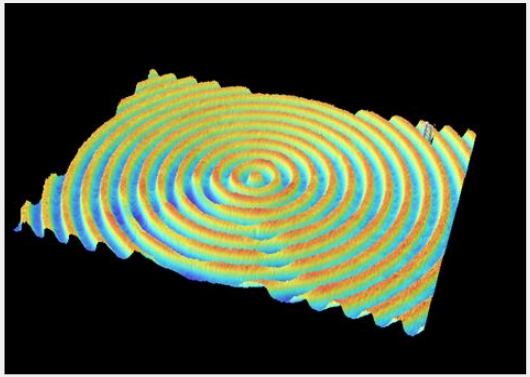
Elastic modulus: 0.5-0.7 GPa vs 1 GPa

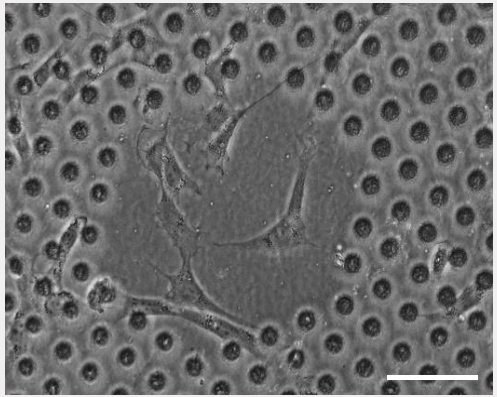


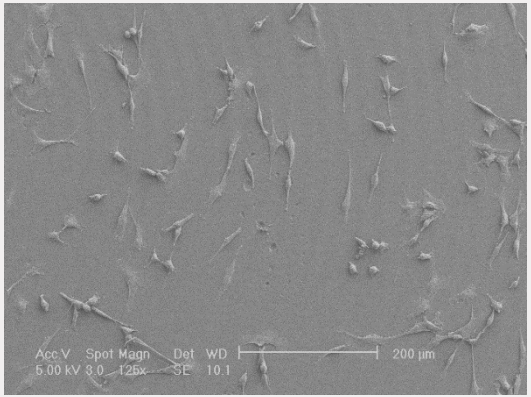
TU/e

Directing Cell Migration





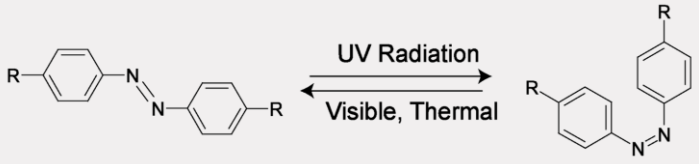


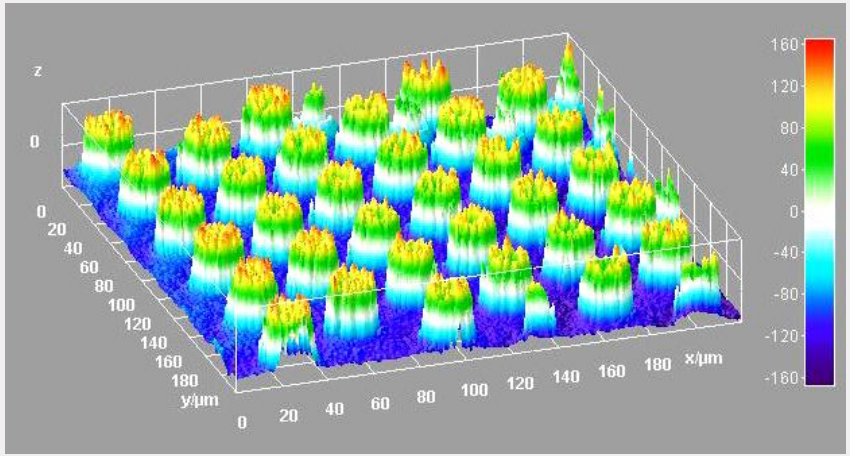


together with Gülistan Koçer, and Pascal Jonkheijm, University Twente

TU/e

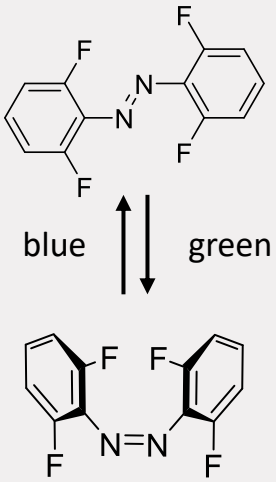
Towards visible light responsive surfaces





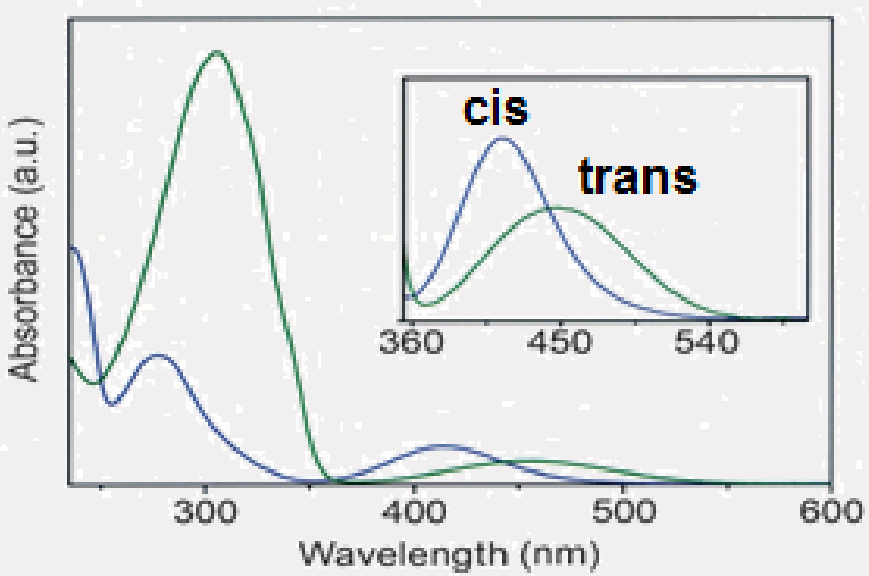
Visible light responsive surfaces, multi stable surfaces

Fluor-substituted azobenzene



Cis isomer has a very long lifetime: years!

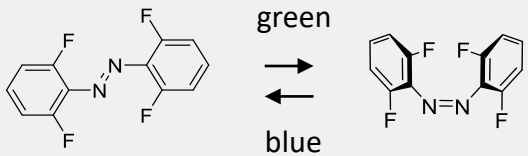
n → π* bands of *cis* and *trans* isomers

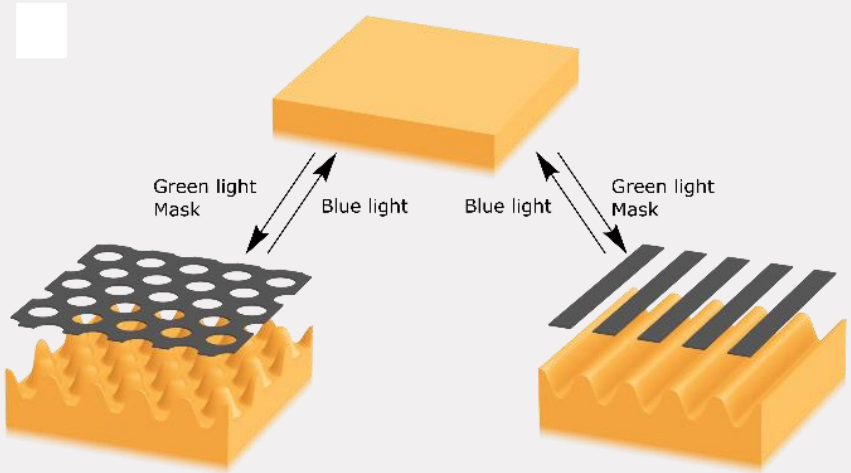


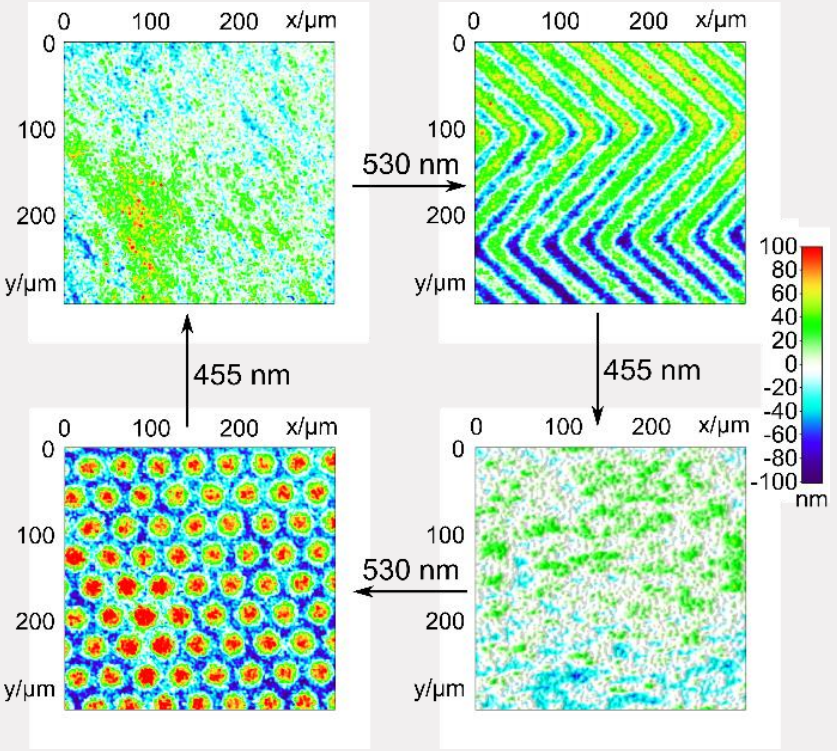
Hecht, Bleger et al, J. Am. Chem. Soc. 2012, 134, 20597

TU/e

Re-configurable visible light responsive surface topographies

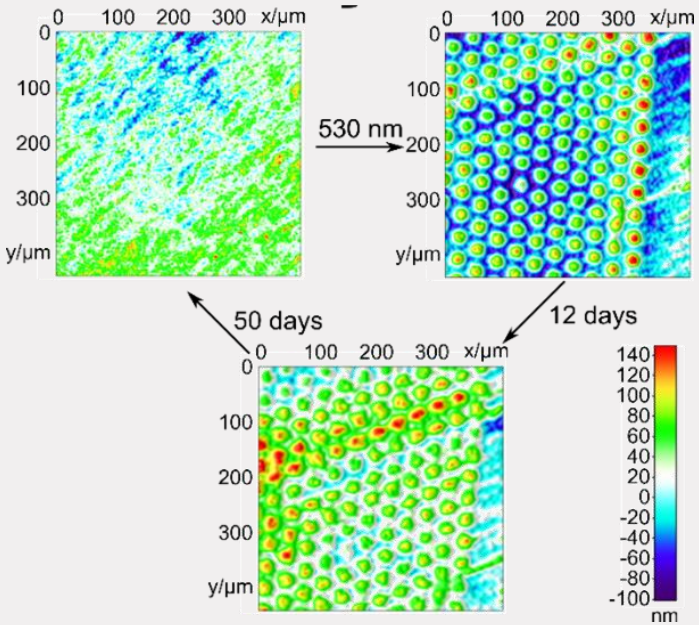


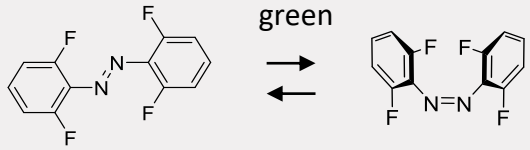


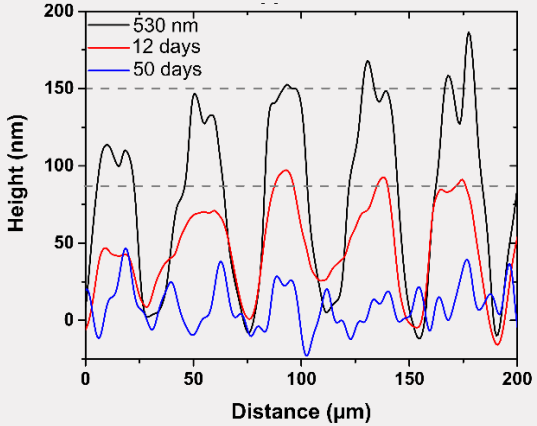


Stable visible light responsive surface topographies

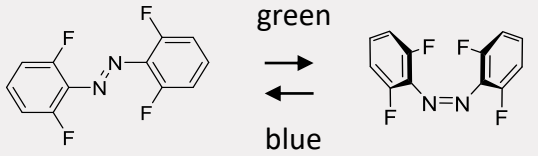
Green light

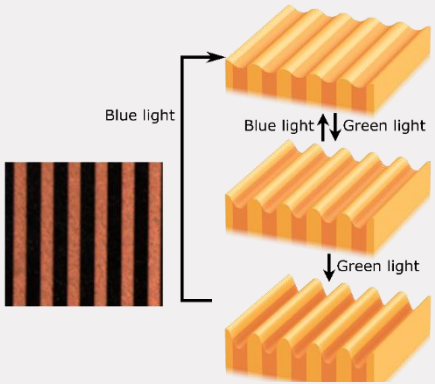


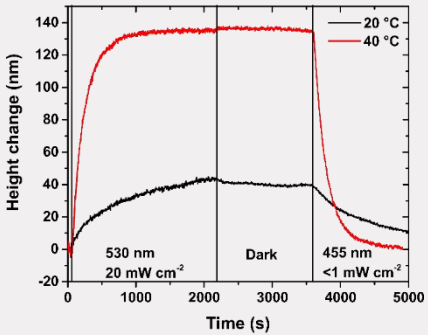


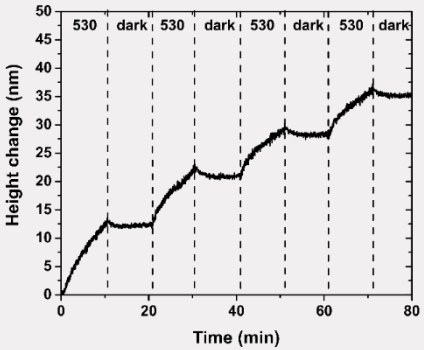


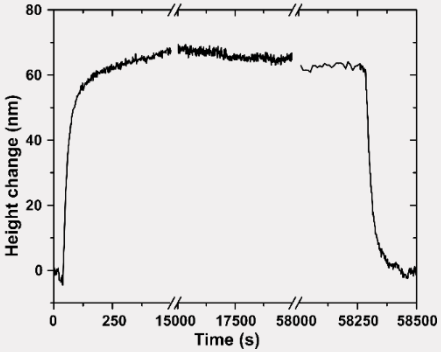
Pre-configurable multi-stable visible light responsive surface topographies











Dynamic Coatings as Antimicrobial Coatings?

Surfaces with antimicrobial properties based on special metal- or metal oxide-layers or on immobilised biocides.
Photodynamically switchable surface coatings that can change their topology in distinct microscale areas and thereby prevent the adhesion of microorganisms.

Taking dynamic coatings to the next level; challenges and obstacles

Kathleen Stout, PhD. - Zuyd Hogeschool & Cyriel Mentink, PhD. - CHILL - Geleen (Netherlands)

TU/e

Acknowledgement