

Light and Thermal Responsive Liquid Crystal Films

For Micro Robotic Applications

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2019 CNF REU PROGRAM



Cornell
University





Harvard's Octobot



5 mm

15x playback

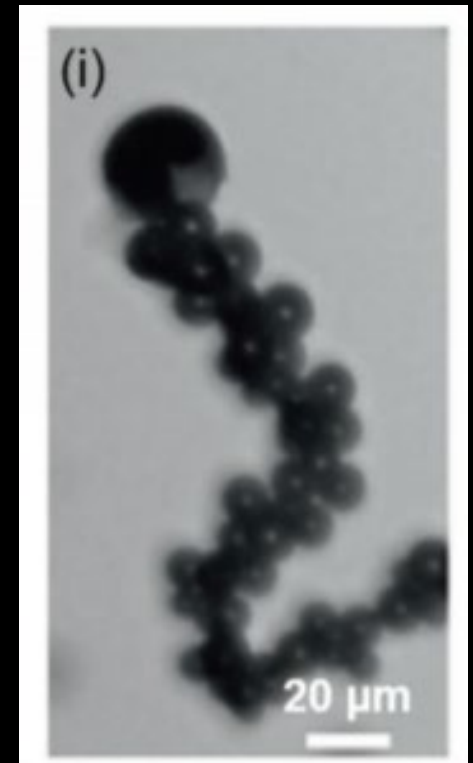
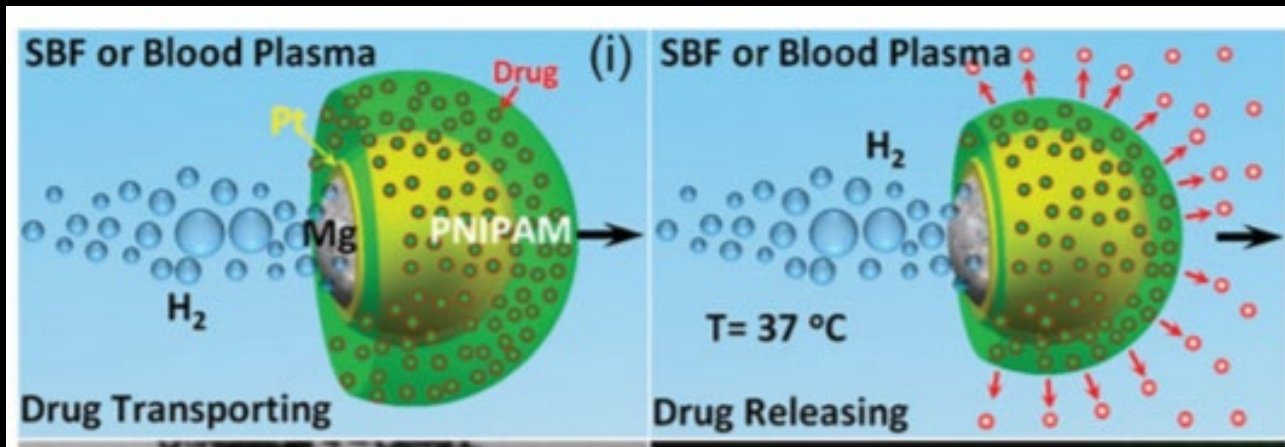


<https://www.youtube.com/watch?v=CDohWwEXQ68>

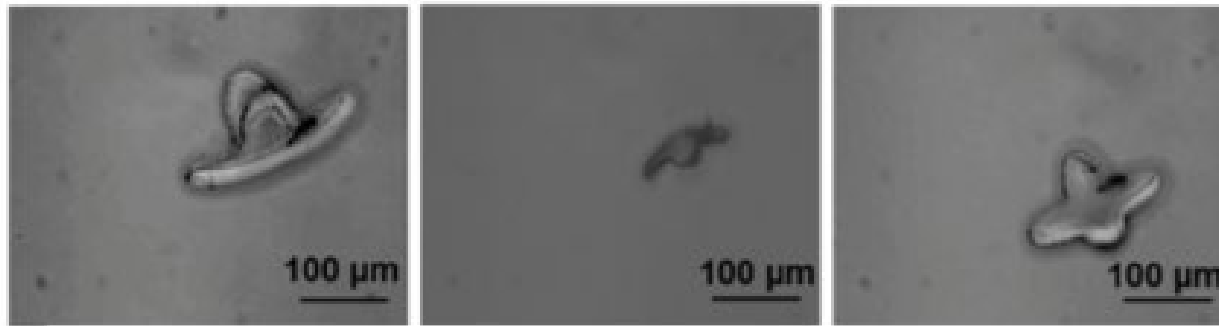


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and Technology Facility

Current Micro"robots"



Heat-driven
microrobots



Mariana Sanchez, Swimming Microrobots: Soft, Reconfigurable, Smart, Advanced Functional Materials,(2018)

Research Goal

- **Create a soft microrobot that is small, functional, and versatile**



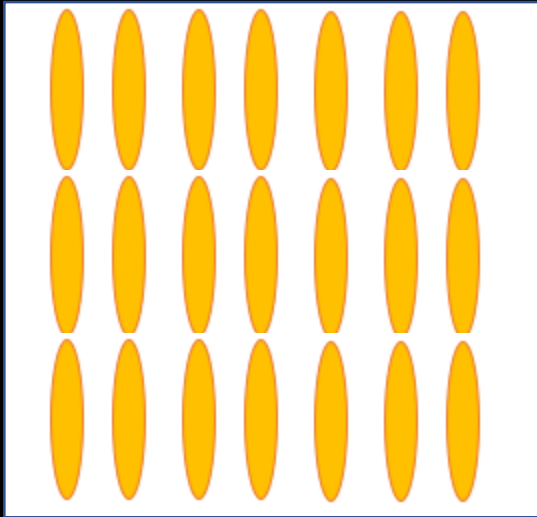
What is Needed

- **Decrease size**
- **Control film by changing alignment of liquid crystal (LC)**
- **Make it responsive to external stimuli**

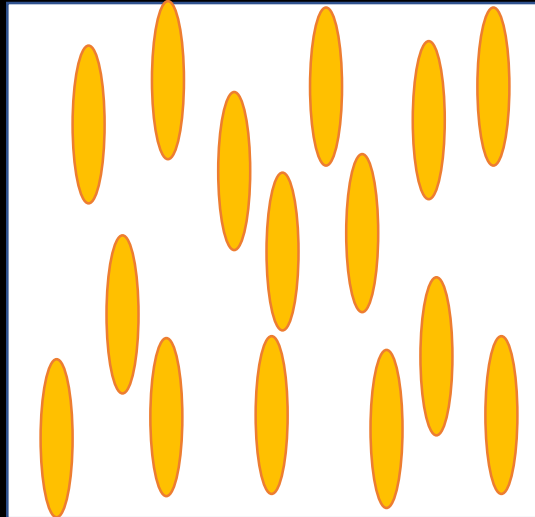


LC Phases

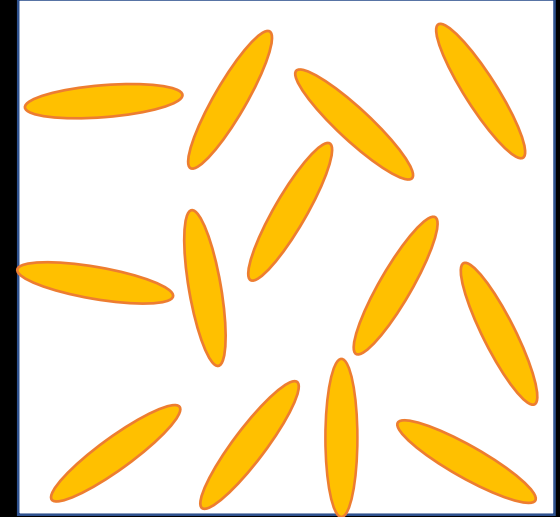
Crystal



Liquid Crystal



Isotropic

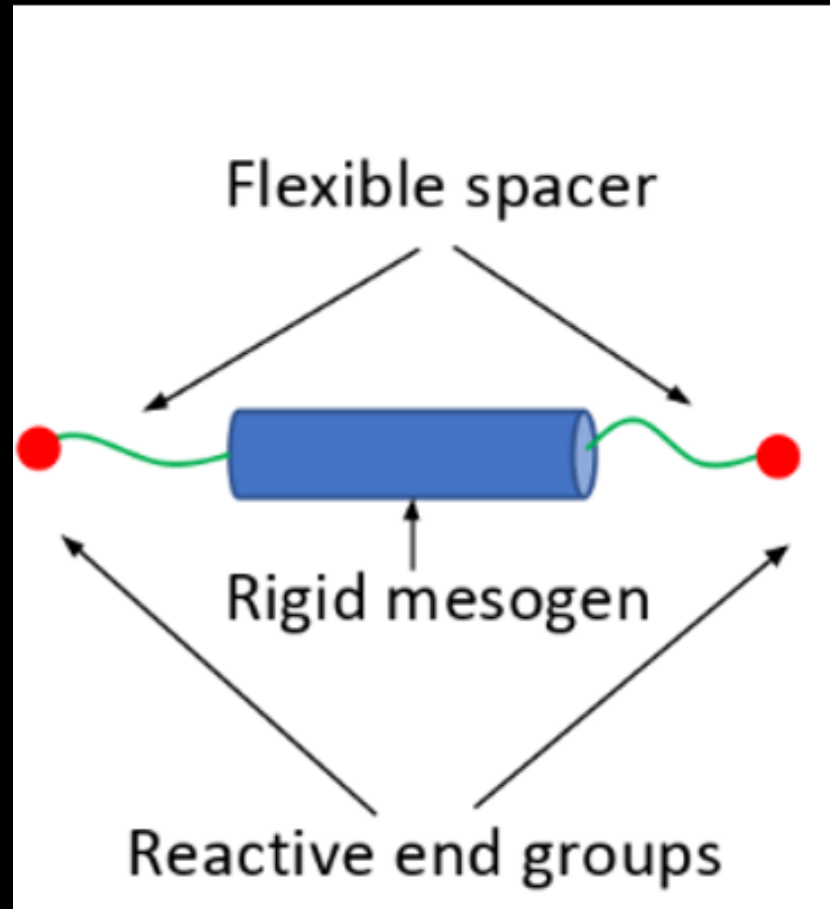


Temperature Increase

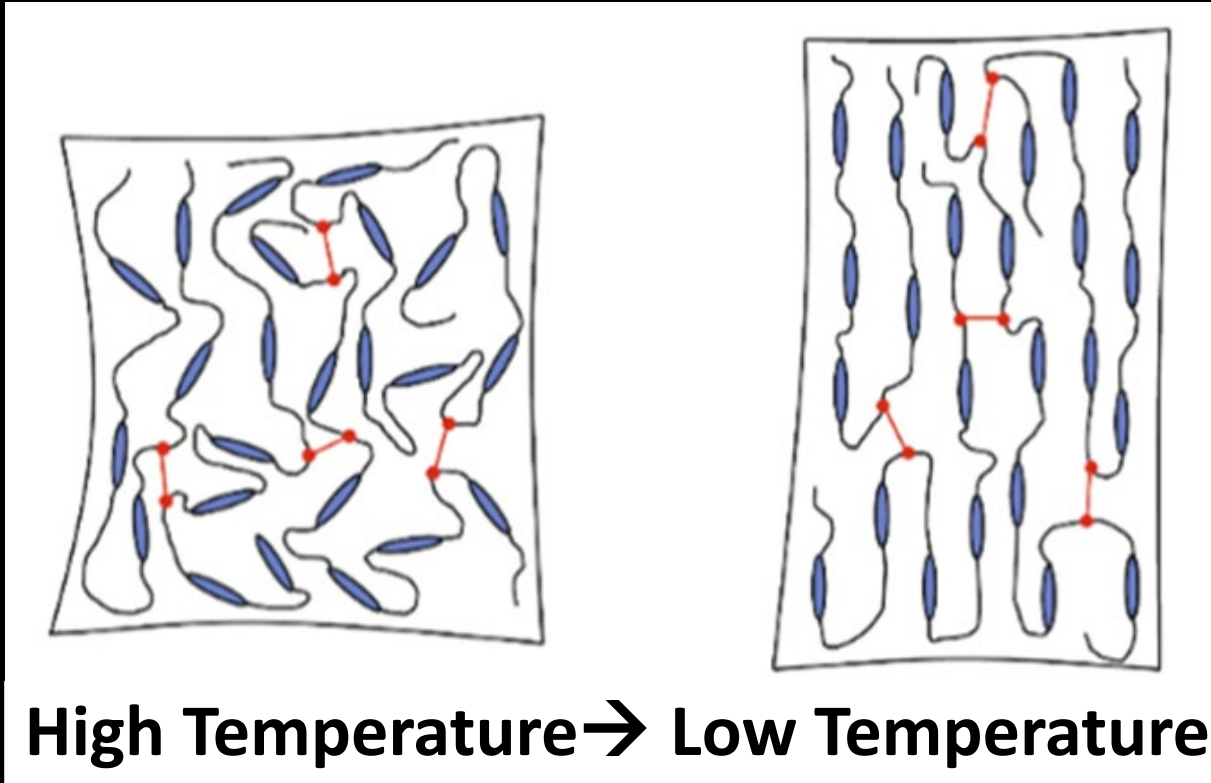


Liquid Crystal Polymer

LC molecules form polymer



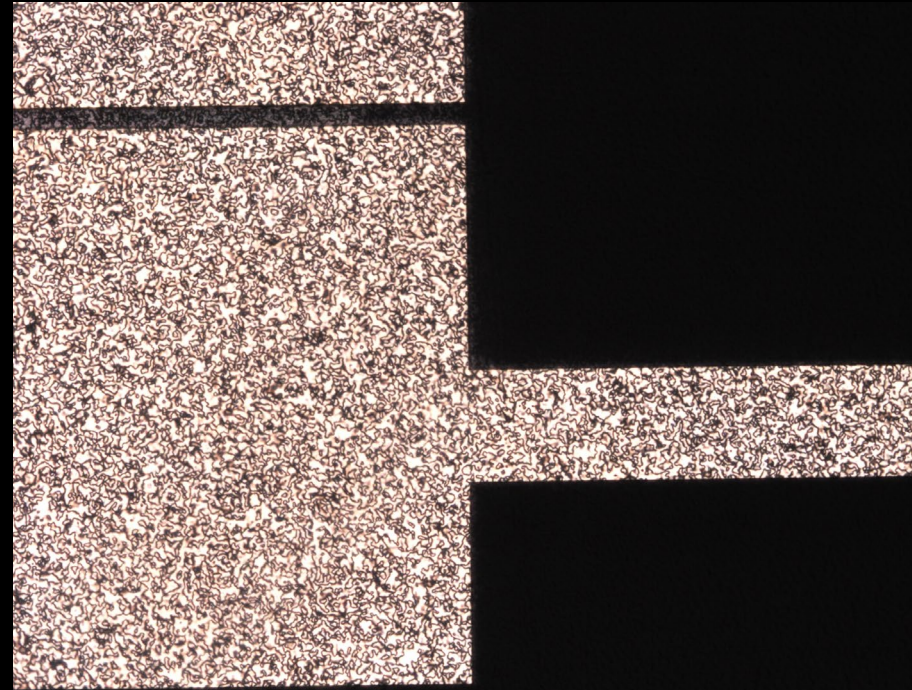
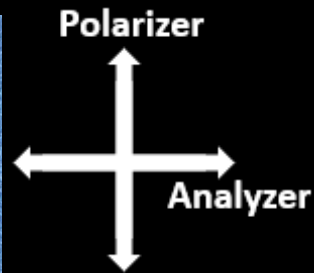
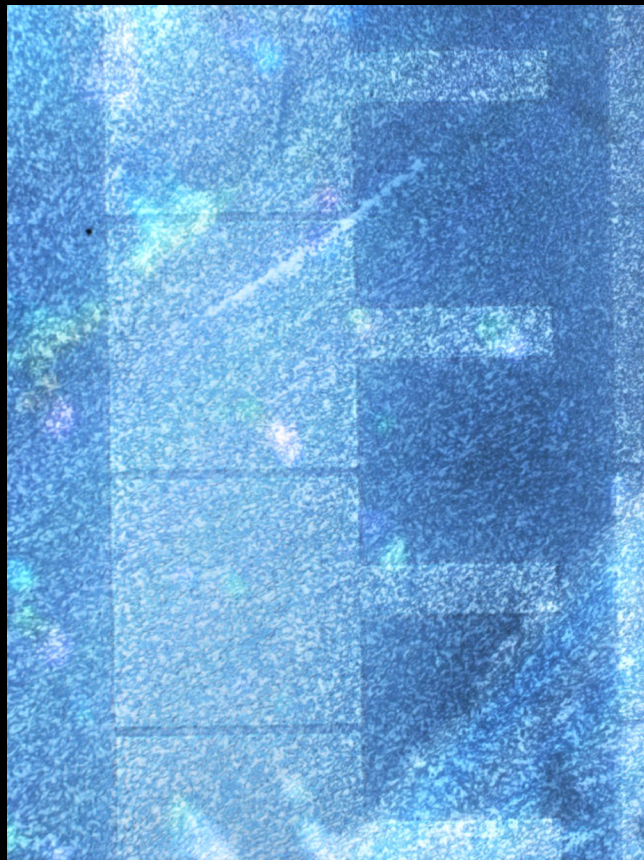
Liquid Crystal Polymer Response



Phase transition by light:

- Photo-thermal effect
- Photoisomerization effect

Creating the LC Polymeric Patterns

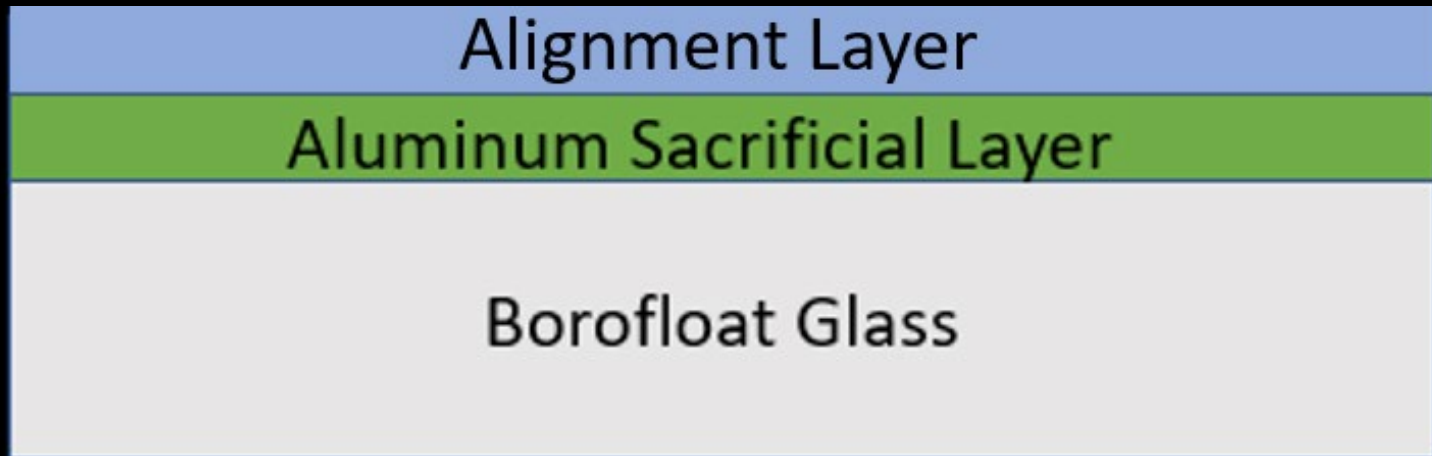
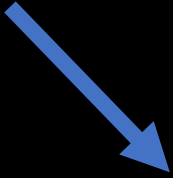


100 μm

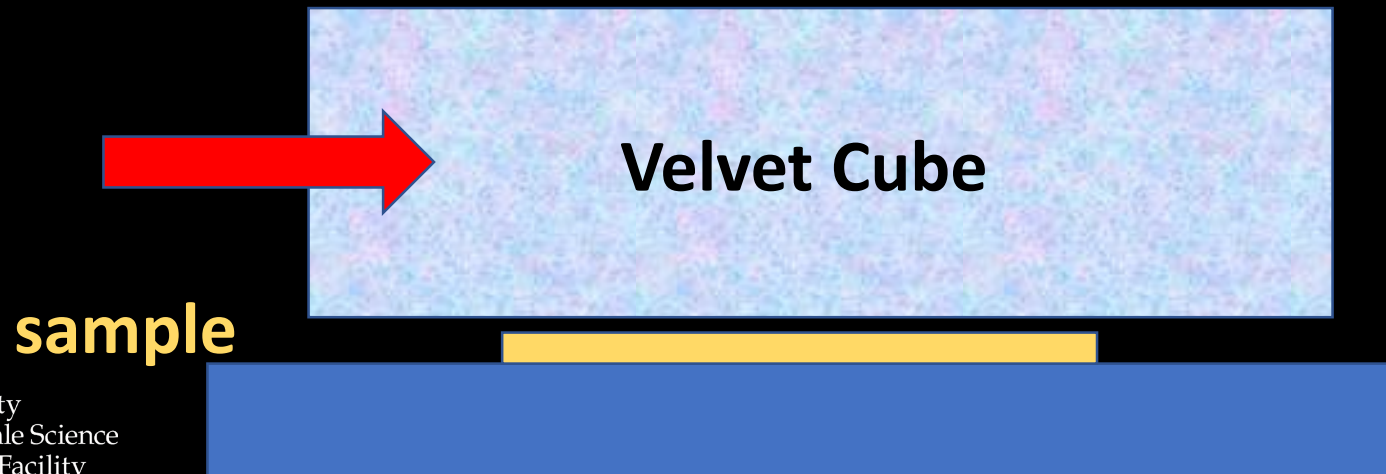
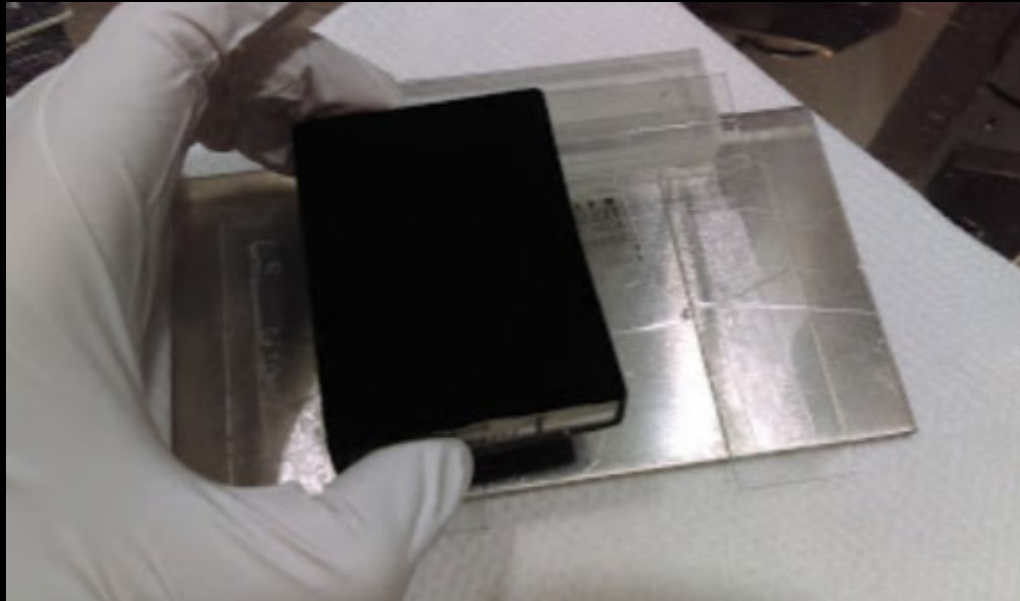


Alignment

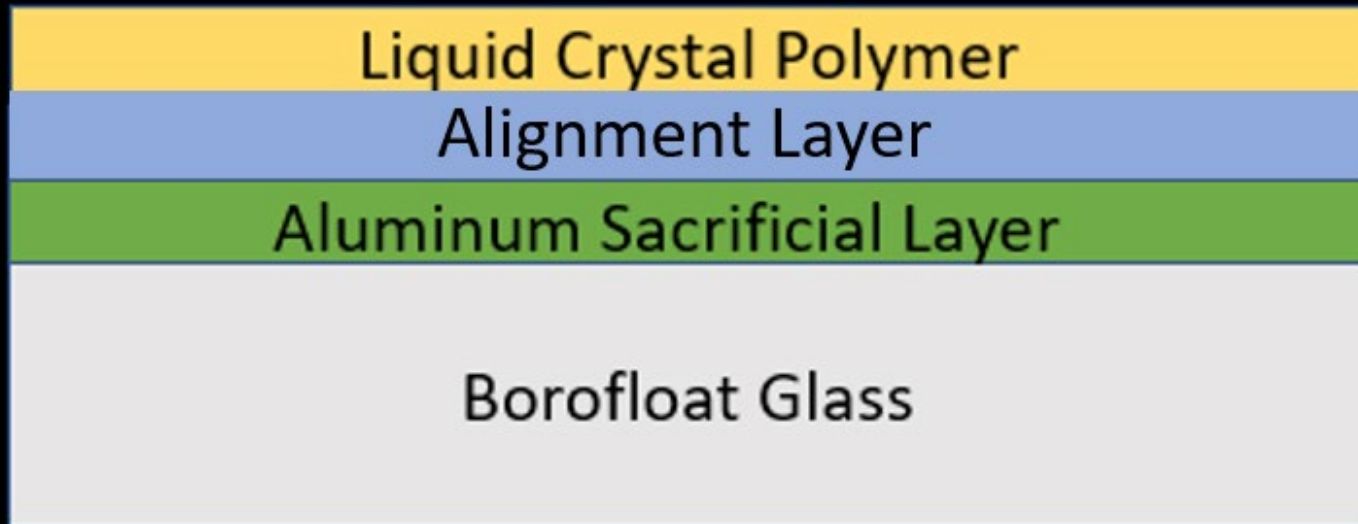
PI 2555

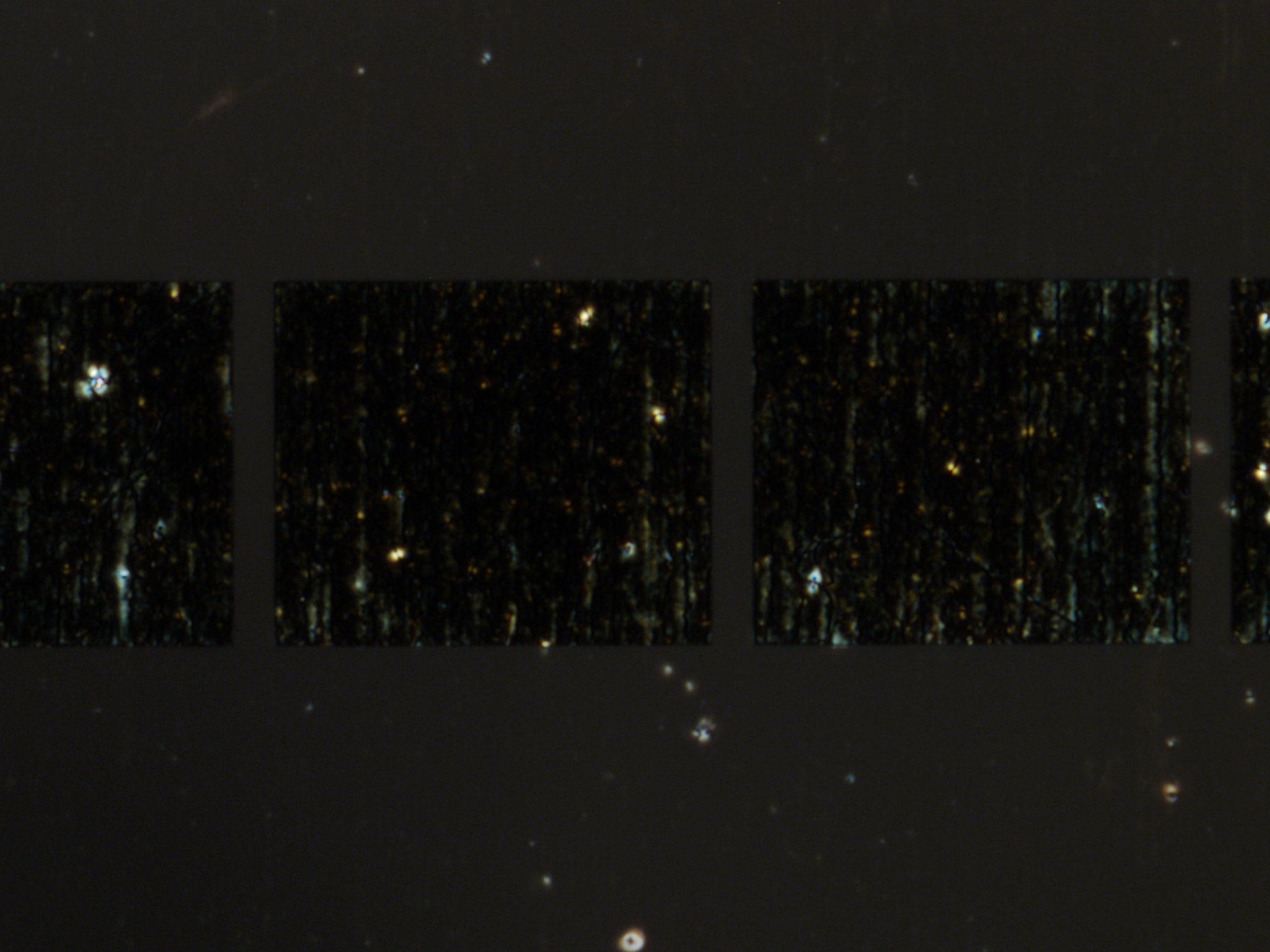


Aligning the LC

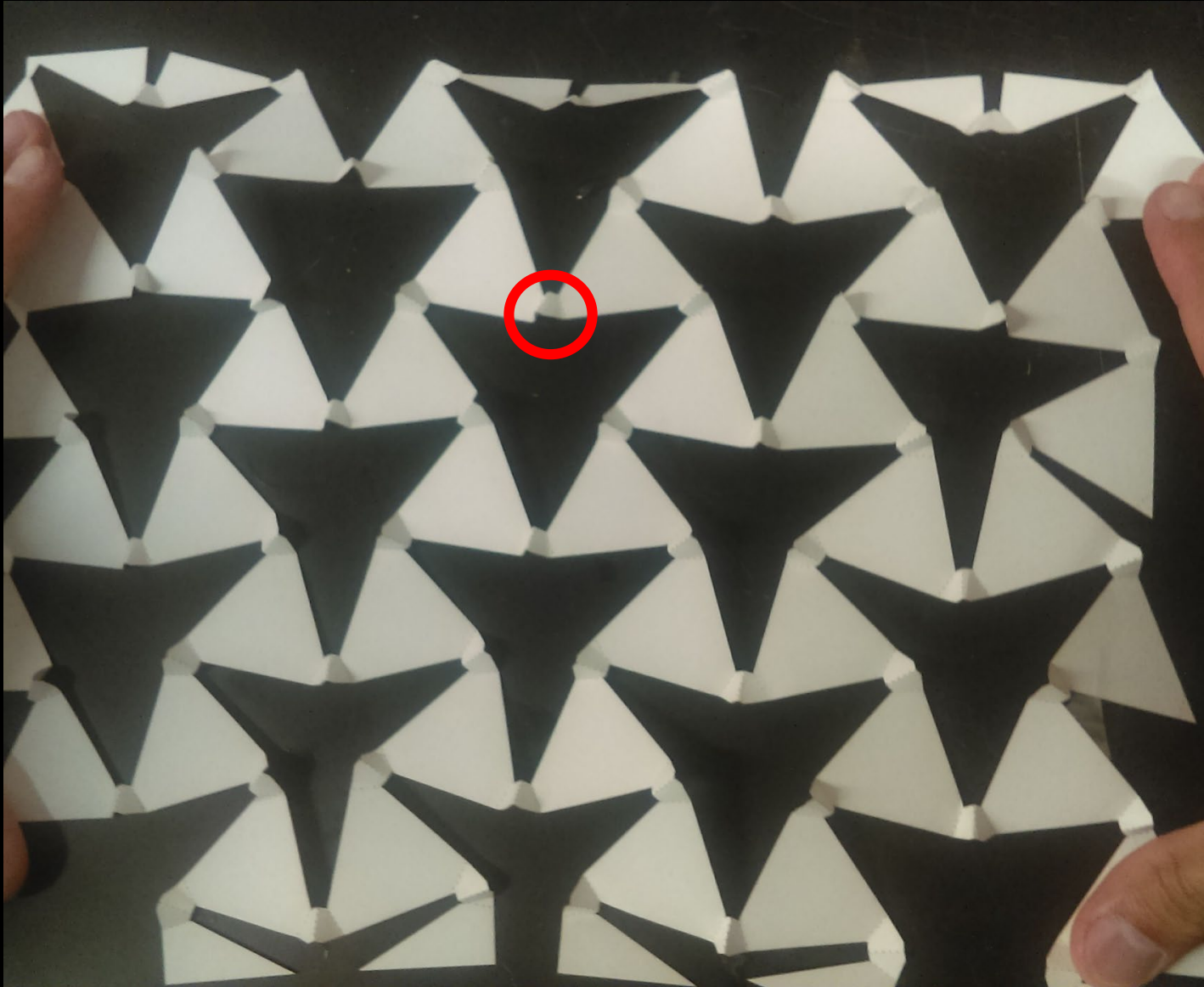


Alignment





Auxetic Patterns

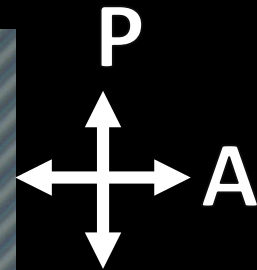
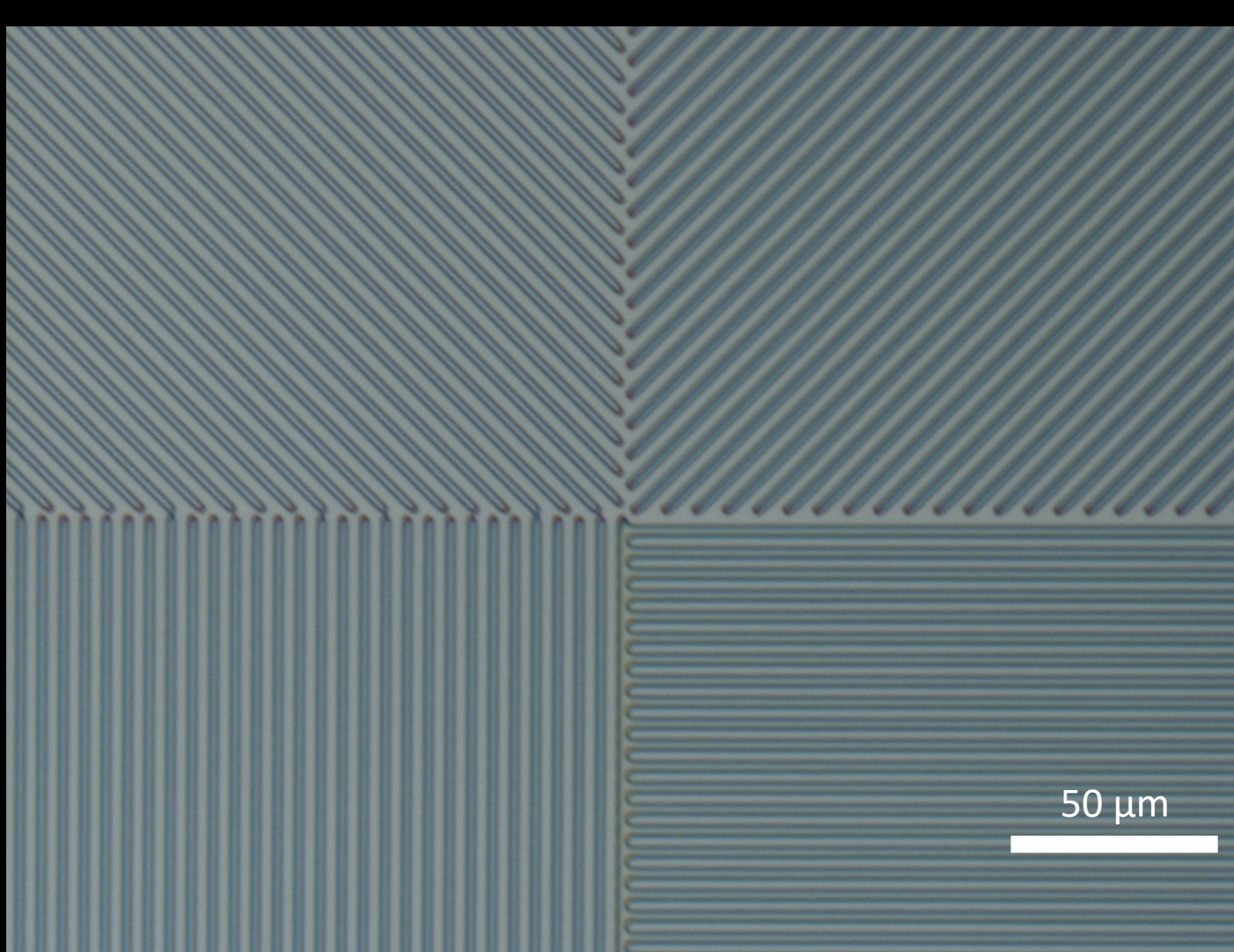


Hillel Aharoni, Universal Inverse Design of Surfaces with Thin Nematic Elastomer Sheets, PNAS (2018)

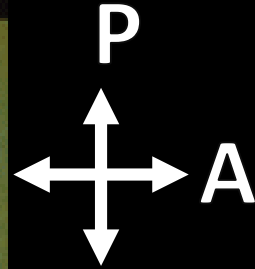
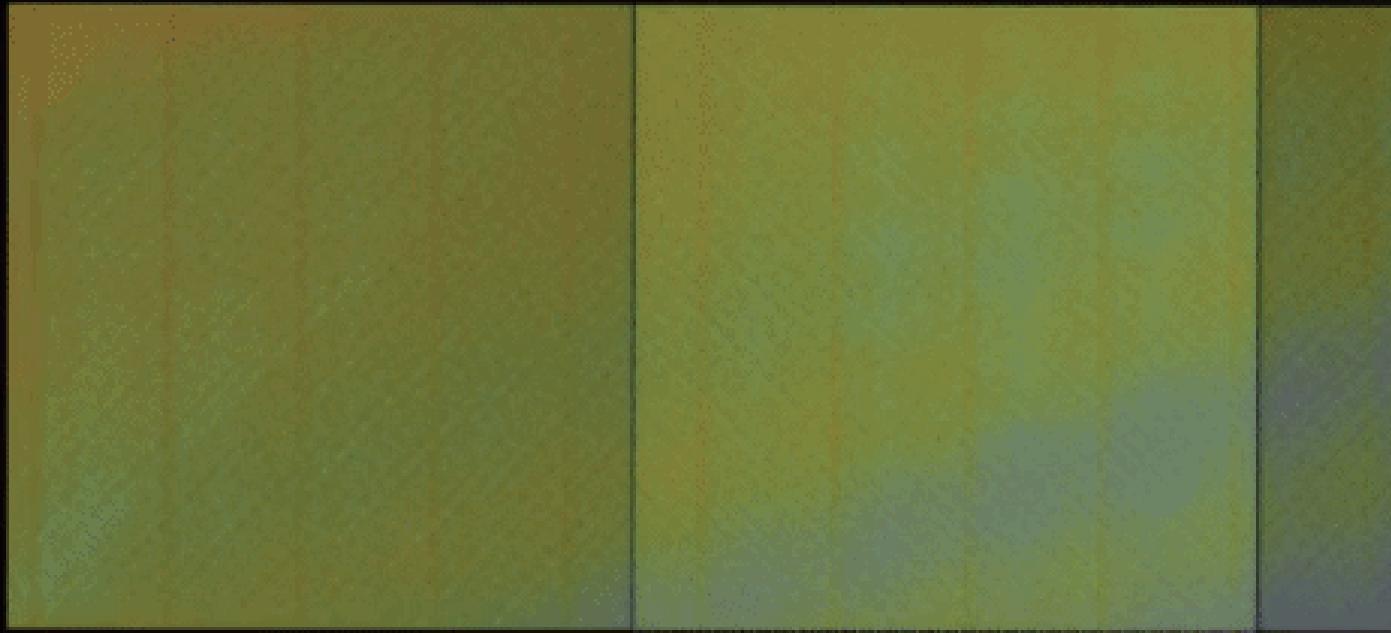
The chemical structure shows a linear chain of carbon atoms. The first three carbons are part of a 1,1,2,2-tetrafluoroethyl group (CF₂CH₂CF₂). This is followed by a repeating unit of 1,1,2,2-tetrafluoroethylene (CF₂=CF-CF₂-CF₂) where the double bond is represented by a zigzag line. The chain ends with a propyl group attached to a silicon atom, which is also bonded to three chlorine atoms (SiCl₃). The entire structure is highlighted with a red oval.



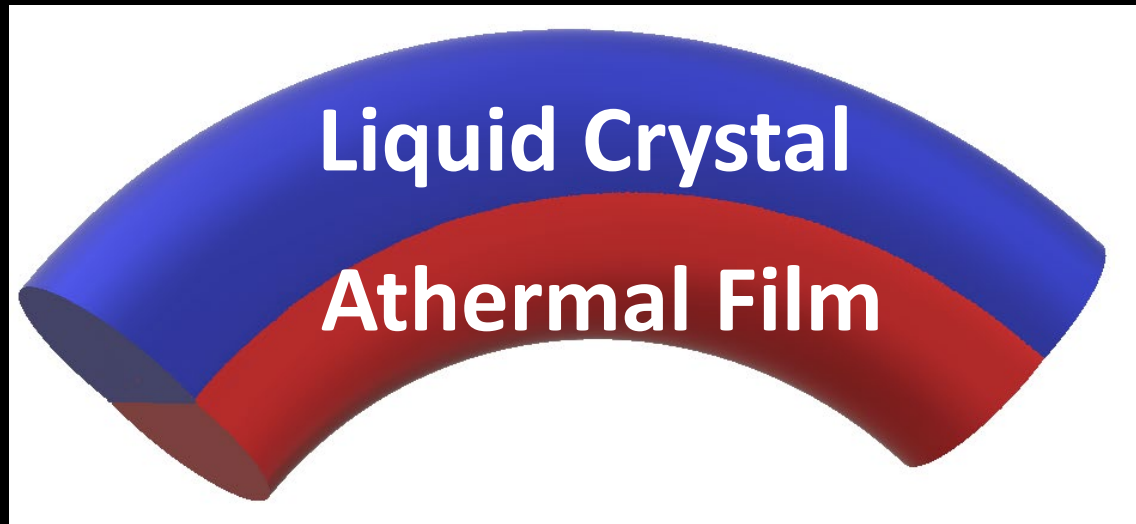
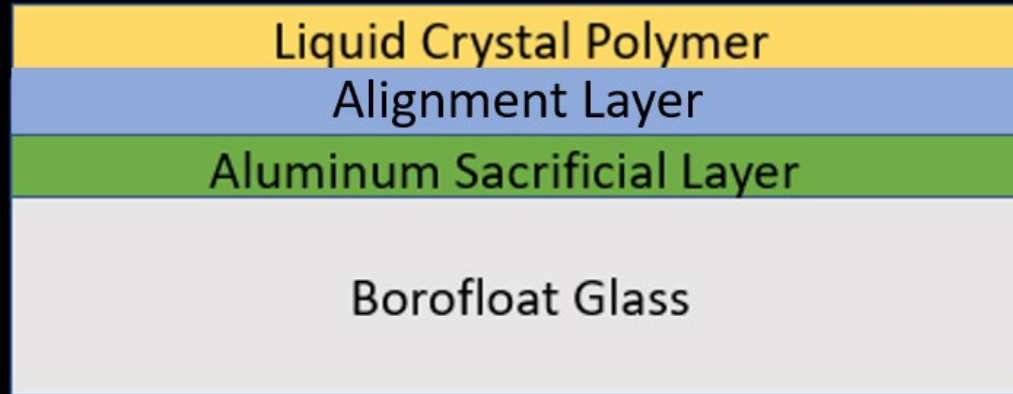
1.5 μm grooves in Si



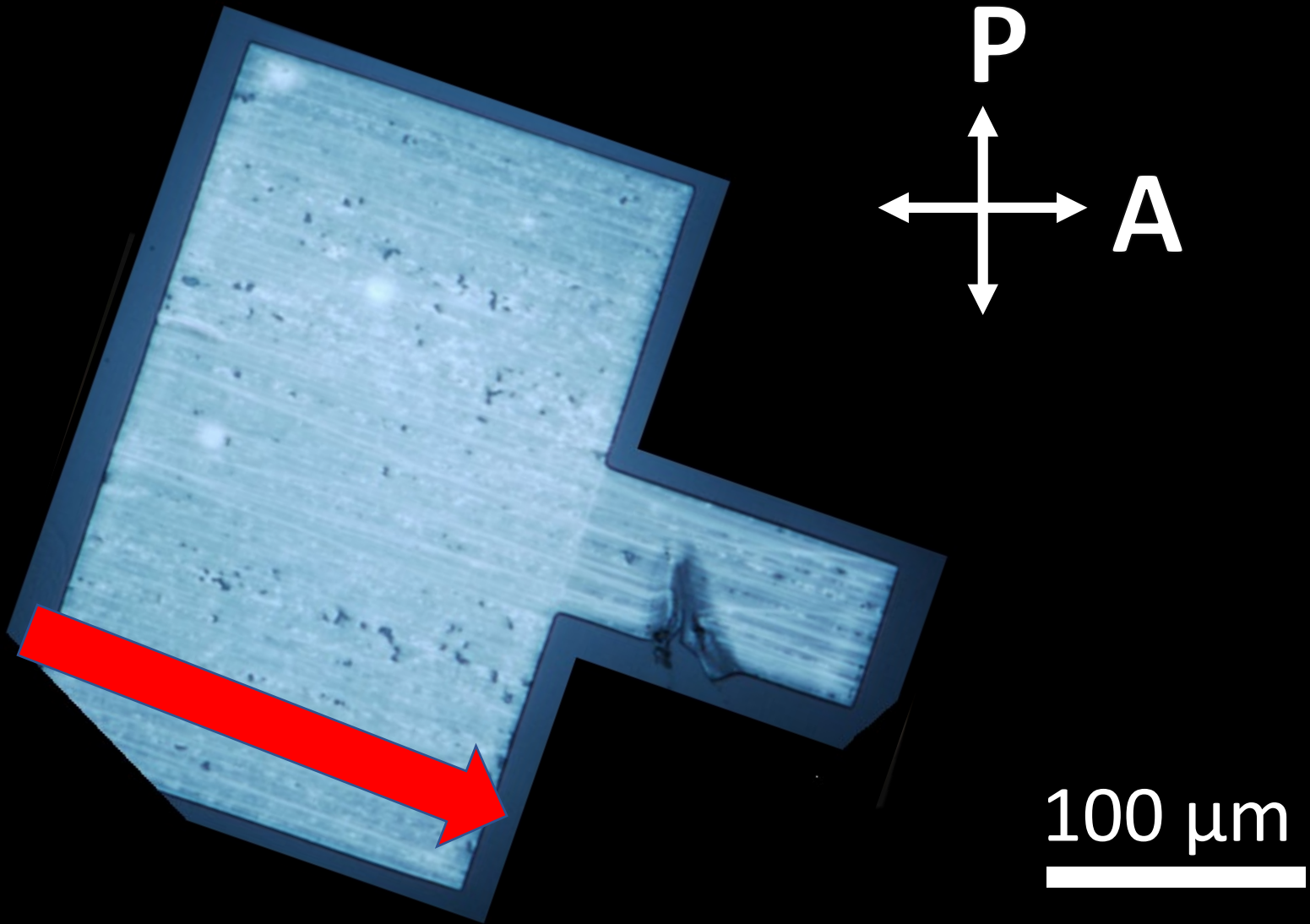
1.5 μm grooves in Si



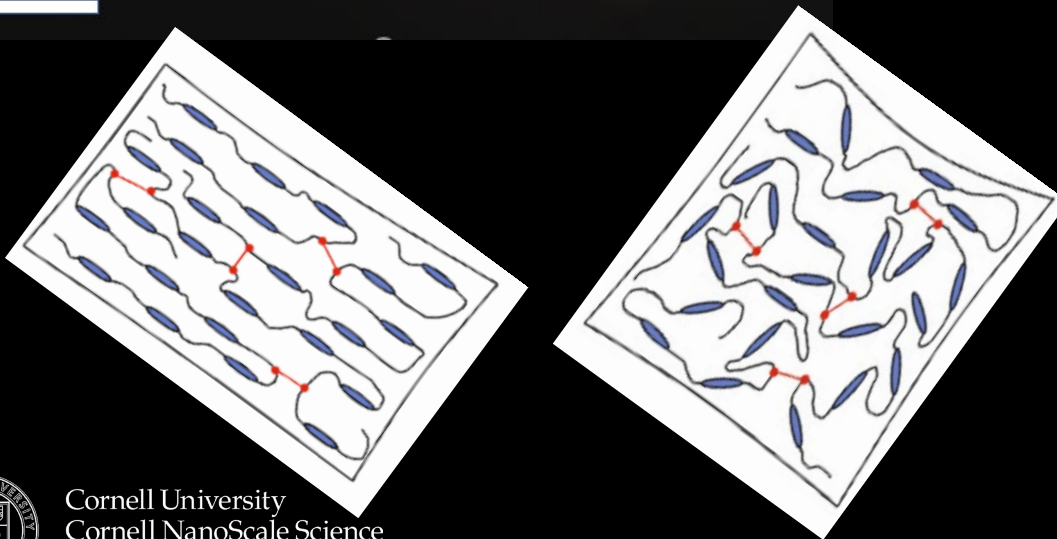
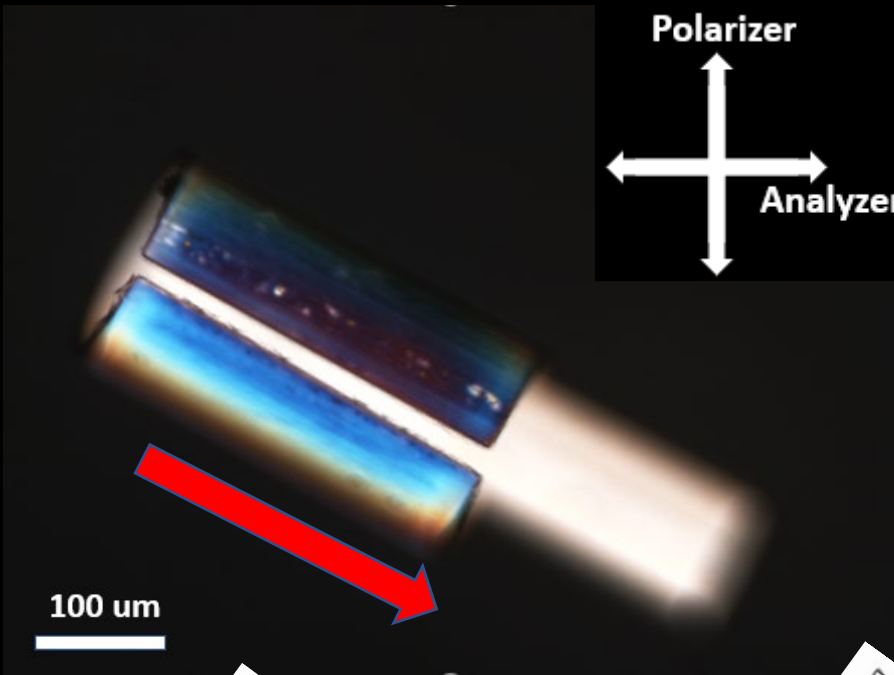
Actuation



Actuation



Hug Bot



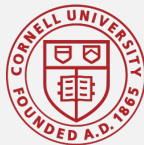
Accomplishments

- **Developed LC precursor and scalable microfabrication technology**
- **Aligned LC in multiple orientations**
- **Actuated aligned LC polymer samples**



Acknowledgements

- **National Science Foundation**
- **National Nanotechnology Coordinated Infrastructure**
- **Cornell NanoScale Science & Technology Facility**
 - **NSF grant no. ECCS-1542081**
- **Project PI: Itai Cohen**
- **Mentor: Qingkun Liu**
- **CNF REU Program Coordinator & Staff**



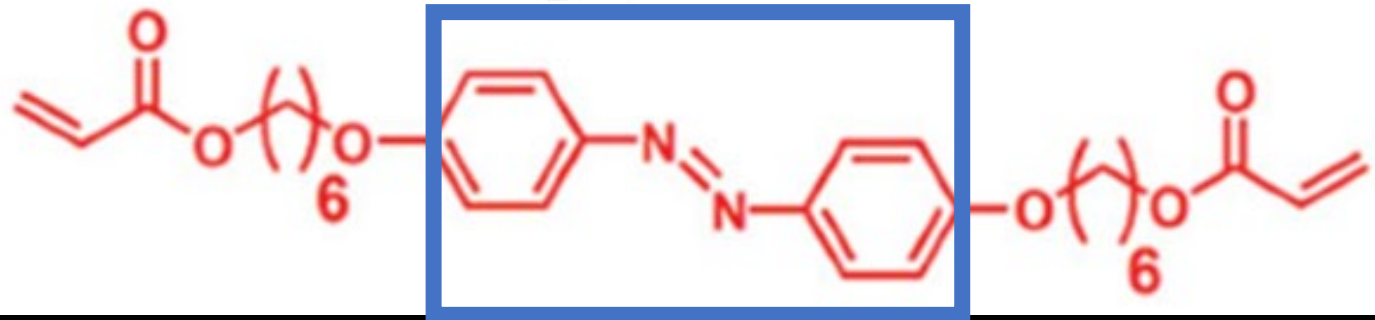
**Cornell
University**



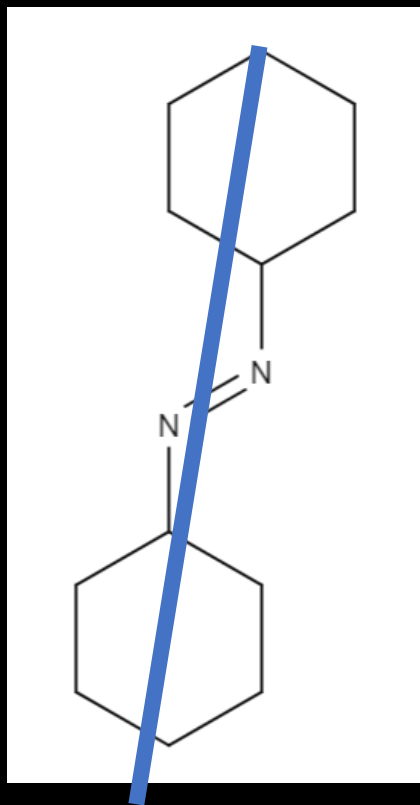
Activate by light

Photo-responsive

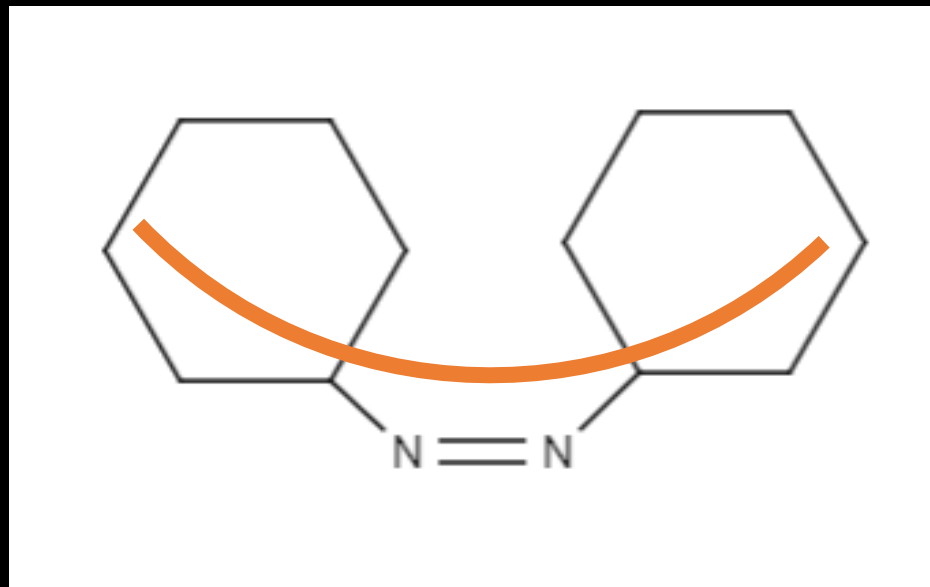
2Azo



Activate by Light

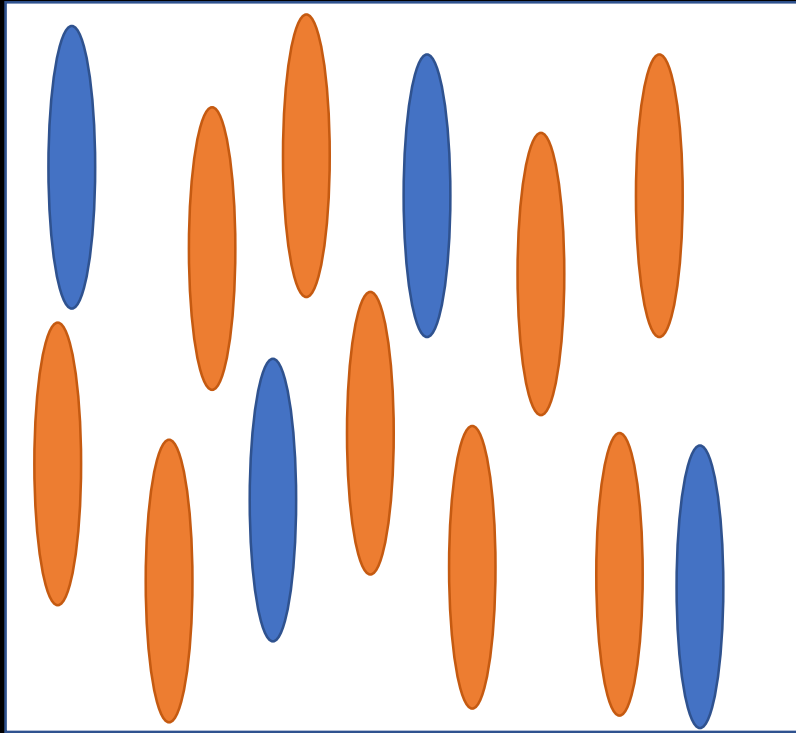


Trans



Cis

Activated by Light



Trans



Cis