Nano White Paper
Group 5

Introduction

Liquid-crystalline elastomers(LCE) materials exhibit good mechanical deformation when subjected to various stimuli (e.g.heat, light, electrical fields), thus offering advantages for many applications such as soft robots and microactuators. [1-6] The reversible shape-changing behavior of LCSs is governed by the molecular orientation of these materials.[7]

Here we propose using a magnetic field to program the orientation of the LC director, which switches between aligned LC mesogens and randomly oriented mesogens. We can further use complex 3D-patterned magnetic fields to create arrays of microstructures with area-specific molecular orientations. These arrays can give rise to dynamic changes in optical transmittance and differentiation patterns.[8] Then we can tune the optics properties of these materials. This work can be used to design light sensors, smart buildings, instantaneous privacy screens and polarimeters.

Concept

It is difficult to synthesize actively deformable microstructures, especially for the hierarchical assembly of arrays of LCE microstructures. Our concept is inspired by the work (fig.1) published in PNAS, which used magnetic field to program the liquid-crystalline elastomer microstructures.[6]

Here we try to change the strength of current and the range of energization to generate different magnetic fields, then program the orientation of LCEs in different layers. After that, we assemble different layers of LCEs with area-specific molecular orientations. We hope these various combinations enable us to change the optics properties of these materials.

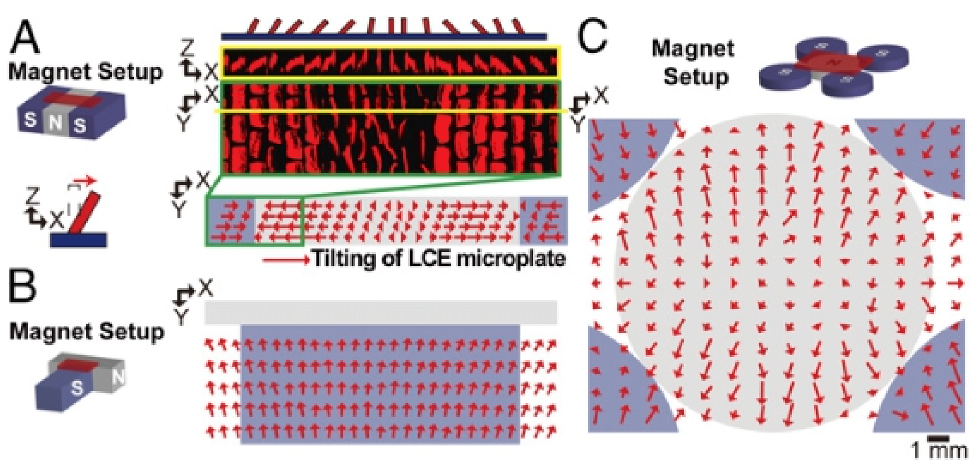

Figure1

Prototype Design

The LCE prototype (fig.2) is according to the effect of the magnetic field on the material. We propose flexible electromagnetic fields to generate different magnetic fields by changing the strength of the current and the range of energization, so that the material will have various directionalities, and then it can judge the pass/fail of light in different directions.

The possible application of the prototype varies with the number of units. The single unit can be used for light sensors and detecting underground magnetic materials. The overlap of two units can be used for polarimeters. When stacking multiple units, the combination can be applied for encryption, for whether the light passes or not can represent the zeros and ones in binary strings. Besides, glasses made by the material enable people to recognize the temperature in different urban areas, which can be applied in smart city planning and intelligent design (fig.3).

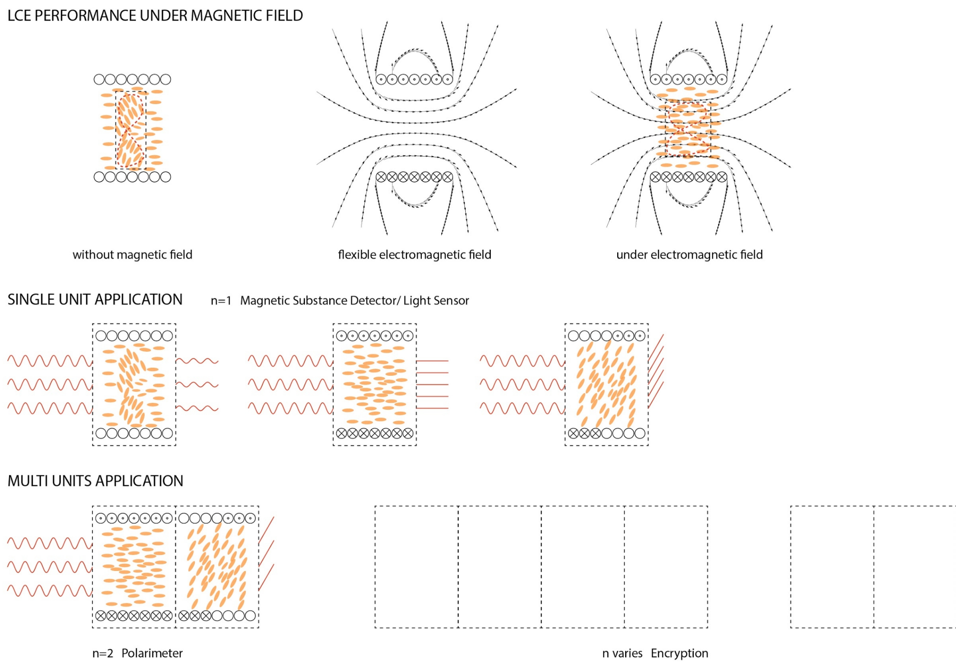

Figure2

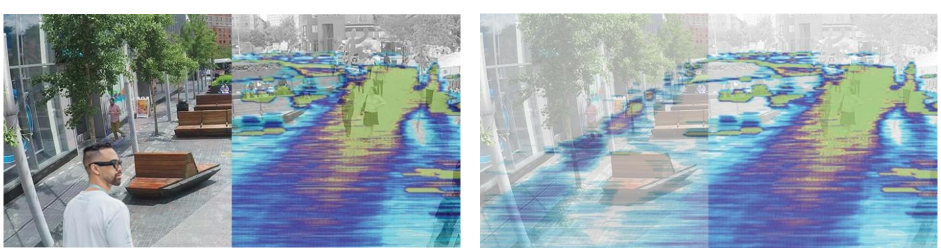

Figure3

Results

The Experiment 2 (Deformation of LCE films) explored the deformation behavior of laminate LCE films under different conditions. Individual discs were synthesized on the top surface of a cylindrical magnet. Sample 1(fig.4a) is an individual film. Lamination involved coating a thin layer of monomer mixture on top of individual films, stacking them on top of each other, and polymerizing the adhesive layer. Sample 2(fig.4b) is 2 discs laminated together. Sample 3(fig.

4c) is 2 discs laminated together with a hinge in the center (fig.4). Different crosslinking densities which could likely account for the difference in strain rate were used.

In the experiment, samples were placed in silicone oil to act as a frictionless surface at 180℃. And the result shows that only Sample1 bent (fig.5), while Sample2 and Sample3 didn't deform. Possible explanations include the "adhesive" LCE layer used to make the laminates was too thick or unaligned and ended up inhibiting deformation of the LCE, or the films buckled in opposing directions caused forces generated by the two films cancelled each other out.

This experiment is relevant to our concept that laminated different numbers of discs together to achieve diverse possible applications (fig.2). In our vision, the superposition of layers will cause various deformation effects. Yet in the experimental results, only the individual film underwent an ideal deformation. Thus, in the real application, the possible reasons caused such phenomena - the thickness of the LCE layers and the interaction forces between layers need to be taken into consideration. In addition, in this experiment, all layers are under the same temperature. The stimuli is uniform. This is different from our concept, while we will generate different magnetic fields for each layer. So we think in our concept, it is possible to realize the deformation of the combination of different layers.

Overall, we think the solutions can be applying reasonable thickness to the material, as well as separating the layers when use them in optical or encryption applications.

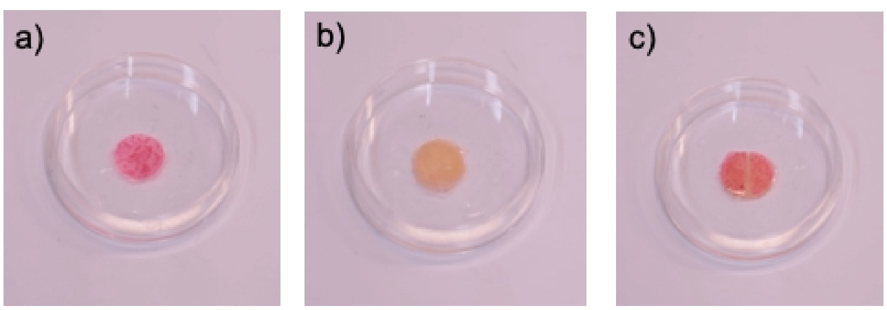

Figure 4

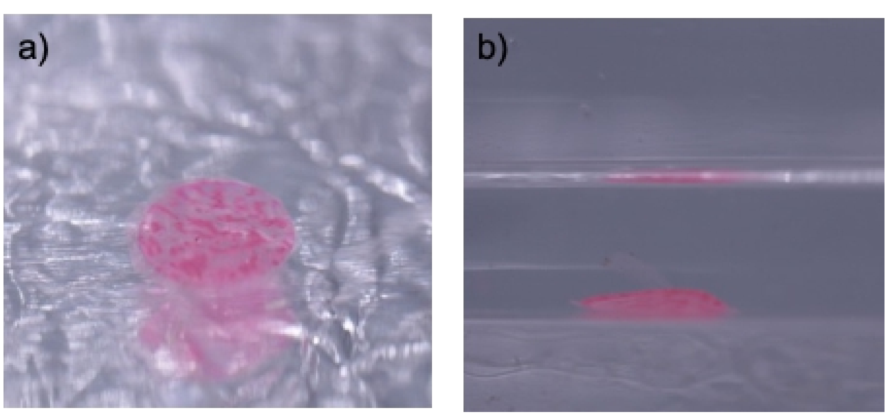

Figure 5

Reference

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