# PHOTOALIGNMENT FOR 3-D CONTROL OF NEMATIC LIQUID CRYSTALS

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Precise control of liquid crystal orientation on surfaces is key for the development of electro-optical devices and programmable soft robots, as the orientation on the surfaces determines the bulk properties of the liquid crystal. Among the strategies to control liquid crystal orientation, photo-patterning is unique for its high spatial resolution and the possibility to control the alignment dynamically. Here, we show how controlled in-plane alignment can give rise to complex topological structures in nematic liquid crystals [1].

However, one of the challenges is to achieve a spatial control of the out-of-plane (tilt) angle. We demonstrate a simple method to obtain three-dimensional control of the tilt angle of nematic liquid crystals. The method can be easily implemented in most laboratories and it is based on a two-step photo-alignment process. In the first step, we use polarized light to define the in-plane orientation of the liquid crystals. In the second step we use unpolarized light to set the out-of-plane orientation. The method enables smoothly varying orientational patterns. We demonstrate the method fabricating a gradient-index lens with a parabolic refractive index profile, which remains stable without the need for external electric fields. Our findings suggest a route for the development of next-generation photonic devices and actuated materials, with potential applications in molecular self-assembly, re-configurable optics, and responsive matter.

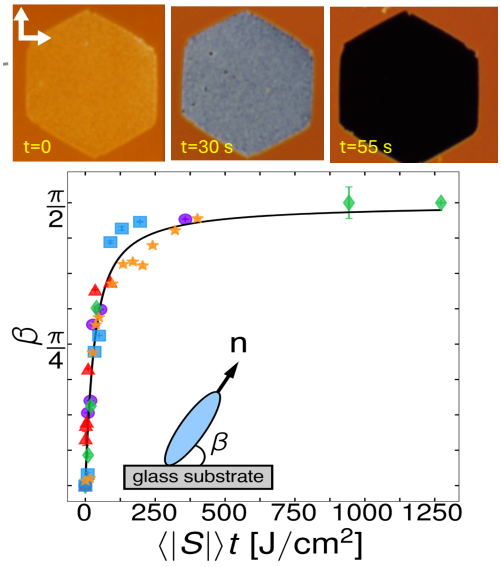


*Fig.1 Top: liquid crystals between polarizers, an illuminated patch during the second exposure step, with progressively high tilt angle. Bottom: tilt angle as a function of the irradiating energy per area during the second exposure.*

References

1. A. Modin, R. Leheny, F. Serra, *Adv. Mater*. 2024, 36, 2310083.
2. A. Modin, B. Ash, K. Ishimoto, R. Leheny, F. Serra, H. Aharoni, *Proc. Natl. Acad. Sci.* 2023, 120, e2300833120