Optical measurements on a new reconfigurable liquid crystal wave plate

Chris Desimpel[1], Kristiaan Neyts[1], Steven Verstuyft[2], Dries Van Thourhout[2], Koen D'havé[3], Per Rudquist[3]

[1] Liquid Crystals & Photonics group, Elis Department, Ghent University, Sint-Pietersnieuwstraat 41, BE-9000 Gent, Belgium, Chris.Desimpel@elis.UGent.be

[2] Photonics Research Group, Intec Department, Ghent University, Gent, Belgium

[3] Liquid Crystal Group, Chalmers University of Technology, Götheborg, Sweden

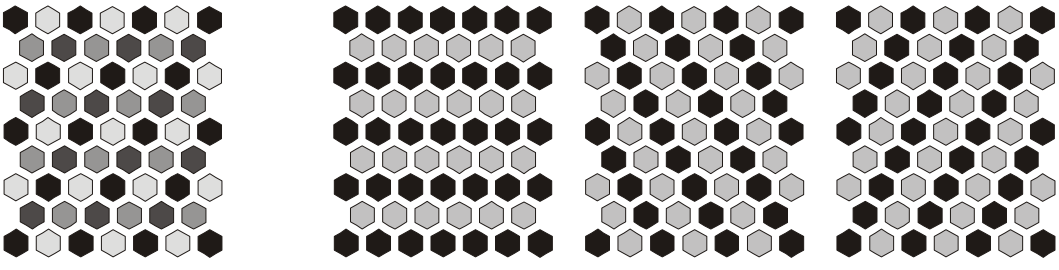
Keywords: *liquid crystal wave plate, experiments*

1. Introduction

In reference [1], we described a novel liquid crystal device, based on a four-electrode unit, arranged in a hexagonal array as shown in Figure 1. Full three-dimensional simulations were performed using a finite elements algorithm and demonstrating three stable orientations of the director in the plane parallel to the substrate surface. Applications for the device are situated in the field of multistable wave plates, spatial light modulators and electrically controllable anchoring. In this contribution, the first experimental results are demonstrated.

2. Objectives

The constructed device consists of a layer of regularly shaped hexagonal electrode pads interconnected by electrodes on the bottom glass substrate, covered by a dielectric layer, a liquid crystal layer and a top glass substrate. The dielectric layer in between the electrodes and the liquid crystal shields the strong vertical components of the electric field, which tend to disrupt the horizontal alignment of the liquid crystal.



(a) four groups of hexagonal electrodes

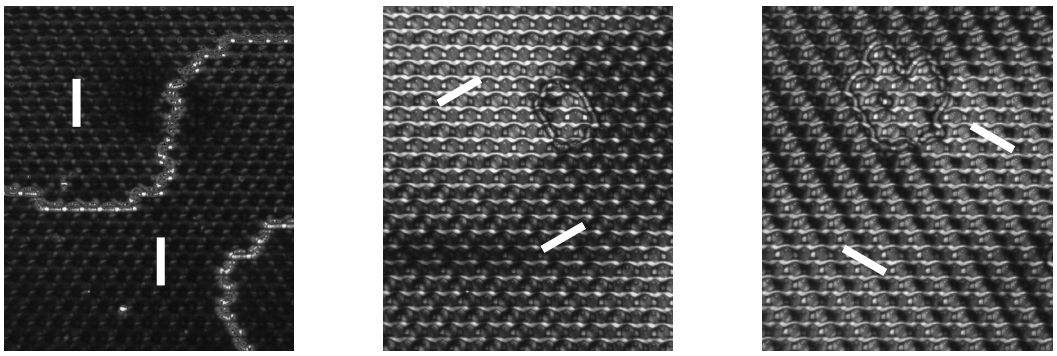
(b) the four electrode groups, switched in groups 2 by 2

Figure 1: The electrod layer of the reconfigurable wave plate. (a) the four groups of separately addressable hexagonal electrodes (indicated with 4 different grey levels), (b) three different driving configurations by addressing the electrode groups in pairs 2 by 2 (the grey levels indicate the potential)

The electrodes are interconnected by vias in four different groups, indicated with different grey levels in Figure 1a. Addressed in pairs of 2 by 2, the electrodes at equal potential form roughly parallel lines comparable to the in-plane switching mode of liquid crystals, as illustrated in Figure 1b. In [1] was shown that the horizontal electric field is on average perpendicular to the parallel rows. In this way, the director can be aligned along three different directions in the plane parallel to the substrate surfaces.

3. Experimental results

The hexagonal electrode pads in the constructed device have a side length of 5 μm and are spaced 3 μm apart. The dielectric layer was made with the polymer benzocyclobutene (Cyclotene) and has a thickness of 1 μm. The liquid crystal material used is E7, with a thickness of 2.1 μm. The surfaces in contact with the liquid crystal are treated with FC4430 (3M) to have a low azimuthal anchoring, essential for uninhibited horizontal rotation of the director.



(a) Driving configuration C_1 (b) Driving configuration C_2 (c) Driving configuration C_3

Figure 2: Microscope pictures in reflection of the three applied driving configurations with the polarizer and analyzer along the edges of the images. (Image dimensions 140 x 115 μm)

By voltage driving and microscope observation we show that the device behaves as expected, aligning the director in three different directions as in Figure 2. Driving configuration C_1, yields an average parallel electric field along the vertical axis of Figure 1, which gives a dark state between crossed polarizers, as shown in Figure 2a. The average director in the other driving configurations makes angles of ±60°, which gives a transmission as shown in Figures 2a and 2b. By using different driving voltages, the detailed behavior of the device can be demonstrated.

4. Conclusion

By means of experiments, the functionality of a new electrically reconfigurable, liquid crystal wave plate based is demonstrated.

5. References

[1] C. Desimpel, J. Beeckman, H. Desmet, K. Neyts, R. James, F.A. Fernández, A four-electrode liquid crystal device for 2π in-plane director rotation J. Phys. D-Appl. Phys., 2005, 38, 3976-3984

Acknowledgments: The research of C. Desimpel is funded by a PhD grant of the Institute for the Promotion of Innovation through Science and Technology in Flanders (IWT-Vlaanderen). The research is a result of collaboration within the framework of the European Research Training Network SAMPA and the Interuniversity Attraction Pole program PHOTON-network of the Belgian Science Policy.