Experiments on azimuthal degenerated anchoring surfaces

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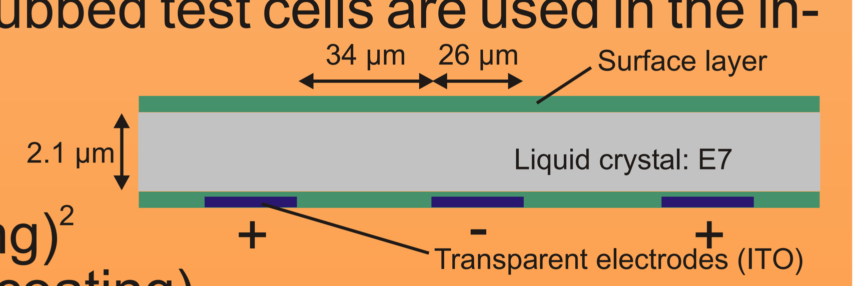
Abstract

Classical rubbed alignment layers keep the liquid crystal director at the surface tightly in a fixed orientation. New applications require other types of alignment layers such as planar azimuthal degenerated anchoring surfaces[1,2,3]. The aim is to obtain a surface anchoring where the director has a tendency to lie in the plane parallel to the glass surfaces, but without a preferential azimuthal direction. This is important to avoid the effects of memory and flow alignment[1] and enables free rotation of the director at the surface of the liquid crystal. This contribution compares different alignment materials to achieve such conditions for nematic liquid crystal devices.

Applications are situated in the field of multistable wave plates, electrically controllable anchoring and the reduction of the threshold voltage of liquid crystal displays.

1. Introduction

In a number of simple experiments four materials are compared for obtaining azimuthal degenerate planar anchoring (= anchoring parallel to the surfaces without preferred azimuthal direction). Non-rubbed test cells are used in the in-plane switching mode of liquid crystals.

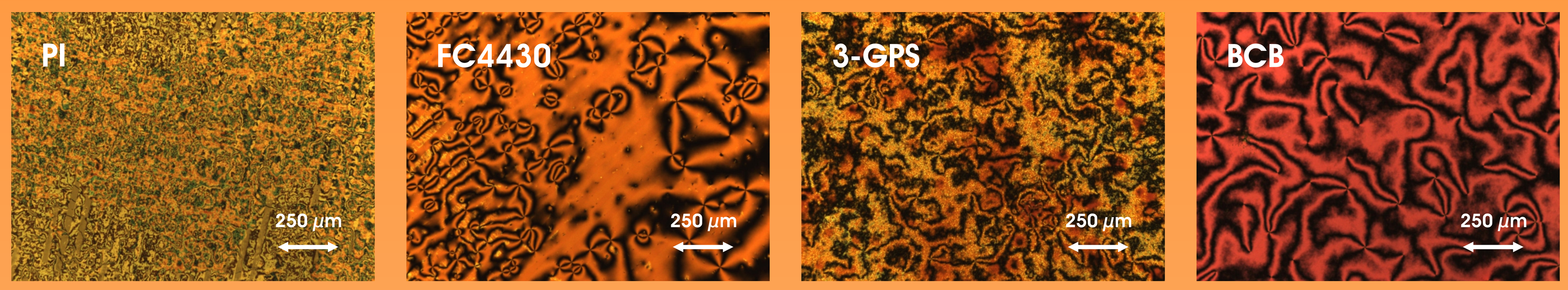


Tested surface materials:

- PI2610 (poly-imide, deposited by spin coating)[2]
- BCB (benzocyclobutene, deposited by spin coating)
- 3-GPS ((3-glycidoxypropyl)trimethoxysilane, deposited by spin coating)[1]
- PI2610 + FC4430 (surfactant on top of poly-imide, deposited by dip coating)[2]

2. Schlieren textures

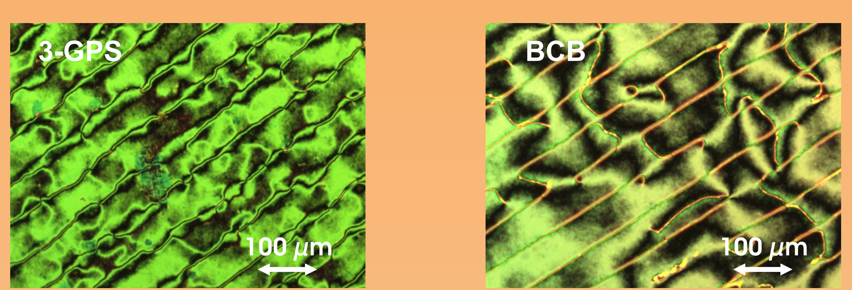
Observation of liquid crystal cells between crossed polarizers under the microscope. The cells are filled with the liquid crystal E7[4] while heating to the isotropic state.



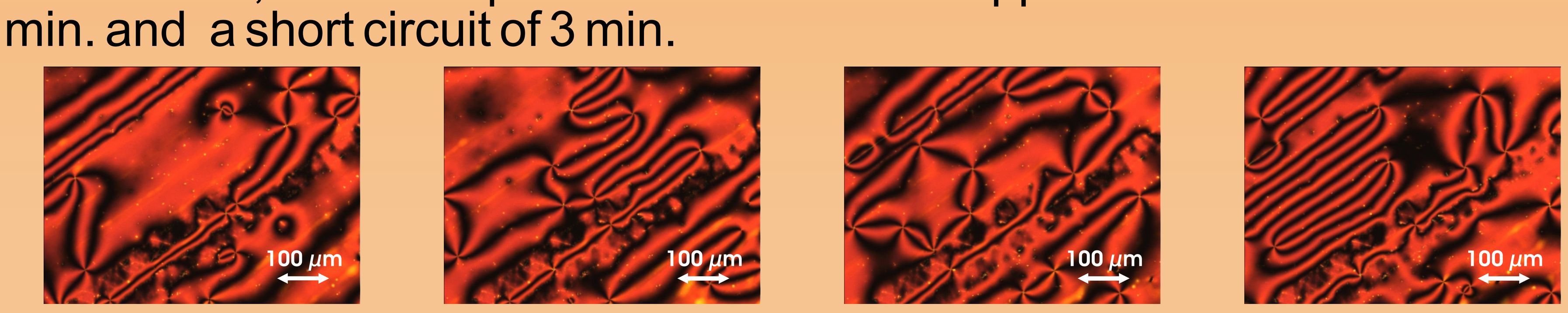
Non-rubbed nematic liquid crystal cells give rise to a Schlieren texture[2,5]. The initial anchoring strength for FC4430, 3-GPS and BCB is much lower than for PI, which yields much larger homogeneous regions in the texture.

3. Influence of an electric field

For 3-GPS and BCB, the original Schlieren texture is restored after applying a voltage and a line appears above the center of the electrodes. This line arises from the director switching, which occurs in opposite directions at both sides of the line. It is narrow because of the strong memory alignment.

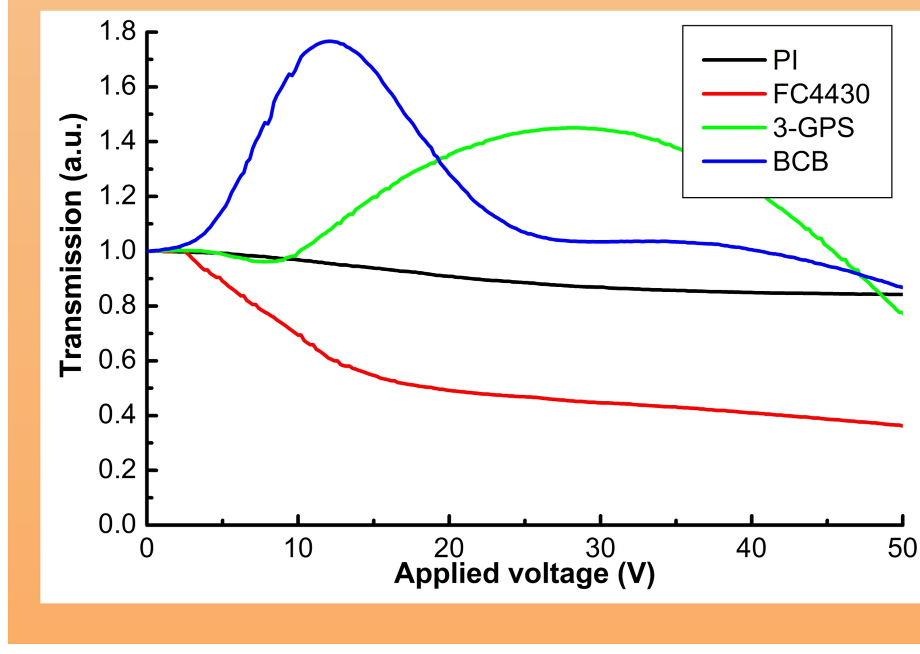


For FC4430 relaxation after a strong electric field results in a different Schlieren texture, free of defect lines. Thus the memory effect is reduced. Between each picture below, a 1 kHz square wave of 100 V is applied to the electrodes during 1 min. and a short circuit of 3 min.



4. Average transmission measurements

The test cells are placed between crossed polarizers, with the electrodes parallel to the entrance polarizer. The whole pixel surface is illuminated with monochromatic light while measuring the transmission as a function of the applied voltage (1 kHz square waves).



- PI: strong anchoring at the surfaces, only limited change in transmission due to director rotation only in the bulk
- FC4430, 3-GPS and BCB: reduction of the threshold voltage and much larger change in transmission due to reorientation of the surface director
- apparently two thresholds: reorientation between the electrodes and on top of the electrodes

5. Estimation of the anchoring strength

Comparison of the transmission-voltage characteristic in a homogeneous region between two electrodes with the one-dimensional approach of the in-plane switching mode of liquid crystals allows to estimate the anchoring strength.

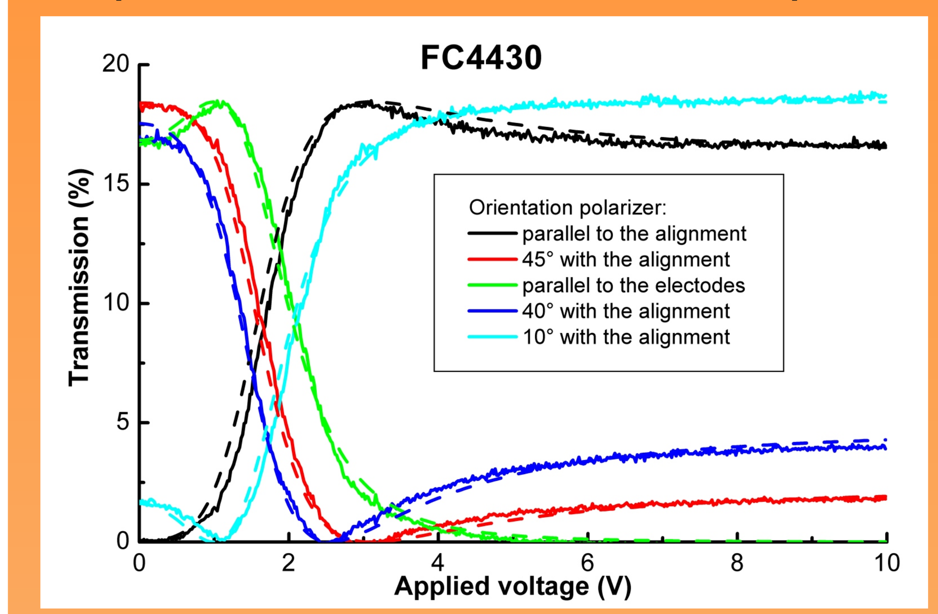
Modeling of the liquid crystal[6,7,8]:

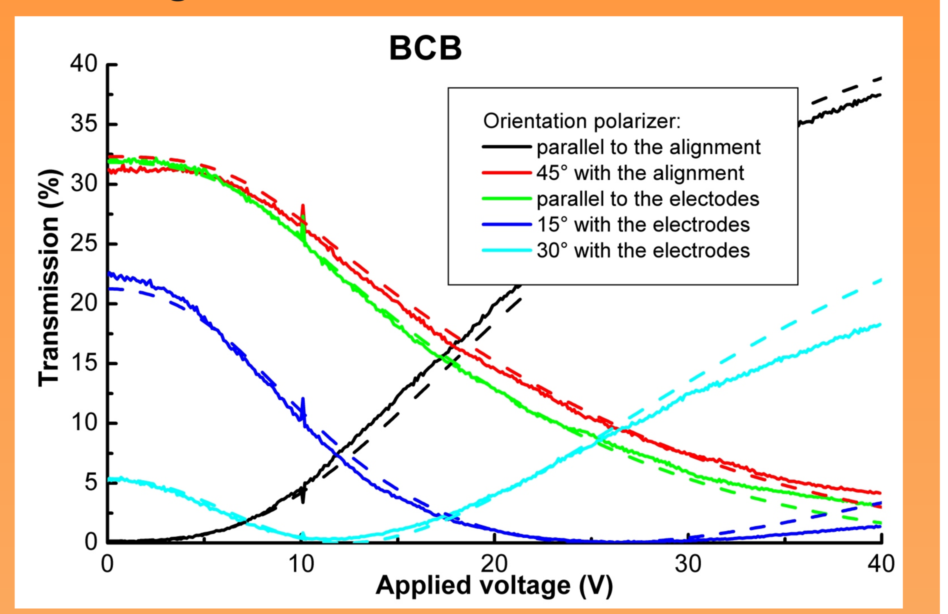
$$W \quad \frac{1}{2}\ {}_{0}^{d}\ k_{22}\ \frac{d}{dz}\ {}^{2}\quad {}_{0}\quad \cos^2\quad E^2\ dz\ \frac{C}{2}\sin^2\quad 0\quad {}_{0}\quad \sin^2\quad d\quad {}_{0}$$

Measurement:

Transmission-voltage characteristic in a homogeneous region between two electrodes by using a microscope and a 10-bit CCD-camera.

All parameters are known except for the anchoring *C*.





After fitting:

- FC4430: $C = 0.4\ 10^{-6}$ J/m^2, low compared with literature
- BCB: best fit for strong anchoring

6. Conclusions

Different materials were tested for use as planar, azimuthally degenerated anchoring surfaces.

- PI: strong anchoring
- 3-GPS and BCB: initially weakly anchored, but strong memory effect
- FC4430: strong reduction of the memory effect

Acknowledgments

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