Molecular Crystals and Liquid Crystals Incorporating Nonlinear Optics

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl17

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Slavomír Pirkl [a], JindŘIch Tuček [a] & Vladimír Schiffmann [a]

[a] Institute of Chemical Technology, 532 10, Pardubice, Czechoslovakia

Version of record first published: 22 Sep 2006.

To cite this article: Slavomír Pirkl , JindŘIch Tuček & Vladimír Schiffmann (1990): Ferroelectric Liquid Crystal Electrooptic Cell with High Contrast Bistability, Molecular Crystals and Liquid Crystals Incorporating Nonlinear Optics, 192:1, 317-321

To link to this article: http://dx.doi.org/10.1080/00268949008035648

Mol. Cryst. Liq. Cryst. 1990, Vol. 192, pp. 317–321
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Printed in the United States of America

FERROELECTRIC LIQUID CRYSTAL ELECTROOPTIC CELL WITH HIGH CONTRAST BISTABILITY

SLAVOMÍR PIRKL, JINDŘICH TUČEK, VLADIMÍR SCHIFFMANN
Institute of Chemical Technology
532 10 Pardubice, Czechoslovakia

Abstract Electrooptic cell with surface stabilized ferroelectric liquid crystal having high contrast bistability was realized using a conventional rubbing method. Permanent quasi-bookshelf structure with stripped texture was induced by applying a low frequency electric field in the cell.

Rubbed polymeric layers are usefull for a low cost LC displyas production. We have investigated possibilities of utilization of the rubbed polyvinyl alcohole (PVA) layers for realization of electrooptic cells with surface stabilized ferroelectric liquid crystal (SSFLC).

The FLC materials used in our experiment were commercial chiral smectic mixtures CS-1011 (CHISSO Corp.) and ZLI-3654 (E.MERCK AG.). The sample cell was prepared by sandwiching the FLC materials between two glass substrates with transparent ITO electrodes on which the PVA alignment layer was coated and rubbed (MOWIOL 26-88). The cells with antiparallel rubbing directions were investigated since in this configuration defects arise several times often than in the cells with parallel rubbing. The investigated cells had thickness d in a range from 0.9 to 2.0 μm (measured interferometrically). A good alignment with solitary zig-zag defects was obtained

by slowly cooling the cells from the isotropic to the SmC^{X} phase without an electric field application.

Microscopic observations and electrooptical measurements were carried out before and after the application of the square-wave electric field.

Firstly, voltage dependences of switching times were measured under application of AC square-wave (50 Hz). As it can be seen in Figure 1, the voltage dependence

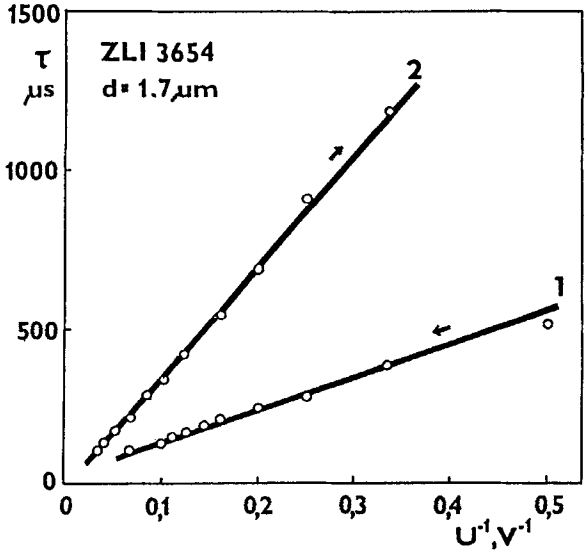

FIGURE 1 Voltage dependences of switching times in the SSFLC cell before (1) and after (2) the electric field treatment at 25°C.

at increasing voltage differs from that for decreasing voltage. This fact gives evidence for a texture change under electric field. The new texture is stable even after the driving voltage is cut off and initial texture can be restored only by repeating of the alignment process. The switching times are slightly longer in the texture arised under an AC electric field but electric-

field -treated cells have a perfect bistability with high contrast (Figure 2). This observation is in agree-

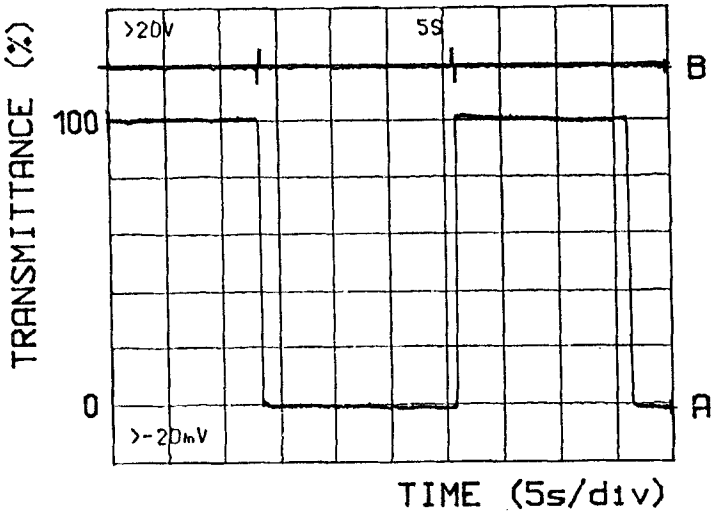

FIGURE 2 The optical response (trace A) to the bipolar pulses $\pm$ 20 V (B). FLC mixture ZLI 3654, cell gap d = 0.9 /um.

ment with the results published by Hartmann[1] for ZLI 3654 (alignment layer Nylon 6.6) and Sato et al.[2] for a phenylpyrimidine FLC mixture (alignment layer N-methyl aminopropyl triethoxysilane).

Carefull microscopic observations have shown that the new texture which begins to arise at voltages about $\pm$ 15 V/um is striped with long and slender domains perpendicular to the smectic layers (Figure 3).The contrast between dark and light domains is very small and the domains are best evident when the cell is rotated by an angle near extinction. The distance between the dark or light stripes is about 2.4 /um for both investigated mixtures, i.e. approximately half of the pitch value.

A similar texture was also described by Sato et al.[2].

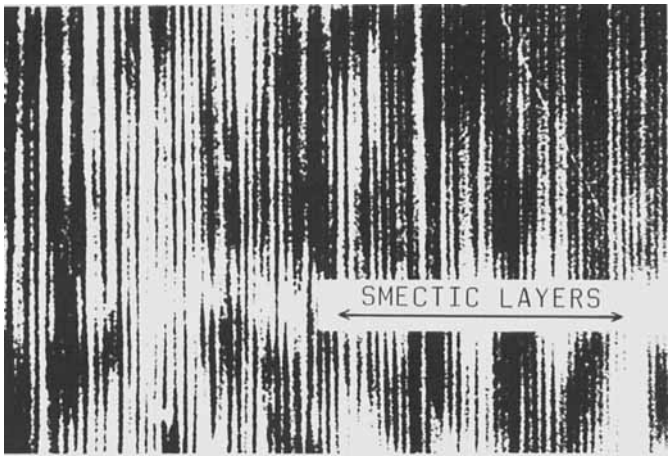

FIGURE 3 A micrograph showing the striped texture in the SSFLC cell after low frequency AC electric field treatment (± 25 V, 10 Hz). FLC mixture ZLI 3654, cell gap d = 1.7 μm, 580x magnification.

In the cells before electric field treatment, the optical extinctions in the memory state were obtained when the cell was rotated by an angle less than a half of the cone angle and the extinction directions were assymetric in respect to therubbing direction. These cells were coloured and perfect extinction could not be obtained. On the basis of optic and electrooptic behaviour we assume that the stable states are the two twisted states in non-treated cells.

In the treated cells, a half of the apparent cone angle between the two extinction positions in the memory condition was found nearly equal to that observed under a DC electric field, i.e. 23°, for both mixtures investigated. This value is also near the tilt angle showed by the mixture producers. A perfect extinction with almost black colour was obtained and no relaxation

phenomenon of the transmittance was observed. This suggests that in the treated cells the stable states are the two uniform states in the quasi-bookshelf structure.

We are concluding that the permanent quasi-bookshelf structure with improved bistability can arise by applying a low frequency electric field in the SSFLC cells with appropriate combination of liquid crystal material and surfactant.

ACKNOWLEDGEMENT

The authors would like to thank CHISSO Corp. and E.MERCK AG. for supplying the FLC mixtures.

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2. Y. Sato et al., Jpn J. Appl. Phys., 28, L 483 (1989).