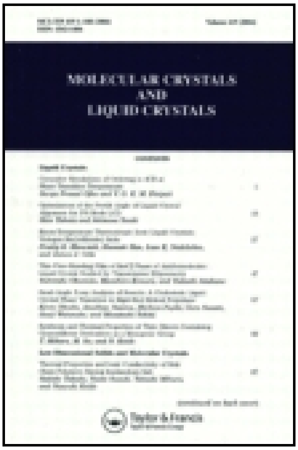

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Fabrication and Electrooptical Characterisation of an AFLC-MIM Device

C. Rodrigo [a], X. Quintana [b], M. Köberle [b], R. Bürkle [b] & J.M. Otón [a]

[a] Dept Tecnología Fotónica, ETSI Telecomunicación, Ciudad Universitaria, E-28040, Madrid, Spain

[b] Labor für Bildschirmtechnik, Uni. Stuttgart, Allmandring 3b, D-70550, Stuttgart, Germany

Version of record first published: 04 Oct 2006

Mol. Cryst. Liq. Cryst., 1999, Vol. 331, pp. 349-354
Reprints available directly from the publisher
Photocopying permitted by license only

Fabrication and Electrooptical Characterisation of an AFLC-MIM Device

C. RODRIGO[a], X. QUINTANA[b], M. KÖBERLE[b], R. BÜRKLE[b] and J.M. OTÓN[a]

[a]*Dept Tecnología Fotónica, ETSI Telecomunicación, Ciudad Universitaria, E-28040 Madrid Spain and* [b]*Labor für Bildschirmtechnik, Uni. Stuttgart, Allmandring 3b, D-70550 Stuttgart Germany*

The electrooptical behavior of antiferroelectric tristable cells with active matrices has been evaluated by preparing MIM displays filled with Chisso CS-4001 AFLC material. MIMs were fabricated by a standard 3-mask process. The displays are 2", 96×128 pixel multiplexed test cells. The cell gap is 1.5 μm in all cases; silica spacers were used. A number of alignment layers and variations in surface conditioning were employed. Single face and double face treatments were tested. An analysis of addressing waveforms has been carried out, aiming to obtain reproducible analogue grayscales. The dynamic range, temperature dependence, and spatial homogeneity of the resulting optical response are presented.

Keywords: antiferroelectric liquid crystal; active matrix; MIM diodes; addressing modes

INTRODUCTION

Since the discovery of antiferroelectric liquid crystals (AFLC), and the demonstration of their analogue greyscale capability, much research work has been done in order to achieve video-rate, high resolution, wide viewing angle flat panel displays. Besides their intrinsic greyscale generation, high switching speed and mechanical stability, AFLC cells can be made tristable in actual working conditions[1], thus being excellent candidates for the next generation of multiplexed passive matrix displays. At present, several companies are preparing large[2] and small[3] flat panel displays based on tristable AFLCs and passive matrices.

Recently[4], a new type of AFLC materials named thresholdless AFLCs have been discovered. As opposed to regular tristable AFLCs, these materials do not show hysteresis nor tristability, therefore their multiplex rate in passive matrices is limited. However, at least two companies (Toshiba and Casio[5]) have announced prototypes of thresholdless AFLC displays with active matrices to take advantage of their reduced switching time, natural in-plane switching (IPS) of nearly all ferroelectric cells and the wide viewing angle derived from this effect.

Thresholdless AFLCs in active matrices, moreover, feature lower switching voltages and remarkably higher contrast than tristable AFLCs. This is due to the so-called pretransitional effect[6] (PE) by which the transmission of the tristable AFLC dark state is increased by the multiplex driving.

In this work, active matrix test cells using MIM diodes have been prepared and filled with tristable AFLC. The purpose was twofold. On one hand, the use of MIMs as active matrix for AFLC cells had not been tested yet. On the other hand, active matrices allow the temporal separation of addressing pulses and data pulses. In this way, if different contributions to the PE effect are found, these could be separately studied.

CELL MANUFACTURING

2" diagonal active MIM diode cells of 96×128 pixels filled with antiferroelectric liquid crystal CS-4001 (Chisso) have been fabricated (see fig.1). First, active matrix plates with MIM diodes were prepared, followed by the fabrication of the upper substrate (counter plate) containing only data lines. Two different parallel polymer alignment layers were tested. The performed cell gap was in all cases 1.5 μm; silica spacers were used. Cell assembly was performed with a MA6 Karl Suss contact aligner in the same way as in passive cells. Cells were filled in a vacuum chamber with temperature control on the cell and the liquid crystal to achieve a programmable cooling process.

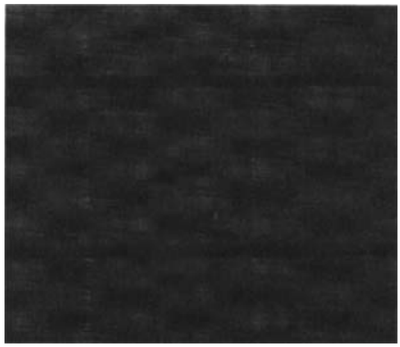

FIGURE 1 . AFLC-MIM active matrix (CS-4001 + Nylon 6)

MIM Fabrication Process

The active substrate (fig.2) was processed with Ta_2O_5 in the following manner. First of all, a 150 nm Ta film was deposited with DC sputtering and patterned using dry etching inside an atmosphere of CF_4 and O_2. The Ta

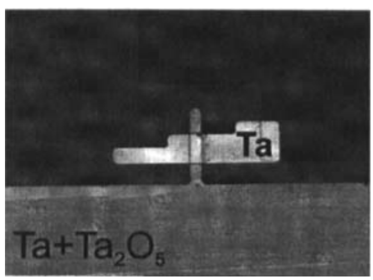

FIGURE 2. Zoom detail of a MIM

lines were anodised in a 0.01% citric acid solution, resulting into a Ta_2O_5 Poole-Frenkel conduction layer, the addressing lines, approximately 20μm wide. A 80 nm thick ITO layer was deposited by reactive DC sputtering with Ar and O_2 content. The resistivity is quite low: 24 Ω/□. The pixel electrodes were defined by wet etching and the ITO annealed at 350°C for 1 hour in oxygen atmosphere. Finally, 160 nm Ta MIMs were DC sputtered and patterned using dry etching again inside a CF_4-O_2 atmosphere.

Further details of MIM manufacturing have been published elsewhere[7].

<u>Alignment Layers</u>

Two different alignment layers were tested: poliimide AL5417 (JSR Electronics) and Nylon 6 (Aldrich). Both were spin coated, rubbed with a velvet brush and aligned parallel to each other. Both polymers showed good alignment results, being Nylon 6 the best.

A test was made to check that MIM devices were not damaged with alignment and rubbing process. Several cells were aligned with Nylon 6 deposited only on the upper substrate (data lines). Comparing to both-sides aligning, the main electrooptical parameters were maintained. No degradation has been noticed upon continuous switching for several weeks. In both cases, samples resulted quite stable.

ELECTROOPTICAL CHARACTERISATION

Cell characterisation has been made with a typical 3 level scheme[8]. The addressing waveform is programmed via a GPIB interface into a Standford Research DS-345 arbitrary waveform generator and amplified with a FLC Electronics F10A linear amplifier. Optical data are collected form a Tektronix TDS 420 via the same interface and processed in a computer. A typical optical response and greyscale profile is shown in fig. 4a. Data voltages can be maintained within a range of about 5 V. Greyscale evolution with selection time and temperature is presented in fig. 4b. Approximately, increasing each degree of temperature needs 1 V less in the data to achieve the same switching state. A systematic study of optimum waveforms and working conditions is currently under study.

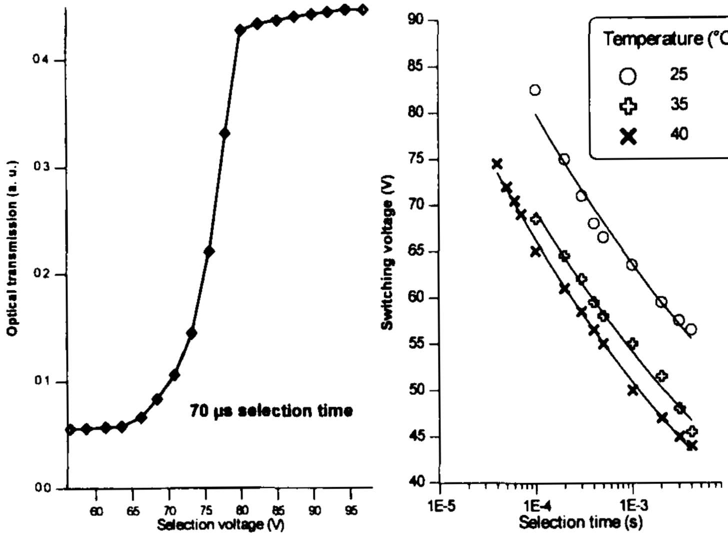

FIGURE 4. Greyscale evolution with selection time and temperature with Nylon 6 alignment layer.

CONCLUSION

The feasability of MIM as active matrix for tristable AFLC displays has been demonstrated. Stable greyscales have been found. Nylon 6 has shown the best alignment properties. Optimisation of the device is presently being studied.

ACKNOWLEDGEMENTS

This work has been supported by grants 06T/028/96 from the Comunidad Autónoma de Madrid, and TIC96-0825 from Spanish CICyT. CR also wants to thanks Prof. E. Lüder for his invitation to the *Labor für Bildshirmtechnik* (Uni. Stuttgart).

References

[1] S. Quentel, C. Rodrigo and J.M. Otón, *J. Soc. Informat. Display,* **4** (1) 19 (1996)
[2] Denso Corp. *"Flat Panel Display Production Plan"* Denso News 970728a, *cf.* <www http:// *www.denso.co.jp*> (Jan.1998)
[3] E. Tajima, S. Kondoh, and Y. Suzuki, *Ferroelectrics* **149**, 255 (1993)
[4] A. Fukuda, *Asia Display'95*, 61 (1995)
[5] B. Stebler, *Information Display* **2**, 20 (1998)
[6] M. Johno, K. Itoh, J. Lee, Y. Ouchi, H. Takezoe, A. Fukuda, and T. Kitazume, *Jpn. J. Appl. Phys.* **29**, L107 (1990)
[7] V. Hochholzer, E. Lüder, T. Kallfass and H-U. Lauer, *SID 94 Digest* 423 (1994)
[8] K. Aota et al., *Digest of Technical Papers SID* 219 (1991)