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

Use of Ptfe Alignment Layers in Passive Addressed Ssflc Displays

F. Campoli [a], R. Beccherelli [a], A. D'alessandro [a], V. Ferrara [a], A. Gáloppa [a], G. Padeletti [b], S. Petrocco [c] & P. Maltese [a]

[a] Department of Electronic Engineering, "La Sapienza" University, Via Eudossiana 18, 00184, Rome, ITALY

[b] CNR Institute for Materials Chemistry (ICMAT), Monterotondo Stazione, 00016, Monterotondo, Rome, ITALY

[c] CNR Solid State Electronic Institute (IESS), Via Cineto Romano 42, 00156, Rome, ITALY

Version of record first published: 04 Oct 2006

To cite this article: F. Campoli, R. Beccherelli, A. D'alessandro, V. Ferrara, A. Gáloppa, G. Padeletti, S. Petrocco & P. Maltese (1997): Use of Ptfe Alignment Layers in Passive Addressed Ssflc Displays, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 304:1, 357-362

To link to this article: http://dx.doi.org/10.1080/10587259708046982

Mol. Cryst. Liq. Cryst., 1997, Vol. 304, pp. 357–362
Reprints available directly from the publisher
Photocopying permitted by license only

USE OF PTFE ALIGNMENT LAYERS IN PASSIVE ADDRESSED SSFLC DISPLAYS.

F. CAMPOLI[1], R. BECCHERELLI[1], A. d'ALESSANDRO[1], V. FERRARA[1], A. GALLOPPA[1], G.PADELETTI[2], S. PETROCCO[3], P. MALTESE[1].

1 Department of Electronic Engineering, "La Sapienza" University, Via Eudossiana 18, 00184 Rome, ITALY.

2 CNR Institute for Materials Chemistry (ICMAT), Monterotondo Stazione, 00016 Monterotondo (Rome), ITALY.

3 CNR Solid State Electronic Institute (IESS), Via Cineto Romano 42, 00156 Rome, ITALY.

Abstract Polytetrafluoroethylene (PTFE or Teflon®) layers have been developed as orientation films in order to produce ferroelectric liquid crystals displays with improved addressing behaviour. PTFE layers have been friction deposited on glass substrate with ITO electrodes at various temperatures in the range 130 °C-200 °C. The PTFE layers have been used to assemble displays which were addressed and showed no hysteresis, reduced image sticking and reduced switching time with respect to standard test cells employing rubbed polymers as alignment layers. In order to assure the best electro-optical performance, PTFE films have been characterized from the point of view of uniformity and thickness as function of deposition parameters.

INTRODUCTION

The production of alignment films is of fundamental importance for the fabrication of nematic as well as surface stabilized ferroelectric liquid crystal (SSFLC) displays. It is already known that thin PTFE layers may be used to induce preferred orientations in a variety of substrates[1,2]. The present work shows that PTFE can align very well ferroelectric liquid crystal in surface stabilized cells and compares the aligning properties of PTFE layers to those of a well-studied conventional polymer (nylon 6[3,4]). PTFE films were friction deposited in our laboratory at high temperatures[5,6] and their structure was investigated by mean of atomic force microscope (AFM) and scanning electron microscope (SEM), as reported in the first part of this paper. Film thickness was measured by SEM, and the molecular structure was investigated by AFM.

ALIGNMENT FILM INVESTIGATION

Preliminary considerations

PTFE films have been deposited on glass substrates by friction employing a mechanical deposition system designed by us. Friction was experimentally investigated and optimized respect to velocity and pressure at temperatures in the range from 130 °C to 200 °C.

Films deposited at temperatures between 150 °C and 180 °C can align the liquid crystal and may be usefully employed to produce working displays. Films deposited at temperatures higher then 180 °C were neither analyzed nor used to assemble test cells, as at those temperatures there is a massive transfer of polymer to the glass substrate (films are visible by eye inspection), and cell thickness may hardly be controlled. Films deposited at temperatures lower then 150 °C have scarce interest from the point of view of liquid crystal alignment, nevertheless they were analyzed by AFM to clarify the relationship between the deposition temperature and the structure of deposited films.

SEM investigations

Only samples which assured the best display performances were analyzed by SEM, in order to measure thickness and evaluate the degree of homogeneity. The films were deposited at temperatures in the range from 160 °C to 180 °C, gold shaded and softly scratched by a sharp blade in order to cut only the thin layer of gold and PTFE, as Figure 1(a) shows. Film thickness was measured by tilting the microscope electron beam of 80 degrees. Thicknesses of 360 Å and 460 Å were measured in the case of films deposited at 160 °C and 180 °C, respectively, as Figures 1(b) and 1(c) show. An intermediate thickness was measured for films deposited at 170 °C. Also, it was observed, as reported in Figure 1, that all films are satisfactory homogeneous, and that no massive PTFE deposits are present. Polyamide films, used in our lab for liquid crystal alignment in standard displays[7], have also been analyzed by SEM and compared with PTFE layers. Polyamide films were obtained by spinning a solution of nylon 6 in trichloroethanol, dried, rubbed, annealed and rubbed again. It was found that the thickness of these films is comparable to that of PTFE films: a thickness of 750 Å, as Figure 1(d) shows, was measured in the case of films just dried and a lower thickness of 500 Å in the case of annealed and rubbed films.

AFM investigation

AFM measurements were carried out in air in contact mode (repulsive forces) using a Nanoscope III, Multimode Digital Instrument equipped with conventional Si_3N_4 cantilevers and tips. The range of forces in AFM is from 10^{-7} to 10^{-11} N.

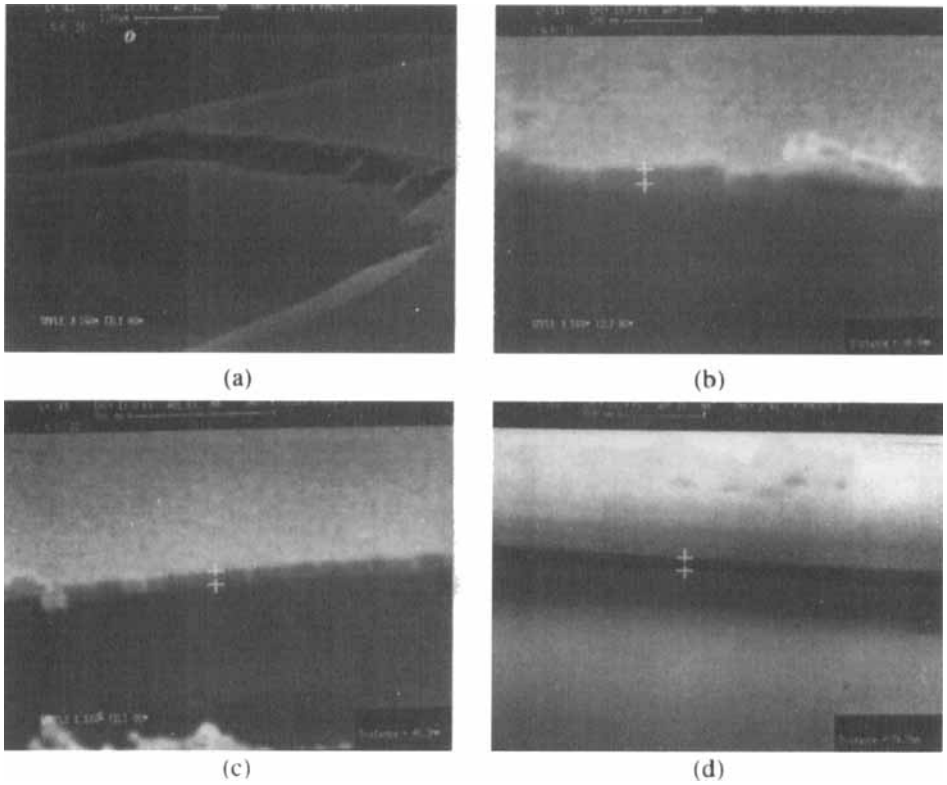

FIGURE 1. SEM (a) PTFE scribed surface; (b) thickness measurements of PTFE films deposited at a 160°C; (c) at 180°C, and of (d) amorphous Nylon 6.

The structure of PTFE films deposited at 170 °C is shown in Figure 2(a) and 2(b) at different resolutions: Figure 2(a) corresponds to an area of 2x2 μm^2, and Figure 2(b) to an area of 1x1 μm^2. There is a structure aligned in the direction of friction, which may be identified as aligned polymer chains.

An AFM picture of alignment nylon film is reported in Figure 2(c). It is clearly visible a less dense structure and a lower degree of orientation than in PTFE films. The higher density and degree of order showed by PTFE films is probably due to the molecular structure of this polymer, with polymer chains which form rigid helices arranged in very compact domains. PTFE film structure appears very similar to obliquely evaporated SiO_x while Nylon 6 resembles the ones of commercially available polyimides as shown by AFM investigation[8] .

Finally, the AFM picture of a PTFE film deposited at 130 °C is reported in Figure 2(d). In this case no presence of aligned domains is evident unlike films deposited at higher temperatures, which explains why films produced under these deposition conditions can not align the liquid crystal.

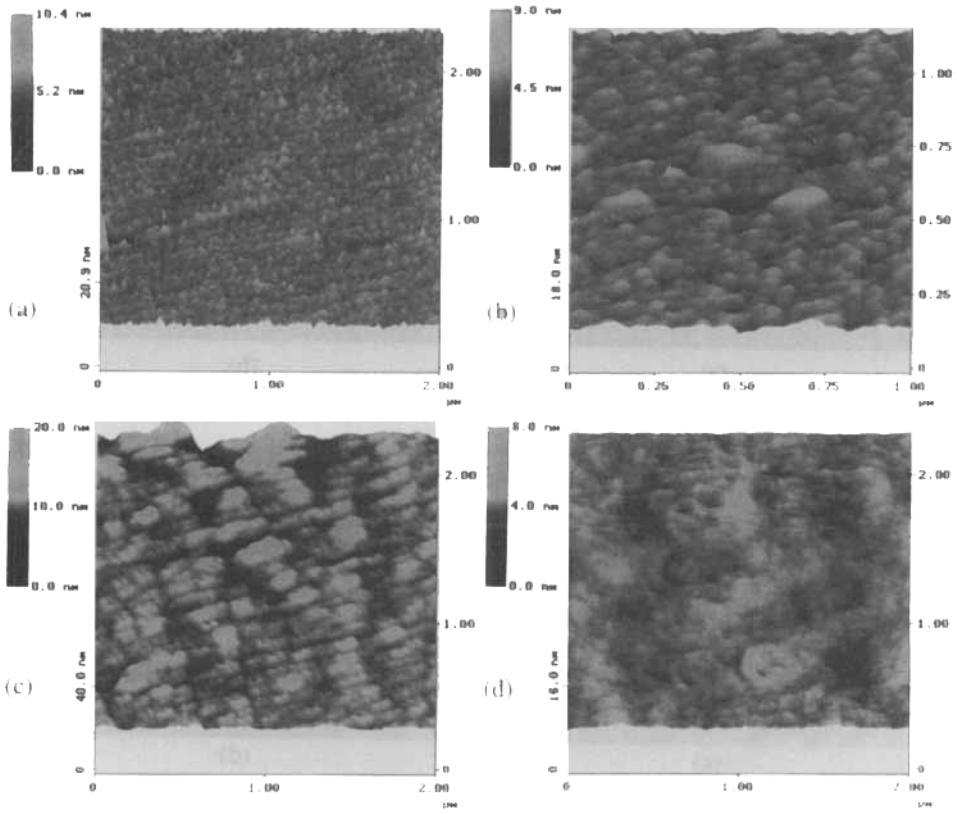

FIGURE 2. AFM (a) PTFE at 170°C resolution 2x2 μm, (b) at 170°C resolution 1x1 μm, (c) nylon 6 resolution 2x2 μm, (d) PTFE at 130°C resolution 2x2 μm. (See Color Plate XIII).

The average film roughness was also evaluated from AFM measurements and results are reported in Table 1. Here R_a is the average roughness, Z_r is the maximum excursion range of the tip perpendicularly to the film, and R_q is standard deviation, all expressed in nm. The values were calculated at a resolution of 1x1 μm^2, for nylon 6 films (amorphous and rubbed) and PTFE films deposited at 170 °C. PTFE films are more homogeneous than nylon ones as the reported values of roughness show. In SSFLC cells, reduced roughness means a reduced effective contact area, which reflects in smaller anchoring forces and, therefore, in a faster response.

TABLE 1 Roughness of samples.

Resolution 2x2 μm^2	Nylon 6 amorphous	Nylon 6 rubbed	PTFE at 170°C
R_a (nm)	1,07	0,67	0,45
Z_r (nm)	13,5	6,1	5,8
R_q (nm)	1,5	0,9	0,6

CELL OPTICAL RESPONSE MEASUREMENTS

Test cells were assembled using PTFE alignment layers deposited at temperatures in the range from 150 °C to 180 °C. Matrix displays were fabricated assembling two glass substrates with conventional ITO electrodes produced from ITO covered glasses (Donnelly Applied Films Corporation). By means of a photolitographic process, 1.5÷1.6 μm thick photoresist spacers were patterned on one of the substrates, then the alignment film was deposited on both substrates[9]. The cells were filled under vacuum with the liquid crystal blend ZLI-4851-025 (Merck).

The electrooptical performance of the single pixel was evaluated using a gradation addressing cycle designed by Maltese et al.[10]. The selection and data waveforms employed are shown in Figure 3. In order to evaluate hysteresis and sticking parameters standard data cycles were defined.[10]

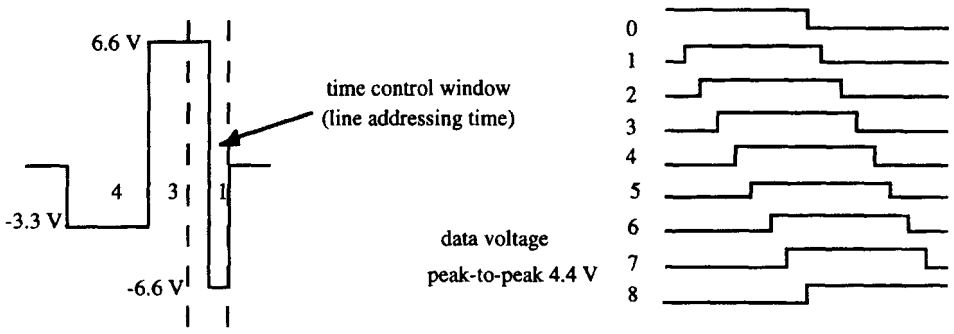

FIGURE 3 Selection and data waveforms used to address test cells.

Measurements were performed at constant temperature (23±1 °C). Typical hysteresis cycles are plotted in Figure 4 for PTFE cells on the left-end and nylon ones on the right-end, for comparison.

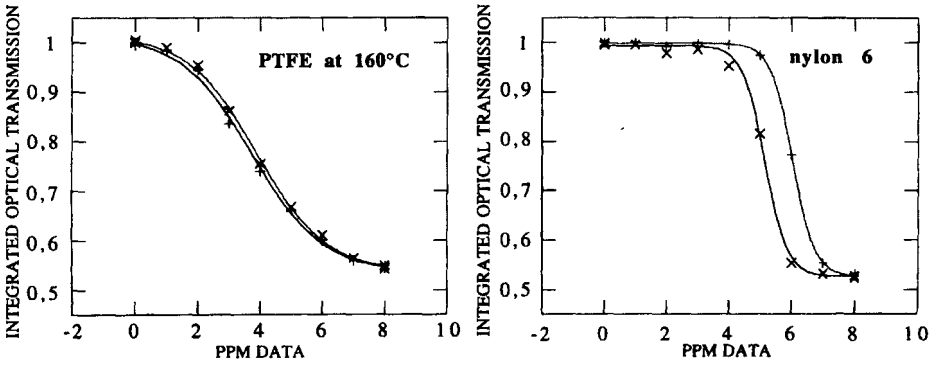

FIGURE 4 Recorded addressing hysteresis cycles

In Table 2 normalised measured values of shift and sticking are reported as defined by Maltese et al.[10]; The third row reports mean line-addressing times (t_{mean}) which are related to response time. Displays using PTFE layers showed a strong reduction of hysteresis, together with a sensible reduction of sticking and response time. The strongly reduced hysteresis and faster response time might be related to a anchoring force probably reduced, as roughness measurements seem to suggest.

TABLE 2 Comparison between cell optical performance

	Nylon 6	Teflon 160°C
Shift	0.88	0.15
Sticking	0.8	0.3
t_{mean} (μs)	490	295

CONCLUSIONS

PTFE films have been deposited and investigated as alignment films for ferroelectric liquid crystal displays. Their structure is comparable to that of standard polyamide films in respect to thickness and homogeneity, as evidenced by SEM measurements. AFM measurements showed that degree of molecular order is even higher in the case of PTFE films. It has been observed that the structure of PTFE films strongly depends on the deposition temperature and that only PTFE films deposited in a small range of temperatures can properly align the liquid crystal. Anyway, the best advantage of employing PTFE films respect to traditional polymers is a dramatic improvement of liquid crystal electrooptical performances which allows the fabrication of reproducible grey scale analog devices at low cost.

REFERENCES

1. J. C. Wittmann and P. Smith, Nature, 352, 414 (1991).
2 S. Quentel, Thesis, Université de Montpellier II (1993).
3. W.J.A.M. Hartmann, PhD Thesis Philips Research Laboratories, Eindhoven (1987).
4 L. Mulatier, Thesis, Commissariat à l'Energie Atomique Division LETI du Centre d'Etudes Nucléaires de Grenible (1988).
5 Y.Uchiyama and K. Tanaka, Wear, 58, 223 (1980).
6 C.M. Pooley and D. Tarbor, Proc. R. Soc. London A. 329, 251 (1972).
7 P. Maltese, F. Campoli, A. d'Alessandro, V. Foglietti, A. Galbato, A. Galloppa, G. Rafaelli and M. Wnek, Ferroelectrics, 179, 153 (1996).
8. M. Matuszczyk, T. Matuszczyk, S. T. Lagerwall, Y. B. Kim, M. Wnek and P. Maltese, Ferroelectrics, in press (1996).
9. A. d'Alessandro, F. Campoli, R. Beccherelli, M. Wnek, A. Galloppa, A. Galbato and P. Maltese, MELECON, Bari, 3, 1513 (1996).
10. P. Maltese, R. Beccherelli, F. Bernardini, M. Wnek and F. Zuliani, Ferroelectrics, Vol. 178, p. 27 (1996) .