Electro Optical Study of the Liquid Crystals & Polyimides For High Reliability Performance

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Abstract

To achieve the high reliability performance in IPS cell, finding a good combination of Liquid Crystal (LC) materials and Polyimide (PI) is very important as they play a key role in IPS cell. Several LC materials and PIs have been introduced for preparation of their different combinations. Electro optical characteristics such as voltage holding ratio, residual DC and AC image sticking have been investigated for the different system of the LC material and PI in the test panels in an attempt to find the effects on the display reliability performance and image sticking.[1)3)]

Introduction

The recent growth of TFT-LCD market has been further accelerating the demand for fast response time, high contrast ratio& brightness, wide viewing-angle characteristics. To improve these characteristics we have tried circuit driving technique, various TFT array and the optimization of cell parameters as well as the approach of multi domain like S-IPS, FFS and VA mode.

Recently many researchers have devoted to improve the characteristics of cell components such as LC materials, color PR, alignment layer and optically compensated films etc for enhancement of the response time, contrast ratio, brightness and viewing angle. Though super performance of materials we still have lots of qualitative problems such as reliability, and also we need to find the optimized combination of each material in the aspect of matching properties related to the interaction between LC and PI.

In this paper, we made possible combinations of LC and alignment layer whose singles are structurally different and characterized them by electro-optical measurements such as VHR, residual-DC, AC image sticking . The best combination of cell materials based on the experiment results shows good reliability performance and guarantees image sticking-free.

The study on the interface formed between LC material and PI was collaborated with Electro Materials Research Laboratories of Nissan Chemical and Merck Advanced Technologies (MAT).

Experiment

1.Sample Combination

The characteristics of LC materials and alignment layer consisting of test cell were summarized in **Table 1.**[2)]

		Characteristics
LC	LC1	LC mixture which contains CN terminal group
	LC2	LC mixture which contains ester-bridged compounds
	LC3	LC mixture which contains CF_2O-bridged compounds
PI	PI1	PAA containing rigid structure
	PI2	PAA containing LC-like structure
	PI3	PAA containing flexible structure

Table 1. Characteristics of LCs & PIs

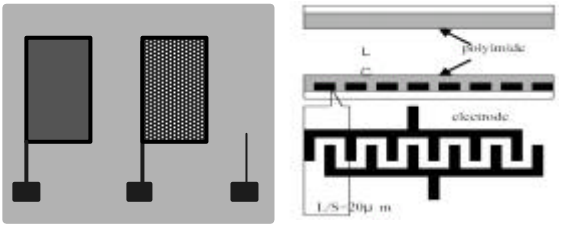

Figure 1. A brief sketch of the test cell

2.Test cell fabrication

The test cells which are made of glass substrates with comb-like electrode were assembled parallel (cell gap: 6㎛) **(Figure 1).** PI films were cured at 220℃for 30min after being printed on the glass substrate and rubbed by rayon cloth. The thickness of films was 100nm.

3.Measurement

3-1 VHR depending on temp & UV irradiation

VHR of the test cells was measured at various temperature (20℃, 60℃, 100℃) and under UV irradiation condition (3000mJ~5000mJ).

3-2 RDC (Residual DC)

RDC of the test cells was evaluated by DAM (Dielectric Absorption Method) at 23℃. (**Figure 2)** A 10V as direct current to the test cell was applied for 30min and then discharged for 1sec. Then RDC versus time was plotted. [4)]

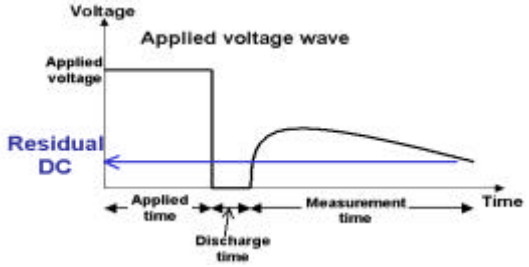

Figure 2. Schematic diagram of dielectric absorption

3-3 AC image sticking

The IPS-mode cells with two pixels were constructed under the same condition described previously in section 2. After a 30V as alternative current was applied to one of two pixels for 3hr at 60℃ and then cut off. Observed was different degree of brightness between two pixels which can indicate the level of image sticking. (**Figure 3**)

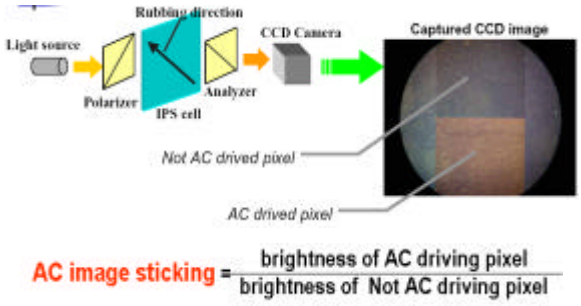

Figure 3. Evaluation method of AC image sticking

Results and discussion

1.Influence of VHR on the reliability performance

VHR of test cells was measured at various temperatures and intensities of UV radiation. (**Figure 4**) Test cells were made of two substrates printed with fixed polyimide and then filled with LC 1, 2 and 3. As shown in Figure 4, VHR depends on LC because the different structures of single molecules within LC can affect VHR. Drastic deterioration of VHR values were observed in the CN-group contained LC 1 while LC3 which contains CF_2O bridged compounds exhibited the highest VHR values over temperature load and UV irradiation.

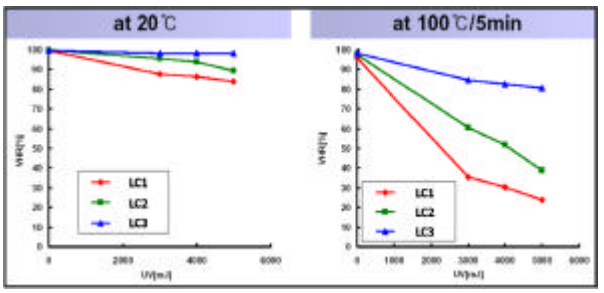

Figure 4. VHR of LCs by UV and thermal stress

Table 2 demonstrates the effect of polyimides as well as LC materials. In the some TC such as LC3 containing a polar CF_2O bridged compound and PI1 containing rigid PAA VHR values are high. Especially TC with LC3 remains high VHR values independent of temperature.

PI	LC	VHR (Voltage Holding Ratio)	
		20℃	60℃
PI 1	LC 1	99.1	96.7
	LC 2	99.5	98.2
	LC 3	99.5	98.8
PI 2	LC 1	97.7	93.2
	LC 2	99.0	96.9
	LC 3	99.4	98.2
PI 3	LC 1	98.4	94.9
	LC 2	99.1	96.3
	LC 3	99.3	98.3

Table 2. VHR Characteristics depending on LCs and PIs

2.Influence of RDC on the Image sticking

The RDC values were obtained in the test cells using three kinds of liquid crystal materials and alignment layers to compare. (**Figure 5**) The lower initial RDC value and the steeper RDC curve imply generally the lower image sticking & DC mura degree. CN terminated LC1 has the higher initial RDC value than

those of other LC materials and super fluorinated LC materials such as LC2 and LC3 show better properties, especially good in discharging rate in the combination with PI2 and PI3 than LC1 as shown in **Figure 5.** These phenomena may come from an interaction between LC and PAA which has LC-like moiety and flexible main chain. Both LC1 and PI1 are the worst in terms of each material but the combination of LC1 and PI1 actually shows the lower RDC than the other ones (Figure 5(a)). As RDC curves vary by different combination of PI and LC material, the results instructed that selection of PI depends on which kind of LC mixture concept is used or vice versa.

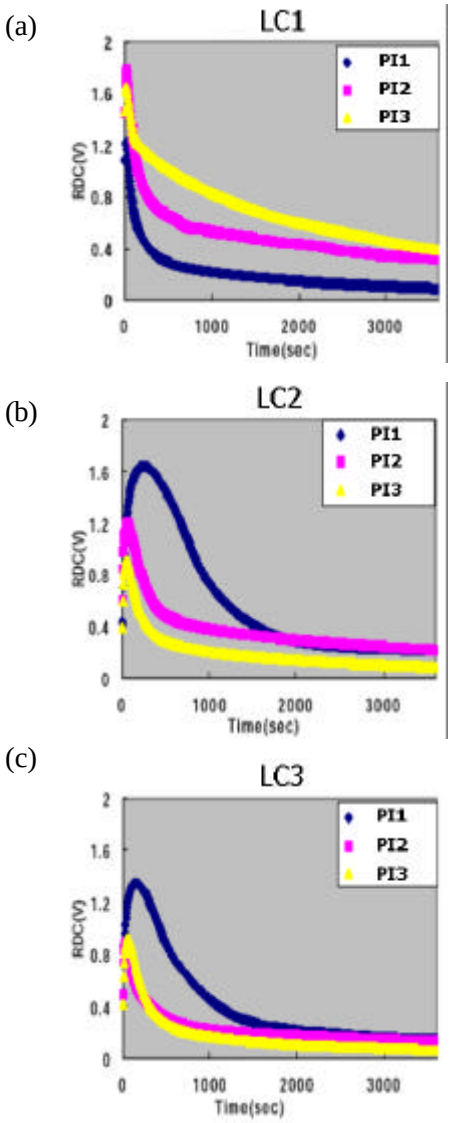

Figure 5. RDC measurement & curve characteristics

LC materials were aligned homogeneously in the cells with two pixels. An electric field was applied parallel to check the AC image sticking.(Figure 6) In short, The weaker AC image sticking can be expected when the azimuthal surface anchoring energy is higher.

LC like PI2 with PAA structure showed the lower level of AC image sticking for all three LC mixtures which may come from its similarity in structure to LC materials. We can understand that they are appropriate for each other because of their similar structures and finally make adequate anchoring energies on the surface.

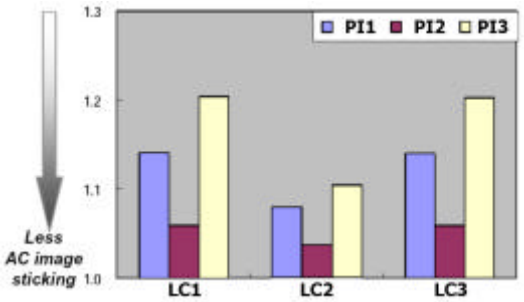

Figure 6.Evaluation results of AC image sticking

Conclusion

Reliability parameters such as VHR, RDC and AC image sticking have been evaluated in the different combination of PI and LC material. Combination of LC3 and PI2 can be expected to fulfill the highly demanding requirement of display reliability. Further investigation will be continued in the real panel state.

Acknowledgement

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Reference

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