Inorganic Salt Doped Soluble Polyimide Type Alignment Layer for Improving Panel Reliability and DC Image Sticking Properties

Tae-Rim Lee*, Seung-Kwang Roh, Young-Nam Lim, Kyeong-jin Kim, Hyun-Ho Shin,
LG. Display Co., Ltd.
1007, Deogeun-ri, Wollong-myeon, Paju-si, Gyeonggi-do 413-811, Korea
Phone : 82-31-933-7535, E-mail: rimick@lgdisplay.com

Abstract

Polymide is widely used alignment material of recent commercial LCD panel structure. Generally, polyimide alignment material is classified soluble polyimide type and polyamic acid type with their main bond structure of solution state. specially, compared to polyamic acid alignment layer, soluble polyimide type alignment layer have excellent reliability during long term LCD driving cause of their high imidazation ratio(%), high voltage holding ratio(%) and low ion density. The other side, this type alignment materials has significant DC image stickicng side effect for using in-plane switching mode lcd structure cause of their slow DC discharging property. we applied inorganic salt to usual soluble polyimide type alignment layer and found out this technique had good DC image sticking property without any loss of reliability property in inplane switching LCD cell structure. This approach leads excellent DC image sticking property with maintaining high reliability property this approach confirmed improves an image sticking and a reliability simultaneously from the horizontality aligned LCD mode whose relatively bad image sticking property.

1. Objectives and Background

Liquid crystal display(LCD) has grown into the most effective flat panel display(FPD) technology through satisfying various technological demands in the wide applications (Cellular phone, Notebook, Monitor, TV, etc…). recently, LCD has been gradually used for information display cause of lots of merits for this usage. (no burning, high brightness, low power consumption and etc.). but for this usage, compared to normal LCD, it needs to has more specific characteristics during long-term driving condition, for example, image sticking and high temperature reliability to prevent uneven failure during long term driving with sticky pattern at high temperature (figure 1)

Fig 1. various uneven failure at long-term LCD Driving

In general, the causes of both Image sticking and reliability at LCD are related to various technologies including panel, mechanics and circuit design. but basic properties are strongly related with liquid crystal and alignment layer in LCD cell. because these phenomena are mainly resulted from impurity adoption at DC charged region in panel.

Usually, within LCD driving, various impurities (organic, ionic, water, and etc.) in liquid crystal (LC) cell move to DC charged region. and during long-term sticky pattern driving, they are seriously trapped at DC charged region in cell layer. this damage can change effective driving voltage of liquid crystal, so, it appears different brightness compared with normal area at same driving condition. also, sticky pattern enhance this phenomena because it can not change DC charged region in LC cell. (Figure 2)

with this brief mechanism, we can easily find it is effective method of improving image sticking and reliability to minimize impurities and enhance DC discharging ability of liquid crystal and alignment layer. liquid crystals are generally related with various electronic and optical properties of LCD. so, it is not easy to make panel have good image sticking and high reliability without any change of various display property with liquid crystal (brightness, response time, and others.). so, we are focused our activities on controlling alignment layer.

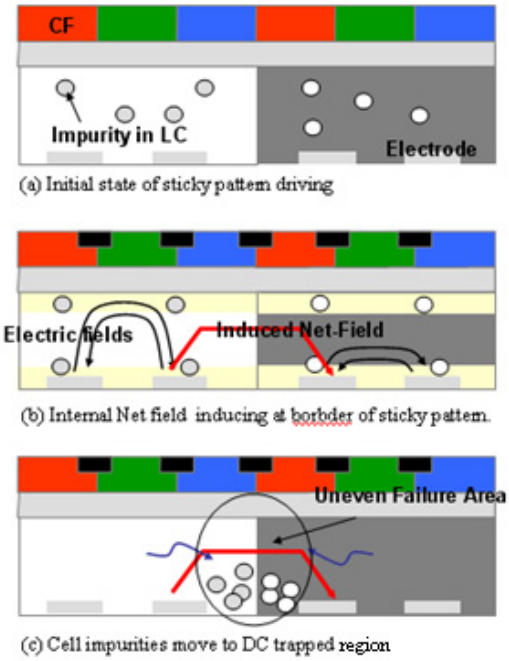


Fig 2 Brief mechanism of uneven failure at LCD

In general, the chemical structure and physical properties of alignment layer related to not only decide initial direction of liquid crystal, but also decide DC stability of LC cell with controlling DC charging-discharging ability in LC cell. (In general, residual DC in cell directly has an bad influence on DC image sticking. and this property is strongly related with resistivity of alignment layer. high resistivity alignment layer appears low DC charging - low DC discharging property compared to low resistance material. Figure 3).

So, to make low image sticking and high reliability cell with controlling alignment layer, we must design alignment layer have low impurity (or slow mobility of impurity) and low resistivity.

It can make low image sticking with fast residual DC discharging in LC Cell and high reliability with low impurity in LC cell. but in real case, it is not easy to make polyimde alignment layer have both properties cause of unique trade-off relationship between low impurity and low resistance. in other words, usually, high impurity have influence on lowering resistivity of polyimide layer. on the other side, high resistivity make impurities have slow mobility. in general, polyamic acid type alignment layer is the former, soluble polyimide type alignment layer is the latter.

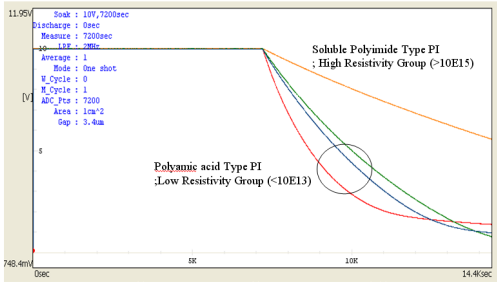


Fig 3. General Cell DC property in IPS cell for various PI resistivity.(DC decay graph after 2hr,10V DC Stress at RT)

soluble polyimide type alignment layer have excellent reliability cause of their high imidazation ratio(%), high voltage holding ratio(%) and low ion density. the other side, this type alignment materials has significant DC image sticking side effect cause of their slow DC discharging property due to high resistivity.

To make cell have both high reliability and low image sticking with alignment layer, we tried to adopt various inorganic salt to usual soluble polyimide type alignment layer for lowering resistivity without any change in impurity property. (Table. 1.)

	Panel Properties		Electronic Properties			
	Image Sticking	Long-Term Reliability	Voltage Holding Ratio (%)	Ion Density	Resistivity	Residual DC Decay
Soluble PI Type Alignment Layer	Bad	Good	High	Low	High	Slow
Polyamic Acid Type Alignment Layer	Good	Bad	Low	High	Low	Fast
Ideal Alignment Layer	Good	Good	High	Low	Low	Fast

Table 1. general properties of each type PI alignment layer

2. Experimental and Results

2-1.Preparation of salt doped PI solution

At first, we tested solubility of various inorganic salt materials to commercial PI Solution (JSR, JALS-146, S-PI) for selecting best material have good solution coating property and uniform dispersion property within all PI layer.

Inorganic Salt	Method I		Method II	
	100ppm	1000ppm	100ppm	1000ppm
MgSO4	X	X	X	X
KBr	X	X	O	O
NaCl	X	X	X	X

Table 2. Solubility test results for each inorganic salts

we used three kinds of inorganic salt (MgSO4, KBr, NaCl). each inorganic salt mixed into 25grams SPI type PI solution with each content (100ppm, 1000ppm). after stirring 30min, we checked solubility with eyes. but it resulted all kind of salts appear no solubility(Method I). so, first inorganic salts mixed into 1gram of water at first, then mixed these solution into 25grams SPI type PI solution(Method II). with this procedure, in case of KBr salt, we could obtain perfectly clear inorganic salt doped PI solution.

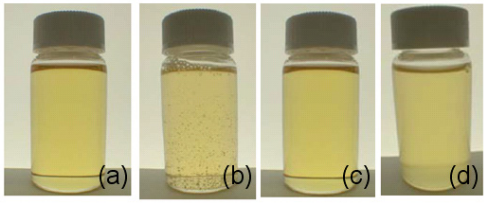


Fig. 4. Results for each mixing condition

(a) KBr 100ppm, Method II, perfect clear

(b) MgSO4 100ppm, Method I, participated

(c) KBr 1000ppm, Method II, perfect clear

(d) MgSO4 100ppm, Method II, turbid

2-2. Preparation of LC Cells

Figure 5 shows the structure of the IPS-LC cell used in this study. LC cells were prepared to measure the effect of the inorganic salt doped PI films on the VHR, ion density and Residual DC for forecasting image sticking and reliability. The alignment films were deposited first by spin-coating of dilute solution of PIs with gamma-butyrolactone on the substrates and then cured at 220℃ for 1hr. the thicknesses of PI films were kept at 100nm. The PI films were rubbed with a rubbing machine using a rayon cloth. The samples were in-plane switching mode cells(Fig 5), which were filled with nematic LC (ZGS-5273, Chisso).

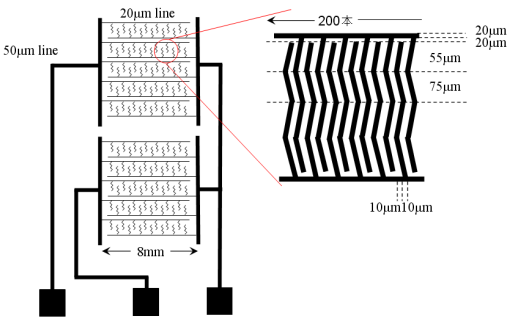


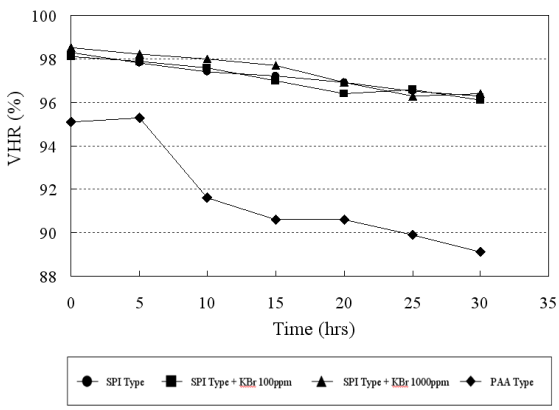
Fig 5. Detail LC Cell structure for Test

2-3. Measurement of Electronic properties of LC cells

For studying reliability, the values of VHR, ion density and their decay behaviors were measured with a measurement unit (Toyo Corporation, Model 6254). During 30hrs, the values of VHR were measured at 100℃ under 1V, 60us pulse, and 100us frame period condition. and, the values of ion density were also measured at same condition under 10V, 0.1Hz pulse condition. on the other hand, for studying DC image sticking, the values of residual DC were measured with same measurement unit. DC decay value in LC cell were measured during 2hrs at 60℃ after inducing 10V DC voltage for 2hrs.

2-4. Results and Discussion

The time versus measured VHR and ion density of each LC cells are shown in Figure 6. the VHR and ion density of LC cells with KBr doped PI shows almost same initial value and same decay level compared to values of normal soluble PI cell . with this result, we could confirm inorganic salt doped PI system doesn't effect LC cell reliability. and it also doesn't related with inorganic salt contents. a suggested model of this result which inorganic salts in bulk PI can't lower VHR and ion density of the LC cell is shown in Figure 7. the inorganic salts have high polarity. they can strongly interact with polar groups in PI structure and can't move into LC layer. so, LC cell with inorganic salt doped PI shows almost same reliability like normal soluble PI.



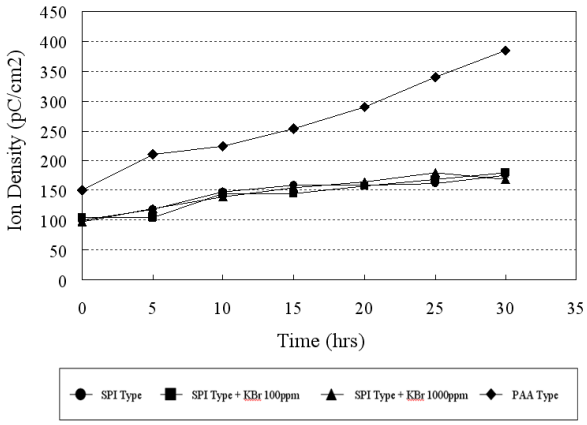


Fig. 6. The measurement result curves of VHR and Ion density for each cell condition

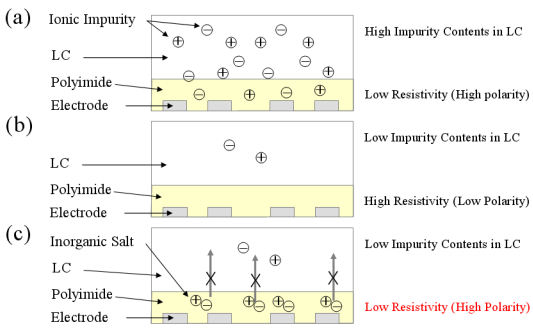


Fig. 7. Inorganic salt doping effect in LC cell
(a)Normal PAA type PI case (b)Normal SPI type PI case
(c)Normal SPI type PI + Inorganic salt case

The residual DC decay of each LC cells were also measured for DC image sticking.(Figure 7). the residual DC decay was enhanced by inorganic salt doping. and also, this enhancement value increased with increasing inorganic salt contents. especially, LC cell with 1000ppm KBr condition appeared almost same decay level with normal polyamic acid type alignment layer. its shows inorganic salt doping method can effectively lower bulk resistivity of PI layer. so, it can enhance decay speed of residual DC in IPS LC cell.

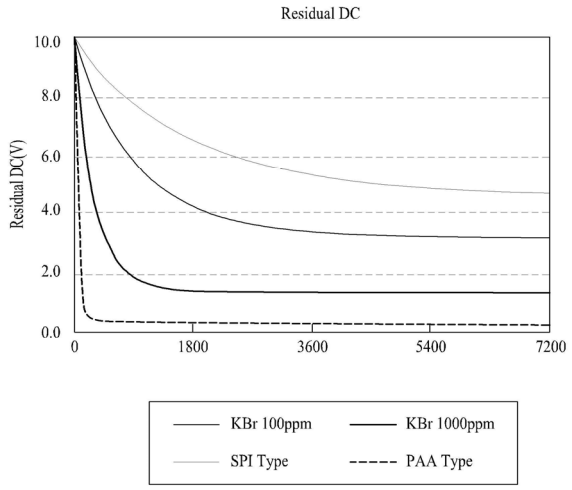


Fig. 8. the measurement result curves of R-DC for each cell condition

with these results, we could confirm inorganic salt doped soluble PI alignment system can improve DC image sticking level in IPS LC cell without any loss of reliability.

3. Conclusions

Until now, it is hard to use Soluble PI type alignment layer to IPS mode LCD for improving reliability, cause of serious DC image sticking.
In this study we employed inorganic salt in order to increase DC discharging property without increasing impurity for solve this problem. and with this approach, we have successfully developed new LC cell system for information display usage to improve both long-term reliability and image sticking level. also, we
could know that inorganic salt doping method can reduce bulk resistivity of bulk PI layer without increasing ionic impurities in LC layer.
no doubt, these new technology will simply provide the better performance for long-term driving usage of LCD.

4. Acknowledgements

We deeply appreciate Mr. Nishikawa, LCD materials laboratory of JSR corporation for kindly support in the research.

5. References

[1] Ritsh Kamoto, *SID Technical Digest*, p124 (2007).

[2] K. Tsutsui, T. Sakai, SID Technical Digest, p1166 (2003)

[3] Hyang-yul Kim, Jae-hyung Kim, *Liquid Crystals*, Vol. 29, No. 8, 1051 (2002)

[4] Masahito Oh-e, Katsumi Kondo, *Liquid Crystals*, Vol. 25, No. 6, 669 (1998)

[5] Masahito Oh-e, Yoshiyuki Umeda, *Jpn. J. Appl. Phys.*, Vol.36, 1025 (1997)

[6] H. J. Park, Luc. Lai, *SID Technical Digest*, p204 (2003)

[7] Michinori Nishikawa, Takayoshi Suganuma, *Jpn. J. Appl. Phys.*, Vol. 33, 1113 (1994)

[8] M. Inoue, M. Akimoto, *International Display Workshop*, p159 (2008)