Investigation on The Effects of 365nm UV Light Irradiation on The Polyimide Alignment Film

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ABSTRACT

We have investigated the effects of ultraviolet light with wavelength of 365nm irradiation on polyimide alignment film. We compared image quality and image sticking of a IPS-LCD before and after irradiation, the experiment showed mura appeared and image sticking became bad through irradiating a certain amount of exposure energy.

1 INTRODUCTION

Nowadays numerous display technologies such as liquid crystal display (LCD), organic light emitting diode display (OLED), mini-LED or micro-LED display and quantum dot LED (QLED) display have drawn most attention in consumer electronics industry, depending on their distinctive merits [1]. LCD still is the mainstream application in recent years by virtue of low cost, can be as big size, the mature technology and long service life. It is well known the uniform alignment of LCs on substrate surfaces is very important in LCD, the polyimide (PI) alignment film has been widely used to align LC molecules because of its excellent thermal stability, chemical resistance, high mechanical strength, good transparency, adhesive strength, and strong anchoring energy [2].There are rubbed PI and photosensitive PI based on the process of conventional mechanical rubbing and polarized deep ultraviolet (DUV) light illumination. 365nm UV light is generally used in LCD manufacturing process, for example, curing seal in processes of substrates assemblage and panel thinning. It is believed that LC molecular is easy to be affected by 365nm UV light irradiation, however, there is almost no research on photostability of PI. In this article, we showed the effects of 365nm UV light irradiation on rubbed PI or photosensitive PI, and fully confirmed cross linker content and resistivity of PI have a significant importance on image quality and image sticking of LCD.

2 EXPERIMENT

2.1 Sample preparation

In order to confirm the change of LCD after 365nm UV light irradiation, a 5.5” IPS cell (no upper and lower polarizer) was used as the mode in this paper. As shown in table 1, five polyimide samples (from Nissan chemical co., Ltd) were applied for cell preparation, among them polyimide 1 was rubbed PI, the other four were photosensitive PIs (254nm photo-decomposition type). The cells were prepared by using the same materials besides LC.

Table 1 Details of five polyimide samples

Polyimide	Alignment method	Cross linker content	Resistivity (Ωcm)
PI1	rubbing	standard	5.0×10^{14}
PI2	photoalignment	standard	5.0×10^{13}
PI3	photoalignment	standard×1.5	5.0×10^{15}
PI4	photoalignment	standard×3	5.0×10^{13}
PI5	photoalignment	standard×3	1.0×10^{13}

The cell was divided into two areas equally, one area A was covered by the black mylar film, and another area B was irradiated vertically by using 365nm UV light for a exposure energy of 2800mJ/cm^2 at approximately 70mW/cm^2 (Figure 1).

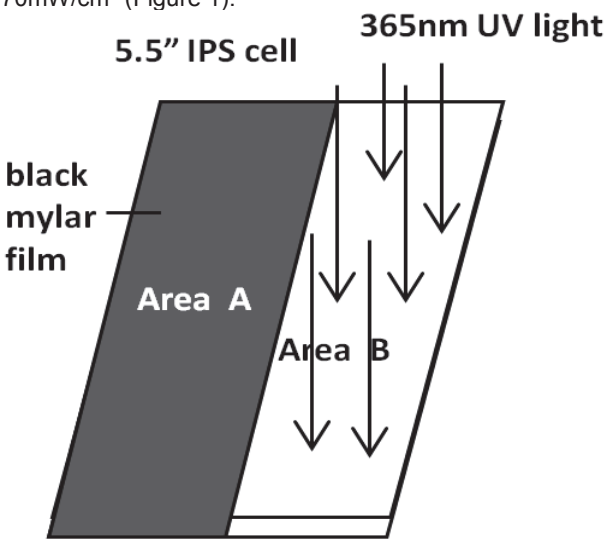

Fig. 1 Schematic diagram of 365nm UV light irradiation

2.2 Evaluation methods

Image quality and image sticking were both of the most important issues on LCD, the irradiated cells were attached with upper and lower polarizers, and then were given a driving voltage to compare the difference of image quality in two areas (A and B).

10*10 chessboard (with white L255 and black L0 block pattern) was used as burn-in pattern (Figure 2) and L127 pattern was taken as reference one. After 365nm UV light irradiation, the cells were burned for 2 hour, then switched to L127 pattern and measured image sticking decay phenomenon of area A and area B. The measure environment is fully dark room state at 25℃.

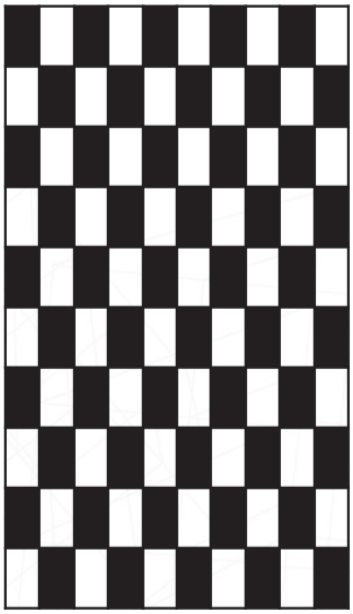

Fig. 2 10*10 chessboard with white L255 and black L0 block pattern

3 RESULTS and DISCUSSIONS

The phenomenon of split screen mura was carefully observed as shown in photograph 1. We defined JND values to evaluate the level of mura, the minimum JND value indicated the slightest phenomenon of mura, and the higher JND value indexed worse image quality, and there was no mura when JND value was less than or equal to 2.2. To find the relation between quantification factors and JND values (human vision) mura was judged by one experienced umpire. Cells were judged immediately after irradiation and a period of releasing time.

Photo. 1 The phenomenon of split screen mura

The result is shown as Figure 3. It is confirmed that 365nm UV light has an effect on the IPS cell, and the only difference of these five samples is polyimide alignment film, but the level of split screen mura is not the same, so it shows that 365nm UV light could impact PIs. Fig. 3 shows that the level of split screen mura is not only relate to an amount of crosslinking agent in PI, but also relate to the value of the number of resistivity. And split screen mura becomes more and more light as releasing time increases. When using PI1 ans PI2 with the lowest cross linker content, JND value of PI2 is bigger than PI1, it means that the resistivity is smaller, the mura is more serious. When using PI2 ans PI4 with the same value of resistivity, JND value of PI4 is bigger than PI2, it means that the cross linker content is more, the mura is more serious.

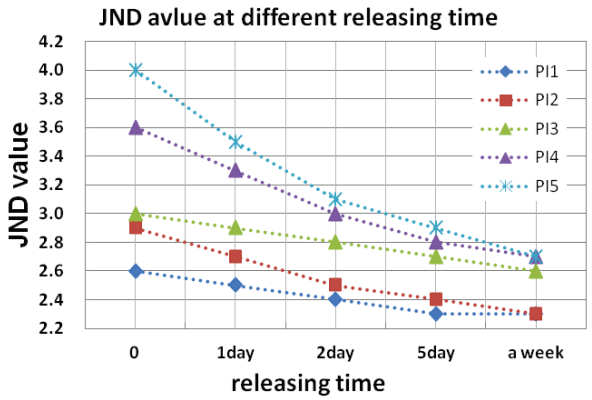

Fig. 3 JND value of split screen mura at different releasing time

We found that the root cause of split screen mura is charge accumulation in PI, charge accumulation results in brightness of area B is different from area A. This is why split screen mura is directly bound up with crosslinking agent and resistivity, because under component of PI contains crosslinker, crosslinker is easy to occur charge accumulation, and under component of PI is more sensitive to UV light when it's value of resistivity is smaller, then under component of PI occurs charge accumulation with cross linker after irradiation. All know, low resistivity accumulates charge easily, but also releases it quickly, and high resistivity has little accumulation, but also has slow release, so charge releasing rates of PI2, PI4, PI5 are faster than PI1, PI3.

As Photograph 2, image sticking phenomenon of area B is obvious, which is proved that 365nm UV light will cause image sticking failure. We normalized the measured data to get the image sticking phenomenon, and figure 4 shows the five samples' IS level of two areas for comparison. Image sticking of area B of all cells became bad after irradiation, and the proportions of variation of PI1, PI2 are minimum, the proportions of variation of PI4, PI5 are maximum. It is considered closely related to cross linker content, when 365nm UV light irradiate cells, charge is gathered through under component of PI and cross linker, then, charge stocked at the interface LC/PI film by electrically driven, and produced more residual DC voltage in area B.

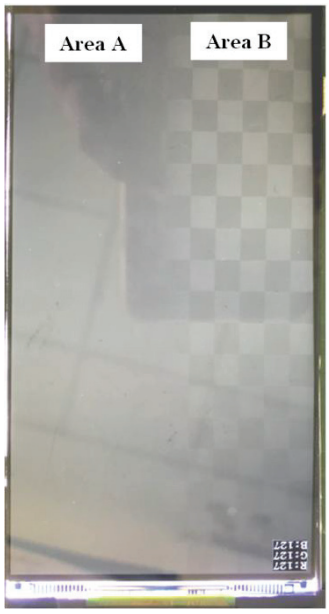

Photo. 2 Image sticking phenomenon of two areas

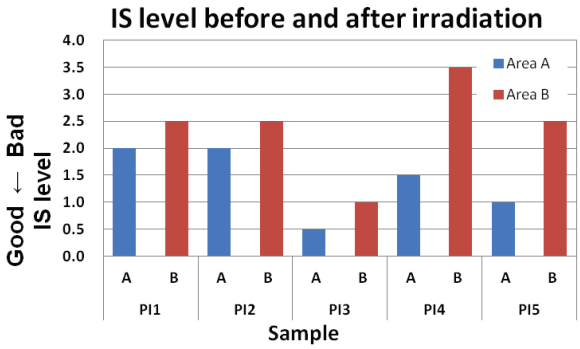

Fig. 4 Image sticking level of two areas of five cells

As shown in Fig. 5, "optimum Vcom" voltage was measured by flicker method at 25 degree immediately after irradiation, both area A and B. "Optimum Vcom" voltage could have an indirect characterization on residual DC voltage, charge stocked at the interface LC/PI film by electrically driven, then caused a DC offset in LC cell, which made an unbalance Vcom. Human will adjust Vcom to optimum position to keep it in balance, "optimum Vcom" voltage of area B is bigger than area A, it means residual DC voltage becomes higher after irradiation, which is the main reason to induce the worse image sticking phenomenon [3].

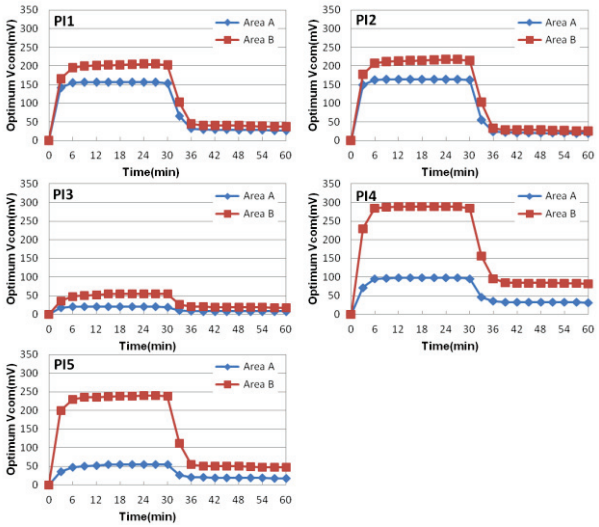

Fig. 5 Vcom shift of five cells after 365nm UV light irradiation

4 CONCLUSION

According to our research, we confirmed that 365nm UV light in addition to affect LC molecule, can also affect PI film in IPS LCD. It was proved that high cross linker content caused bad image quality and more image sticking, also the great resistivity was very important for dissipation of split screen mura. We can make use of this consequence on development and preparation of PI materials.

REFERENCES

[1] J. Song, S. Kim, H. Nam, S. Roh, J. Lee, D. Sakong, J. Souk, "Novel Manufacturing Process of TFT-LCD Featuring C/F on Array and Its Applications." SID Digest, pp. 1018-1021 (2000).

[2] Ho, Jacob Y. L., V. G. Chigrinov, and H. S. Kwok. "Variable liquid crystal pretilt angles generated by photoalignment of a mixed polyimide alignment layer." Appl. Phys. Lett. 90, 243506 (2007).

[3] K. T. Huang, Andy Chao, C. H. Yu. "P-123: Image Sticking Analysis of Different Q-time LC Cell by Machine Vision." SID Digest, pp. 38(1):665-668 (2012).