Eliminate Circular Bright Spots Resulting from Poor Compatibility between PI and Liquid Crystal in LCD

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Abstract
Poor compatibility between PI (polyimide liquid crystal alignment agent) and liquid crystal in LCD can lead to poor liquid crystal alignment and deflection performance, as well as the appearance of bright spots, resulting in a decrease in panel yield. This article analyzes the formation mechanism of these bright spots. Finally, we address this issue by designing a PI structure.

Author Keywords
Polyimides; LCD displays;

1. Introduction
With the advancement of LCD panel manufacturing technology, the use of liquid crystal paired with polyimide liquid crystal alignment agents to control liquid crystal deflection has emerged as a mainstream technique[1-3].The compatibility between liquid crystal and liquid crystal alignment agents has become a technical crux. Poor compatibility can result in issues such as residual images, bright spots, and Mura[4-6]. This article presents a design scheme for polyimide liquid crystal alignment agents that can significantly minimize the occurrence of bright spots.

As shown in Figure 1, the compatibility between polyimide and liquid crystal is poor, resulting in bright spots during the panel manufacturing process.

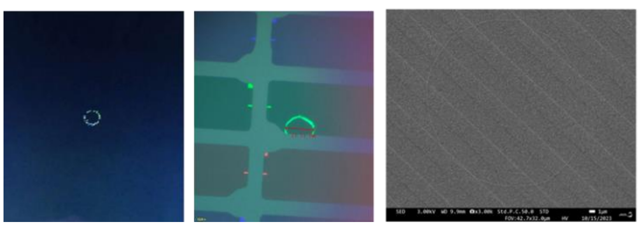

Fig. 1. Image of circular bright spots(On the left is visual inspection, in the middle is OM microscopy, and on the right is SEM)

Infrared spectroscopy analysis was conducted on circular clustered objects, and the results indicated that the composition at the convex position is consistent with that of the surrounding components, as illustrated in Figure 2. This suggests that the abnormality arises from uneven reaction during the PSA (Polymer Sustained Alignment) process[7-9]. Upon investigating environmental factors, it was discovered that the positions of the circular bright spots align with the support points of the robotic arm. Therefore, it can be concluded that the squeezing by the robotic arm causes uneven alignment of liquid crystals, leading to inconsistent UV light intensity during the PSA process and resulting in RM aggregation.

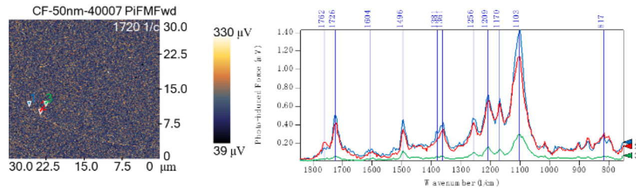

Fig. 2. Infrared spectroscopy testing of protruding

2. Experiment
2.1 Polyimide structure design
Conduct experiments to compare the effectiveness of improving bright spots using the existing polyimide side chain structure PBCH5DAB (1,3-phenylenediamine, 4- [4- [4- [(trans, trans) -4'-pentyl[1,1'-dicyclohexyl]-4-yl]phenoxy] -) and structure 1 (as depicted in Figure 3). Add 0.5%, 1%, 3%, 5%, 10%, 15%, 20%, 25%, and 30% PBCH5DAB and Structure 1 synthetic polyimide solution respectively, and then dilute the solution with NMP (1-Methyll-2-pyrrolidone) and BC (2-butoxy ethanol) to achieve a solid content of 4%. As indicated in Table 1, a total of 15 samples were obtained for both the control and experimental groups.

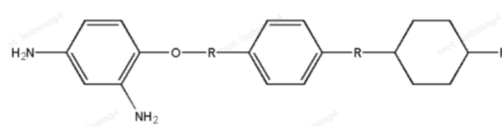

Fig. 3. Structure 1 (n represents an alkyl group with n carbon atoms, fluorinated alkyl group)

2.2 Product properties
Spin coat the obtained polyimide alignment agent onto TFT substrates featuring ITO slit structures and CF substrates with PS structures, and bake on a hot plate at 80°C for 120 seconds. Subsequently, bake in a hot air circulation oven at 185°C for 1200 seconds to produce a 100 nm PI film. Apply frame glue mixed with 3.6um silicon balls around the TFT substrate using a glue applicator. Use a pipette to dispense a 5×5 liquid crystal matrix onto the TFT substrate's surface. Then, place the TFT and CF substrates under hot pressure at 120°C for 2 minutes. Subsequently, the PSA (Polymer Sustained Alignment) process is carried out through the application of voltage and UV light irradiation, resulting in the formation of an alignment structure. Ultimately, the upper and lower substrates are affixed with orthogonal polarizing plates to enable display functionality.

Light up the sample with a DC voltage of 5V and maintain it for 72 hours. As shown in Table 1, the bright spot levels of different samples were determined. The criteria for judgment are shown in Figure 4.

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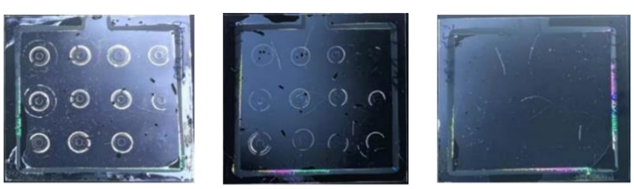
Table 1. Experimental performance of different samples

number	structure	proportion	grade
1	PBCH5DAB	1%	×
2	PBCH5DAB	5%	×
3	PBCH5DAB	10%	×
4	PBCH5DAB	15%	×
5	PBCH5DAB	20%	×
6	PBCH5DAB	30%	×
7	Structure1	0.5%	×
8	Structure1	1%	×
9	Structure1	3%	×
10	Structure1	5%	△
11	Structure1	10%	○
12	Structure1	15%	○
13	Structure1	20%	○
14	Structure1	25%	△
15	Structure1	30%	△

× represents severe bright spots, JND>4.0; △ represents mild bright spots, 3.0>JND>2.5; ○ represents no bright spots, JND<2.0;



JND > 4.0 3.5 > JND > 2.5 JND < 2.0

Fig. 4 Actual improvement of bright spots

3. Conclusion

Based on this, it can be concluded that replacing PBCH5DAB with structure 1 can significantly mitigate bright spot defects, with a preferred addition ratio of 10% to 20%.

4. Reference

1. C. K. S, W. C. H and C. H. T, "A MAIC approach to TFT-LCD panel quality improvement," Microelectronics Reliability, 46, 1189-1198 (2006).
2. M. Katayama, "TFT−LCD Technology", Thin Solid Films, 341, 140−147 (1999).
3. L. C. T, "Revolution of the TFT LCD technology", Journal of display technology, 3, 342–350 (2007).
4. L. Xiang, H. Hehe, N. Ce, S. Guangliang, Y. Wei , W. Ke, L. Xinhong, L. Woobong Lee, W. Gang, X. Jianshe Xue, J. Jung mok, Z. Shengdong, "Investigation into sand mura efects of a-IGZO TFT LCDs," Microelectronics Reliability, 63, 148–151 (2016).
5. X. Chen, Y. Kecheng, W. Anni, C. Chunxu, L. Wei, "A Mura Detection Method Based on an Improved Generative Adversarial Network," IEEE Access, 9, 68826-68836 (2021).
6. L. Ji, Y. Yongming, M. Hong, "Research progress of color photoresists for TFT-LCD," Dyes and Pigments, 225, 112094 (2024).
7. M. Koichi and K. Kazuki, "The World's First Photo Alignment LCD Technology Applied to Generation Ten Factory," SID symposium digest of technical paper, 41, 579-582 (2010).
8. T. Michael F, R. Thomas P, L. J. Anthony, K. Hirotsugu, Kikuchi, S. James M and K. Sanat K, "Near-surface alignment of polymers in rubbed films," Nature, 374, 709–711 (1995).
9. L.Tae. Rim, K. Jin. Ho, L. Seung. Hee, J. Myung. Chul and B Hong. Koo, "Investigation on newly designed low resistivity polyimide-type alignment layer for reducing DC image sticking of in-plane switching liquid crystal display," Liquid Crystals, 44(4), 738–747(2016).