Improve The Contrast Ratio on 20.1" S-IPS TFT-LCD with Ion-Beam-Alignment Technology

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ABSTRACT

The contrast ratio, brightness, and uniformity of S-IPS panel, whose alignment process was employed by ion-beam-alignment (IBA) technology, were improved significantly compared with the convention rubbing's panel, because the light leakage has been reduced in dark state effectively. The IBA technology could generate a panel whose pretilt angle was stable and low after post-treatment process.

1. Introduction

S-IPS (Super In-Plane Switch) technology consists of common IPS technology and multi-domain technology. Therefore S-IPS technology is one of solutions for shooting the color shift. Let S-IPS would panel conform to TFT-LCD TV marketing asking which color level display, balanced impressions, and view angle were all excellence. The pretilt angle of IPS panel has to close zero degree. However the rubbing process would accomplish this objective except the gap between rubbing roll and alignment layer was very small. Unfortunately, if the gap was too small, it will damage the alignment layer, i.e. static electricity effect, polyimide debris, and rubbing mura. Hence it is our purpose, which ion-beam-alignment (IBA) process instead of mechanical rubbing alignment process.

Nevertheless, if IBA process without post treatment, a lot of dangling bonds would be formatted due to the argon ion bombarded the C-H bond during IBA process. These dangling bonds were instable, and provided higher reaction ability. The display performance of TFT-LCD would be degraded because the polyimide alignment layer with higher reaction ability would react on liquid crystal and seal agent easily. Hence the post treatment process is a necessary procedure in order to maintain the stability of the alignment layer [1-6].

We present the study on the probability of next generation with IBA process for polyimide alignment layer treatment.

2. Experimental Procedures

In this investigation, the material of alignment layer is polyimide. The polyimide solution herein is made by Chisso®, whose solid content is 2.5 wt%, and viscosity is 8.7 mPa·sec. The operating parameters are listed in Table 1. The hydrophile property of substrate surface influences the polyimide droplets leveling result in the uniformity of film thickness, so the pre-cleaning process includes the UV irradiation.

The experimental flow chart of this study was shown in Figure 1, and the detail descriptions were as below. The TFT and color filter substrates whose the dimension is G3.5 were ink-jet printing with Chisso® polyimide, then they were baked, cured and carried out the ion-beam-processed. The ion-beam species used for this research was argon. The cell gap was maintained at ca 4 μm by using photo-spacers. In addition, these panels were filled with nematic LC of Merck®. By the way, ink-jet printing technology is able to correspond with the greater size panel. Comparison between commercial APR printing process and ink-jet technology is shown in Figures 2(a) and 2(b), respectively. The maximum utility rate of polyimide for ink-jet process is up to 95%, which is higher than that for the APR printing process ca. 25%.

On the one hand, there are several important factors, which are incident ion-beam angle, vacuum pressure, stage-moving rate, etc. regarding the ion-beam- processed, and the notable one is incident ion-beam angle. In this investigation, the parameters of incident ion-beam angle were fixed to 15°. On the other hand, as the polyimide surface would be extreme activity, the post treatment was a necessary after IBA process. The parameters of post treatment are included pressure of hydrogen, concentration of hydrogen, flow rate of hydrogen, saturation time, temperature of the post treatment chamber and the spacing between the filament and the polyimide alignment layer, etc.

3. Results and Discussion

3.1Uniformity of the display performance

Through the designed pattern and the optimum process parameters of the ink-jet printing conducted in our previous experiments [5-6], the film coating result and uniformity of film thickness were excellence.

Table 2 listed the data of the optical measurement at the panel with the different alignment process. It reveals that the central or average brightness of panel, which was manufactured in rubbing process, would less than that in IBA process ca 17%. Figures 3(a) and 3(b) show the images of the 64th gray scale in the panel with rubbing alignment and IBA process. Comparing Figure 3(a) with Figure 3(b) would prove the phenomenon of enhanced brightness by IBA process again. In addition, they also expose that the uniformity of the brightness with IBA panel was better than that of rubbing panel via analyzing the images of RGB sub-pixel.

Figure 4 shows the uniformity of the dark state in the panel with rubbing and IBA process. The light leakage in dark state could be detected as shows as the arrows in Figure 4(a), but 4(b). Therefore the result of optical measurement exhibits that the contrast ratio of IBA panel was raised ca 100 than that of rubbing panel as listed in Table 2.

The principles of rubbing and IBA process were illustrated in Figure 5. IBA process obtains alignment effect because the argon ions bombard the surface of the alignment layer [1], and rubbing process depend on the rubbing grooves, which was generated by the cloth fibre rolled on the surface of alignment layer. However, the diameters of argon ion and cloth fibre are 1.42 Å and 20 μm. The size of the argon ion is less than that of cloth fibre about 140,000 times, thus the alignment density of IBA panel is much more than that of rubbing panel. It could explain why the IBA process is able to raise brightness and reduce deviation of brightness. Besides, rubbing process produced the polyimide debris that would pile up at the terminal of pixel/ground electrodes as shown in the arrows of Figure 4(a). The polyimide debris disturb the alignment effect of LC layer was the primary reason of the light leakage in dark state. IBA process is non-contact alignment process cna not produce any polyimide debris. Hence there is no light leakage can be discovered in the Figure 4(b). It points out that the contrast ratio is improved apparently with IBA technology.

3.2 Stable pretilt angle

Figure 6 shows the result of variation pretilt angle of three panels, and points out the average of pretilt angle was 0.031º within only 0.009º during six months. Because IBA process with post treatment is finished, the surface activity of alignment layer will be decreased effectively [6], and the pretilt angle can preserve in stable and low situation for a long time. However, the pretilt angle of panel with rubbing process is ca 2 ~ 3º, so IBA technology was able to satisfy the requirement which the pretilt angle of IPS mode panel must be approached 0º.

3.3 Real panel

This investigation for aligning LC on polyimide film was built up by employing the S-IPS real panels and choosing the optimum IBA processed parameters. The purpose of this method was that substituted as the mechanical rubbing process, and was applied to a color 20.1" VGA (640* RGB*480) S-IPS real panel that was the world's largest TFT-LCD panel. The IBA processed TFT substrate and color filter substrate were assembled to turn into a real panel, which the LC molecules were excellently aligned. Figure 7 shows the image of the real panel which clearly illustrating that the IBA real panel was able to display the well-quality image or the cinema.

4. Conclusion

We employed rubbing and IBA process to obtain the alignment effect on the alignment layer, polyimide. The contrast ratio would increase about 27%, as the IBA technology was a non-contact alignment process, which could not generate any polyimide debris. IBA process would raise the brightness of panel ca 17% and uniformity of panel ca 18%, because the alignment species size of IBA was much less than that of mechanical rubbing, and hence the alignment effect was throughout the entire surface of the alignment layer. Consequently, the contrast ratio, brightness, and uniformity of S-IPS panel, which was employed in IBA technology, are evident better than that in conventional mechanical rubbing process.Similarly, IBA technology with complete post- treatment process could yield stable and low pretilt angle.

This procedure of TFT-LCD fabrication was successfully applied to the 20.1" VGA (640*RGB*480) S-IPS real panel, which was capable of displaying the fine-quality image.

Acknowledgment

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Table 1 The parameters of ink-jet process.

Stage Velocity	10 ~ 30	mm/ sec
Frequency	1 ~ 3	kHz
PI Pitch (Ink-Jet Direction)	50 ~ 3000	mm
Droplet weight	95.5 ×10-9	g/ drop
Gap from Head to Glass	1	mm
Leveling Time	15 ~ 30	sec
Pre-bake Temperature	40 ~ 70	°C
Pre-bake Time	3	min

Table 2 The results of optical measurement.

Item	IBA	Rubbing
Average of contrast ratio with 5 points	501.1	395.3
Deviation of contrast ratio (%)	8.5	54.9
Centeral brightness (cd/m^2)	462.6	396.1
Average of brightness with 5 points (cd/m^2)	435.7	375.3
Uniformity of brightness with 9 points (%)	85.0	67.2

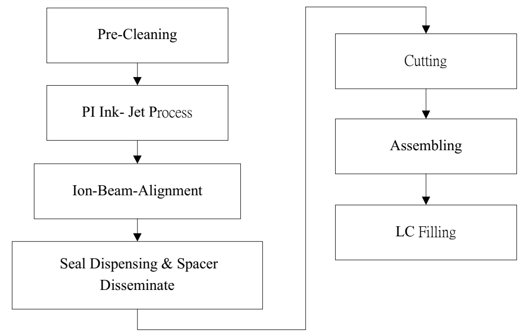


Figure 1 The experimental flow chart of this study.

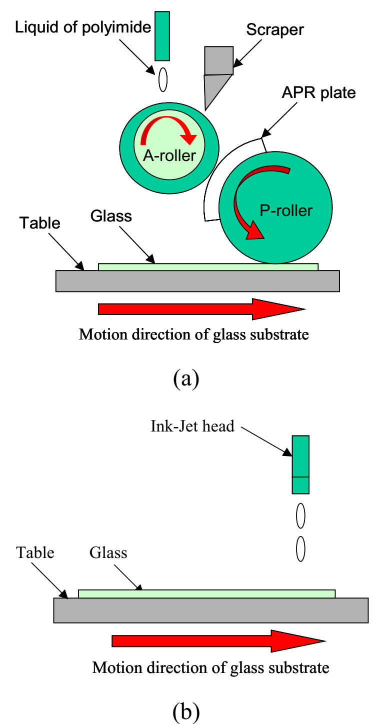
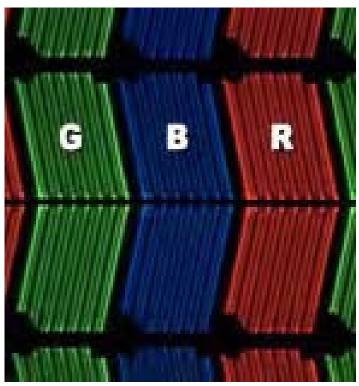


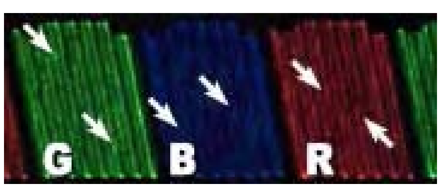
Figure 2 The scheme diagram of the alignment layer coating process. (a) APR printing and (b) ink-jet Process.

(a)

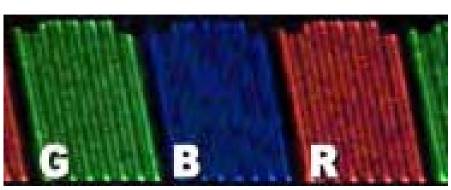


(b)

Figure 3 The images of the 64th gray scale in the panel with the different alignment process. (a) rubbing and (b) IBA process. R: red; G: green; B: blue.



(a)



(b)

Figure 4 The uniformity of the dark state in the panel with different alignment process. (a) rubbing and (b) IBA process. R: red; G: green; B: blue.

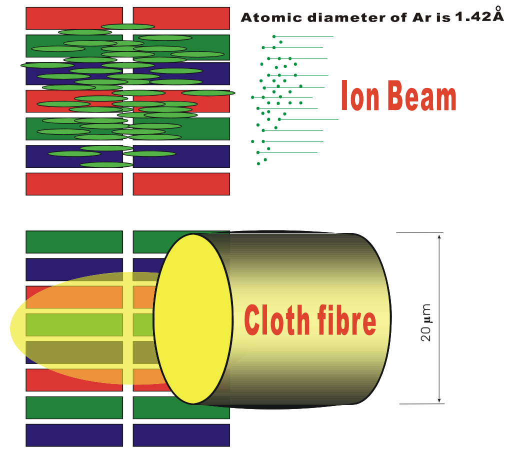


Figure 5 The schematic diagram of rubbing and IBA process.

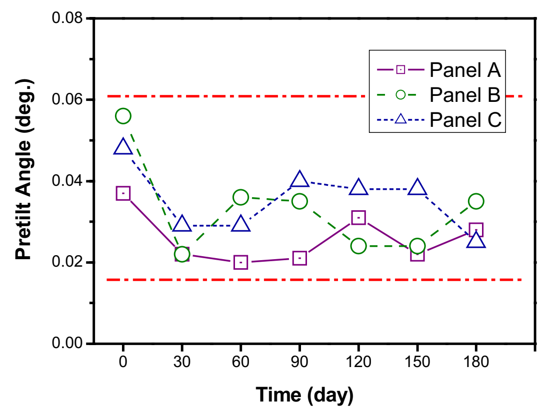


Figure 6 The variation of the pretilt angle during six months. All of the data were between two dash-dot lines.

Figure 7 Photograph was taken from a 20.1" S-IPS that was fabricated using the manufacture technology with PI film after IBA process.