Liquid crystal alignment on the inkjet printed polyimide by using new alignment method

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Abstract

We studied the nematic liquid crystal (NLC) alignment capability with a new alignment method utilizing an inkjet printed polyimide (PI) layer. A good, uniform LC alignment was achieved by the good PI printing using a new alignment method. The pretilt angle generated on the printed PI layer using the alignment method was almost the same as that on printed PI layer using rubbing alignment method. In addition, the good electro-optical performances of the new aligned twisted nematic (TN) cell with printed PI surface was obtained

1. Introduction

Inkjet printing is considered to be a key technology in the field of the next generation display. Recently, much effort has been invested in turning inkjet printing into a versatile tool for various industrial manufacturing processes, in order to accurately deposit minute quantities of materials in liquid crystal displays (LCDs) [1].

This inkjet technology gives birth to low cost, high speed, non-contact, and environmentally friendly processes [2]. For example, a pioneer in consumer inkjet printers has been conducting extensive research into industrial inkjet applications with the goal of applying the company's proprietary Micro Piezo print head technology to mass production [3-4]. Most recently, inkjet technology used in a mass production process to form a rubbed polyimide (PI) surface on liquid crystal displays was reported by K. Hiruma et. al [5].

However, the rubbing method has certain drawbacks even though rubbed PI surfaces have suitable characteristics such as a uniform alignment [6]. Thus, a non-contact alignment technology would be highly desirable for future generations of large, high-resolution LCDs. Also, a micro-rubbing technology with atomic force microscopy (AFM) tip on alignment layer has been successfully studied by S. Varghese et al [7]. Here we present a comprehensive study on LC alignment capability by utilizing a new alignment in the inkjet printer. In this study, we investigated the LC alignment effects with a new alignment on the printed PI layer.

2. Experimental

ITO-coated glass substrates with dimensions of 50.8 mm × 50.8 mm × 1.1 mm were used for all measurements reported here. An alignment layer is formed by inkjet printer which used piezoelectric inkjet head (Dimatix co.).

Figure 1 shows the principle of the new alignment method for LC alignment. First step is just PI printing process by using cartridge with PI for making printed PI film. And then the film was baked at 180℃ for 1hr. After curing, the printed PI film was aligned with the new alignment process. New alignment method is that the printed PI in the substrate was aligned by using an empty cartridge for aligning LC; the printer has the droplet ejection with high firing voltage and ejection speed.

The thickness of the printed PI layer was set at 100 Å.

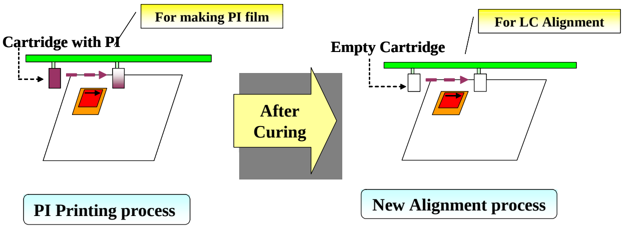


Fig. 1 The principle of the new alignment method

Also, another PI was uniformly coated on indium-tin-oxide (ITO) electrodes by a spin-coating method to compare printed PI. And then both alignment layers was formed by curing at 180℃ for 1hr.

The substrate surfaces were rubbed with a rubbing machine. The cells with rubbing process on the spin coated PI film and new alignment process on the printed PI film were fabricated as an anti-parallel configuration which was used for pretilt angle measurements, and the thickness of the cell was about 22μm. The NLC had a positive dielectric anisotropy (Δn = 0.225, from Merck Co.). The pretilt angles were measured by the crystal rotation method at room temperature. Also, TN cells on printed PI using rubbing and new alignment process were fabricated for EO characteristic comparison. The EO test cells filled with the NLC ZLI-4792 (Δn =0.0969, from Merck Co.). The EO performance characteristics of TN cells were measured using EOM (Electro-Optic Measurement) at room temperature.

3. Results and discussion

Figure 2 shows optimized ink and waveform stabilized the linearity of the droplet flight path. Top side of droplet flight path is reflection image. Down side of droplet flight path is real image. Also, the high quality PI layers on ITO surfaces were achieved by using printing process like this.

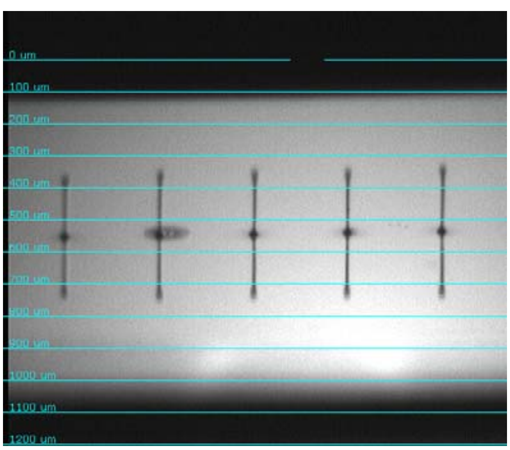


Fig. 2 Optimization of ink droplet ejection for alignment layer by driving waveform.

Figure 3 shows the microphotograph of the substrate on the printed PI film by using inkjet printer. The printer condition for making PI film was adjusted by PI viscosity, ejection speed, ejection distance and etc. After optimization of jetting condition, a good and uniform PI layer was achieved by using inkjet printer.

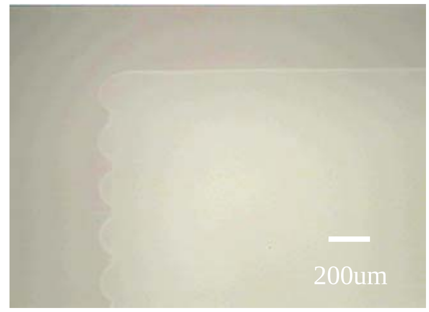
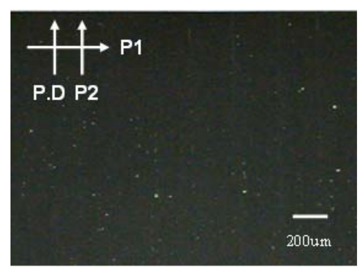


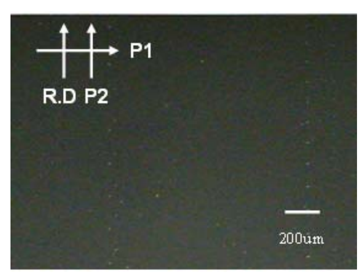
Fig. 3 Microphotograph of the substrate on the printed PI film.

Figure 4 shows the microphotograph of the LC cells on printed PIs with new alignment method using inkjet printer and rubbing alignment. The good LC alignments of the printed PI were obtained. It showed new aligned LC cell on printed PI surface was the same LC alignment capability as rubbed LC cell on the printed PI surface.

The pretilt angle generated on printed PI layer using the alignment method was almost the same as that on printed PI layer using rubbing alignment method.



(a) New alignment method



(b) Rubbing method

Fig. 4 Microphotograph of the LC cells on the printed PI film.

Figure 5 depicts light transmission as a function of the voltage applied in the new aligned and the rubbing-aligned TN cell on the printed PI film. A similarly acceptable V-T curve could be achieved in the new aligned TN cell compared with rubbing-aligned TN cell on the printed PI film. The threshold voltage of the new aligned TN cell was lower than that of the rubbing-aligned TN cell on the printed PI film.

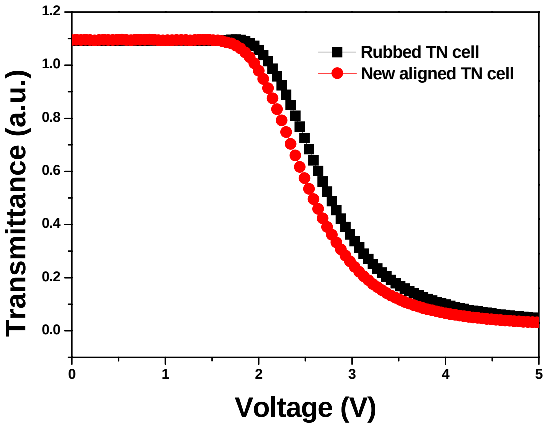


Fig 5. V-T characteristics of new aligned TN cell and the rubbing-aligned TN cell on the printed PI film.

Figure 6 shows the response time characteristics of the new aligned and the rubbing-aligned TN cell on the printed PI film. The response time of the new aligned TN cell on the printed PI film was 19.8 ms (rising time: 7.7 ms, falling time: 12.1 ms) whereas that of the rubbing-aligned TN cell on the printed PI was 23.7 ms (rising time: 9.2 ms, falling time; 14.5 ms). Both cells showed fast and stable response time characteristics.

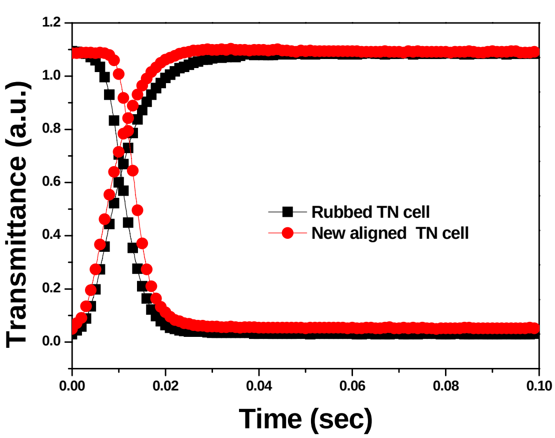


Fig. 6 Response time characteristics of new aligned TN cell and the rubbing-aligned TN cell on the printed PI film.

4. Summary

In this study, the new alignment method and printed PI films as alignment layers were used for application to TN-LCDs. A good, uniform LC alignment was achieved by using a new PI printing method. The pretilt angle generated on printed PI layer using the new alignment method was almost the same as that on printed PI layer using rubbing alignment method. The LC alignment effects and the EO performance characteristics of TN cells on the printed PI film show insignificant difference. Finally, the new aligned TN cell on the printed PI film is applicable to other display modes because it showed acceptable characteristics, as well as the rubbing-aligned TN cell.

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5. References

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