Polymer Bulletin 37, 799–804 (1996)

Polymer Bulletin


# Surface alignment of ferroelectric liquid crystals using side chain ferroelectric liquid crystal polymer

**Sung-Ho Jin** [1,*], **Jong-Cheon Lee** [2], **Dong-Kyu Park** [3]

[1] Samsung Central Research Institute of Chemical Technology, 103-12, Moonji-Dong, Yusong-Gu, Taejon, Korea 305-380
[2] Samsung Display Devices, 575, Shin-ri, Taean-Eub, Kyungki-Do, Korea 445-970
[3] Kyungsung University, 110 Daeyeon-Dong, Nam-Ku, Pusan, Korea 608-736

Received: 6 June 1996/Revised version: 5 September 1996/Accepted: 9 September 1996

## ABSTRACT

New surface alignment material for surface stablized ferroelectric liquid crystal displays (SSFLCDs) is investigated. Side chain ferroelectric liquid crystal polymer (SCFLCP) such as Poly{methyl 4-[[[S-(-)-2-methyl-1-butoxy]carbonyl] phenyl ]4'-hexyloxybenzoyl}Siloxane was used as the alignment layer which resulted in good uniform alignment of FLC molecules without zig-zag defects. However, RN-715 polyimide alignment layer showed random alignments with some zig-zag defects in the SSFLC cells. After the field stablization of $\pm 20$ V AC, the typical stripe-shaped patterns appeared. Good electro-optical performance was observed by using SCFLCP.

## INTRODUCTION

SSFLCDs have been known for their high information content, high contrast ratio, wide viewing angle, fast switching and bistability characteristics (1). The synthesis of bistable ferroelectric liquid crystal materials and their alignment by utilizing standard rubbing techniques have been investigated in a wide range of electro-optic devices (2, 3). The uniform alignment of the molecules of the liquid crystals is difficlut to obtain by merely injecting the liquid crystal between upper and lower substrates. Therefore, for uniform alignment, an alignment film is generally provided between the substrates for uniform alignment.

One method of obtaining liquid crystal molecular alignment is controlled by gradient vapor deposition of the inorganic materials without using rubbing treatment. This method is utilized in laboratory scale preparation only because of the difficulty in large scale production due to spatial non-uniformity and low yield.

Alternatively, organic alignment films obtained by coating an organic polymer, followed by rubbing with a piece of cloth are generally used.

Among organic polymers, polyimides have been mainly used in consideration of the

* Corresponding author

requirements for alignment films, such as efficiency in mass production and alignment efficiency for liquid crystal molecules.

Recently, there has been much interest in side chain liquid crystal polymers as alignment layers for liquid crystal displays (4,5,6,7).

We have synthesized side chain ferroelectric liquid crystal polymer and investigated the electro-optical properties of ferroelectric liquid crystal devices.

## EXPERIMENTAL

### Alignment film coating and baking

SCFLCP was dissolved in chloroform at a concentration of 3 wt%. This solution was spin-coated on upper and lower substrates having a transparent conductive layer coated thereon, by a method for manufacturing a conventional liqud crystal display device. The solvent was completely removed by heat treatment for 10 min in a vacuum oven at 50℃.

### Alignment treatment and substrates sealing

The alignment film coated on the upper and lower substrates in the above alignment film coating and baking step was rubbed by a typical rubbing method. Thereafter, a sealent was printed on one of the substrates and a spacer of 1.5 $\mu$m was dispersed for spacing cells. The upper and lower substrates were sealed under uniform pressure with heating so that the sealent was cured to complete an empty cell.

### Liquid crystal injection and electro-optical measurement

Felix-T250 ferroelectric liquid crystal material from Hoechst was injected into the empty cell in an isotropic phase and cooled to room temperature at a rate of 1℃ per minute. Then, the alignment state was observed under a polarized optical microscopy. A bipolar pulse of 60Hz frequency, 64 $\mu$s pulse width and $\pm$20V pulse height were applied to evaluate bistability.

RN-715 polyimide manufactured by Nissan Chemicals Industaries was used as the comparative alignment material. RN-715 polyimide was diluted to 3 wt% using a mixed solvent of NMP and butylcellosolve (weight ratio 75:25), spin coated at 3000 rpm for 20 seconds, pre-dried at 80℃ and baked at 260℃ for 60 min.

## RESULTS AND DISCUSSION

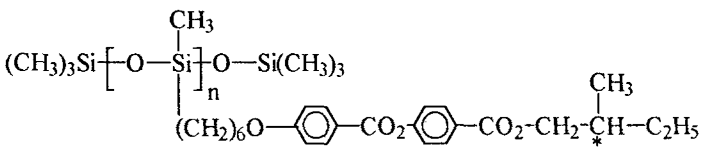
The structure of the SCFLCP is shown in **Scheme 1,** together with thermal data. The synthesis is described elsewhere (8).

The material used was Felix-T250, which has the phase transitions, Cryst (-8℃) SmC$^*$ (62℃) SA (78℃) N$^*$ (85℃) I, according to DSC measurement in heating cycles.

The polymer obtained was a white viscous material at room temperature. Number- and weight-average molecular weights determined by gel-permeation chromatography. The number- and weight-average molecular weights of the SCFLCP were ca. 15000 and 22000. We could prepare 500~1000 Å thick well aligned layers of SCFLCP and RN-715 polyimide

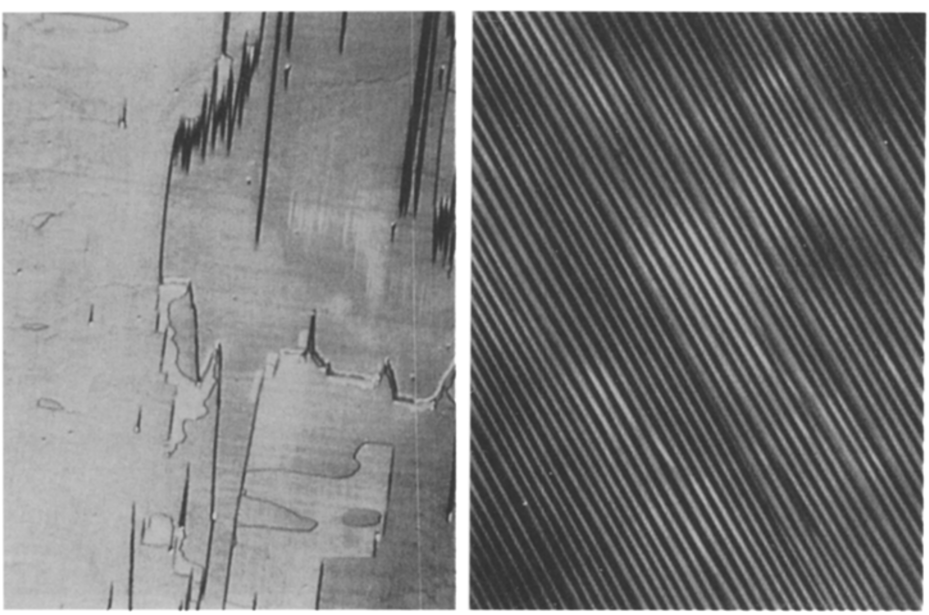
The microphotographs of alignment layer observed in each cell are shown in Figure 1 and 2. Figure 1(a) shows the previous state of electric field stablization and Figure 1(b) shows the alignment state after applying an electric field using a triangular waveform of $\pm$20V and 60Hz in SCFLCP,

A defect free uniform alignment was obtained in the cell with an application of the field. For comparision, a RN-715 polyimide alignment layer was used.



Tg: -7.2°C
Sc-I: 76.8°C

**Scheme 1**



(A) (B)

Figure 1. Cross-polarized microscopic photographs of the FLC cell by using SCFLCP; before the treatment of the electric field (A), after the treatment (B).

Figure 2 shows the microphotographs of RN-715 alignment layer before (a) and after (b) applying voltage.

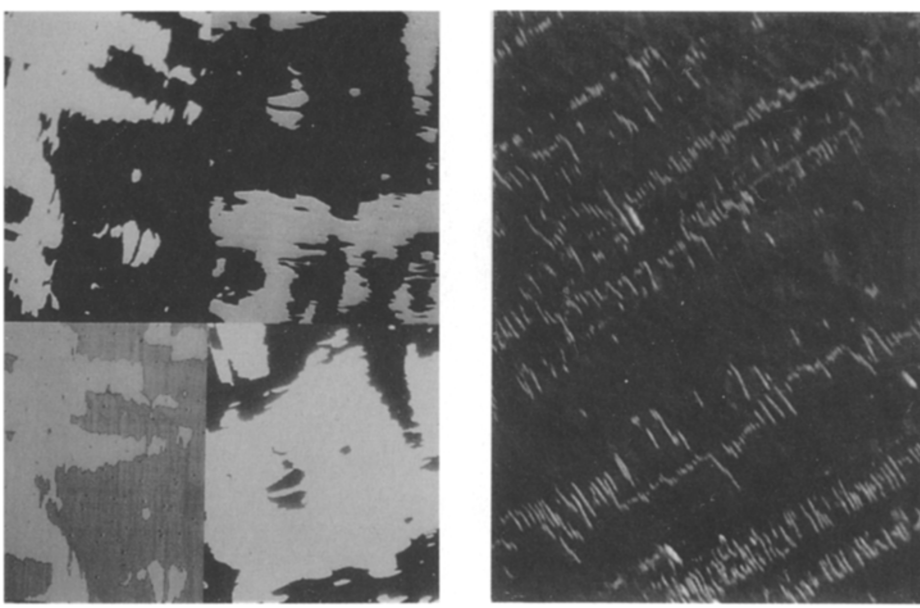
As can be seen in Figure 2, the zig-zag defects appeare after applying an electric field which were completely absent in Figure 1(b).

The absence of zig-zag defects means that the chevron tips points in the same direction all over the cell, since the zig-zag defect is known to be the boundary of the chevron structures with the opposite orientation.

A voltage-transmission relation was measured for each cell. Figure 3 shows an example of the electro-optical performance of an SSFLCD with SCFLCP and RN-715 polyimide alignment layers. A triangular wave of $\pm$20V, pulse height of 64$\mu$s at 60 Hz was applied to each cell which was set in the cross Nicol with the polarizer axis parallel or perpendicular to the smectic layer direction.

An excellent memory capability reaching almost 100% and high contrast ratio near 15:1 were successfully attained by using SCFLCP alignment layer.

However as described in Figure 2, RN-715 polyimide cell shows zig-zag defects, so leakage of transmittance is observed. Thus memory effect and contrast ratio are poor than SCFLCP cell.



(A) (B)

Figure 2. Cross-polarized microscopic photographs of the FLC cell by using RN-715 polyimide; before the treatment of the electric field (A), after the treatment (B)

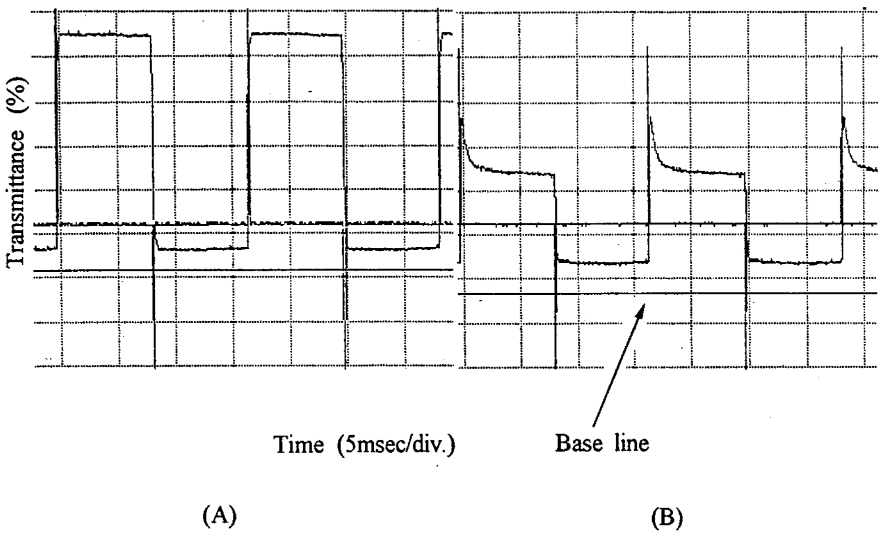



Figure 3. Electro-optical responses of SCFLCP (A) and RN-715 polyimide (B) measured by applying triangular wave voltage of 60 Hz

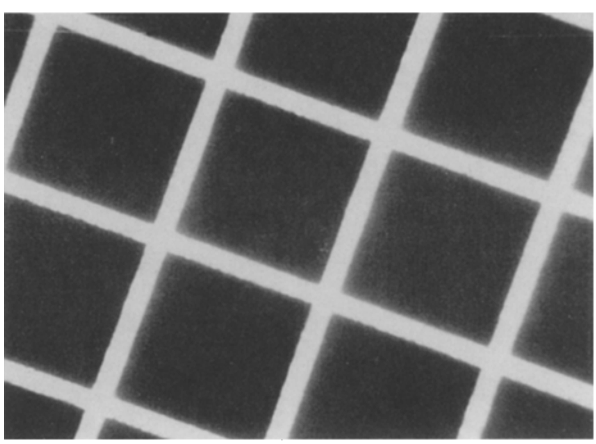


Figure 4. Polarized micrograph of the SCFLCP aligned cell, showed memory state

Figure 4 shows the memory state of a matrix cell with rubbed SCFLCP alignment layers. It shows uniform molecular alignment of black memory state for more than 6 months. And the vertical and horizontal lines are not extinguished because in these regions there are no electrodes.

Further detailed research for tilt angle and anchoring energy are left for the future.

## REFERENCES


(1) N. A. Clark and S. T. Lagerwall (1980) Appl. Phys. Lett 36:899

(2) J. S. Patel, T. M. Lesilie and J. W. Goodby (1984) Ferroelectrics 59:137

(3) T. Uemura, N. Ohba, N. Wakita, H. Ohnishi and I. Ota (1986) Proc. Int. Display Res. Conf., Tokyo (SID and ITE) 464

(4) M. Murakami and H. Fuji (1993) Mol. Cryst. Liq. Cryst 225:259

(5) S. E. Chung, S. W. Kang, K. K. Park, S. H. Jin and J. C. Lee (1995) Synthetic Metal 71:2227

(6) S. H. Jin, J. G. Park, S. E. Chung, K. W. Kang and J. C. Lee (1995) SID DIGEST:536

(7) S. H. Jin, V. N. Raja, D. S. Shankar Rao, S. W. Kang, J. C. Lee and S. S. Lee (1996) Liquid Crystals Vol 20, No 1, 41 (1996)

(8) H. Finkelmann and G. Rehage (1982) Makromol. Chem., Rapid Commun 3:859