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Jong-Chul Kim [a], Toshiyuki Watanabe [a] & Seizo Miyata [a]

[a] Graduate School of Bio-applications & Systems Engineering, Tokyo University of Agriculture and Technology, 2-24-16, Naka-machi, Koganei-shi, Tokyo, 184, Japan

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PREPARATION OF RETARDATION FILM FOR STN-LCD WITH WIDE VIEWING ANGLE BY DRAWING AND POLING

JONG-CHUL KIM, TOSHIYUKI WATANABE, SEIZO MIYATA
Graduate School of Bio-applications & Systems Engineering, Tokyo University of Agriculture and Technology, 2-24-16, Naka-machi, Koganei-shi, Tokyo 184, Japan

Abstract The viewing angle characteristic of film-compensated super-twisted nematic - liquid crystal display (FSTN-LCD) using retardation film prepared by drawing and poling was characterized. At the result, viewing angle of FSTN-LCD representing 10:1 contrast ratio was ± 40 degree at vertical and horizontal direction. Especially, at the vertical direction of LCD panel, this result of FSTN-LCD is more wide than that of STN-LCD.

INTRODUCTION

Supertwisted nematic liquid crystal displays (STN-LCDs) have a capability for high-duty multiplexing [1], and it is used as flat screens in word processors and laptop computers. However, STN-LCD causes a problem that the display has a bright yellow or blue birefringence color as a result of the interference of the optical normal modes propagating in the layer. Therefore to obtain black-and-white (B/W) STN-LCD several compensators were developed such as double-layered STN-LCD (DSTN-LCD) [2] and film-compensated STN-LCD (FSTN-LCD) [3-4]. DSTN-LCD compensated by reverse-twisted STN LC cell showed high contrast ratio and wide viewing angle, however it was heavy and thick because of double-cell structure. Thus FSTN-LCD compensated by birefringent polymer film, retardation film is widely used at present because it is light and thin and has good productivity owing to low cost. However, the viewing angle characteristic and contrast ratio of FSTN-LCD is generally not better than that of DSTN-LCD. Thus to optimize FSTN-LCD having high contrast ratio and wide viewing angle, it has been seen that it is very important to control the three-dimensional characteristics of refractive index to improve viewing angle characteristic of FSTN-LCD.

[5] Namely, Refractive index of film-thickness direction n_z should be larger than refractive index of the direction perpendicular to the drawing direction n_y as shown in the following equation: [6]

$$n_x \rangle n_z \rangle n_y \quad \text{and} \quad n_z = \frac{(n_x + n_y)}{2} \tag{1}$$

where refractive index of drawing direction is n_x. However, it is difficult to achieve this relation of refractive indices by drawing only because in-plane birefringence can be only controlled. Therefore a special method to increase n_z is required, in present, these special methods [7-8] have been used, however to increase n_z is very difficult.

We proposed that in-plane and out-of-plane birefringence of novel functionalized side-chain phenoxy polymers having the side chain that has large dipole moment μ and linear polarizability a could be simultaneously controlled by drawing and poling. [9] And then, retardation film of STN-LCD satisfying three-dimensional characteristic of refractive index such as eq. (1) was prepared by this technique. [10] In this paper, we discuss about the viewing angle characteristic of FSTN-LCD using retardation film prepared by drawing and poling.

CONFIGURATION OF STN-LCD, FSTN-LCD, AND RETARDATION FILM

Figure 1 schematically shows the construction and of the transmissive STN-LCD and FSTN-LCD using retardation film prepared by drawing and poling. These two LCDs were set to show blue mode by the control of all optical axes. LC cell was prepared by Chisso Petrochemical Co. The configuration data of the used LC cell and retardation film are shown in Table I. Retardation R and refractive index were measured by Optical Birefringence Analyzer KOBRA-21ADH of New Oji Co. Retardation films were prepared by novel phenoxy polymer containing 73 mol% p-nitrophenyl carbamate. [10]

Table I Configuration data of STN LC cell and retardation film

	Retardation R (nm)	Δn	Twist angle (degree)	Thickness (μm)	Refractive index		
					n_x	n_y	n_z
STN LC cell	814	0.117	240	6.96	-		
Retardation films	407	0.087	-	45	1.6213	1.6126	1.6169

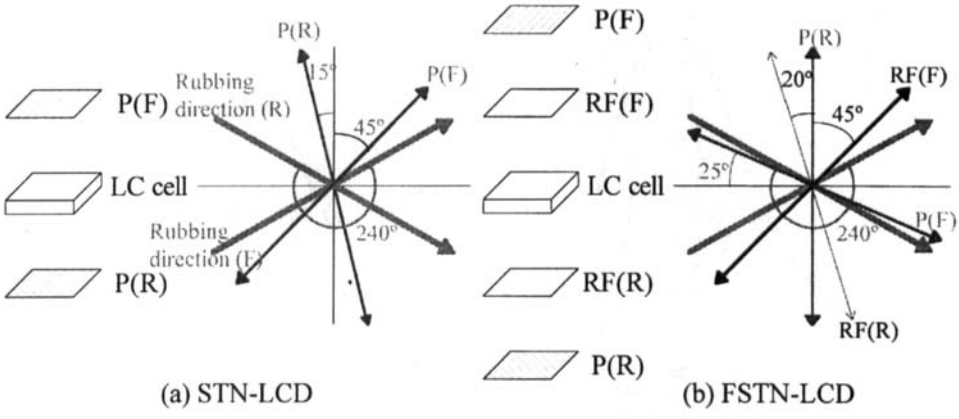

Figure 1 Basic Construction of STN-LCD and FSTN-LCD. P(F) is front polarizer, P(R) is rear polarizer, RF(F) front retardation film, and RF(R) is rear retardation film.

These retardation films were uniaxially drawn about 2.3 times and poled in the influence of 102 V/μm electric field, and then showed the same three-dimensional characteristic of refractive index such as eq. 1 and retardation R was not nearly changed to ± 40 tilt angle.

VIEWING ANGLE CHARACTERISTIC COMPARISON OF STN-LCD WITH FSTN-LCD

The applied voltage of LCD was confirmed by the measurement of transmittance as a function of applied voltage. At the result, selected state voltage was decided at 2.60 Volt and non-selected state voltage was decided 2.4 Volt, and these voltage was decided to obtain the maximum contrast ratio. According to this result, viewing angle characteristics of STN-LCD without retardation film and FSTN-LCD using retardation film were measured by UV/vis spectrophotometer, and then shown in Figure 2. In the STN-LCD, contrast ratio in the front was good, however viewing angle was narrow, and especially viewing angle in the vertical direction was more narrow. Viewing angle representing contrast ratio above 10:1 was +40 ~ −32 degree in the horizontal direction and +22 ~ −14 degree in the vertical direction. Comparing this result, viewing angle of FSTN-LCD was more wide than that of STN-LCD although contrast ratio in the front was a little smaller. And Viewing angle representing contrast ratio above 10:1 of FSTN-LCD was ±40 in both of horizontal direction and vertical direction.

In conclusion, retardation film of FSTN-LCD can be prepared by drawing and poling

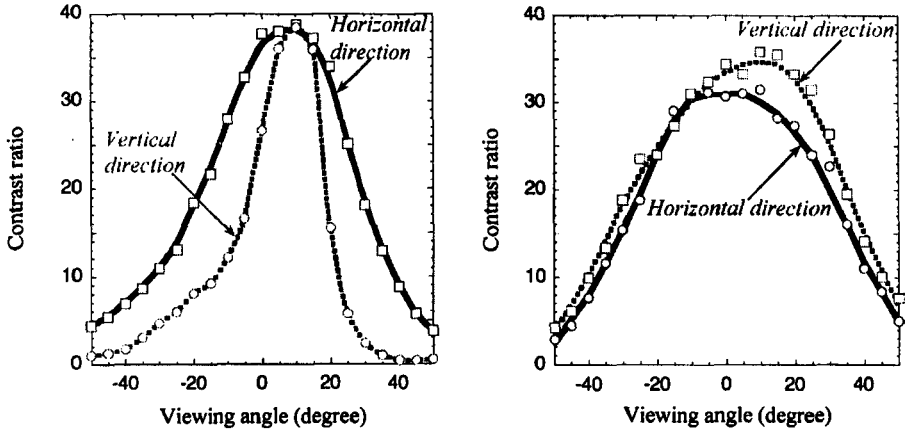

Figure 2 Viewing angle characteristic comparison of STN-LCD without retardation film with FSTN-LCD using two retardation films at the both sides of LC cell.

and viewing angle of FSTN-LCD using retardation film prepared this technique was more wide than STN-LCD.

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