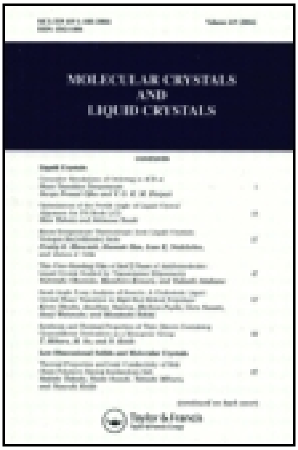

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Observation of an Optical Anisotropy of Rubbed Polyimide Film on Actual LCD Panel

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Observation of an Optical Anisotropy of Rubbed Polyimide Film on Actual LCD Panel

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An optical anisotropy of rubbed polyimide (PI) film on glass was evaluated by using reflection ellipsometry, and an optical anisotropy on an actual LCD panel was observed for the first time. A linear relationship between the parameter DΔ of a PI film on an actual LCD panel and that on an glass substrate was also observed. Reflection ellipsometry was shown to be a valuable method for investigating rubbed PI film on an actual LCD.

Keywords: polyimide; rubbing; ellipsometry; liquid crystal display

1. INTRODUCTION

Controlling the alignment of liquid crystal is necessary to produce high quality liquid crystal displays (LCDs). Polyimide films are used to align the liquid crystal, and the process is widely considered to a result of an intermolecular interaction between the liquid crystal and the molecular alignment of the rubbed polyimide films[1-3]. Previously, we suggested using reflection ellipsometry to evaluate rubbed polyimide films[3-9],and an optical anisotropy of rubbed polyimide (PI) film on glass was evaluated by the means. To measure the optical anisotropy of rubbed PI film on a single pixel in an LCD panel, a very high precision of the rotation is necessary. When the sample is rotated 360° , the precision needed is less than approximately 5 μm (in-plane movement distance). Such precision is very difficult to achieve. We succeeded in measuring the optical anisotropy of rubbed PI film on an actual LCD panel by using a feedback system composed of an in-plane movable stage and a rotating stage[10] (as shown in Fig. 1).

An optical anisotropy of rubbed PI film on glass was evaluated by using reflection ellipsometry. To quantify the results, we introduced the parameter DΔ (as shown in Fig. 3). It is defined as the difference between the maximum and minimum phase components of polarization (Δ). We demonstrated that the optical anisotropy DΔ may also be used to index the molecular alignment in an LCD panel.

2. METHOD[10]

Optical anisotropy of reflected light polarization was observed by rotating a sample. To measure the optical anisotropy of rubbed PI film on an actual LCD panel, we must fix the measurement point to the same pixel when rotating the sample. We observed the optical anisotropy of a rubbed PI film on an actual LCD panel by using a feed back system composed of an in-plane movable stage and a rotating stage[10].(as shown in Fig. 1) Every time the sample was rotated, the measurement point was recentered to the same pixel by using the in-plane movable stage.

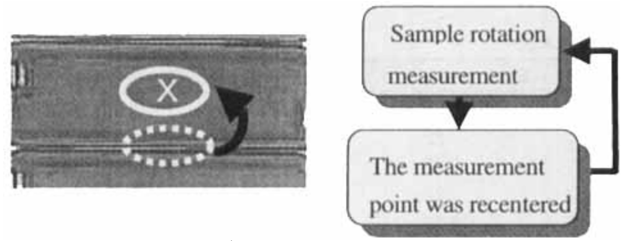

FIGURE 1 Feedback system

3.EXPERIMENT

The values of DΔ of the rubbed PI film on the actual LCD panel were estimated from those on glass prepared under the same rubbing conditions. To confirm that the experimental and simulation estimations were accurate, we prepared rubbed PI films on LCD (TFT, CF) substrate and on glass substrate (Corning 7059). The polyimide, PI-A (Nissan Chemical), was obtained from polyamic acids by imidization. The polyamic acid was coated on the substrates to make the samples. Imidization of the coated polyamic acids were performed by curing at 230℃ for 150 min after pre-baking for 1 min at 90℃.

We also demonstrated the correlation of DΔ with PI on the glass and on the LCD panel under various rubbing conditions. The films were rubbed using the conditions as shown in Table 1. The rubbing strength (RS) was expressed using Seo's definition[11-12]. The anisotropy of the reflected light polarization was observed by rotating the samples on their surfaces and using an ellipsometer with an He-Ne laser (MARY-102, FiveLab). The incident angle of the light was 50°.

TABLE 1

Rubbing conditions (*1 coming and going)

	Depth(mm)	Stage speed(mm/s)	Numbers	Rotation speed(rpm)	RS(mm)
TFT	0.20	7.22	1	1000	2.32
	0.20	7.22	2	1000	4.64
	0.20	7.22	5	1000	11.6
	0.20	7.22	10	1000	23.2
	0.20	7.22	5	100	0.58
	0.20	7.22	5	300	3.48
	0.20	7.22	5	1000	11.6
CF	0.20	7.22	1	1000	2.32
	0.20	7.22	2	1000	4.64
	0.20	7.22	5	1000	11.6
	0.20	7.22	10	1000	23.2

4. RESULTS AND DISCUSSION

We measured the phase components of the polarization (Δ , φ) of the PI on the actual panel (TFT substrate) and on the glass under the same rubbing conditions. (marker, Fig. 2) As shown , the absolute value of the polarization (Δ , φ) of the PI on the glass is quite different from that on the actual panel with an influence of the substrate. The DΔ of the PI on the actual panel was less than that on the glass. The simulation which considered multiple layers suggests that this may be a result of the influence of the substrate(solid line, Fig. 2). In other words, the order parameter of PI on both the glass (0.23) and the actual panel (0.24) were almost the same (Table 2).

TABLE 2

The parameters of PI

	On the glass	On the actual panel
Order parameter	0.23	0.24
Tilt(deg)	35.1	35.1
Anisotropic layer(nm)	36.1	36.1
Isotropic layer(nm)	167	167

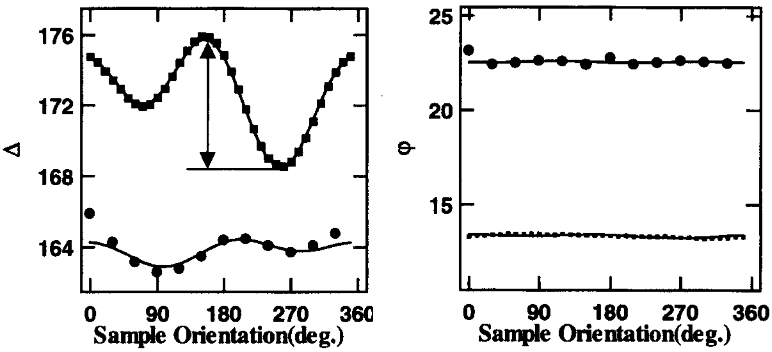

FIGURE 2 Dependence of observed and simulated polarization (Δ,φ) of reflected light for PI films on TFT substrate and glass substrate (solid line; simulation, ●; experimental data for TFT, and ■; experimental data for glass)

4.1 TFT Substrate (Thin Film Transistor)

Fig. 3 shows the DΔ of the PI on the TFT substrate and on the glass under various rubbing conditions (numbers and rotation speed). The DΔ of the PI on both the TFT substrate and on the glass tended to increase as rubbing strength increased. This demonstrates the accuracy of the estimation.

We compared the value of DΔ under various rubbing conditions (Fig. 4). We see a linear relationship between the parameter DΔ of the PI film on the TFT substrate and that on the glass substrate. The correlation factor was 0.89. This shows that the DΔ of rubbed PI film on TFT substrate can be estimated from that on glass under various rubbing conditions. This method of estimation also gives information regarding the molecular alignment of the PI on the LCD panel, because measuring the anisotropy of PI film on glass is fast and easy.

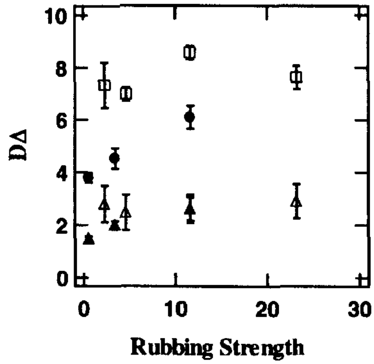

FIGURE 3 Optical anisotropy (DΔ) of PI on TFT substrate and prepared glass for rubbing strength. Number of rubbing times ●; glass ,▲; TFT. Rotation speed □; glass , △; TFT

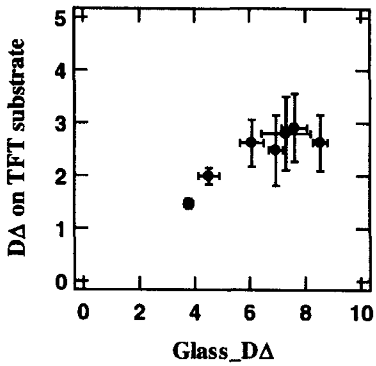

FIGURE 4 Optical anisotropy (DΔ) of PI on TFT substrate and that on the prepared glass

4.2 CF substrate (Color Filter)

Fig. 5 shows the DΔ of PI on the CF substrate and on the glass under various rubbing conditions (number of rubbing times). The DΔ of the PI on both the CF substrate and on the glass tended to increase as rubbing strength increased.

We compared the DΔ of the PI on the CF substrate and that on the glass (Fig. 6). A linear relationship between them was observed, and the correlation factor was 0.99.

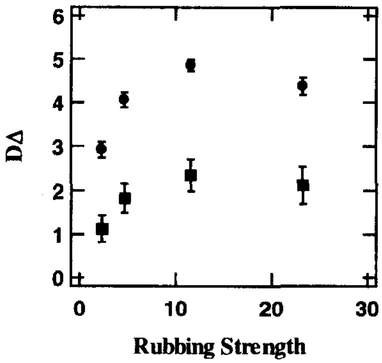

FIGURE 5 Optical anisotropy (DΔ) of PI on CF substrate (■) , and on prepared glass (●)

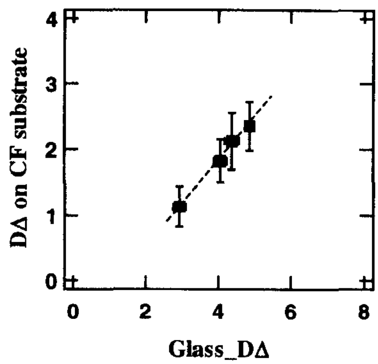

FIGURE 6 Optical anisotropy (DΔ) of PI on CF substrate and on prepared glass

5.CONCLUSION

We succeeded in measuring the optical anisotropy of PI on an actual LCD panel. We conclude that optical anisotropy may also be used to find the index of molecular alignment in an actual LCD panel.

6.ACKNOWLEDGEMENT

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