Poster: A Novel ECB cell using bend structure for Nematic Liquid Crystal on Rubbed Polyimide Surface

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Abstract
In this paper, we have improved a novel ECB mode using bend structure with high tilt angle in the unique condition by Hot plate equipment. The new control of tilt angle for nematic liquid crystal (NLC) with negative and positive dielectric anisotropy on the rubbed homeotropic polyimide (PI) using baking method by Hot plate equipment was investigated. LC tilt angle decreased with increasing baking temperature and time. We suggest that the development of the novel ECB cell using control of tilt angle on the homeotropic surface is a promising technique for the achievement of fast response time and high contrast ratio.

1. Introduction
A growth of LCD-TV market is expected. From the viewpoint of TV application, improvement of viewing angle, brightness, and response time characteristics are impartment. For a LCD-TV, the movie pictures change rapidly. Therefore, the improvement of response time is a key technical feature for the LCD-TV. Many display modes have been developed to improve viewing angle characteristics, such as TN with negative retardation films [1], dual-domain (DD) TN [2], muti-domain VA [3], and in plane switching (IPS) [4]. Each mode has its own disadvantage as slow response time, low aperture, and complicated production process.

Presently, the optically compensated bend (OCB) or π cell has advantage the wide viewing angle and fast response time. However, conventional OCB cell forms bend structure from splay orientation in the initial state as the cell applied voltage. But, in the OCB cell, because the cell need initial voltage to form this bend structure, driving voltage is high, and have shortcoming using biaxial compensation film. Especially, transforming from the splay to bend state for using OCB cell was difficult problem [5,6]. So, we have designed a novel ECB cell by new tilt angle control to improve fast response device. New tilt angle control method is controlling tilt of homeotropic orientation in particular condition. Tilt angles of vertical alignment layer have displayed almost 90°. Previously, many researchers have discussed the LC pretilt angles on the rubbed PI surface with homogeneous alignment [8-13]. However, the control of tilt angle with wide range from homogenous to homeotropic in NLC on the PI surface has not been yet reported. The novel ECB cell can be used enough to utilize new tilt angle control.

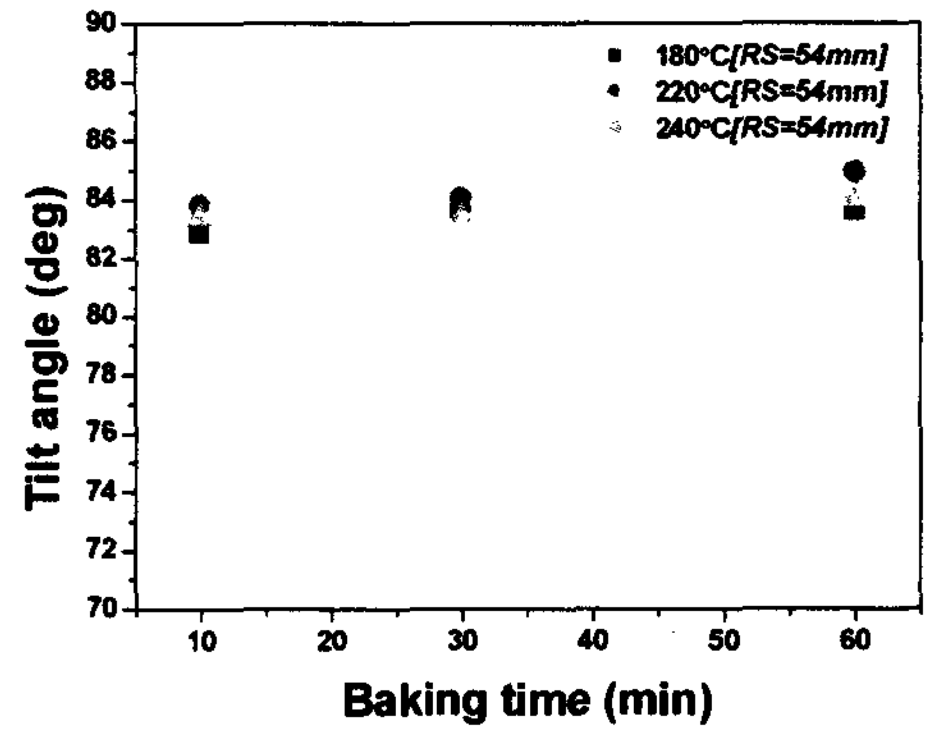
In this article, we are reporting on generating tilt angle in NLC with on the homeotropic polyimide (PI) surface. Also, the improvement of EO characteristics of the novel ECB cell using new tilt angle control on the homeotropic PI surface was investigated.

2. Experiment and Results
In this experiment, a polymer with homeotropic alignment layer (JSR Co., Ltd.) was used. The polymers were uniformly coated on indium-tin-oxide (ITO) electrodes by a spin-coating method. First, using a convention curing method by Oven equipment to obtain alignment layer, the polymers were formed by curing at 180℃ ~ 240℃ for 0~1 hr. Second, by new tilt angle control method, using curing method by Hot-plate equipment at the specific condition, the polymers were formed by curing at 180℃ ~ 240℃ for 0~1 hr. The thickness of the PI layer was set at 500Å. The substrate surfaces were rubbed with a rubbing machine. The rubbing strength (RS) has been defined in previous papers [14,15]. The cell was fabricated as a sandwich type with anti-parallel structure, and the thickness of the cell was 60㎛ for LC pretilt angle. Also, the novel ECB cell using the PI surface formed new tilt angle control method in

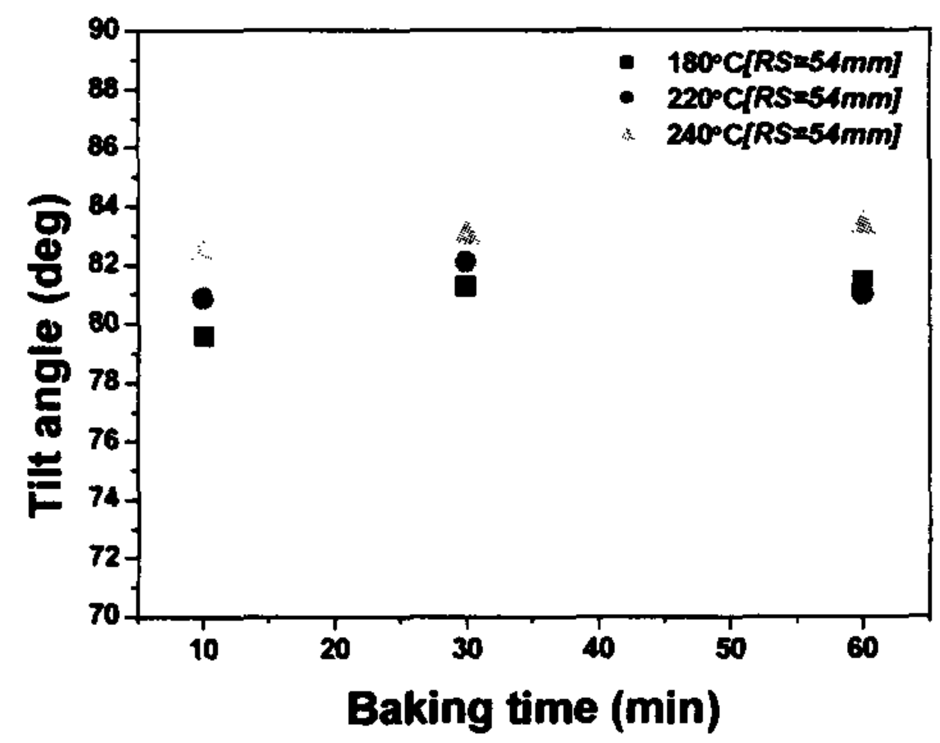
special condition was assembled with the parallel rubbing direction. The thickness was about 5.0μm. NLC had negative dielectric anisotropy (Δε = - 4, from Merck Co.) and positive dielectric anisotropy (Δε = 8.2, from Merck Co.). The pretilt angles were measured by crystal rotation method at room temperature using TBA 107 (Tilt-Bias Angle Evaluation, from Autronic Co.) equipment. The transmittance (V-T) and response time characteristics were measured by the DMS 701(display measurement system, Autronic Co., Ltd.) equipment.

Figure 1 shows the NLC tilt angles on homeotropic PI surfaces as a function of rubbing strength and dielectric anisotropy with conventional baking method by Oven equipment. The tilt angle of the NLC with positive dielectric anisotropy was lower than that with negative dielectric anisotropy. Tilt angle of the NLC with negative dielectric anisotropy was kept regardless of curing temperature and time. It is considered that the lower pretilt angle in NLC is attributed to steric interaction between the LC molecular and the side chain of polymer on the rubbed PI-1 surface. We think that steric interaction is one cause in generation of tilt angle among the other many interactions.

Figure 2 shows tilt angle in NLC on the homeotropic polyimide surface as a function of Hot-plate temperature and time using negative type NLC. Tilt angle of the NLC with negative dielectric anisotropy was kept regardless of curing temperature and time at the 180℃, but tilt angle decreased a little according as curing time increases in occasion that Hot plate temperature is 220℃. And, tilt angle decreased to about 81° according as increase for curing time in occasion that Hot plate temperature is 240℃. Generation of tilt angle of nematic liquid can be thought that homeotropic aligning capability decreases by stress to side chain of polymer as curing temperature and time increase.



(a) Negative type LC



(b) Positive type LC

Figure 1. The NLC tilt angles on homeotropic PI surfaces as a function of rubbing strength and dielectric anisotropy with conventional baking method by Oven equipment.

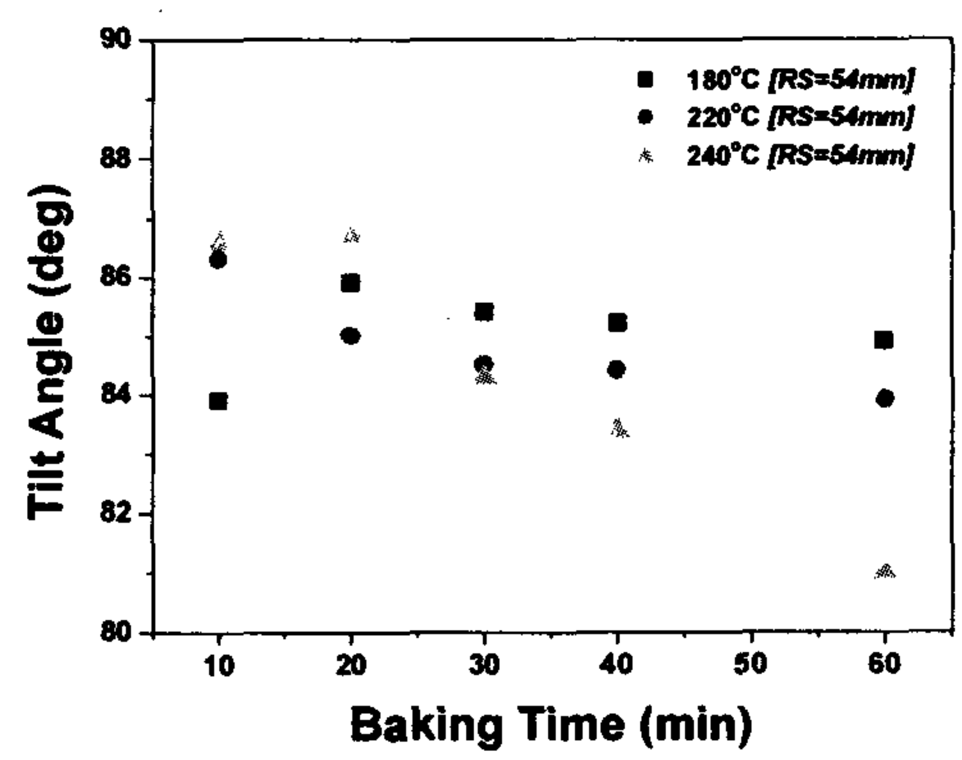
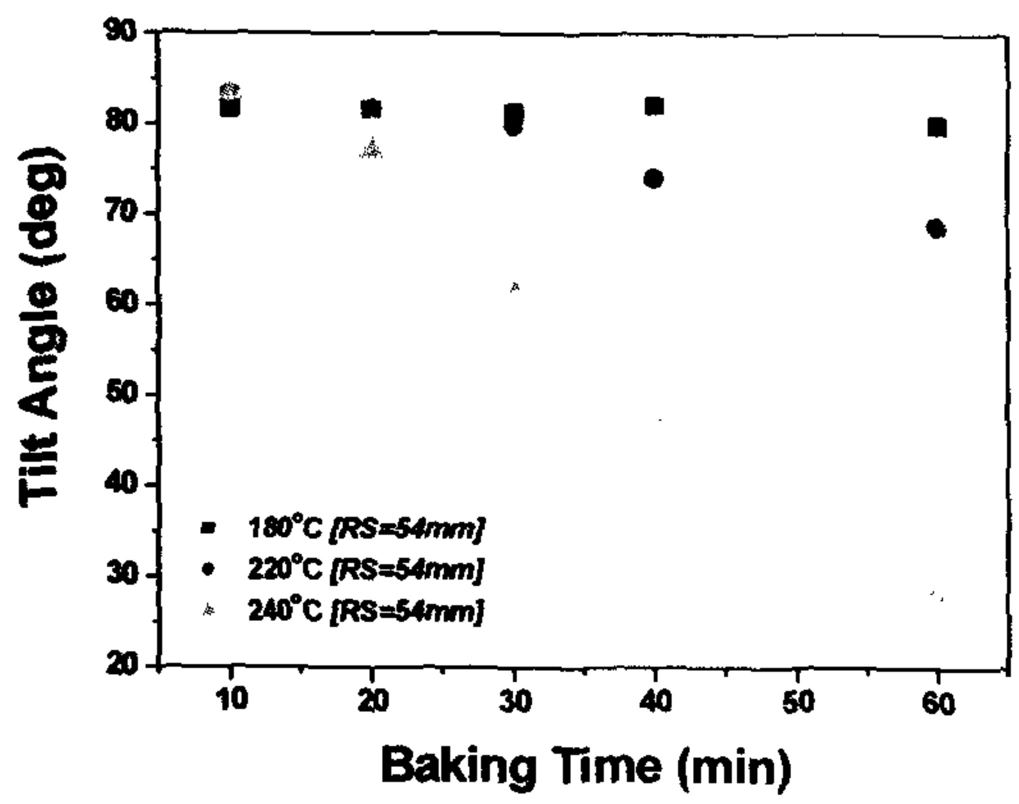
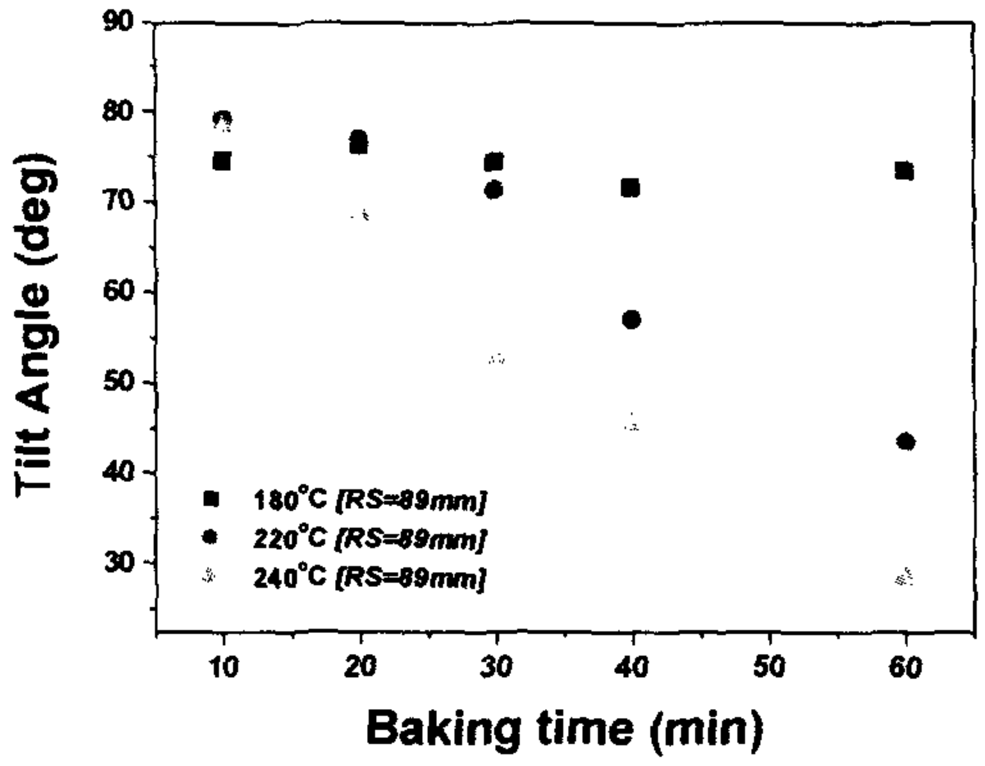


Figure 2. Tilt angle in NLC on the homeotropic polyimide surface as a function of Hot-plate temperature and time using negative type NLC.

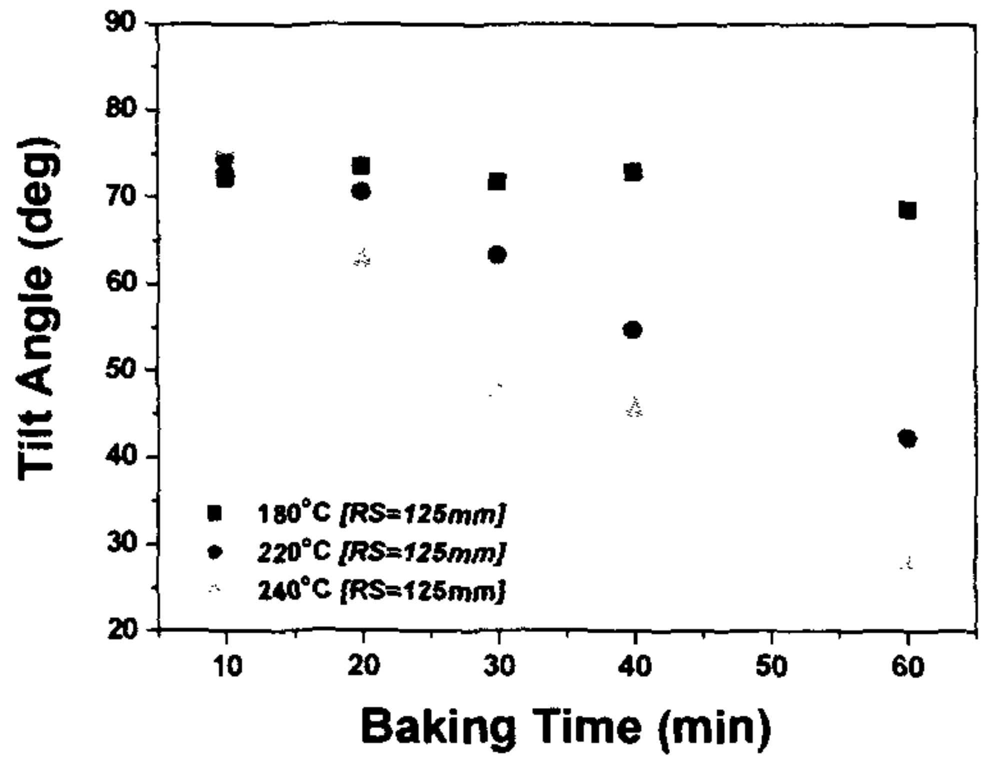
Figure 3 shows tilt angle in NLC on the homeotropic polyimide surface as a function of Hot-plate temperature and baking time using positive type NLC. Figure 3 exhibited tilt angle in the NLC on the polymers surfaces formed curing temperature at 180℃ ~ 240℃, when rubbing strength (RS) is 54~125mm. The tilt angle of positive type NLC was lower than that of the negative type NLC as a function of all rubbing strength on the polymer surface. The tilt angle of NLC generated on the polymer surfaces by Hot-plate equipment decreased with increasing rubbing strength, curing time, and curing temperature. Moreover, tilt angle decreased to about 17° when Hot-plate temperature was 240℃. Therefore, LC tilt angle of negative type NLC on the rubbed homeotropic PI surface was a slightly decreased with increasing baking temperature and time. But LC tilt angle of positive type NLC on the rubbed homeotropic PI surface was significantly decreased by increasing temperature and time with hot plate baking from 80° to near 20°. Finally, on the polyimide baking with Hot plate equipment, LC tilt angle of positive type NLC on the rubbed homeotropic PI surface was more decreased than that of negative type NLC on the rubbed homeotropic PI surface. From the results, generation of tilt angle of nematic liquid can be thought that homeotropic aligning capability decreases by stress to side chain of polymer according as curing temperature and time increase. The generation of LC pretilt angle is attributable to dipole-dipole interaction on the rubbed PI surface for homogeneous alignment.



(a) RS=54mm



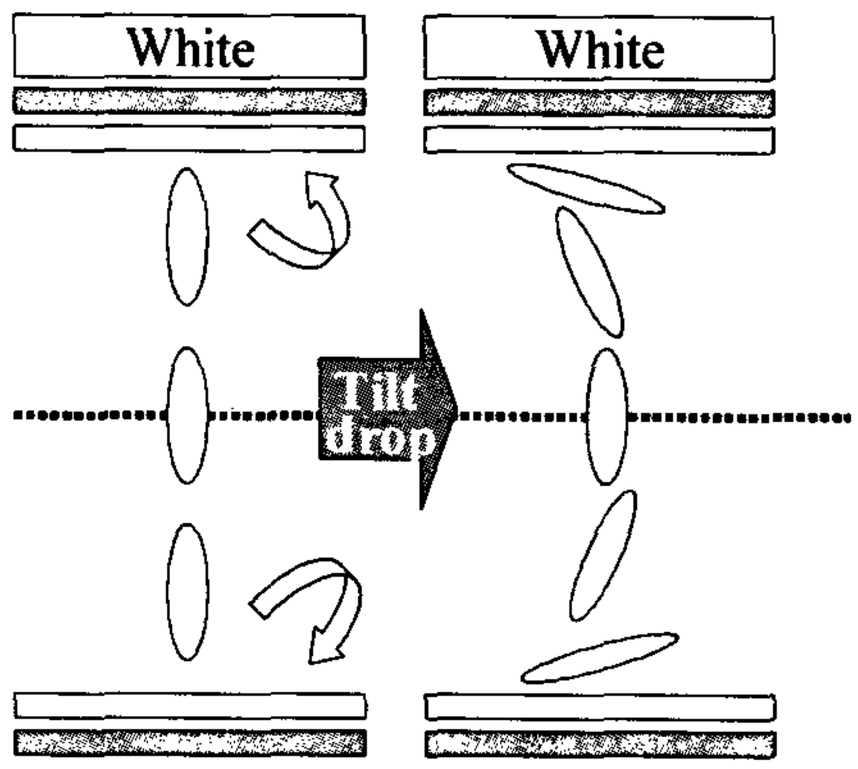
(b) RS=89mm



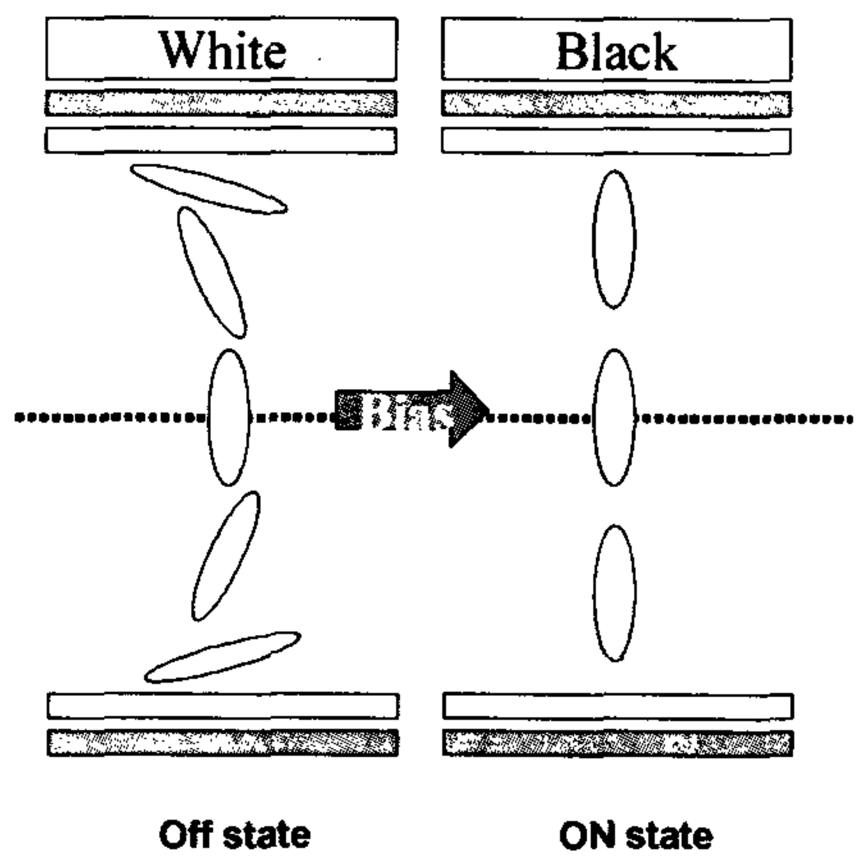
(c)RS=125mm

Figure 3. Tilt angle in NLC on the homeotropic polyimide surface as a function of Hot-plate temperature and time using positive type NLC.

Figure 4 shows the schematic diagram of the novel ECB cell structure which use bend structure with high tilt angle. In the OCB cell, LC director transforms to the bend state in the initial splay when the voltage is applied to the cell. However, in the novel ECB cell structure, LC director transforms to bend state by forming decrease of tilt angle using new tilt angle control as shown in Fig 4(a). In the off-state, the LC directors are aligned parallel to the glass substrates. Under the crossed polarizers and in the normal viewing direction, there was only an ordinary wave and no phase retardation to modulate light polarization. Therefore, the off-state of the novel ECB cell was white in the normal direction. In the on-state, because positive type of LC do parallel to the applied voltage, the novel NCB cell was black. To form bend structure, tilt angle is thought that must have scope of 40 to 60. Finally, we have designed this novel ECB cell using bend structure with high tilt angle in the unique condition by Hot-plate equipment.



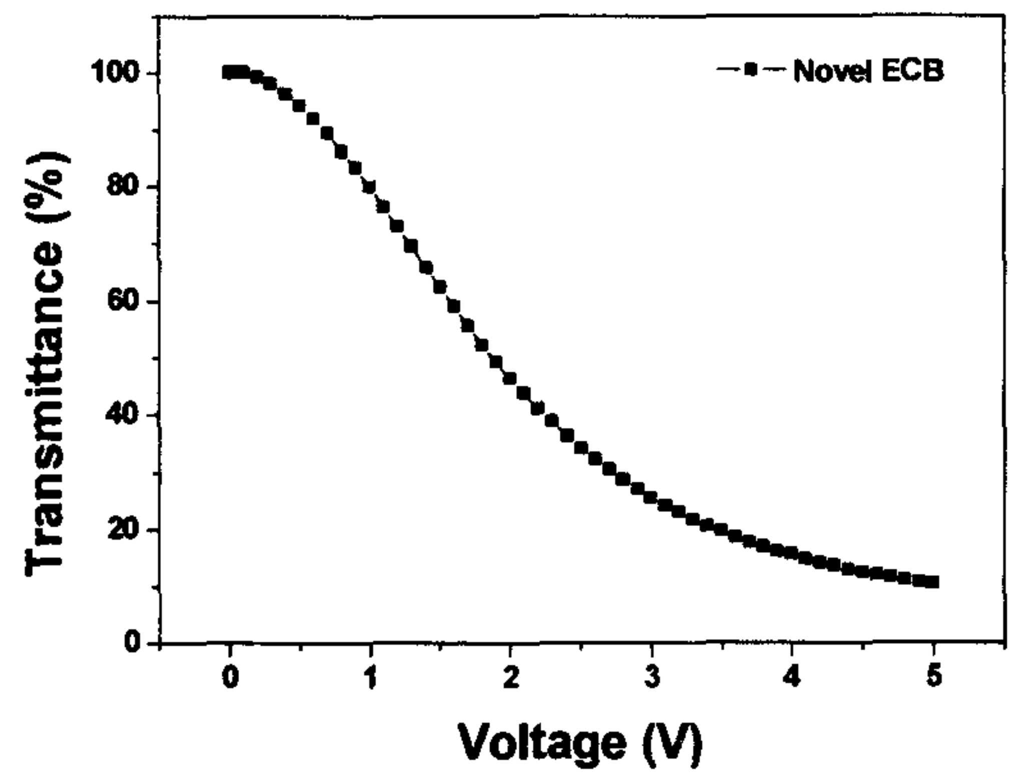
(a) Structure of the novel ECB cell



(b) Principal of the OCB cell

Figure 4. Schematic diagram and Principal of the H-ECB cell.

Figure 5 shows the V-T and response time curves for the novel ECB cell on the homeotropic rubbed PI surface using tilt angle in the unique condition. A Stable V-T curve of the novel ECB mode was measured as shown in Fig 5(a). A fast response time characteristic for the novel ECB cell was obtained.



(a) V-T curve

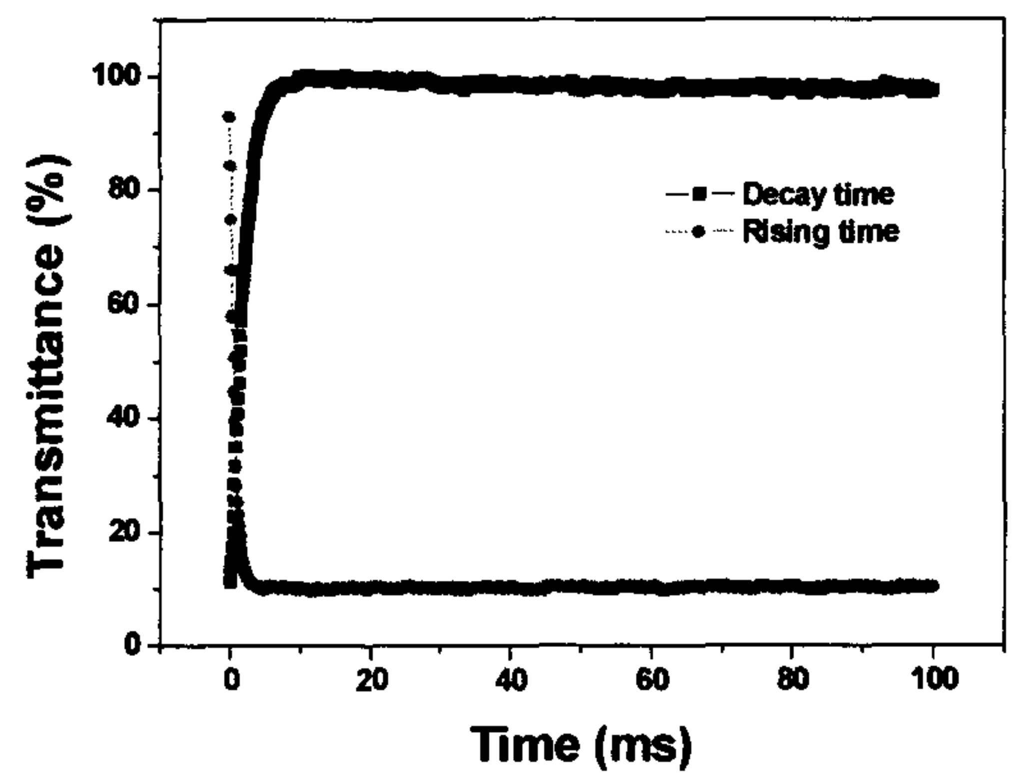


Figure 5. V-T and response time characteristics of the novel ECB cells.

Table 1 shows the response time for the novel ECB cell. The response time for the novel ECB cell was measured at about 5.1 ms. Consequently, good V-T curve and fast response time can be achieved by using the novel ECB cell.

Table 1. Response times for the novel ECB cell.

LC operating modes	τ_r(ms)	τ_d(ms)	τ(ms)
The novel ECB cell	3.7	1.4	5.1

3. Conclusion

In conclusion, the control of tilt angle for nematic liquid crystal (NLC) with negative and positive dielectric anisotropy on the rubbed homeotropic polyimide (PI) using baking method by Hot-plate equipment was investigated. As varying several baking conditions, we obtained various tilt angles, and it was investigated the stable LC alignment at that time. LC tilt angle of positive type NLC on the rubbed homeotropic PI surface was significantly decreased by increasing temperature and time with Hot-plate equipment from 80° to near 20°. Also, we investigated the EO performances for the novel ECB cell using bend structure with high tilt angle in the unique condition by Hot-plate equipment. The fast response time characteristics of the novel ECB cell can be improved. We suggest that the developed the novel ECB is a promising technique for the achievement of a fast response time and a high contrast ratio.

4. Acknowledgement

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5. References

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