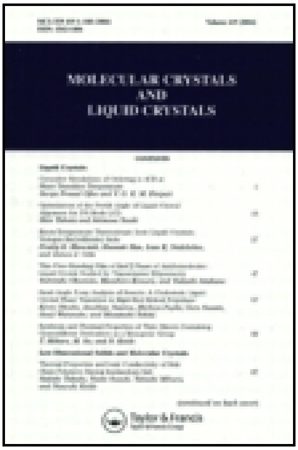

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Relationship between Pretilt Angle of Nematic Liquid Crystal and Surface Structure of Alignment Layer

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Fabrication method of alignment layer was investigated to verify which mechanism is dominant in generating the pretilt angle of LC. The surface energy and the geometrical surface structure were systematically controlled by combining the rubbing and Langmuir-Blodgett(LB) methods. Two layers of LB film were deposited on the top of rubbed polyimide films to remove the surface energy generated by rubbing. In a rubbed polyimide film, polymer chains array in a certain angle which increase with the rubbing strength. The rubbed film with two LB layer showed the contact angle to be the same as the LB film, while the pretilt angle of LB layer on rubbed film was reduced. Therefore it is concluded that the pretilt is more affected by the surface structure of the polyimide alignment layer than the surface energy.

Keywords: pretilt angle; LB film; alignment layer

INTRODUCTION

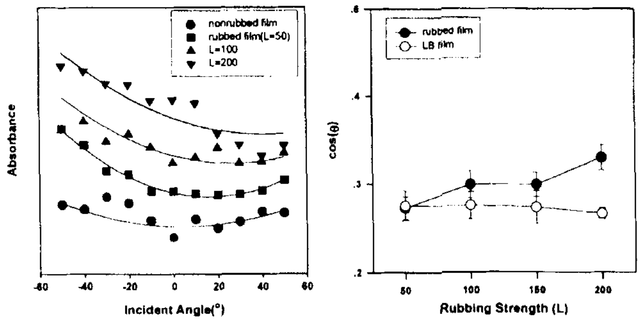
Pretilt angle is an important parameter in the design of LC devices. However, the mechanism that determines the pretilt angle has not been understood yet. It was reported that the pretilt angle changed with the rubbing strength. When the rubbing strength is varied, various components of the polymer surface, such as a surface energy, a geometrical surface structure, and so on, also change[1]. Therefore, it is difficult to reveal the mechanism of generating the pretilt angle on a rubbed alignment layer. In this paper, an investigation was attempted to verify which of the two important components, surface energy and geometircal surface structure, dominantly affects the the generation of the pretilt angle of liquid crystals.

EXPERIMENTAL

PMDA/ODA polyimide was used to form an LC alignment layer at various rubbing strengths. The rubbing strength is defined by the rubbing parameter(L)[2]. In order to cancel the variation of surface energy induced by rubbing, tow layers of the polyimide LB film were deposited on a rubbed film with various rubbing strengths. The dipping direction was the same as the rubbing direction. The out-of-plane orientation of the polyimide layer was determined by IR spectroscopy. The samples were positioned perpendicular to the incident beam direction, z. The rubbing direction was parallel to the polarization direction, y. The sample rotation axis was along the x direction.

RESULTS AND DISCUSSION

Figure 1(a) shows the absorbances at 1240 cm^{-1} (C-O-C), which is along the polyimide molecular axis according to the incident angle and rubbing strength. For nonrubbed samples, the absorbance was nearly symmetric with respect to the center, zero degree. On the other hand, the absorbance values for rubbed samples were found to be asymmetric[3]. The asymmetry increased with the rubbing strength.



(a) (b)

FIGURE 1. (a) Relationship between incident angle and peak intensity. (b) The contact angles of water on the rubbed and LB polyimide films.

This result suggests that the rubbed polyimide chains form a certain angle with the substrate surface, which increases with the rubbing strength. To meaasure the surface energy of polyimide alignment films, the contact angle(θ) measurement method was used. The samples used were rubbed polyimide films and polyimide LB films deposited on the rubbed films. In the rubbed films, as in Figure 1(b), cosθ increased with the rubbing strength because the polar component of the surface increased [1]. On the other hand, in the LB films, there were no changes, because the two LB film layers over the rubbed films canceled the surface energy effect induced by rubbing. Figure 2 shows the variation of the pretilt angle with the rubbing strength. In both the rubbed-only films and LB films, pretilt angle gradually increased with the rubbing strength. In the LB film, the pretilt angles were smaller than that of the cell of the rubbed-only film because the structure of the rubbed film was smoothed by the LB film. In the previous result, the polarity of surface of polyimide LB film did not change with the rubbing strength.

Therefore, the pretilt angle in the cell which was made by the rubbed polyimide alignment layer, was more greatly affected by the surface structure of the polyimide alignment layer than by the surface energy of the alignment layer.

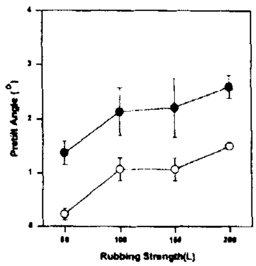


FIGURE 2. The pretilt angles variation of liquid crystal cell with the rubbing strength by the crystal rotation method.

CONCLUSION

In a rubbed polyimide film with two LB layer showed the contact angle to be the same as the LB film, while the pretilt angle of LB layer on rubbed film was reduced. The pretilt angle of nematic LC in the cell which was made by the rubbed polyimide alignment layer was more greatly affected by the geometrical surface structure of the polyimide alignment layer than by the surface energy of the alignment layer.

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