Properties on VA mode Alignment Film by Rubbed with AFM/FFM

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Abstract
The friction characteristics of vertical alignment (VA) mode alignment film (AF) by artificial rubbing were studies with AFM/FFM. The result was that the frictional asymmetry was not appeared by the rubbing conditions. The frictional force and surface morphology was high by the increase of the strength rubbing. This was explained by curved structure according to the potential of mutual interaction between the probe and the surface. Pre-tilt angle tend to decrease based on rubbing strength.

1. Introduction
In order to obtain pre-tilt uniformity in liquid crystal display (LCD) products, appropriate conditions at AF Process are required. It is understood that the disposition arrangement of LC molecules is produced from interaction of AF material molecules[1], however the origin of pretilt angle is still unknown. Further study is required in surface configuration and pre-tilt uniformity of AF about LC alignment control. We reported of AF side chain, which forms pre-tilt using FFM [2]. In the case of VA mode, twisted nematic (TN) mode produced varying frictional asymmetry based on pre-bake temperature. This was explained by leaning intermolecular repulsion caused by the side chain density and uniformity on AF surface. For understanding of mutual interaction between surface friction characteristics by side chain and pre-tilt angle AF of VA mode is required for further evaluation.
In this paper, the VA mode AF surface friction characteristics about artificial rubbing conditions with AFM/FFM were investigated. The pre-tilt angle was evaluated in the same conditions.

2. Experimental
The samples were cured on ITO substrate in 230°C that coated with post-bake temperature. The rubbing conditions were the pile impression is from 0.2mm to 0.6mm, stage speed 30mm/sec, spin speed 400rpm. The rubbing cloth is adapted rayon. The surface characteristics of AF were analyzed with AFM/FFM. NanoScope IV AFM of Digital Instruments was used in FFM mode. The probe was triangular silicon cantilever (force constant 0.12N/m) with a square pyramidal stylus of silicon nitride. The normal load was set at 12.57nN. The friction loop showing the torsion (friction signal) of the cantilever was also recorded.

3. Results and Discussion
3.1 Frictional property by rubbing condition
Fig. 1 shows the AFM and FFM result at VA mode AF on surface. The FFM image of contrast differences on rubbing condition did not appear. It was found friction loop did not show any frictional asymmetry affected by slope of the side chain, rather steady trend. As it was found in friction loop, rubbing strength positively correlated with total friction.
Fig. 2 shows pile contact depth according to total friction, which was based on rubbing condition, and its roughness. As the pile impression increases, AF surface roughness increases along with the total friction. Shindo et al., measured that friction anisotropy of CaSO4(001) surface. All friction was high in big curved structure of [010] direction rather than small curved period [100] direction [3]. A II of these friction forces are described by atomic interaction of potential curves between surface and probe. Taking into account the identical condition where the least amount of side chain exposure, one can state that the high cured structure in pile impression 0.6mm has greater friction.
3.2 Pre-tilt angle by rubbing condition

Fig. 3 shows the pre-tilt angle after injecting LC according to rubbing condition. The decrease of pre-tilt angle is found based on the pile impression strength. As arrange of side chain changes, pre-tilt angle size decreased. It could be stated that AF of side chain arrangement is promoted by rubbing strength.

Fig. 1 AFM (a1-c1) and FFM image (a2,a3-c2,c3) of VA mode AF on surface (scan size 5mm sq.). Friction loop was recorded along the broken line in (a2). Total friction was detected higher according to the rubbing pile impression increase from 0.2mm (a4) to 0.6mm (c4).

![AFM and FFM images](image)

Fig. 2 Comparison of surface roughness and torsion signal (total friction). The total friction was increased with surface roughness according to pile contact depth strength.

Fig. 3 Result of pre-tilt angle after injecting LC according to rubbing condition.

4. Summary

We studied characteristic of surface friction based on rubbing conditions at AF of VA mode. While the pre-tilt angle decreased, roughness of surface and total friction increased along with the pile contact depth strength. The pre-tilt angle is closely related with configuration of polymer molecules of side chain.

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References