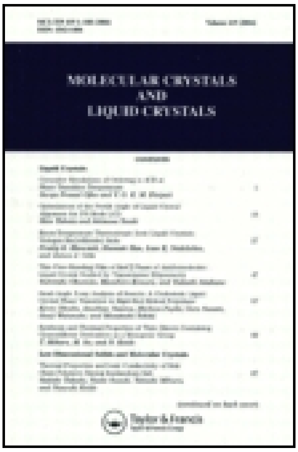

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Two-Dimensional Mapping of Surface Inhomogeneities in Organic Thin Layers

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Two-Dimensional Mapping of Surface Inhomogeneities in Organic Thin Layers

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We have developed spatio-dimensional imaging techniques for optically characterizing the uniformity and the quality of organic thin layers such as the alignment layer of a liquid crystal. These techniques rely on the laser scanning polarization modulated detection in the visible range and the reflectance imaging in the ultraviolet (UV) range. Surface inhomogeneities on the alignment layer associated with the static defects and the chemical contaminants can be clearly observed in a spatial map constructed by the phase retardation and the UV reflectance image.

Keywords: alignment layer; phase retardation; ultraviolet light

INTRODUCTION

The liquid crystal display (LCD) technology relies heavily on preferred molecular alignment in the bulk, which is predominantly governed by surface treatment[1]. Among several methods of molecular alignment on the substrate, the use of rubbed polymer layers[2] is of particular interest because of its simplicity and applicability over large area for mass production. However, the rubbing process modifies the surface morphology of the polymer layer in a contact way and potentially produces surface inhomogeneities on the alignment layer. Moreover, the cleaning process of the rubbed surface may involve chemical contamination. Therefore, an early detection of defects such as physical scratches, dust particles, and chemical contaminants, introduced into the LCD panel, is extremely important for LCD production. A reliable and viable tool of such detection system has not been developed so far.

In this work, we have proposed optical methods of characterizing the uniformity and the quality of the LC alignment layer in a non-contact way. Surface inhomogeneities on the alignment layer are clearly observed in a spatial map of the phase retardation measured with a visible light and a reflectance image formed with the ultraviolet (UV) light. The phase retardation map is obtained using a system of laser scanning polarization modulated detection in the transmissive mode and the UV image, captured with a charge-coupled device, is constructed in the reflective mode.

EXPERIMENTALS

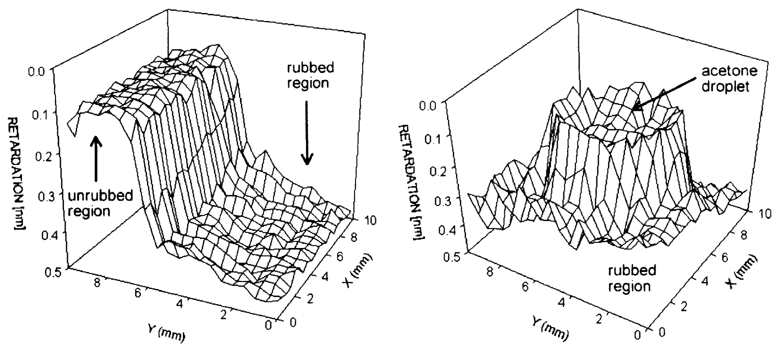
The substrates used in this work were transparent indium-tin-oxide (ITO) coated glasses on which the polyimide (PI) of AL3046 (Japan Synthetic Rubber Co.) was spin-coated. The thickness of the PI layer on each substrate was about 300 Å. Two different types of inhomogeneous substrates were prepared: one had both the rubbed and unrubbed regions and the other was contaminated purposely with a small droplet of acetone on the rubbed substrate.

The laser scanning system of the polarization modulated detection[3] was equipped with a rotary and a translational stages on which the substrate was placed[4]. A He-Ne laser with the wavelength of 632.8 nm was used as a monochromatic light source. The ac component of the transmitted intensity through the substrate, monitored with a lock-in amplifier (SR830, Stanford Research Systems), was stored and analyzed in a computer for spatio-dimensional mapping. For constructing the UV reflectance image of the substrate, captured with a charge-coupled device, a He-Cd laser with the wavelength of 325 nm was used in the reflective mode. All the measurements were performed at room temperature.

RESULTS AND DISCUSSION

The three-dimensional maps of the phase retardation measured through the PI alignment layers are shown in Fig. 1. Due to an induced birefringence of an alignment layer by rubbing process, as shown in Fig. 1(a), the rubbed and unrubbed regions were clearly distinguished. The area scanned was about 1 cm^2 and the variations of the phase retardation within the rubbed or unrubbed region was less than 5×10^{-2} nm. This indicates that our scanning system of the polarization modulated detection is sensitive enough to measure a very small anisotropy (about 0.4 nm) produced by rubbing in the alignment layer.

Figure 1(b), shows the three-dimensional phase retardation map of the PI alignment layer with chemical contaminant of acetone. Since a small droplet of acetone destroys the surface morphology of the rubbed PI alignment layer, the difference of the phase retardation between the clean rubbed and the contaminated regions is definitely revealed. In the contaminated region with acetone, the magnitude of the phase retardation is nearly the same as that in the unrubbed case, implying that acetone substantially removes the aligning capability of the PI alignment layer.

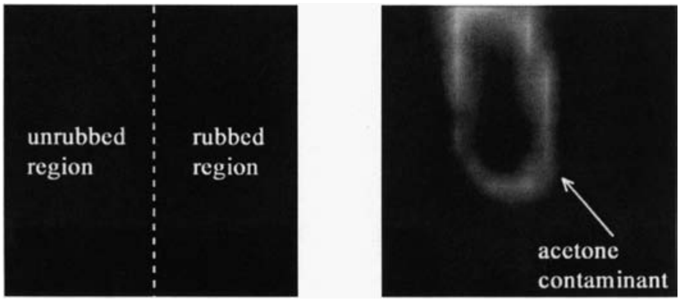


(a) (b)

FIGURE 1 : The three-dimensional phase retardation maps of PI alignment layer : (a) partially rubbed and (b) with an acetone contaminant. For each map, the area scanned was about 1 cm^2.

In the reflective mode using the visible light, it is difficult to characterize the quality of the PI alignment layer because of transparency of the ITO glass substrate in the visible range. However, the reflectance image formed with the UV light provides more accurate information about the surface inhomogeneities since the glass substrate experiences the strong absorption in the UV range.

The UV reflectance images of the PI alignment layers partially rubbed and with acetone are shown in Fig. 2. The UV reflectance, as shown in Fig. 2(a), was rather insensitive to the rubbing process, so that the difference in the reflective intensities between the rubbed and unrubbed regions was barely observed. Therefore, a reflectance microscopy was employed to distinguish between the contaminated and the clean rubbed regions by using the scattering of light at an interface between the clean PI region and the one dissolved by acetone.



(a) (b)

FIGURE 2 : The UV reflectance images of PI alignment layer : (a) partially rubbed and (b) with acetone contaminant. The area captured was about 1 cm^2.

CONCLUDING REMARKS

We have demonstrated that a laser scanning system of polarization modulated detection is a viable tool for an early detection of surface inhomogeneities of the PI alignment layer associated with irregular rubbing and/or chemical contaminants. Moreover, for detecting the chemical contaminants only, the UV differential reflectance microscopy in the reflective mode turns out to be more powerful than the polarization modulated detection due to its fast acquisition speed and wide area scanning capability.

Acknowledgment

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