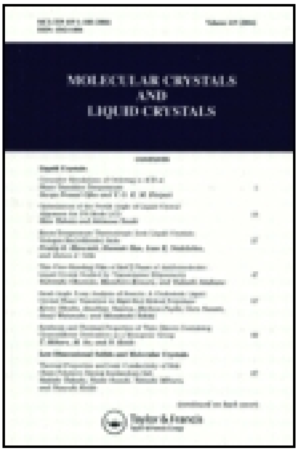

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Fabrication of Alignment Layer Coated Indium-Tin-Oxide Prepared by Ultraviolet Nano-Imprinting Lithography

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Fabrication of Alignment Layer Coated Indium-Tin-Oxide Prepared by Ultraviolet Nano-Imprinting Lithography

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Nanoscale grating patterns coated indium-tin-oxide (ITO) layers were fabricated using the ultraviolet (UV) nano-imprinting technique. The nanoscale groove coated ITO that was prepared in this experiment could play a role in alignment layers and conducting electrodes. Performance for LC alignment was characterized by evaluating order parameter. The LC order parameter evaluated on the fabricated layer was comparable to that of the conventional rubbed polyimide layer. We also confirmed that the 90° twisted nematic liquid crystal (TNLC) cell with our nanopattern coated ITO layer exhibited stable electro-optical performance.

Keywords Alignment; electro-optical device; indium-tin-oxide (ITO); liquid crystal; nano-imprinting lithography; twisted nematic (TN)

1. Introduction

Uniform alignment of liquid crystal (LC) molecules is one of the critical factors to influence electro-optical performances of LC devices [1]. Generally rubbed-polyimide (PI) films are used in LC devices to induce homogeneous alignment of LC molecules. Beside of the rubbing method, a variety of methods for generating surface topography have been proposed because LCs can be aligned by topographically micro- or nanopatterned surfaces [2–8]. Recently, Lin *et al.* reported that nano-patterned polymeric surface coated indium tin oxide (ITO) thin film could be fabricated using thermal nano-imprinting lithography (NIL) technique for flexible

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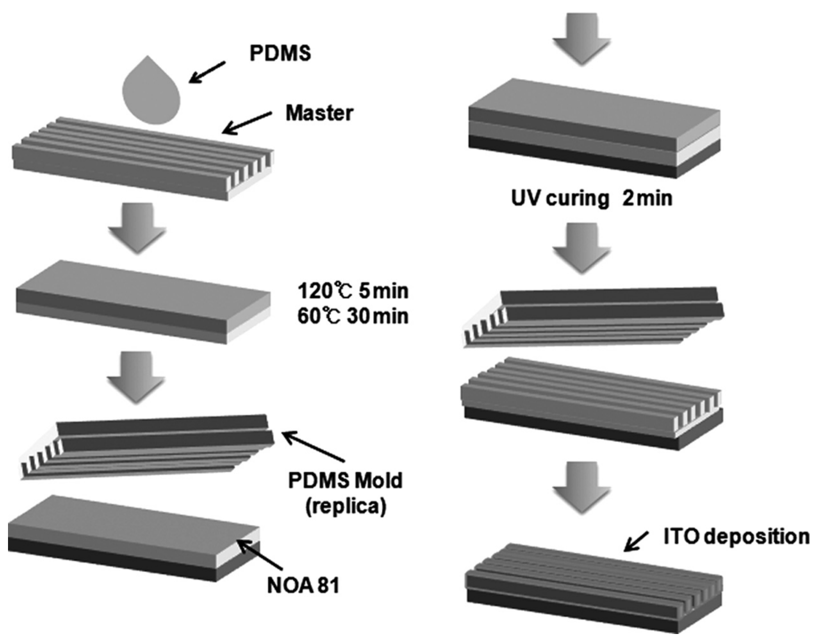
LC devices [8]. The ITO film can play a role as not only an electrode but also an alignment layer. They proposed that the nanopatterned ITO film grown on polymer substrates is promising for flexible plastic LC devices.

In this work, we fabricated nanoscale groove patterned coated ITO employing the ultraviolet (UV) NIL technique for novel LC devices. This nanoscale groove coated ITO can play important roles in alignment layers as well as conducting electrodes for novel LC devices. We focused on the performance for LC alignment on the nanopatterned ITO film by evaluating order parameter of LC. We also fabricated preliminary version of twisted nematic (TN) LC cells using our nanopattern layer, and confirmed the stability and reliability of the fabricated cells by measuring their electro-optical performance.

2. Experimental

2.1. *Alignment Layer Preparation*

The UV-NIL procedure for fabricating topographically nanopatterned alignment layer coated ITO thin films is shown in Scheme 1 [9]. First, the patterned master (period of 218 nm and depth of 98 nm) was converted to a soft polydimethylsiloxane (PDMS) mold, which was fabricated by casting the PDMS precursor against the patterned master ready-made. During two-step curing, (1) at 120°C for 5 min, and (2) at 60°C for 30 min, the PDMS rubber (replica) became rigid and was easily separated from the patterned master to a freestanding film. UV curable polymeric material (NOA 81, Norland Co.) was drop cast on a glass substrate and the prepared replica was pressed against it for 2 min at room temperature under UV irradiation



Scheme 1. The UV-NIL procedure for fabricating topographically nanopatterned alignment layer coated ITO.

(365–436 nm, 15 mW/cm^2). Then, the patterned structure was replicated onto NOA 81 on a substrate. On the patterned layer, ITO as an electrode was sputter deposited at room temperature using an in-line magnetron sputter deposition system equipped with DC power suppliers. The coated thickness was controlled by means of deposition time. After deposition for 1000 s, the sheet resistance was ca. 120 Ω/sp.

2.2. *Evaluating Order Parameter*

To evaluate the LC alignment strength of the imprinted layers coated with ITO, we used dye-doped guest-host LC [10], that is, commercially available nematic LC (E7) doped with 0.7% Methylene Violet dye. The imprinted layers coated with ITO were assembled with 6-μm spacers, and dye-doped guest-host LCs were injected into the isotropic phase to prevent the effects of flow alignment. We observed the dichroic transmittance of the cell with the guest-host LC and calculated the order parameter of the dye. Polarized absorption spectra of the 0.7% dye-doped LC cell were monitored and calculated the dichroic ratio at λ_{max}, $N = D_{parallel}/D_{perpendicular}$, where $D_{parallel}$ and $D_{perpendicular}$ are the optical densities of the cell with light polarization parallel and normal to the nanoscale groove direction of the imprinted layers coated ITO, respectively. The order parameter S is related to the dichroic ratio by the equation [10]

$$S = (N - 1)/(N + 2) \tag{1}$$

2.3. *Cell Construction and Measurement*

LC cells with twisted nematic (TN) mode were fabricated. The cell gap was maintained with 6 μm, and then was filled with liquid crystal (MLC7022-100, Merck Co.) using capillary injection method. The imprinted structures before and after deposition of ITO layer could be confirmed from atomic force microscope (AFM) images. The voltage-transmittance (V-T) characteristics of LC cells were measured using electro-optical measurement system (Sesim Co., Korea).

3. Results and Discussion

Figure 1(a) shows the nanoscale groove of the NOA 81 film after NIL measured by an atomic AFM. The imprinted patterning on the polymer surface was observed to have a period of 200 nm and a depth of 90 nm. The observed period of the imprinted polymer film was in good agreement with that of the master. After the deposition of the ITO film on the nanoscale groove surface of the imprinted polymer layer, the groove structures were still maintained according to the topographical structures of base surfaces, as shown in Figure 1(b). Although the topographical profiles are rather deformed, the obtained dimension of nanoscale groove was still good enough for aligning LC molecules.

Polarized absorption spectra of the 0.7% dye-doped LC cell are shown in Figure 2. We calculated the dichroic ratio at λ_{max}, $N = D_{parallel}/D_{perpendicular} = 3.922$. The order parameter S was calculated to be 0.493 using Eq. (1). This value is comparable to the level of LC alignment for conventional rubbed polyimide (PI) surfaces.

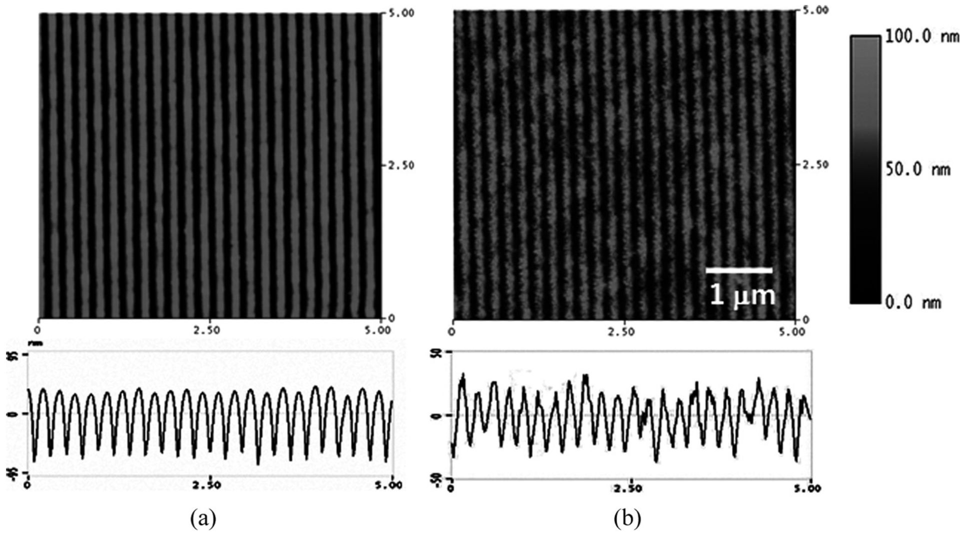


Figure 1. AFM image of (a) the NOA 81 film after NIL and (b) the NOA 81 film coated ITO.

Figure 3 shows the polarized optical microscopy (POM) images of TN cell with our nanopattern coated ITO layer. Under crossed polarizer geometry, normally white state represents the well-aligned TN cell. On the other hand, normally black state observes under parallel polarizer geometry. From Figure 3, we could conclude that well-aligned TN was accomplished using our imprinted layers coated ITO.

Electro-optical characteristics of our TN cell were also evaluated. The V-T characteristics of the LC cells were depicted in Figure 4. Normally black TN geometry with parallel polarizers was employed in order to evaluate the initial black level. The observed black level was approximately 0, which indicates that a perfect 90°

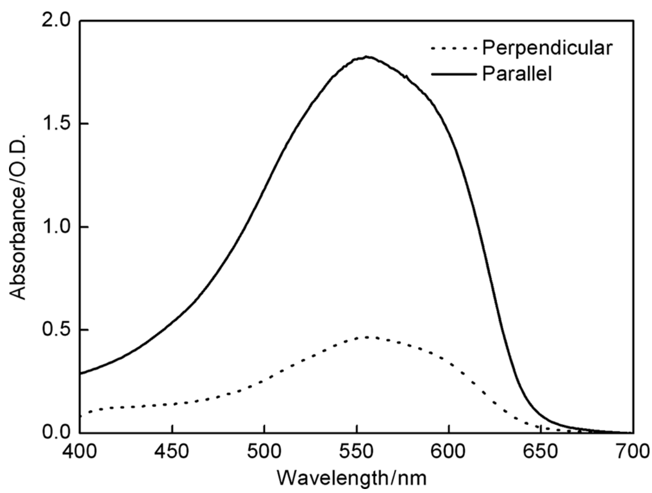


Figure 2. Absorbance spectra of the planar nematic LC cell doped with 0.7% Methylene Violet dye.

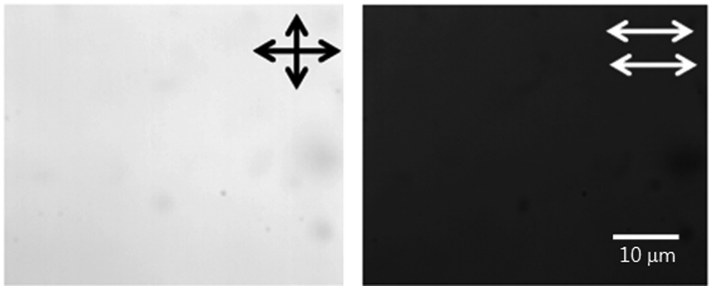


Figure 3. POM image under crossed polarizer and parallel polarizer geometry. Arrows indicate the direction of the polarizers.

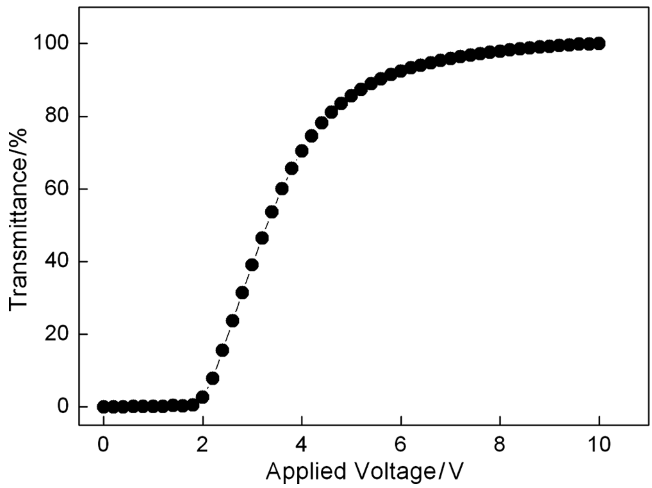


Figure 4. Electro-optical switching curve for our TN cell.

TN cell was fabricated. The electro-optic operation had analog grayscale capability with a high contrast ratio of more than ca. 600:1 between the dark and white states.

4. Conclusion

Nano-scale grating patterns with ITO layer have been successfully fabricated by UV nanoimprinting technique. Nano-scale groove prepared here can play important roles as alignment layers as well as conducting electrodes. Performance for LC alignment was tested by evaluating order parameter. We confirmed that the observed order parameter is comparable to the level of LC alignment on a conventional rubbed PI surface. We also confirmed that the 90° TN LC cell with our nanopattern coated IZO layer exhibited stable electro-optical performance.

Acknowledgments

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References

[1] Choi, S.-W., Takanishi, Y., Ishikawa, K., & Takezoe, H. (2007). *Appl. Phys. Lett.*, *90*, 033115.
[2] Berreman, D. (1973). *Mol. Cryst. Liq. Cryst.*, *23*, 215.
[3] Kim, J. H., Yoneya, M., & Yokoyama, H. (2002). *Nature*, *420*, 159.
[4] Lin, R., & Rogers, J. A. (2007). *Nano Lett.*, *7*, 1613.
[5] Gwag, J. S., Oh-e, M., Kim, K. R., Cho, S. H., Yoneya, M., Yokoyama, H., Satou, H., & Itami, S. (2008). *Nanotechnology*, *19*, 395301.
[6] Chiu, C. H., Kuo, H. L., Chen, P. C., Wen, C. H., Liu, Y. C., & Chen, H. M. P. (2006). *Appl. Phys. Lett.*, *88*, 073509.
[7] Behdani, M., Keshimiri, S. H., Soria, S., Bader, M. A., Ihiemann, J., Marowsky, G., & Rasing, T. (2003). *Appl. Phys. Lett.*, *82*, 2553.
[8] Lin, T.-C., Yu, S.-C., Chen, P.-S., Chi, K.-Y., Pan, H.-C., & Chao, C.-Y. (2009). *Curr. Appl. Phys.*, *9*, 610.
[9] Kim, H. J., Lee, J. G., Kim, H. K., Choi, S.-W., & Kim, S. S. (2010). *Jpn. J. Appl. Phys.*, *49*, 024207.
[10] Wang, Y.-J., & Carlisle, G. O. (2002). *J. Mater. Sci.*, *13*, 173.