KLCC 2006, Vol. 1,
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Periodic patterned LC alignment layers by CFL method

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We suggested a soft-lithographic method for aligning a liquid crystal (LC) in patterned alingment layers. It is demonstrated that a thermoplastic polystyrene layer is patterned on the thermally stable polyimide layer by pressure-assisted capillary force lithography. This method provides multidirectional LC alignment condition simply followed by unidirectional rubbing process.

1. Introduction

In Liquid Crystal Display (LCD) technologies, Liquid Crystals (LCs) are aligned by determining anisotropy on thin polymer film of a substrate. By patterned LC alignment layers, LCs can be aligned in a muti-domain structure, which can be applied to improvement of viewing angle problems.

Photolithography has been the mainstay for pattering that is required to fabricate electronic and optical devices. Nonetheless, photolithography has disadvantages. The sizes of the features it can produce are limited by optical diffraction, and the high-energy radiation needed for small features requires complex facilities and technologies. So a number of non-photolithography techniques have been demonstrated for fabricating high-quality microstructures and nanostructures.

Soft lithography [1] is exactly one of these techniques. Soft lithography covers the diffraction limits of photolithography, provides access to three-dimensional structures, tolerates a wide range of materials and surface chemistries, and is inexpensive, experimentally convenient. Soft lithography have various techniques: microcontact (uCP),[2] replica molding (REM),[3] microtransfer molding (uTM),[4] micromolding in capillaries (MIMIC),[5] solvent-assisted micromolding (SAMIM),[6] and capillary force lithography (CFL)[7].

CFL among above techniques utilizes the capillary filling phenomenon of a polymeric melt into a cavity to pattern the polymer film coated on a substrate.

In this paper we introduced pressure assisted

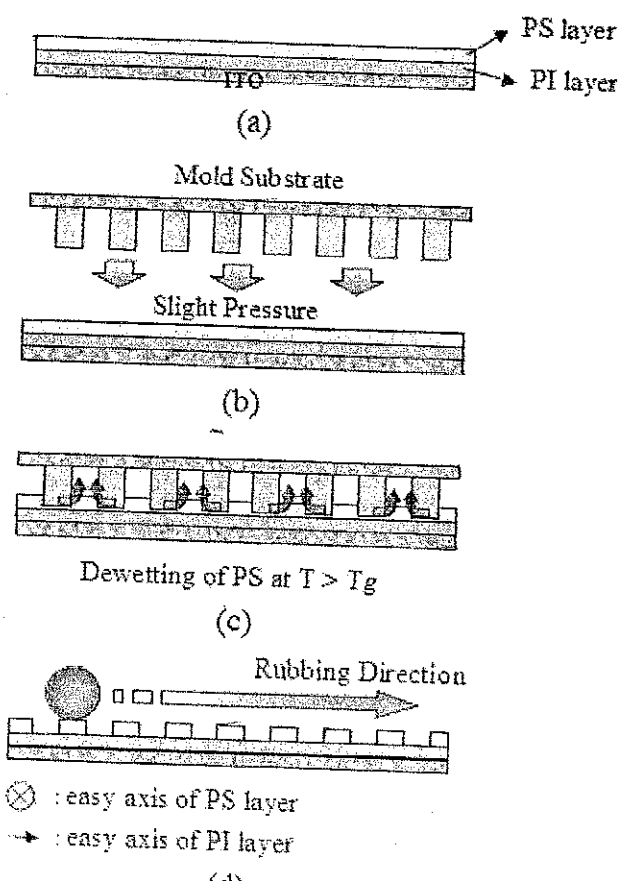

Figure 1. Schematic diagrams of PACFL procedures for patterning of LC alignment layers.

capillary force lithography (PACFL) for multi-domain using selective dewetting process. PACFL requires a slight pressure to achieve the conformal contact of the stiff polymer mold with the polymer layer. Thermoplastic polystyrene (PS)[8] on the thermally stable polyimide (PI) is patterned by PACFL. With this method, PS can be patterned periodic 10um size and can be obtained multi-domain LC structure by unidirectional rubbing.

2. Patterned alignment layers by PACFL

In our fabrication process, the patterning of an alignment layer was executed by single step without any etching process and any photo-masking process, as shown in Fig.1. First, a PI layer and a PS layer was sequentially spin-coated as shown in Fig. 1(a). In our experiment, a homogeneous LC alignment PI, RN1199 (Nissan Chemical Ind.) was used for thermally stable base film. With a patterning material, a thermoplastic isotactic PS (i-PS, Scientific Polymer) diluted in toluene was spin-coated on the PI layer. And then we prepared the patterned mold structure. Figure 1(b) shows patterned mold structure was contacted on the prepared polymer films and was slightly pressed down to achieve conformal contact of the stiff polymer mold. When the combined structure is heated above the glass transition temperature (Tg) of i-PS, the PS layer becomes melted state and the patterned mold structure sinks down to the PI layer as shown in Fig. 1(c). Within the heated combined structure, capillarity forces the PS melt into the void space of the channels formed between the patterned mold and the PS film. After the dewetting procedure was fully accomplished, the structures were slowly cooled down to room temperature and then the mold was removed. We can be obtained patterned PS as shown in Fig. 1(d). Finally the patterned PS was unidirectionally rubbed in a conventional method. Since the i-PS layer aligns LCs perpendicular to the rubbing direction while the uncovered PI layer aligns LCs along the rubbing direction, LCs are aligned orthogonally to each other in PS and PI films.

3. Multi-domain LC structure by patterned alignment layer

The multi-directional LC anchoring effect on the patterned double-layer film was observed by measuring polarization variation in the cell structure shown in Fig. 2(a). Figure 2(b) shows the microscope image of the polymer substrate patterned in a period of 10um. Since the easy axis of the upper and lower layers were orthogonal to

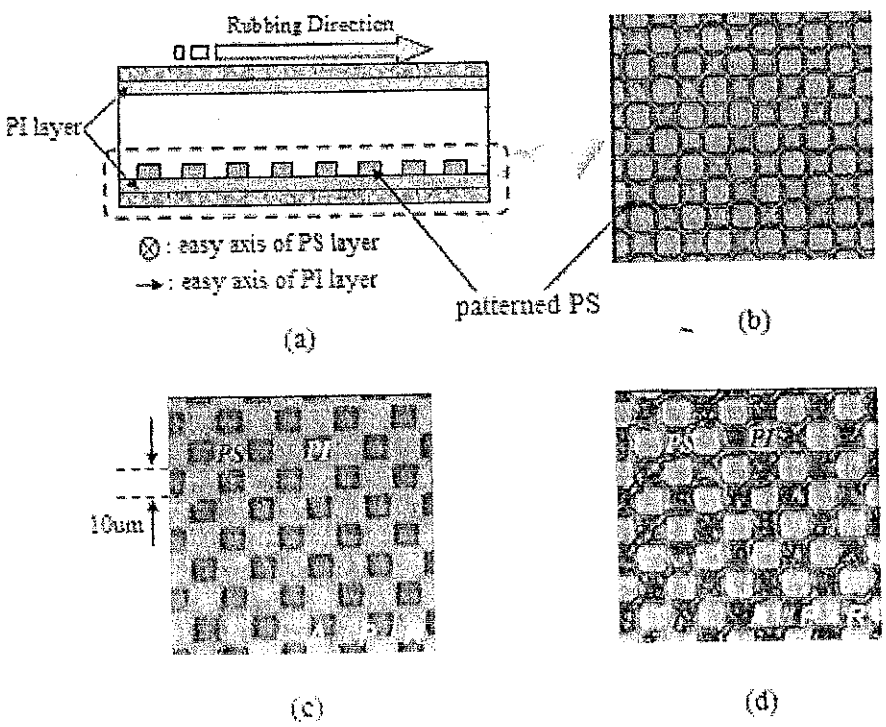

Figure 2. (a) Cell structure, (b) Microscope image of patterned polymer substrate, (c),(d) the polarizing microscope images obtained through the crossed and parallel polarizers, respectively.

each other as shown in Fig. 2(a), the LCs on the patterned i-PS film have a homogeneously planar structure and those on the uncovered PI film have a twisted nematic structure. Therefore, in Fig. 2(c) and Fig. 2(d), the dark and the bright regions correspond to the patterned PS and PI films, respectively. The proposed method has the advantages in its high patterning resolutions as well as its simplicity, which is assumed that it is applicable to sub-micrometer patterning. Our patterning method utilizing difference in the thermal stability and the rubbing-induced easy axis orientation between two polymers would be very useful for improving the performance of the LC devices via manipulation of the patterned LC geometries.

4. Conclusion

In this work, we investigated a soft-lithographic method for aligning a liquid crystal (LC) in patterned alignment layers. It is a pressure assisted capillary force lithography (PACFL) for multi-domain using selective dewetting process. PACFL requires a slight pressure to achieve the conformal contact of the stiff polymer mold with the polymer layer. It is demonstrated that a thermoplastic polystyrene layer is patterned on the thermally stable polyimide layer by PACFL. This method provides multidirectional LC alignment condition simply followed by one directional rubbing process.

Acknowledgement

This work was supported by Korea Research Foundation Grant (KRF-2004-005-D00165).

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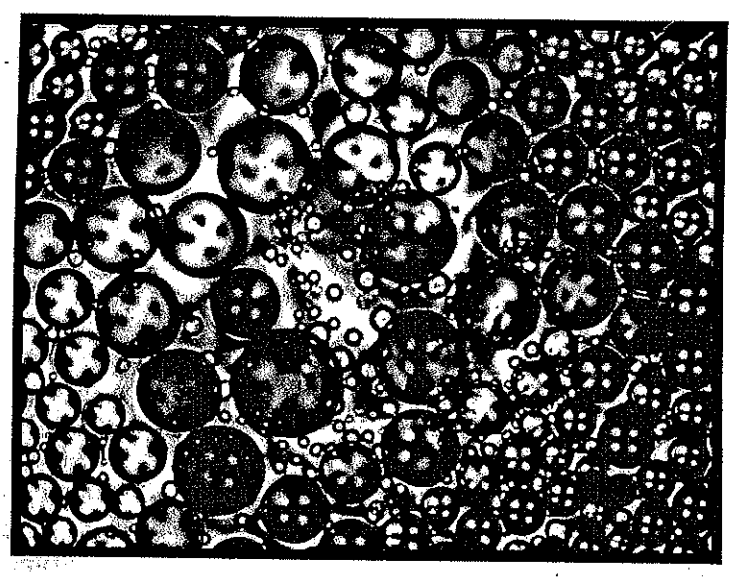
July 21 - 22, 2004



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