63.4: Photocopy Technology in Producing Patterned Alignment Layer

Tao Du, Fan Fan, Qi Guo, Vladimir Chigrinov, and Hoi Sing Kwok
Center for Display Research, Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong

Abstract
In this paper, a method of using photocopy technology in producing patterned alignment layer has been proposed，which is capable of copying any possible alignment patterns with the size as small as 2μm. A patterned polarizer made of quarter wave plates using photoalignment technology is used to transfer the alignment patterns to the photoalignment layer.

1. Objective and Background
Photoalignment technology has been developed for many years and now has been put into practice in the LCD industry. Some Commercialized photoalignment materials are now readily available [1-3]. In addition to the fabrication of LCD alignment, many other applications have been demonstrated. For example, in some photonics applications, photoalignment technology can be used to make special LC alignment patterns in order to active optical elements in the communication system.

Among all the advantages of photoalignment technology comparing with rubbing technology, the capability of producing high quality multi-domain patterned alignment is highlighted. To produce a special designed multi-domain alignment pattern, the conventional method by photoalignment technology is to conduct a multi-step exposure with a mask. For two domains alignment pattern, a process of two step exposure is required, and for n domains alignment patterns, usually a process of n step exposure with masks is required [4-6].

In principal, a patterned polarizer can be used in the photoalignment process to generate patterned alignment patterns in one step exposure; however; designing and producing patterned polarizer are not as convenient [7-9], making one step photoalignment with patterned polarizer not practical at the moment.

In this paper, we propose a new method of making micro patterned polarizer by photoalignment technology, which has low cost and very fast though output, further more, we make use of this patterned polarizer in photoalignment process to photocopy the alignment patterns from the polarizer to the alignment layer in one step exposure.

2. Methodology
a circular polarizer can be made from a linear polarizer plus a quarter wave plate. The quarter wave plate, which has the optical axis at 45° to the optical axis of the linear polarizer, will convert the linear polarized light from the polarizer to circular polarized light. Reversely, a quarter wave plate can also convert circular polarized light to linear polarized light with the output polarization direction at 45° or -45° to the optical axis of the quarter wave plate.

If we put together three layers, including a linear polarizer, a quarter wave plate with the fast axis at 45° or -45° to the optical axis of the said linear polarizer, and another quarter wave plate with the optical axis oriented at a angle θ. With the input be ambient light, the output light through the three stacked layers will be linear polarized at an angle θ+45° or θ-45°, respectively.

Based on the discussion above, we can make the third layer to be a patterned quarter wave plate by photoalignment technology. The different domains in the patterns have different θ value. Thus, a micro patterned polarizer is made. Figure 1 shows the schematic configuration of the photo patterned polarizer.

The patterned quarter wave plate is made of photoaligned Liquid Crystal Polymer (LCP). The process is described in figure 2. To produce the patterned quarter wave plate, one option is to make it by multi-step photoalignment. First we deposit a photoalignment layer on glass substrate. Next the photoalignment layer is exposed in two steps by a suitable light source through a mask. The alignment layer will be photoaligned with the alignment directions depending on the polarization direction of the incident light. Then we deposit LCP with a certain thickness on the alignment layer and polymerize it by UV light exposure. The LCP molecules will be aligned with respect to the alignment direction of the alignment layer. Thus a patterned quarter wave plate is made.

Once the first patterned polarizer is made, a preferable option for producing more such patterned quarter wave plates is to use the patterned polarizer itself, which means the proposed patterned polarizer has a self copy mechanism. This concept can be expended to photocopy of patterned alignment layers, in which the patterned polarizer serves as the master and its pattern will be transferred to the alignment layer in one step exposure.

3. Results
Experiments have been made to test the domain size limit of the photo patterned polarizer. Figure 3 shows an experiment sample of two domain patterned polarizer. By far, we can make micro patterned polarizers with the domain size down to 2μm.

Using this patterned polarizer, we can transfer the designed patterns to photoalignment layers in one step exposure. Figure 4 shows one example of photocopy experiment. According to the principle, the copied patterns on the alignment layer will have the alignment directions at 45° to the alignment directions of the quarter wave plate of the patterned polarizer.

In principle, any possible patterns on the patterned polarizer, if the size does not exceed the limitation, can be copied to the alignment layer in one step exposure, no matter it has 2 domains, 4 domains or infinite domains.

4. Summary
In summary, a method of photocopying alignment patterns to photoalignment layers using photo patterned polarizer has been proposed. Photoalignment technology is used to design the

 ISSN 0097-966X/11/4202-0948-$1.00

patterns of the polarizer with the domain size as small as 2μm. This photo patterned polarizer can be made to have unlimited patterns and can be designed for any wavelength from UV to Inferred. So it can be adjusted to match the properties of different photoalignment materials for photocopying alignment patterns in one step exposure.

5. Acknowledgement

This work is supported by grant CERG 612310, CERG 612208 and CERG 612409.

6. References

[1] E. D. Kvasnikov, V. M. Kozenkov, and V .A. Barachevskii, Birefringence in polyvinyl cinnamate films, induced by polarized light, Dokladi Akademii Nauk SSSR, 237, 633 (1977) (In Russian).

[2] K. Ichimura, Y. Suzuki, T. Seki, A. Hosoki, and K. Aoki, Reversible Change in Alignment Mode of Nematic Liquid Crystals Regulated Photochemically by "Command Surfaces" Modified with an Azobenzene Monolayer, Langmuir 4, 1214 (1988).

[3] V. Chigrinov, S. Pikin, A. Verevochnikov, V. Kozenkov, M. Khazimullin, J. Ho, D. Huang, and H.S. Kwok, Diffusion model of photoaligning in azo-dye layers, Phys. Rev. E, 69, 061713 (2004).

[4] R. Yamaguchi, and S. Sato, Liquid crystal optical sequrity device with polarized latent images, IDW'05 Digest, p.65 (2005).

[5] V.M. Kozenkov, V.G. Chigrinov and H.S. Kwok, Photoanisotropic Effects in Poly(vinyl-cinnamate) Derivatives and Their Applications, Mol. Cryst. Liq. Cryst., 409, 251 (2004).

[6] V.G. Chigrinov, V.M. Kozenkov, and H.S. Kwok, New developments in photoaligning and photo-patterning technologies: physics and applications, In a book "Optical Applications of Liquid Crystals", Ed. by L.Vicari, Institute of Physics Publishing, Bristol and Philadelphia, 201-244 (2003).

[7] Z. K. Kalayjian, A. G. Andreou, and L. B. Wolff, Electron. Lett. 33, 38 (1997).

[8] A. G. Andreou and Z. K. Kalayjian, IEEE Sens. J. 2, 566 (2002).

[9] J. Guo and D. Brady, Opt. Eng. 36, 2268 (1997).

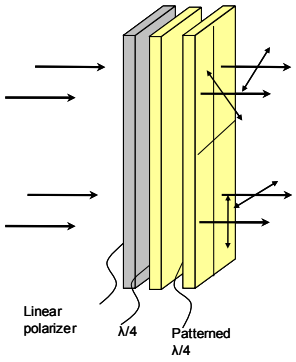

Fig. 1 Scheme of the photo patterned polarizer

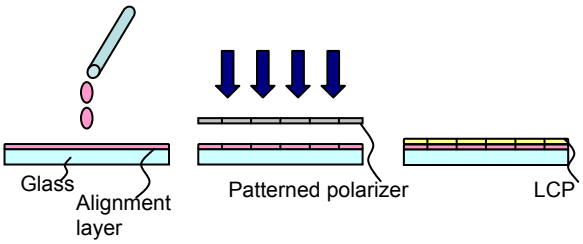

Fig. 2 Self copy photoalignment process of the patterned quarter wave plate

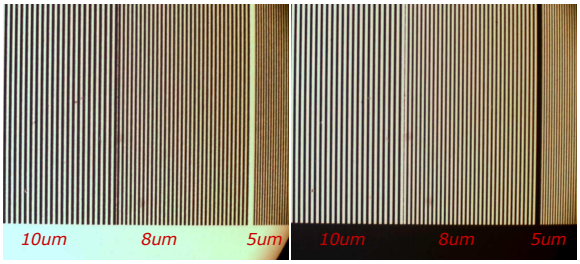

Fig. 3 Example of two domain photo patterned polarizer with small domain size

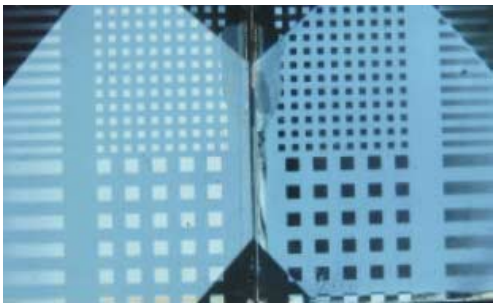

Fig. 4 Example of photocopy experiment