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Photo Degradation Properties of Liquid Crystal Cell Using Focused Blue-Violet Laser Beam

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Degradation of liquid crystal cell under a blue-violet laser beam irradiation has been investigated for an evaluation of a LC cell photostability. The laser beam was focused on the LC layer in the cell. A far field pattern (FFP) was caused by the change of the LC alignment at the focused point after a few minutes irradiation. The FFP changed as a progress of the alignment degradation and it depended on LC materials, polymer materials and their combinations.

Keywords: blue-violet laser beam; far field pattern; nematic liquid crystal; photo alignment; photo degradation; photo stability

INTRODUCTION

Many types of optical devices using a liquid crystal (LC) have been proposed. Recent years, the wavelength modulated in optical devices shifts from infrared-red to blue-violet wavelength due to the enhancement of diffraction properties, the commercial production of blue-violet laser diodes and a high density record in an optical memory media such as a blu-ray disc system. We have also been investigated the LC lens [1–3] for the application to a light pick-up lens and a spherical aberration compensator in the blu-ray disc system. Moreover, it is known that LC devices in the projection type display degrade under the long term irradiation of high power backlight. The shorter wavelength in the white light mainly causes the degradation of the organic alignment layers and LC molecules. The UV stability of the LC

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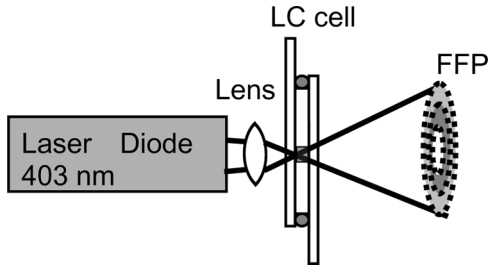

FIGURE 1 Schematic models of laser irradiation and FFP observation.

material, so far, has been reported [4–7]. In this paper, therefore, the photostability of LC cell is evaluated in the visible light wavelength, especially blue-violet light. We investigate the photo degradation of LC materials and their alignment on the substrate surface using a focused blue-violet laser beam. A real time detection of the LC alignment degradation is successfully performed through the far field pattern (FFP) observation.

EXPERIMENTAL

Figure 1 shows the schematic model of the laser beam irradiation and the FFP observation. The laser beam of 12 mW at 403 nm from the laser diode was focused on the LC layer in the cell through the lens which NA was 0.35. We prepared a homogeneous LC cell using rubbed PVA and PI (AL-1254 of JSR, LX1400 of Hitachi Chemical) alignment surfaces. The cell thickness was about 10 μm. The transmission image of the laser beam through the LC cell, that is the FFP, was observed on the screen which was put 50–80 cm behind the cell. The LC alignment at the beam focused point was observed using a polarizing microscope.

RESULTS AND DISCUSSIONS

Figure 2 shows photomicrographs of LC alignment at the beam focused point in the homogeneously aligned cell. The PI of AL-1254 was used. The polarization direction of the laser beam was parallel to the LC direction. When the LC cell of E44 (Merck, $\Delta n = 0.26$) was irradiated with the collimated laser beam about for two days, the LC alignment hardly changed. However it changed by the focused beam irradiation only for a few minutes, when the polarization direction of the laser beam was parallel to the LC director. The interference fringe of concentric circles pattern was observed in the LC cell around the

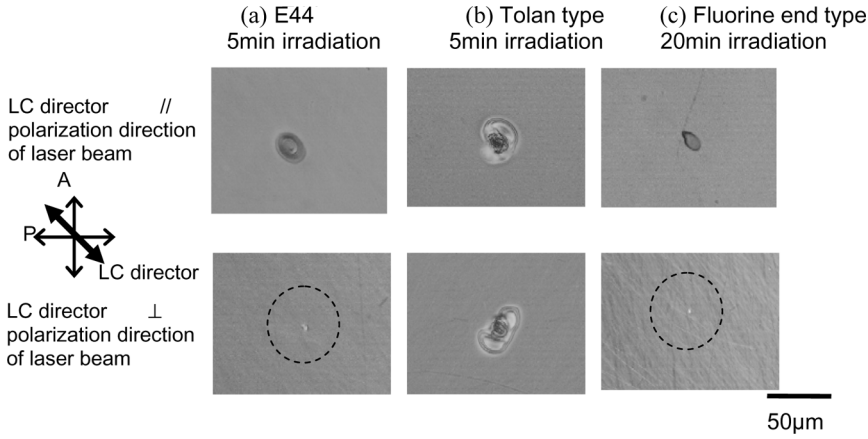

FIGURE 2 Polarization micrographs of the LC alignment at the beam focused point in the homogeneous cell.

beam focused point, as shown in Figure 2(a). On the other hand, we could not observe any degradation in LC cells, when we irradiated empty cells with the focused laser beam for 1200 s and subsequently injected LC. Therefore, these photos show that the retardation value decreases by the degradation of the LC material and/or the increase of the tilt angle on the alignment surface. When the polarization direction of the laser beam is perpendicular to the LC director, the domain size of the alignment degradation was extremely small. The LC of tolan type ($\Delta n = 0.20$) was broken up by the laser beam irradiation and the alignment surface at the center of the domain became rough, as shown in Figure 2(b). The domain size was independent of the polarization direction of the laser beam. Figure 2(c) shows that the alignment degradation domain is very small even though with the laser beam irradiation for 20 min in the fluorine end type LC ($\Delta n = 0.20$) cell. The clearing temperature Tc ($\approx 100^{\circ}C$) of the LC did not change at the irradiation point. This result indicates that this fluorine end type LC has a high photostability.

The concentrical FFP appeared and changed by the laser beam irradiation, as shown in Figure 3. The polarization direction of the laser beam was parallel to the LC direction. The PI of LX1400 was used in these cells. The FFP immediately after the irradiation was almost the same as the laser beam image on the screen without the LC cell, as shown in Figure 3(a). The FFP of the E44 cell changed about after 10 seconds. The alignment degradation was not observed through the microscope at this point, since the degradation point

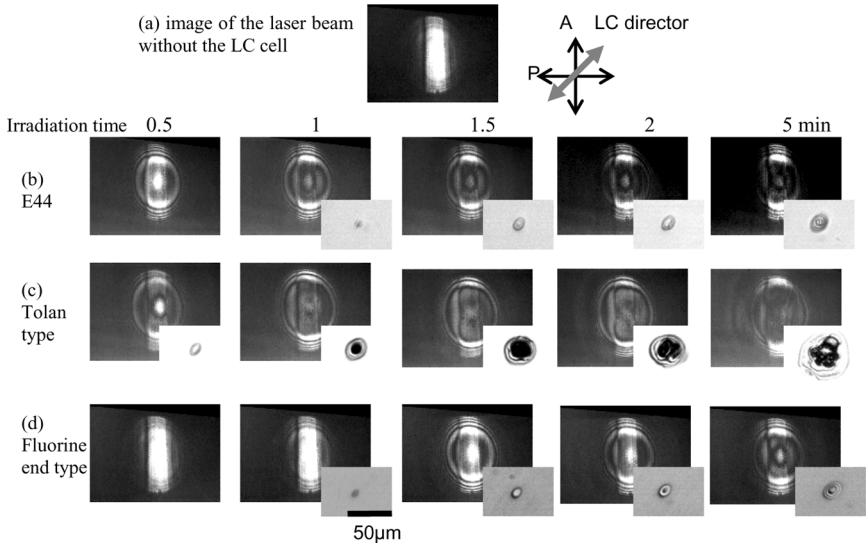

FIGURE 3 Relationship between FFP and LC alignment in the homogeneous cell. Polarization direction of the laser beam is parallel to the LC director.

was too small to distinguish from rubbing scratches and particles. The alignment degradation was confirmed after 1 minute irradiation and the FFP obviously changed, as shown in Figure 3(b). The FFP of tolane type LC cell changed only after a few second and the alignment degradation was confirmed after 30 second. The LC was broken by the laser beam irradiation. The PI layer was also damaged and was not flat any longer at the beam focus point. Therefore, the incident laser beam was scattered and the FFP showed irregular shape, as shown in Figure 3(c). The FFP of the fluorine end type LC cell changed slower than that of E44, as shown in Figure 3(d). Moreover, the photo degradation of the fluorine end type LC on the PI of LX1400 is much larger than that on the PI of AL-1254. On the other hand, almost the same photo degradation of E44 is observed on both PI films.

Next, we irradiated the 90° twisted nematic (TN) LC cell with the focused laser beam. The LC was MLC-2058 (Merck) and PI was LX1400. The polarization direction of the laser beam was parallel to the LC direction on the entrance side of the substrate. The photo degradation was observed at the irradiation time of 1 minute (Fig. 4(a)) and that in the homogeneous cell was not (Fig. 4(b)). The twist angle reduced since the azimuthal anchoring strength became weak. After 3 minutes irradiation, the tilt angle increased in both LC cells. Moreover, the degradation in the TN cell was slower than

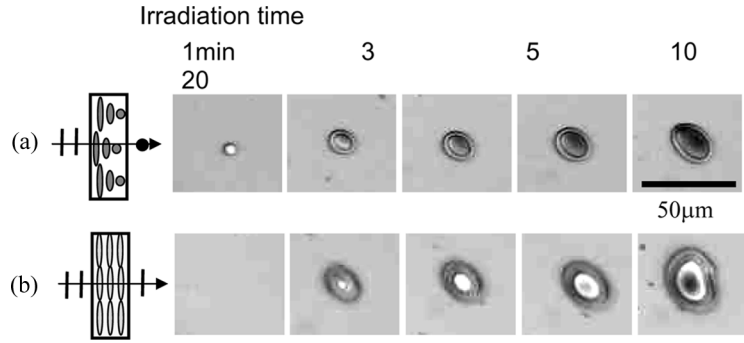

FIGURE 4 Polarization micrographs of the LC alignment at the beam focused point (a) in the TN cell and (b) the homogeneous cell.

that in the homogeneous cell. The polarization plane does not rotate at 90° any longer in the degradation cell in which the twist angle decreases and the tilt angle increases. Therefore, the polarization direction is not parallel to the LC director on the exit side of the substrate.

SUMMARY

We have investigated the photo degradation of the LC cell by irradiating the focused blue-violet laser beam. We generated the LC alignment degradation for a short time within 10 minutes and successfully detected it under the laser beam irradiation by the FFP observation, which makes it possible to do the real time evaluation of the LC cell photostability. This technology is useful tool to qualitatively estimate the photostability of the LC cell.

REFERENCES

[1] Sato, S. (1999). *Optical Review*, *6*, 471.
[2] Ye, M., Wang, B., Kawamura, M., & Sato, S. (2007). *IEE Electronics Letters*, *43*, 474.
[3] Ye, M., Yokoyama, Y., & Sato, S. (2006). *Appl. Phys. Lett.*, *89*, 141112–1.
[4] Lackner, A. M., Margerum, J. D., Miller, L. J., & Smith. Jr, W. H. (1986). *Mol. Cryst. Liq. Cryst.*, *141*, 289.
[5] Naemura, S., Ogiri, S., Sato, H., & Sawada, A. (2000). *Proc. SPIE*, *4107*, 31.
[6] Wen, C. H., Gauza, S., & Wu, S. T. (2004). *Liquid Crystals*, *31*, 1479.
[7] Gauza, S., Wen, C. H., Tan, B., & Wu, S. T. (2004). *Jpn. J. Appl. Phys.*, *43*, 7176.