Control of Laser Speckle Noise by Using Polymer-Dispersed LC

H. Furue,[1,*] Y. Sugimoto,[1] K. Iwami,[1] W. Weng,[2] and M. Ono[2]

1 Department of Materials Science and Technology, Tokyo University of Science, Katsushika, Tokyo, Japan
2 Funai Electric Advanced Technology Research Institute, Tsukuba, Ibaraki, Japan

A laser is an attractive light source because of its high efficiency and brightness with low power consumption and long lifetime, pure color and extremely wide color expression that can be realized by choosing the wavelength of laser light, and high directivity and small etendue of light which contribute to downsizing. These characteristics are strong merits, especially for a projection display system. However, there is a serious problem in utilizing a laser as a light source. Strong interference occurs, originating in the high coherency of laser light and the surface topography of objects such the screen. The dazzling illumination causes an unpleasant feeling in people. This is well known as "speckle noise".[1] Therefore, the suppression of speckle noise is necessary for laser displays. In this paper, to suppress the speckle noise, we offer an idea of using a polymer-dispersed liquid crystal (PDLC) cell in which the speckle pattern can be varied in addition to the optical diffusive effect.

The following materials were used in this research: the nematic LC was E7 (LCC), and the photocurable monomer was NOA-65 (Norland). The E7 LC medium doped with 20wt% NOA-65 was injected in the isotropic phase into on empty cell fabricated using a pair of glass substrates coated with indium-tin-oxide without alignment films. The cell gap was set 10μm. Then, the photocure of the monomer was carried out with UV light (365nm, 20mW/cm^2) at the isotropic phase temperature (90ºC). The laser spot onto screen was observed using the optical measuring system shown in Fig. 1. Common white paper was used as the screen. For the quantification of speckle noise, the digital photograph of the laser spot was analyzed by using Adobe Photoshop Element 10.[2]

Figure 2 shows the UV irradiation time dependence of the microscopic textures in PDLC cells. It is found that the LC droplets are miniaturized as the UV irradiation time increases, and then the texture does not almost vary over 30s UV irradiation. Table 1 shows the reduction ratio of speckle noise in the case using our PDLC cells. It is found that the about 10% reduction can be obtained by the optical diffusive effect in the PDLC cells, which were irradiated over 30s UV, under the quiescent condition. Furthermore, the about 15% reduction can be obtained under the application of a square-formed AC electric field (20Vpp) in the case of PDLC cell irradiated 30s UV. As a result, the maximum reduction ratio is 25.7%. It is guessed that the polymerization progresses even over 30s UV irradiation, and then, the strength of the polymer stabilization effect increases. Therefore, in the case of excessive UV irradiation, the LC molecules cannot be almost reorientated under the application of 20Vpp due to the strong polymer anchoring.

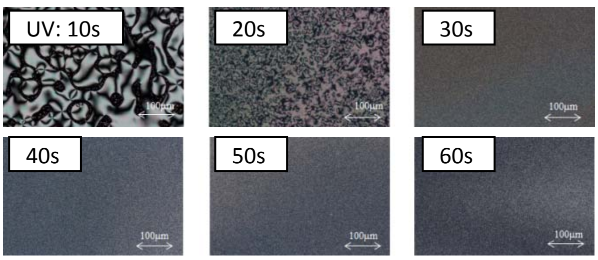

Fig. 1 Microscopic textures of PDLCs.

Table 1 Reduction ratio of speckle noise.

	Reduction ratio of speckle noise (%)		
UV (s)	V=0	20Vpp	Total
10	0	0	0
20	0	0	0
30	11.2	14.5	25.7
40	10.1	0.5	10.6
50	12.2	1.3	13.5
60	7.7	0	7.7

References:
[1] J. C. Dainty: Progress in Optics., **14** (1976) 1.
[2] H. Furue *et al.*: Jpn. J. Appl. Phys., **50** (2011) 09NE14.

* presenting author; E-mail: hfurue@rs.noda.tus.ac.jp