Liquid-crystal device scattering characteristics for switchable arc 3D display

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In recent years, arc 3D display has been developed as new 3D display technology. Arc 3D display was reported by W. Beaty as a simple fabrication method of 3D image[1)]. In addition, Arc 3D display has smooth motion parallax. However, conventional arc 3D display provides only static 3D image. Liquid-crystals (LC) devices[2)] have been proposed for making arc 3D moving images. In this study, active device using dual-frequency LC has been proposed, which can switch on/off directional scattered light by frequency change.

In this paper, we investigate angular distribution of directional scattering intensity from dual-frequency LC device, so as to design active device for arc 3D display.

Figure 1 shows principle of arc 3D display[3)]. By directional scattered light at the arc-shaped scratch, two scattered bright spots, like (L, R), for right and left eyes can be perceived, resulting in a floating 3D spot, G.

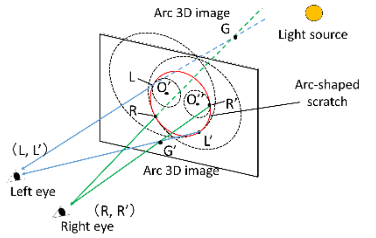


Fig. 1 Principle of arc 3D display

Structure of active LC device is shown in Fig. 2. Our LC active device was composed of polymer and LC prism sandwiched by electrodes. Refractive index of polymer prism was n_p=1.524. Refractive indexes of dual-frequency LC are 1.515 (ordinary) and 1.742 (extraordinary). In dual-frequency LC device, refractive index can be changed by switching between low-frequency and high-frequency applied voltages. Dual-frequency LC device can change deflection angle by applied voltage frequency.

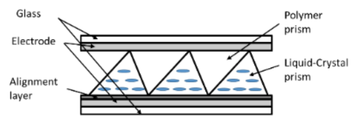
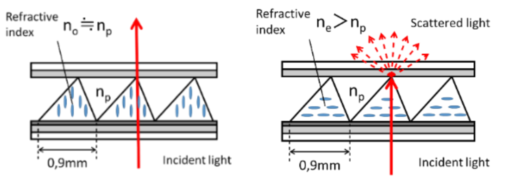


Fig. 2 Structure of dual-frequency LC active device

In low-frequency mode (Fig. 3 (a)), refractive index of liquid-crystals prism is n_o=1.515. Because of $n_o \fallingdotseq n_p$, incident light cannot be scattered. In high-frequency mode (Fig. 3 (b)), refractive index of liquid-crystal prism is n_e=1.742. Because of refractive index difference ($n_e > n_p$), incident light is deflected. Incident light is scattered directionally by the tip of LC prism. Thus, directional scattered light can be switched on/off by switching between low-frequency and high-frequency applied voltage.



(a) Low-frequency mode (b) High-frequency mode

Fig. 3 Operation of dual-frequency LC device

Figure 4 shows experimental system for directional scattered light by changing applied voltage frequency. Applied voltage frequency was switched between 200Hz and 5kHz. In 200Hz, there was no scattered light. In contrast, directional scattered light can be observed over 40 degrees in 5kHz. Thus, directional scattered light can be switched by using dual-frequency LC device, whose intensity has angular distribution over 40 degrees.

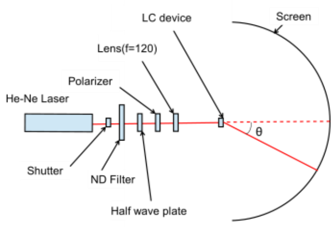
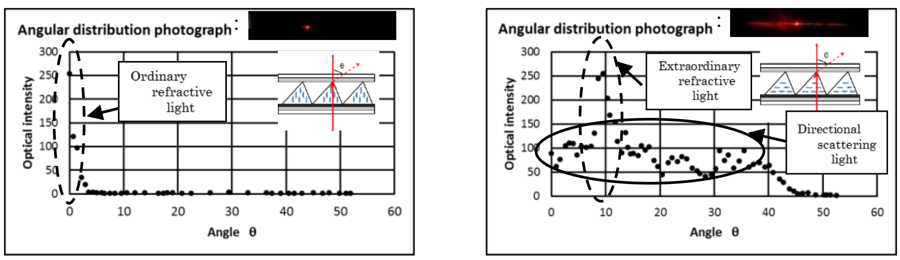


Fig. 4 Experimental system for evaluation directional scattered light



(a) 200Hz (b) 5kHz

Fig. 5 Directional scattered light intensity distribution by changing applied voltage frequency

References

1) W. Beaty "Drawing Holograms by Hand", Proc. SPIE-IS&T Electronic Imaging, Vol. 5005, pp. 156-167, 2003
2) C. Maeda, S. Toyama, N. Saka, H. Yamamoto, and S. Suyama, "Active Liquid-Crystal Device for Arc 3D Display", Proc. IDW '11, vol. 1, pp. 279-282 (2011).
3) N. Yamada, C. Maeda, H. Yamamoto, and S. Suyama,, "Lighting position dependence of perceived depth in arc 3D display", Proc. ITE Technical Report Vol. 36, No. 24 ,3DIT2012-36, IDY2012-21(Jun, 2012)