Patterned Retarder with Wideband and Wide-View Circular Polarizer for Stereoscopic 3D Display

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Abstract

We proposed a novel patterned retarder for stereoscopic 3D display with the polarization glasses, which can show the wide-band property and wide-viewing angle to reduce the crosstalk in the horizontal direction. The proposed optical configuration consists of a biaxial half-wave (HW) plate, a patterned quarter-wave (QW) plate and a positive C-plate. We calculated the phase retardation of each plate and performed optical configuration on the Poincare sphere in the visible wavelength range. From the results, we confirmed that the proposed optical configuration reduced the crosstalk about 80% in horizontal direction compared with that of the conventional configuration.

1. Introduction

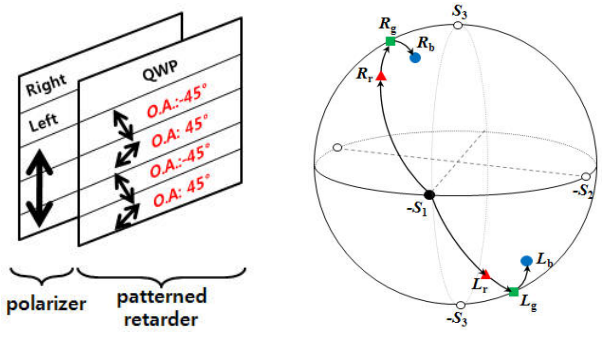
These days, the technology of 3D display is the front-runner of information and communication service of the next generation as high level technique which has an increasing demand and cutthroat technical development competition. Many researchers have made an effort to develop improved 3D technologies such as comfortable 3D image, superior brightness and high resolution. The techniques of displaying 3D images are classified into two major parts of the stereoscopic and the auto-stereoscopic displays.

The stereoscopic 3D display with the polarization glasses provides the left and right images to the eyes of an observer simultaneously. This has more advantages than the other type stereoscopic display, for example, higher brightness, lighter weight of the glasses and no flicker. However, the change of the optical axis of each plate and patterned retarder in the oblique direction deteriorates the quality of images and causes the dizziness due to the crosstalk [1-2].

In this paper, we proposed the novel optical configuration with the wide-band property and wide-viewing angle. The proposed optical configuration is composed of a *HW* biaxial plate, a patterned *QW* plate and a positive *C*-plate. Using the *TECHWIZ LCD* made by SANAYI system, we performed the optical configuration on the Poincare sphere in the horizontal direction (the polar angle θ = 70° and the azimuth angle φ = 0°) and compared the light leakage and crosstalk with the conventional configuration.

2. Results and discussion

As shown in Fig. 1(a), this conventional configuration of circular polarization type consists of a linear polarizer and patterned *QW* plate where their optic axes (O.A.) of left and right pattern are aligned at -45° and 45° respectively. However, this structure has several problems in an oblique direction. One can be the shift of the effective principle axis of the plate. The second reason is the change in the retardation value of the patterned retarder. The last factor is the dispersion of the refractive index of the optical plates along the wavelength. The polarization sates of the three primary colors (*R, G, B*) commonly differ after passing through the retardation films due to the wavelength dispersion properties [3]. For the reasons above, conventional configuration can occur the light leakage and crosstalk which cause the ghost image. Figure 1(b) shows the left and right circular polarization state for the conventional configuration on the Poincare sphere in the horizontal direction. We confirmed that the polarization sates of left and right image changed from circular polarization to elliptical polarization at horizontal viewing angle.



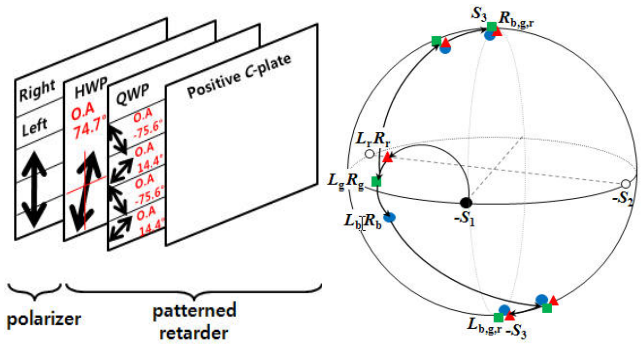
(a) (b)

Fig.1. (a) Conventional configuration of patterned retarder (b) Polarization states of the left ($L_{i=r, g, b}$) and right ($R_{i=r, g, b}$) image in horizontal direction

In order to achieve the perfect separation between the left and right image, we design the optical configuration which satisfies both the wide-band property and wide viewing angle requirements. Our proposed configuration consists of a

biaxial *HW* plate, a patterned *QW* plate and a positive *C*-plate as shown in Figure 2(a). We calculated the optic axis (O.A.) of each plate based on the following relationship [4].

$$2\theta_{QWP} - 4\theta_{HWP} = \pm 90^{\circ} \quad (1)$$



(a) (b)

Fig.2. (a) Proposed configuration of patterned retarder (b) polarization states of the left ($L_{i=r,\ g,\ b}$) and right ($R_{i=r,\ g,\ b}$) image in horizontal viewing angle

The optical axis of *HW* plate is 74.7° and patterned *QW* plates are -75.6° (left), 14.4° (right) respectively. The polarization states after passing through two plates are very close to the ideal circular polarization at normal direction. However, at horizontal direction the relationship in Eq. (1) is no longer satisfied because the change of the phase retardation on two plates. Thus, to improve viewing angle property in the 3D panel, we added positive *C*-plate on the patterned *QW* retarder. Figure 2(b) shows the left and right polarization states of the light for the proposed configuration on the Poincare sphere in the horizontal direction. We could see that the final polarization positions of the divided left and right images are rotated to the polarization position $\pm S_3$ in horizontal direction. Figure 3 compares the calculated light leakage between the conventional and proposed structure for left and right image which pass through the opposite polarization glasses in horizontal viewing angle.

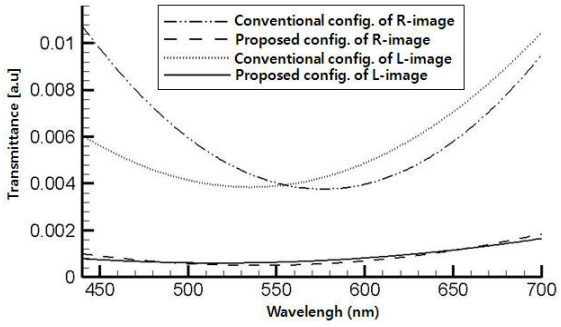


Fig.3. Comparison of the light leakage between the conventional and the proposed configuration for left and right image in horizontal direction

We observed that the proposed configuration showed excellent dark states for entire visible wavelength range. This means final polarization states passing through the proposed structure move completely left and right handed circular polarization state. Figure 4 shows the calculated crosstalk which is the most important factor of 3D effect. We define the crosstalk value as below [5],

$$Crosstalk_{L(R)} = \frac{L(R)B}{L(R)B + L(R)W} \times 100\ [\%] \quad (2)$$

Here, *L(R)B* is the total intensity of the left and right eye at the dark states. *L(R)W* is also an intensity of the left and right eye at the bright states. As expected, crosstalk of the proposed structure is lower about 80% than the conventional configuration.

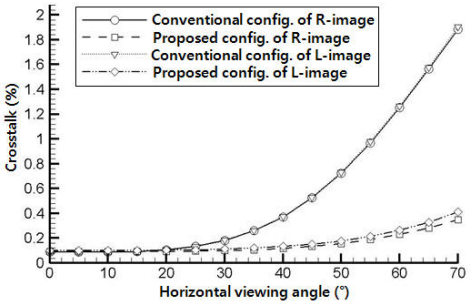


Fig.4. Calculated Crosstalk of stereoscopic display

3. Summary

We suggested a novel patterned retarder configuration with wide-band property and wide-viewing angle by using a biaxial *HW* film, patterned *QW* plate and a positive *C*-plate. We confirmed that proposed structure can improve the 3D viewing angle and reduce the color difference. As a result, the crosstalk diminished about 80% in horizontal direction compared with conventional configuration. This result will make outstanding 3D image quality of stereoscopic display using patterned retarder.

Acknowledgment

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