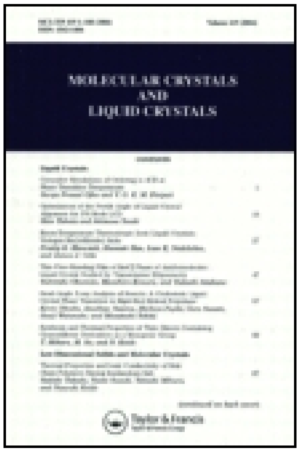

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A New Reflective Color Guest-Host Display with Scattering Effect

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A NEW REFLECTIVE COLOR GUEST-HOST DISPLAY WITH SCATTERING EFFECT

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Abstract

A bright reflective LCD without a backlight is a key device for portable information systems. This paper proposes a new Guest-Host type liquid-crystal display. It consists of a light control film (LCF), a phase change type Guest-Host (PCGH) liquid-crystal layer and a mirror substrate. The device does not need a polarizer that absorbs at least half of the incident lights. The structure is simple in comparison to the reflective PCGH LCD with a geometrically controlled reflection mirror. Optimization of the characteristic of LCF in the new device will promise a very bright reflective LCD.

Keywords ; reflective liquid crystal display, guest-host effect, light scattering

1. Introduction

In a color LCD, the intensity of the incident light is reduced by a color filter, TFTaperture and polarizers. Therefore, the usual color LCD requires a back light to intensify the brightness. However, in order to decrease the power consumption for the future portable system, it is essential to eliminate the back light by improving the transmittance of the LCD. We had already discussed a new reflective type guest-host display with high brightness [1]. The display was composed of a light scattering film, a phase-change-type guest-host cell and a mirror electrode. In this paper, further improved phase change type guest-host cell incorporating a light control film is proposed. The feature of this color reflective LCD is wide viewing angle and high brightness.

2. Structure of Newly Developed Device

A phase-change-type guest-host mode (PCGH mode or White & Taylor type) does not need a polarizer and therefore its transmittance is quite high [2,3]. The viewing angle dependence of the PCGH mode is much better than a LCD using interference or optically rotatory power effects. Therefore, the PCGH cell is quite suitable for the reflective display, and we have already proposed the reflective PCGH LCD with rough surface of reflector as shown in FIGURE 1 [4, 5]. In this LCD, we have clarified that the scattering characteristic was controlled by the geometrical micro structure of the diffuse reflector and could obtain a bright reflective LCD [6]. However, this LCD has disadvantage of complicated fabrication process of the reflector and surface deformation of liquid crystal alignment due to the rough surface of the reflector. Therefore, we have developed a new reflective LCD without the problems mentioned above.

The newly developed reflective LCD is as shown in FIGURE 2 [1]. Main elements of this LCD are a front scattering film, a PCGH liquid crystal layer and a mirror electrode. In the off state the incident light is absorbed by the dichroic dye and the device becomes

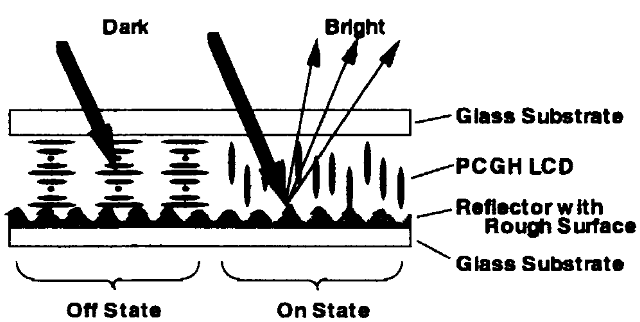

FIGURE 1 Structure of reflective PCGH LCD using reflector with rough surface [4,5,6].

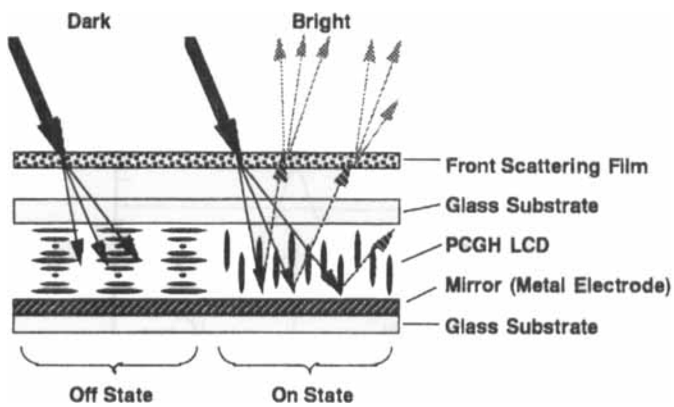

FIGURE 2 A new reflcetive PCGH LCD using a scattering film [1].

dark. In the on state the incident light is scattered by the scattering film and passes through the liquid crystal layer. The film is designed to scatter the incident light to only the front direction and has no back-scattering components. The flat mirror surface reflects the light with the same angle as the incident angle. The reflected light is scattered again by the scattering film and released to the outside of the cell. Consequently, the incident light is scattered twice by the scattering film and therefore effectively wide scattering angle is obtained. The structure of the device is very simple and easily fabricated by conventional processes.

In the experiment, we fabricated the light scattering film by dispersing plastic particles in a polymer matrix as shown in FIGURE 3 [7]. The scattering characteristics of the film can be controlled by diameter, concentration of the particle, refractive indices

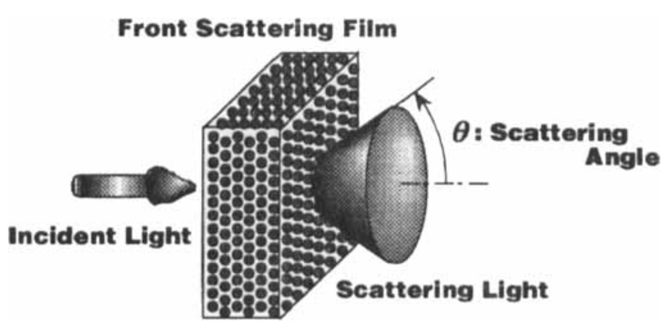

FIGURE 3 Strucure of the scattering film and light propagation [7].

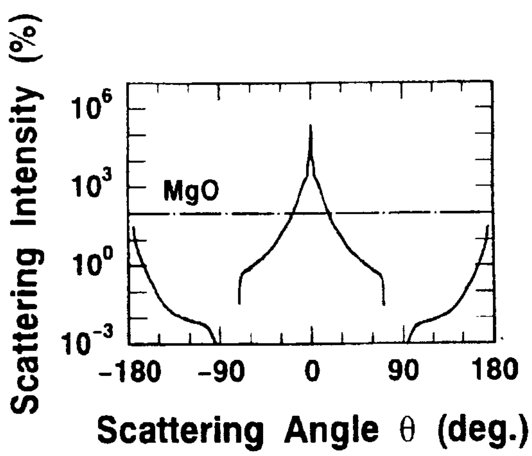

FIGURE 4 Properties of the scattering film. (Angle of the incident light : 0 deg., Concentration of the plastic particles : 15wt%) [1]

of the particle and the polymer matrix, and thickness of the film. The light scattering film scatters only incident light from particular angles and transmits incident light from other angles. FIGURE 4 shows the scattering property of the scattering film. The light source illuminates the device in normal direction. The scattering light intensity of the ordinate was measured in comparison with a scattering characteristic of MgO-standard white. The intensity of the back scattering light is lower than 0.01%. A half width of a scattering intensity is approximately 2 degrees. As the light passes through the scattering film twice in the device, the half width of the scattering becomes 4 degrees.

As a typical reflective LCD, we have designed the phase change voltage to be 10V and contrast ratio 5:1. In this condition, the brightness of the cell in the on state is a function of only $k_{22}/\Delta\varepsilon$ and Δn [4]. In the experiment, ZLI-4803-100 ($\Delta\varepsilon$=51.5 and Δn=0.185) produced by Merck Co. Ltd. was used as a liquid crystal. A thin Ag film evaporated in vacuum is used for the mirror electrode.

FIGURE 5 shows the viewing angle dependency of the reflectance. The incident angle of the light is -15 degrees. The best reflectance of the new reflective type LCD is 300%, which is three times higher than the R-OCB Cell [7] composed of the HAN-cell, one polarizer and the same scattering film.

3. Newly developed color PCGH device incorporating light scattering film

It is predicted from this high brightness that this LCD is applicable to the multicolor

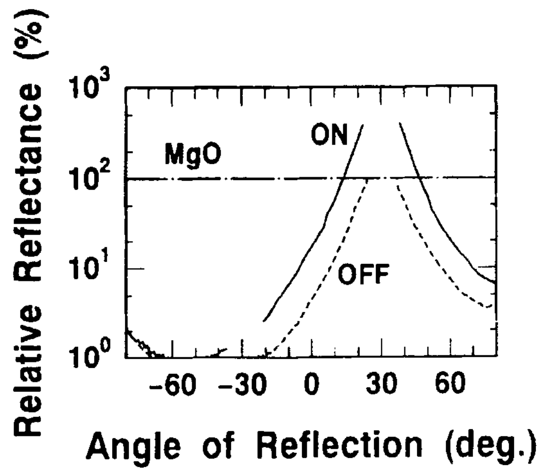

FIGURE 5 Property of the new refflective PCGH LCD. (Angle of the incident light : -30deg.) [1]

display using R, G, B-color filters as shown in FIGURE 6. In this condition, the incident light is absorbed by the color filters. So that, the control of front scattering property of the film and the spectral design of the color filter must be optimized to realize the bright reflective display. The light control film (LCF) [8] is adequate for flattening the viewing angle dependency of reflectance and heightening the intensity in the restricted region. LCF scatters the incident light to the front direction and the characteristic can be precisely

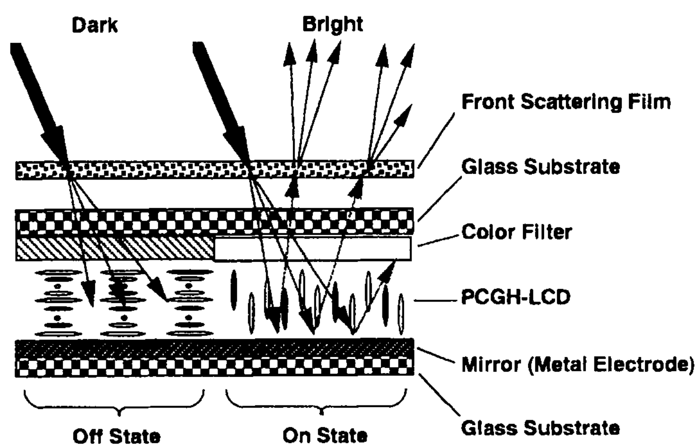

FIGURE 6 A new reflcetive color PCGH LCD using a front scatterng film.

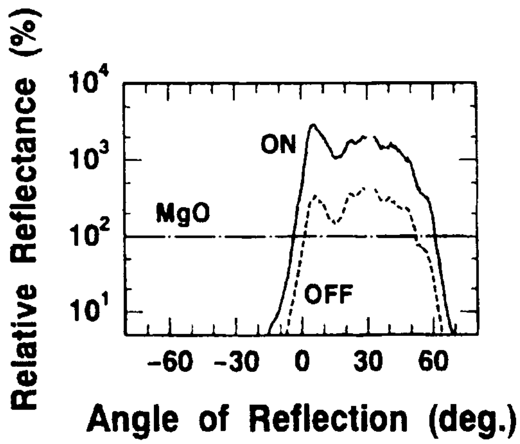

FIGURE 7 Reflectance of the advanced PCGH cell as a function of viewing angle. (Angle of the incident light : -30deg.)

controlled. FIGURE 7 shows the viewing angle dependency of the reflectance of the color PCGH cell with LCF. The ordinate is the reflectance reduced by that of the MgO-standard white. The incident angle of the light was -30 degrees from the normal to the panel and the reflectance was measured in the normal. It is seen from this figure that the cell has higher brightness compared with the MgO-standard white from 0 deg. to 60 deg. The viewing angle of the device is 50% wider than FIGURE 5. FIGURE 8 shows the applied voltage dependency of reflectance of the newly developed color PCGH LCD with LCF. In this case, the characteristics of the R, G, B-color filters were designed for the reflective display. The reflectance of the new LCD at ON state is 400% compared to the MgO-standard white. Disadvantage of the reflective LCD is incapability of gray scale display because of the strong hysteresis.

4. Summary

A new reflective type guest-host display with high brightness is proposed. This display is composed of a light control film, a phase change type guest-host cell and a mirror electrode. The feature of this LCD is simple structure and high brightness. This device is promised for the reflective multicolor display. Optimization of the characteristic of LCF in the new device will promise a very bright reflective LCD.

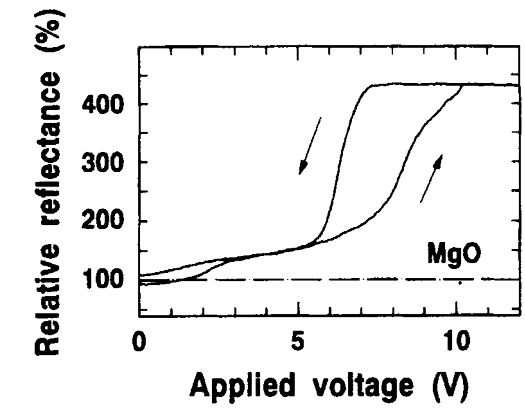

FIGURE 8 Applied voltage dependence of reflectance of newly developed color PCGH LCD with the light control film. (Intensity of normal direction, Angle of the incident light : -30deg.)

Acknowledgments

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