Wavelength Divided Trans-reflective Liquid crystal Displays

D. -K. Yang and F. Zhou

Chemical Physics Interdisciplinary program, Liquid Crystal Institute

Kent State University, Kent, OH 44242, USA

Abstract

We have designed novel trans-reflective liquid crystal displays which utilize dielectric mirrors. The reflective and transmissive modes are operated in different wavelength regions. The displays have the advantages: (1) the brightness as a function of applied voltage is the same for both modes, (2) the backlight and ambient light are utilized efficiently.

1. Introduction

The growing mobile display market requires that displays have low power consumption and the ability to adapt various environment conditions. As a result, transflective liquid crystal displays have received much attention in recent years. These displays have the advantages of energy-saving feature of reflective displays when ambient light is available, where the displays are operated in the reflective mode. They also have convenience of transmissive displays in dark or dimly-lit area, where they are operated in the transmissive mode under backlight.

Conventional transflective displays usually use a transflector which is a semi-transparent mirror [1-3]. The transflector causes light loss because only half of the light is reflected in the reflection mode and half of the light is transmitted in the transmissive mode. In transflective displays using reflective polarizers, the reflective and transmissive modes have inverted images. In the real world, the ambient light sometimes has intermediate intensities which are not comfortable to read in reflective mode, and reduce the contrast ratio of the transmissive mode.

We designed new transflective liquid crystal displays that utilize dielectric mirror which transmit light in some wavelength regions and reflect light in other region. The wavelength regions for transmissive mode are chosen to match the backlight spectrum. Thus the backlight is fully utilized. Furthermore, the transmissive and reflective modes have the same transmission-voltage dependence and thus avoid the contrast ratio reduction effect from each other.

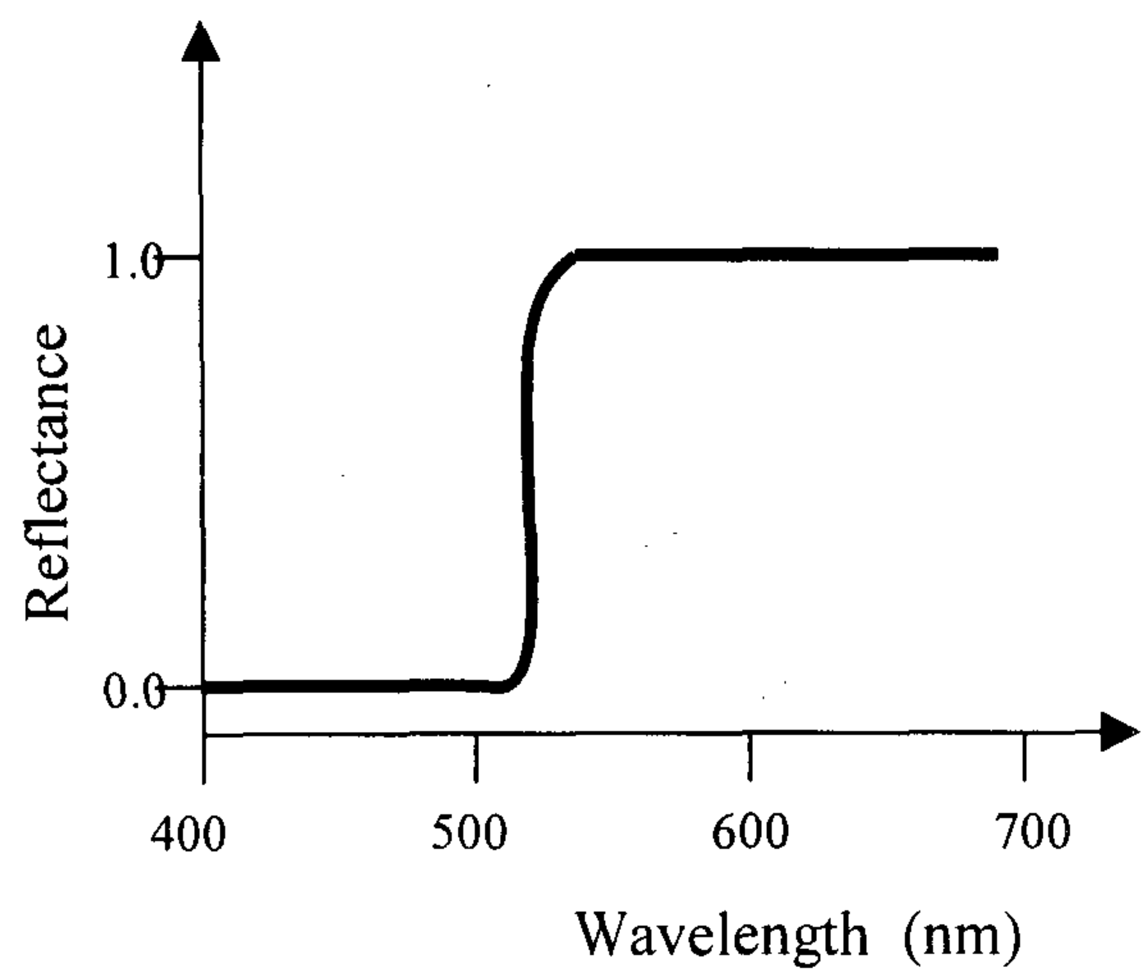

Fig. 1 Schematic reflection spectrum of the dielectric mirror for ECB transreflective display

2. Mono-color display

We designed an ECB transreflective display in which the reflective mode is operated in long wanglength region and the transmissive mode is operated in short wavelength region. The dielectric mirror in the display has the reflection spectrum as shown in Fig. 1. The reflective mode is operated with single polarizer at the front. The wavelengths of the reflective and transmissive modes are different. In the reflective mode, the light propagates down and up the ECB cell while in the transmissive mode the light only propagates through the cell once. Thus it is possible to choose the birefringence of the liquid crystal such that both modes have the same voltage-intensity dependence.

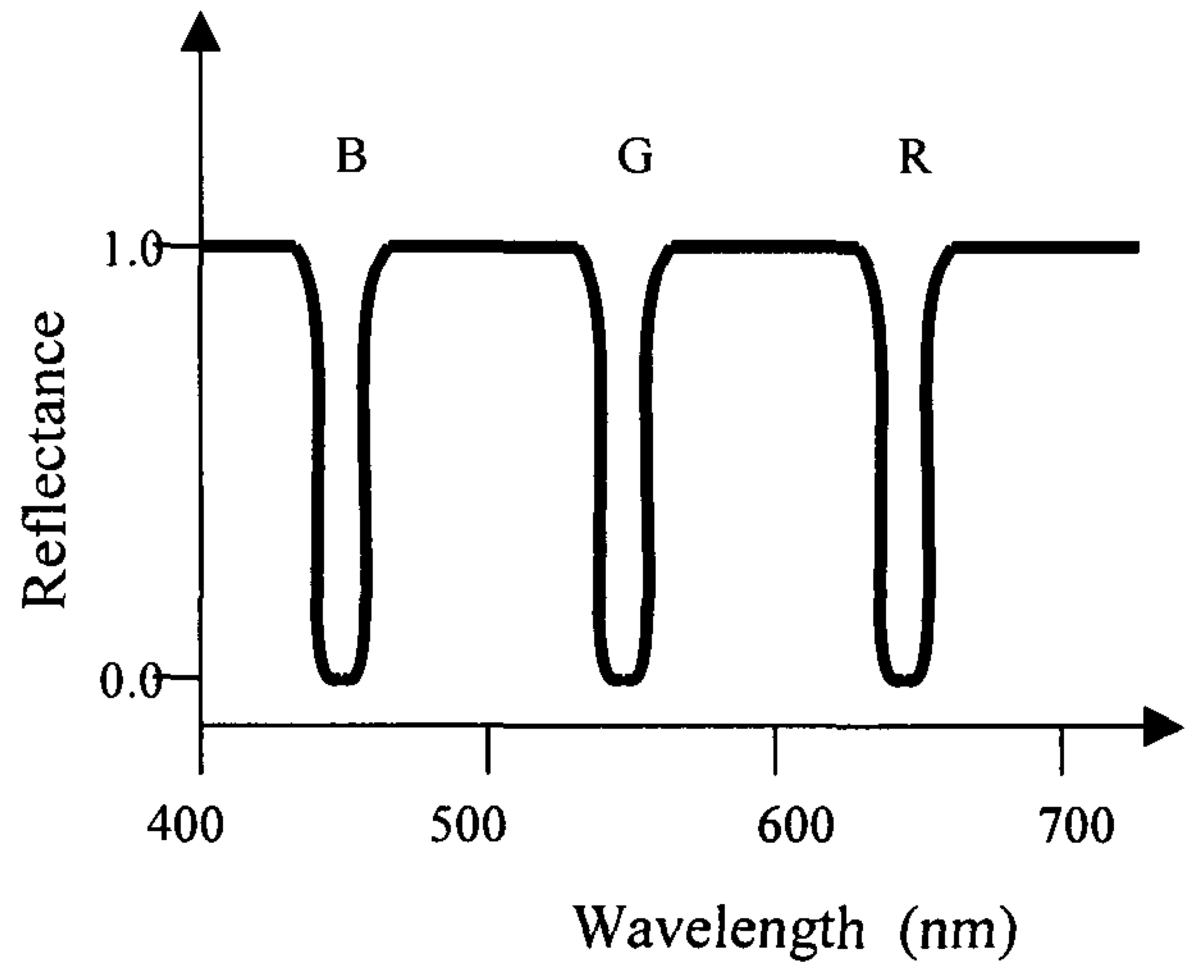

Fig. 2 Schematic reflection spectrum of the dielectric mirror for the full color display

3. Full Color display

We designed a TN transreflective display in which the reflective mode is operated in three wavelength regions and the transmissive mode is operated in rest wavelength regions. The reflective spectrum of the dielectric mirror is schematically shown in Fig. 2. The wavelength regions for the transmissive mode are matched to the spectrum of the backlight (for example LED backlight). Thus the backlight is fully utilized. In the reflective mode, the ambient light in the reflection bands is utilized. Here the liquid crystal cell is a TN display with two polarizers. The dielectric mirror is under the TN. The reflective and transmissive modes have the same voltage-intensity dependence. The drawback is that in the reflective mode the light has to go through the polarizers four times.

4. Conclusion

We have designed transflective displays using dielectric mirrors. They do not need the semi-transparent mirror or gray film, and therefore is energy saving. The reflective and transmissive modes have the same voltage-intensity dependence. Therefore the two modes can be operated simultaneously with good contrasts.

5. Reference

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