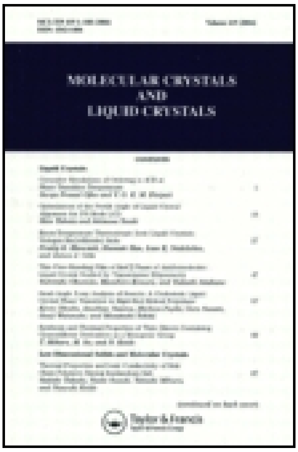

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Electro-Optical Performance of CdSe Active Matrix TN LCDs

B. Bahadur [a b] & D. Lewis [a]

[a] Litton Systems Canada, 25 City View Drive, Etobicoke, Ontario, M9W5A7, Canada

[b] Display Center, MS 105-162, Rockwell Collins Inc., 400 Collins Road, Cedar Rapids, Iowa, 52498, USA

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Electro-Optical Performance of CdSe Active Matrix TN LCDs*

B. BAHADUR† and D. LEWIS

Litton Systems Canada, 25 City View Drive, Etobicoke, Ontario, M9W 5A7, Canada

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Litton Systems Canada has been engaged in developing CdSe active matrix LCDs for many years. CdSe has much higher mobility compared to amorphous silicon, which is the most popular choice for TFTs at present. The high mobility, low temperature process, low cost and ease in fabrication give CdSe TFTs many advantages over amorphous and polycrystalline silicon for high resolution and large area cells. This paper describes the electro-optical characteristics such as contrast ratio and viewing angle of CdSe active matrix TN LCDs fabricated at Litton.

INTRODUCTION

AM LCDs are commonly available in computers, camcorders, projection and small portable TVs, games, cockpits etc. They are strong candidates for high-resolution TV displays. Display sizes up to 21" diagonal are commercially available. Larger sizes have been demonstrated in prototype and lab scale. The primary material for TFT application is amorphous silicon, which has low mobility. Other materials are polycrystalline Si, crystalline Si, CdSe etc.[1–4]

CdSe was the first material used for making active matrix LCDs.[5] Litton advanced the CdSe active matrix technology developed by Panelvision and Westinghouse.[2,5–7] They manufactured and developed CdSe based AM LCDs for several military and avionics applications.[2] CdSe TFT has much higher mobility, lower processing temperatures and easier fabrication compared to amorphous and polycrystalline Si based TFTs. Some of the features of the TFT technology for various materials are shown in Table I. The table clearly shows some of the advantages of CdSe TFT approach.

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† Display Center, MS 105–162, Rockwell Collins Inc., 400 Collins Road, Cedar Rapids, Iowa, 52498, USA.

TABLE I TFT Technology Characteristics

	Polycrystalline Si TFT High Temp. CMOS	*Polycrystalline Si TFT Moderate Temperature CMOS*	*Amorphous Si:H TFT NMOS*	*CdSe TFT NMOS*
Processing				
1. Substrate	Fused Quartz	Glass	Glass	Glass
2. Maximum Process Temperature	950°C	600°C	350°C	400°C
3. Number of Masking Exposures (Typical)	6–8* (*=CMOS)	6–8* (*= CMOS)	8	5–6
4. Dielectric Depositions (LP- or PE-APCVD)	4	4	3	3
5. A-Si Depositions (LP or PECVD)	2	1	2	1 (SEMI)
6. Metal Sputtering (Layers)	2	3	3	3
7. Ion Implantation	Yes	Yes	No	No
8. Hydrogenation	Yes	Yes	Yes	No
9. Device Architecture	Top Gate	Top Gate	Bottom Gate	Bottom Gate
Characteristics				
1. Threshold (V) (typical)	2.0	2.0	1.5	1.5
2. Mobility (cm^2 / V.Sec)	100	40	0.75	200
3. Shift Register @ 15V: Length = 10μm	20 MHz	5 MHz	0.1 MHz	4 MHz[10]
4. Relative Leakage Current	10	10	1	1

CELL FABRICATION

The outline of the TFT fabrication process is shown in Fig. 1. Cr metal is deposited on glass (Corning 7059) and is patterned to form gate electrodes. Then gate insulator (SiO_x) is deposited by PE CVD and CdSe is deposited by thermal evaporation. The semiconductor is then annealed, patterned and passivated with SiO_x. ITO is then deposited and patterned. Vias are etched in the passivation to form the opening for top contacts. Source and drain contact metal, then are deposited and patterned.

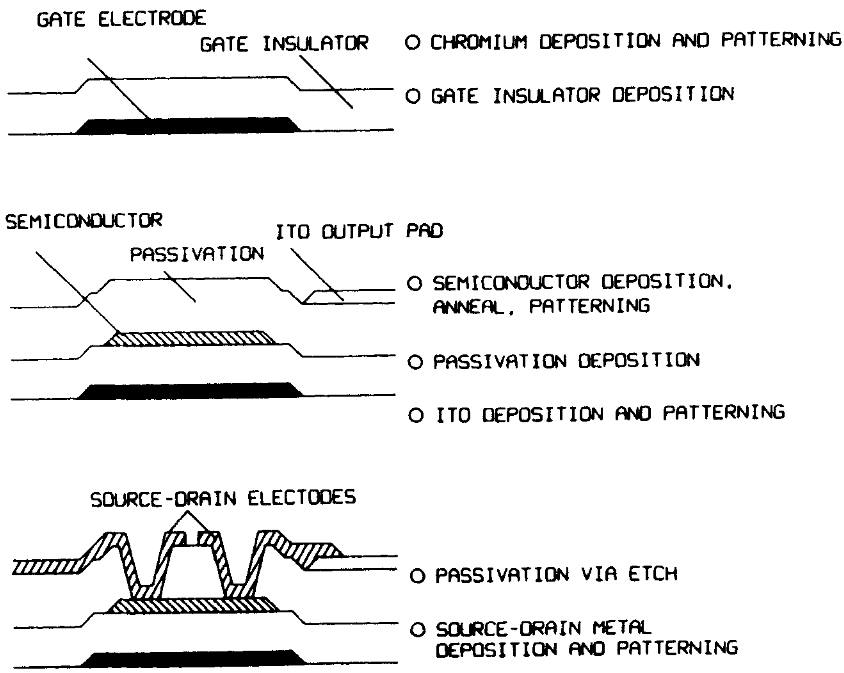

FIGURE 1 Outline of the fabrication process

On a separate glass plate, a light shield is formed by depositing CrO_x (black chrome) and patterning it. Then one of the three colored polyimides (red, green and blue) is spun on, patterned and cured. The process is then repeated for the remaining colors. The planarization of color filter is done and ITO is then deposited to form the back plane electrode.

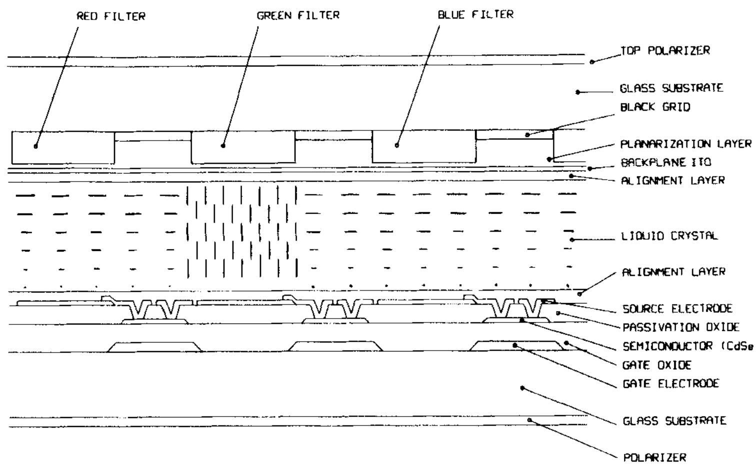

FIGURE 2 Cross sectional view of the active matrix LCD

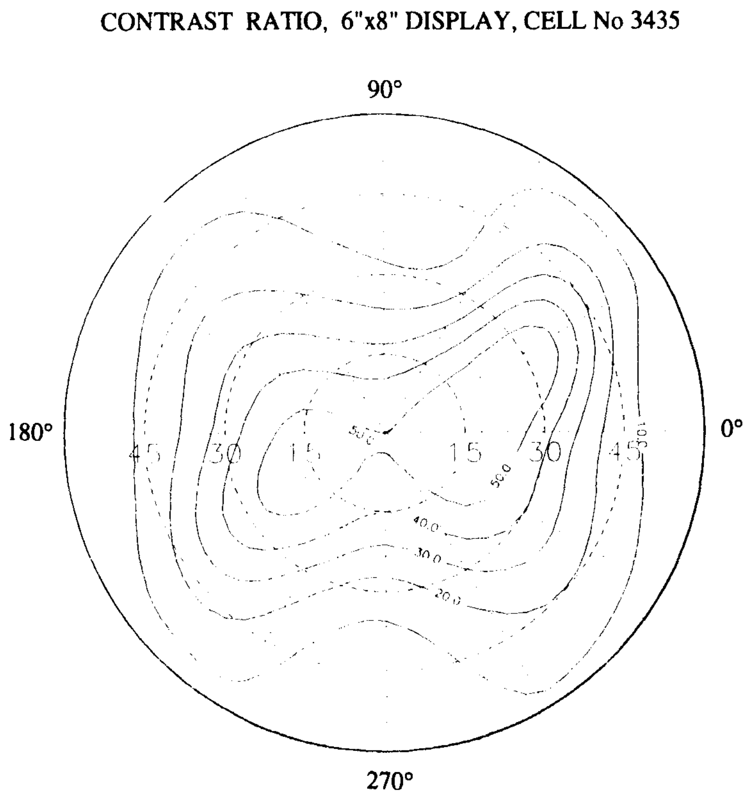

FIGURE 3 Isocontrast plot

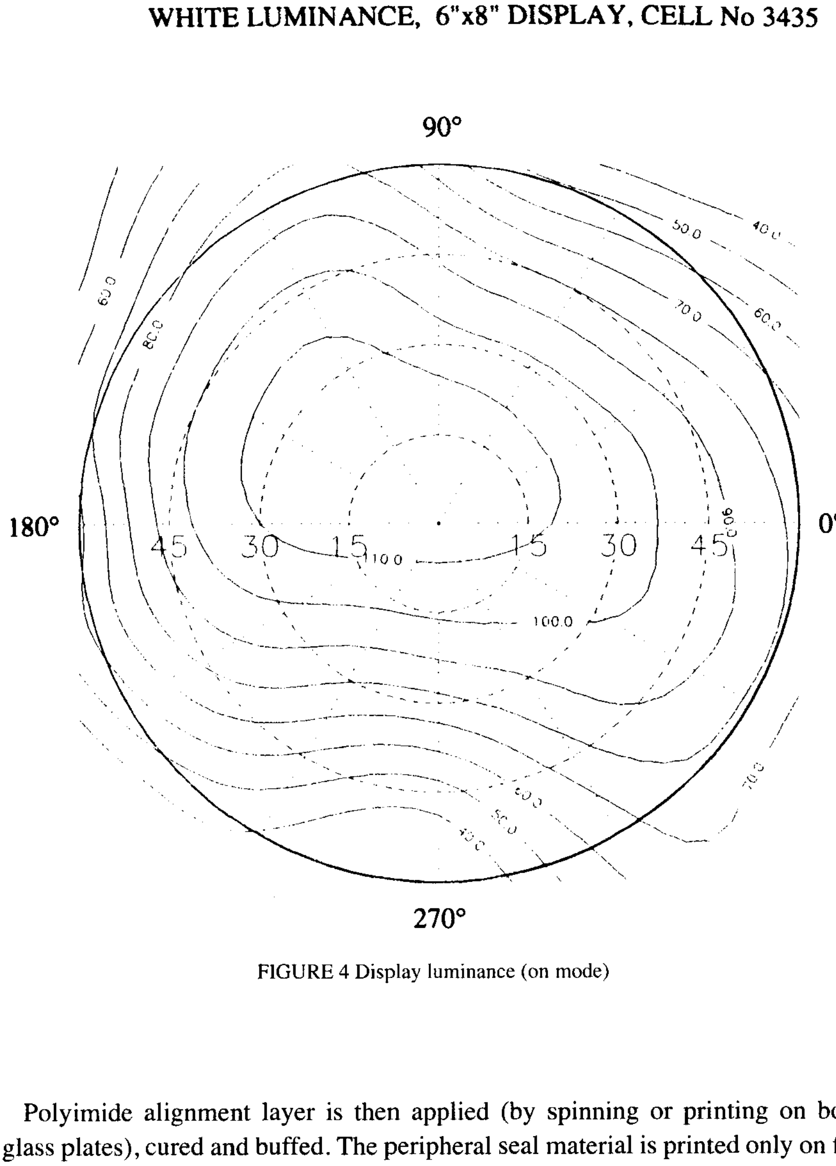

FIGURE 4 Display luminance (on mode)

Polyimide alignment layer is then applied (by spinning or printing on both glass plates), cured and buffed. The peripheral seal material is printed only on filter glass using screen printer and is β staged. An alternate approach is to draw the gasket using a computerised xy controlled syringe. In this method the chances of screen touching the buffed polyimide surface and consequently generating the defective liquid crystal alignment is avoided. Spacers of desired diameter are then electrostatically sprayed only on filter glass. Now TFT and color filter plates

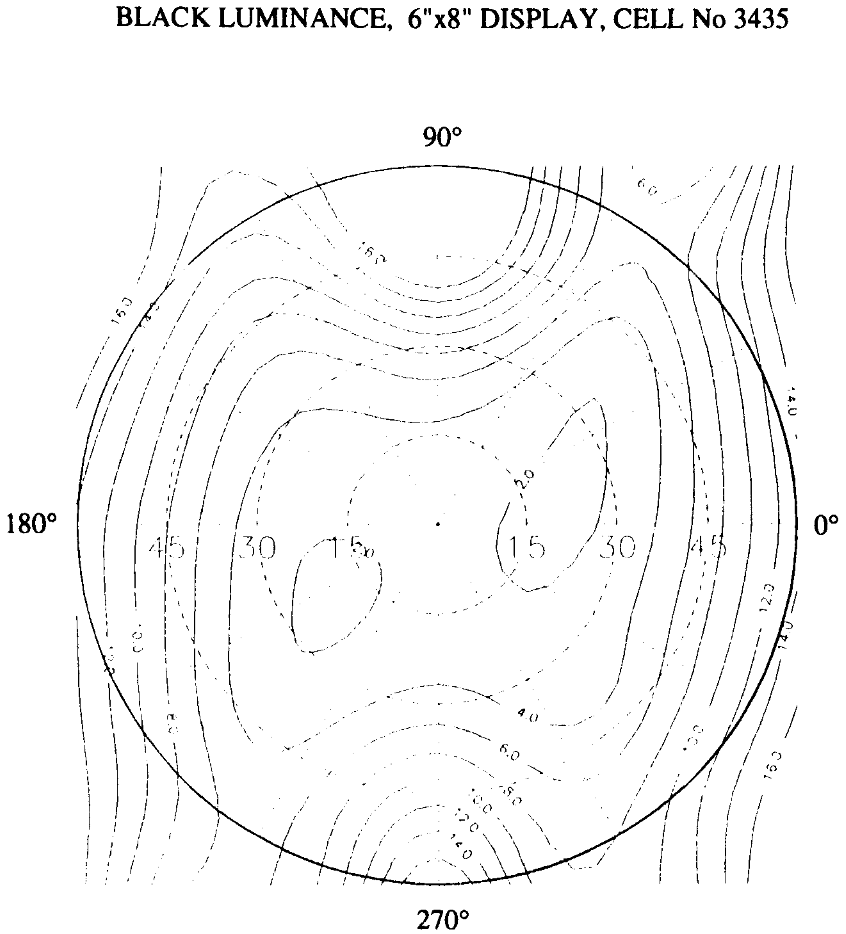

FIGURE 5 Display luminance (off mode)

are aligned using plate aligner and sealed either by UV or heat curing depending on the seal material. The cell is then filled by vacuum filling, excess liquid crystal is removed using bladder press and the fill port is plugged using UV curable epoxy. After curing the epoxy, cell is cleaned and the polarizers are laminated or mounted. The cross sectional view of the TFT LCD, with only green pixels turned on, is shown in Fig. 2.

The cell was designed for normally black mode operation and the color filters had quad (RGBG) pixel arrangement. The cell gap was 5.0 μm according to first Gooch Tarry minimum.[8]

RED LUMINANCE, 6"x8" DISPLAY, CELL No 3435

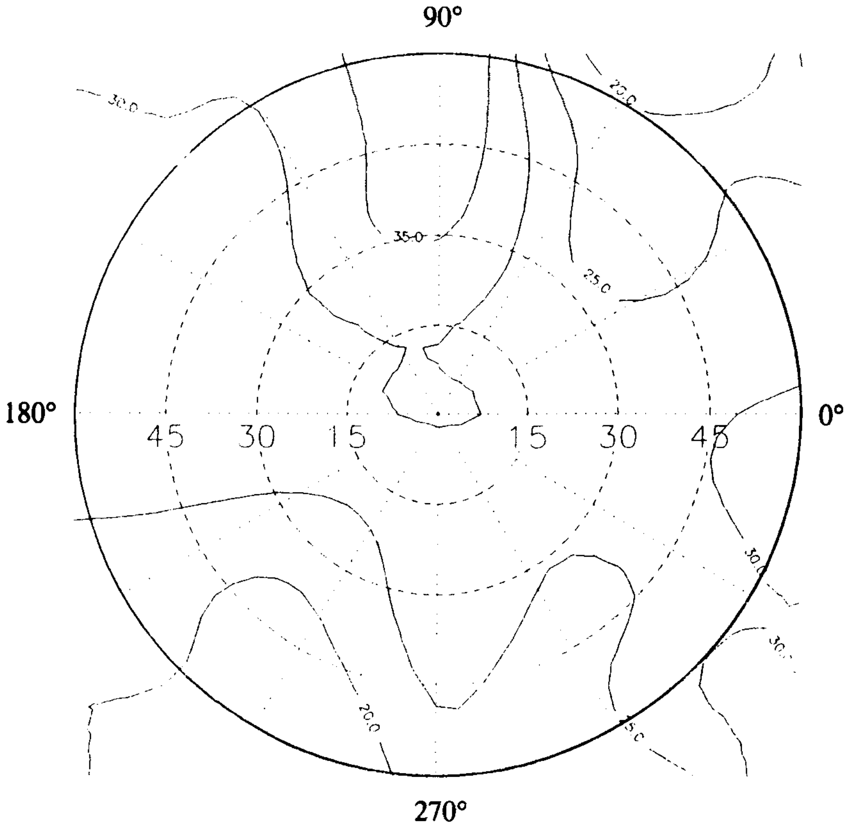

FIGURE 6 Display luminance with only red pixels on

ELECTRO – OPTICAL PERFORMANCE

The luminance and the chromaticity of the off state and on state of the LCD were measured by a system with computer controlled translational and rotational stages and a Photo Research Spectra Scan photometer PR-704. The measurements were made for inclination from 0° to 60° and for azimuth 0° to 360°, both at intervals of 10°. The contrast ratio was calculated by dividing the on state luminance by the off state luminance at each angle. The measurements reported here are done in transmissive mode with a strong triband light source.

GREEN LUMINANCE, 6"x8" DISPLAY, CELL No 3435

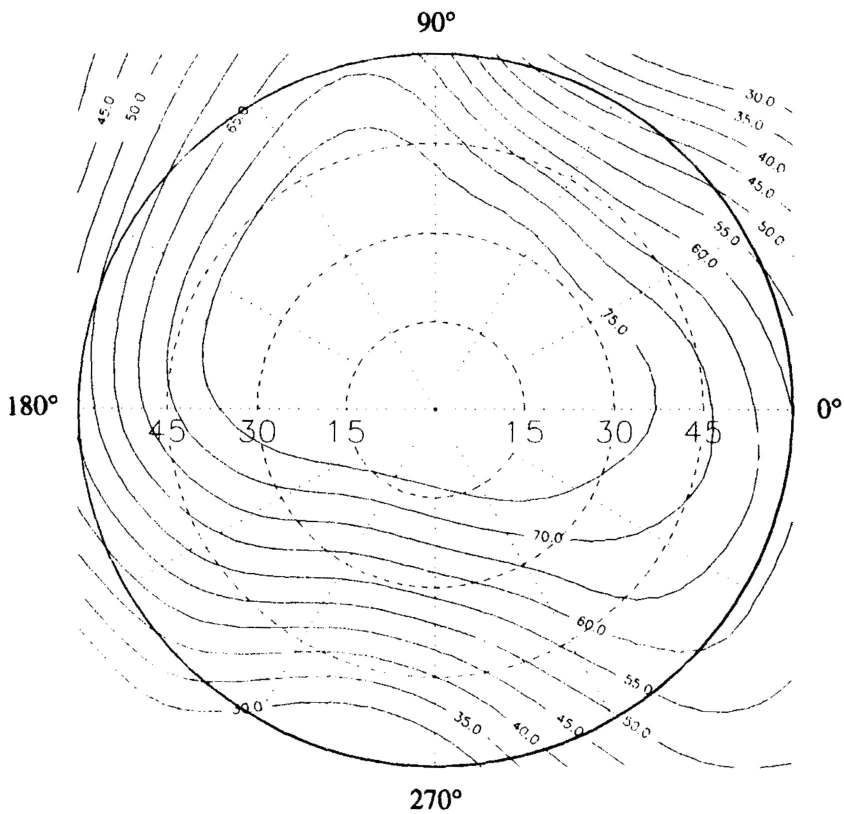

FIGURE 7 Display luminance with only green pixels on

Figure 3 shows the polar plot of the contrast ratio of the display in normally black mode. The polar angle corresponds to the azimuth angle and the radius corresponds to the inclination angle measured from the normal of the display. The circles are drawn at 15°, 30°, 45°, and 60° inclination angles. The display shows quite wide viewing angle with a good straight on (> 50:1) contrast ratio. The gray scale inversions were found to occur at large oblique viewing angles. Adding retardation sheets can further increase the contrast ratio and viewing angle of the display.[9]

BLUE LUMINANCE, 6"x8" DISPLAY, CELL No 3435

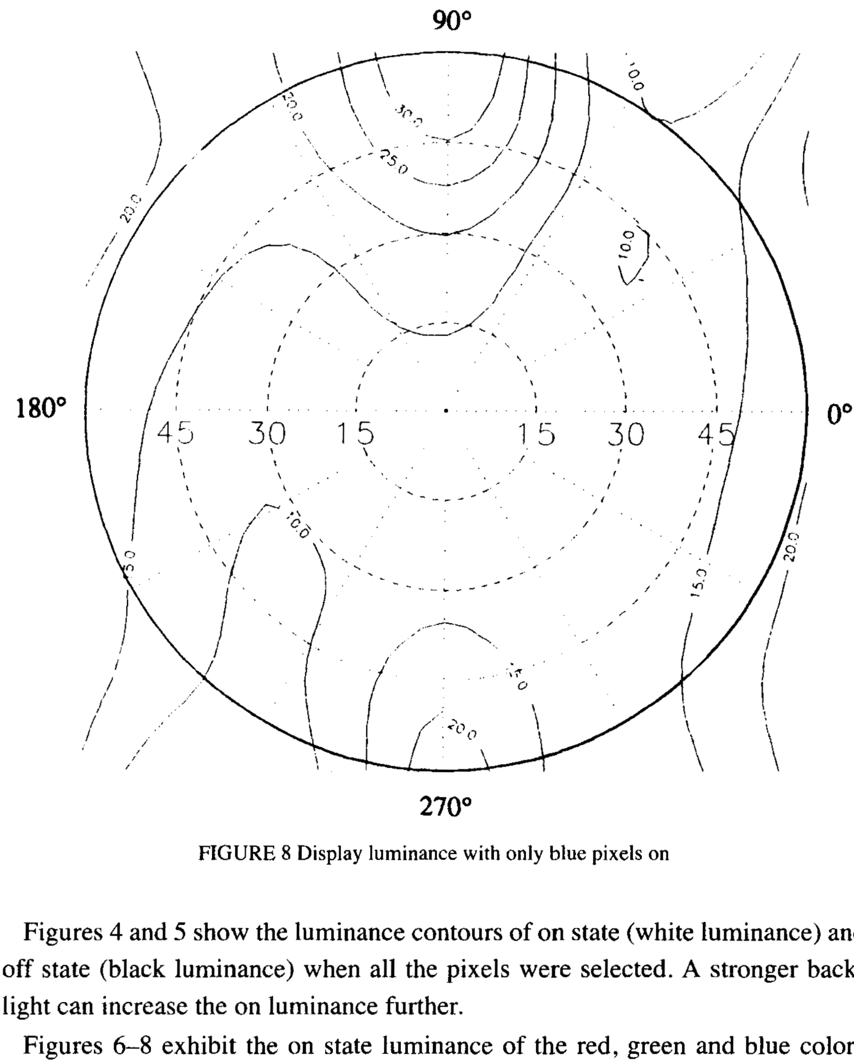

FIGURE 8 Display luminance with only blue pixels on

Figures 4 and 5 show the luminance contours of on state (white luminance) and off state (black luminance) when all the pixels were selected. A stronger back-light can increase the on luminance further.

Figures 6–8 exhibit the on state luminance of the red, green and blue colors respectively.

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