반도체디스플레이기술학회지 제11권 제1호(2012년 3월)
Journal of the Semiconductor & Display Technology, Vol. 11, No. 1. March 2012.

A Study of Optical Properties of Assembled Plasma Display Panel with 3-D Optical Code

Hyun-Myung Park and Jungwon Kang†

†The Department of Electronics and Electrical Engineering, Dankook University

ABSTRACT

The optical properties of PDP, such as the transmittance and reflectance, were analyzed with 3D optical code. Three different ITO-less structures in the front panel are examined. In the assembled panel study, the test 1 structure shows 16.6% and 10.2% higher reflectance than the structures of tests 2 and 3, respectively. In order to check the validation of the simulation result, three 7.5-inch test panels having the same geometry and property are fabricated as simulation models. The calculated reflective properties are compared to the measured data from real panels. The relative difference extracted from the simulation and measurement methods is less than 4.9% and are well matched.

Key Words : Plasma Display Panel, Optical Code, Transmittance, Reflectance

1. Introduction

The beginning of HD (High Definition) digital broad-casting and spreading of high quality contents are leading the new market of flat panel displays. The Plasma Display Panel (hereinafter 'PDP') is one of the promising large size, full color and wall mountable flat panel displays [1-3].

PDP is a display device that is composed of a large number of micro-discharge cells. A cell structure in a PDP is changed or designed in order to improve luminance and efficacy. One of the easy ways to increase luminance and efficacy is increasing transmittance of the front panel and reflectance of the rear panel. However, there are disadvantages of this method; for example, the contrast ratio in the bright condition is de-creased due to high panel reflectance. Therefore, in order to find the optimal direction of cell design, studying the optical property of PDP itself is very important.

The optical simulation method has been used to design and optimize the PDP cell structure [4-8]. The advantage of optical simulation is reducing the time and cost to fabricate a real panel. If the optical properties of each layer of the PDP are provided, then the optical property of the whole panel can be accurately calculated.

In this study, the optical properties of three different ITO-less structures were examined. To reduce production cost, a transparent but expensive ITO can be removed from the front panel [9-11]. The transmittance of front panel, reflectance of rear panel and reflectance of assembled panel were calculated with 3D optical code (LightTools®). Finally, in order to validate the calculated data, three test panels having different electrode structures were fabricated and the measured reflectance of each panel was compared with the calculated reflectance.

2. Simulation Conditions

Fig. 1 shows the conventional cell structure of ITO-less PDP and the cell size of 0.800 mm (H) × 0.270 mm (W) that are compatible with the commercial 50-inch HD PDP. The front panel is composed of black matrix, bus electrode, transparent dielectric layer and MgO. The rear panel is composed of phosphor, barrier rib, white dielectric layer (= white back) and address electrode. The address electrode in the rear

†E-mail : jkang@dku.edu

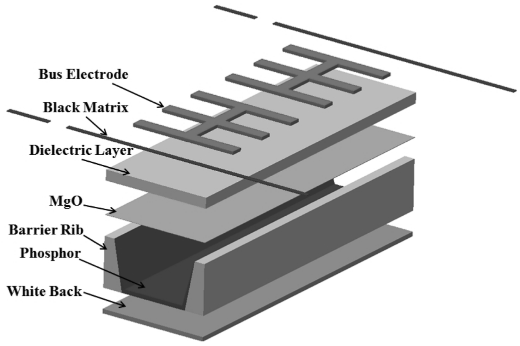
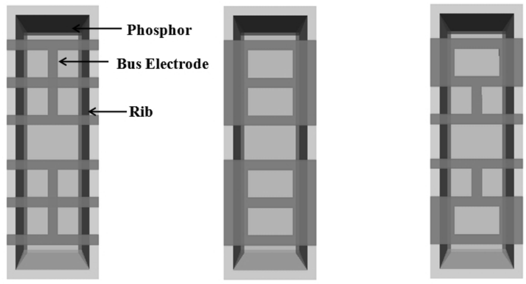
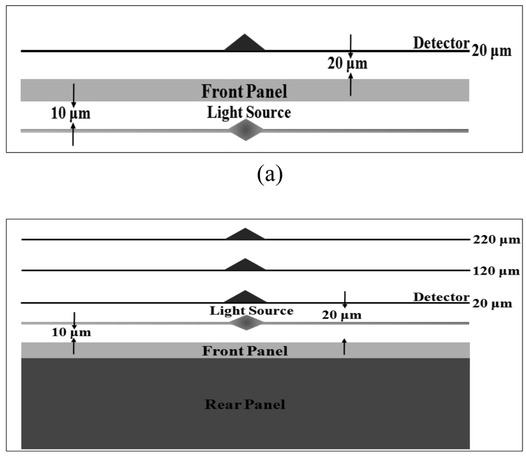


Fig. 1. Cell structure of the model of test 1.



(a) (b) (c)

Fig. 2. Top view of three examined models.



(b)

Fig. 3. Simulation set-up for optical property extraction (a) set-up for transmittance (b) set-up for reflectance.

panel is discarded because it is located under phosphor and white back layers having high reflective property. The optical properties of each layer at 550 nm are shown in Table 1. The optical properties in the visible-light range were used in simulation.

As shown in Fig. 2, three different ITO-less structures are selected for the simulation. Fig. 2(a) is the conventional ITO-less structure, Fig. 2(b) and Fig. 2(C) are the modified structures from Fig. 2(a). Except for the structure of bus electrode in the front panel, the other structures and optical properties of other structures are the same.

Depending on the extracted parameters, such as transmittance and reflectance, the positions of panel, detector and light source are changed. In Fig. 3(a), the simulation set-up of the transmittance extraction is shown. A 6500 K standard light source is located 10 um from the bottom of the panel, and detectors to measure the transmitted light from the panel are located at 20 um from the top of the panel. The area of detector and panel is the same, 9 by 3 cells. For the reflectance extraction, the light source is located between the panel and detector. The distance of light

Table 1. Optical properties of each layer at 550 nm

		Transmittance	Reflectance	Absorption
Front	MgO	88.70%	11.30%	-
	Dielectric Layer	78.10%	11.60%	10.30%
	Bus Electrode	3.20%	68.30%	28.50%
	Black Matrix	11.30%	4%	80.80%
Rear	White Back	30.40%	54.10%	15.50%
	Rib	23.40%	56.30%	20.30%
	Phosphor	25.90%	74.10%	-

source from the top of panel is 10 um, and the distance of detector from the top of panel is varied from 20 um to 150 um. The simulation set-up is shown in Fig. 3(b).

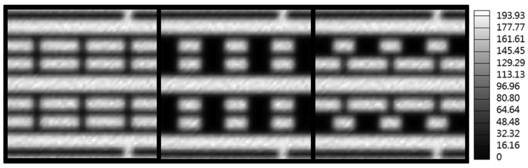
3. Simulation Results

3.1. Transmissive Property of Front Panel

Fig. 4 shows the transmitted light distribution of three different front panels; the panels in tests 1, 2 and 3. Due to the low transmittance of bus electrode, the light distribution difference between panels can be easily distinguished. As shown in Fig. 2, in tests 2 and 3, the panels are big rectangular electrodes at the edge of each cell and their positions are corresponding to the dark area (= area of the lowest transmitted light intensity) in Fig. 4(b) and 4(c). The comparison of the sum of transmitted light between three panels is shown in Table 2. The model in test 1 shows 21.6 % and 11.2 % higher transmittance than the models in tests 2 and 3, respectively.

Table 2. Comparison of the sum of transmitted light between the models of test 1, test 2 and test 3

	Transmitted Light Sum [arb. unit]	Ratio
Test 1	30.0%	1.000
Test 2	23.6%	0.784
Test 3	26.7%	0.888



(a) (b) (c)

Fig. 4. Transmitted light distribution of three different front panels the models of (a) test 1, (b) test 2 and (c) test 3.

3.2. Reflective Property of Rear Panel

Fig. 5 shows the reflected light distribution of rear panel. The optical property and structure of rear panel are the same for all three models. Due to the detector location, the reflected light distributions are changing. In order to observe the intrinsic characteristic of the rear panel, the proper position of detector is 20 um. The sum of reflected light is listed in Table 3. Due to a finite size of the detector, as the distance between the rear panel and detector is increased, the sum of reflected light is decreased.

Table 3. Sum of reflected light depending on detector position

	Reflected Light Sum [arb. Unit]	Ratio
20 um	65.79%	1.000
120 um	60.31%	0.917
220 um	55.05%	0.837

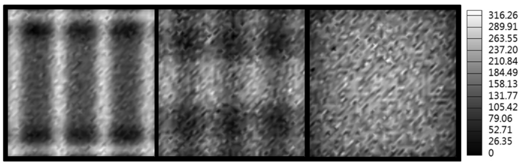


Fig. 5. Reflected light distribution of rear panel under different detector positions.

3.3. Reflective Property of Assembled Panel

In this section the optical property of assembled panel is examined. The simulation set-up is shown in Fig. 3 and the reflected light distributions from three assembled panels are shown in Fig. 6. The reflected light distribution of assembled panel is greatly influenced by the transmissive property of the front panel. The similarity of light distribution between Fig. 4 and Fig. 6 is easily observed. The sum of reflected light intensity is listed in Table 4. Due to the poor transmittance of the panels in tests 2 and 3, the sum of reflected light of tests 2 and 3 is 16.6 % and 10.2 % smaller than that of test 1 model at 20 um detector position.

Table 4. Sum of reflected light of three different assembled panels

	Reflected Light Sum [arb. unit]	Ratio
Test 1	6.58%	1.000
Test 2	5.49%	0.834
Test 3	5.91%	0.898

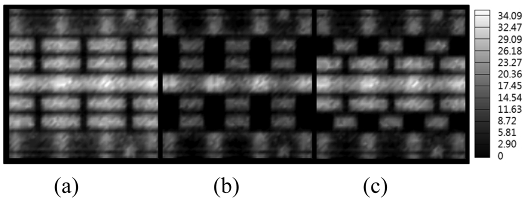


Fig. 6. Reflected light distribution of assembled panel of the models of (a) test 1, (b) test 2 and (c) test 3.

Fig. 7 shows the relationship between the reflected light intensity and wavelength. The reflected light intensity in the blue wavelength region is higher than any other wavelength region. It is due to the inherent property of transparent dielectric layer in the front panel and reflective layers in the rear panel.

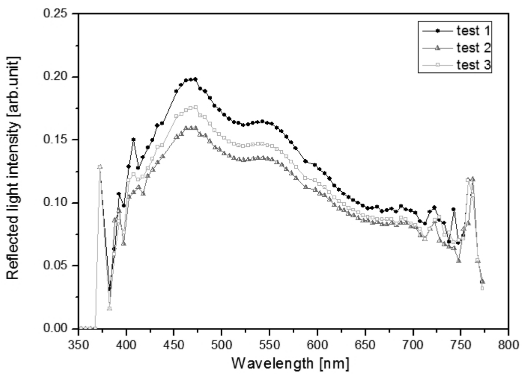


Fig. 7. Reflected light intensity versus wavelength for assembled panels.

3.4. Comparative Result between Simulation and Experiment

In order to validate the simulation result, three 7.5-inch test panels having same geometry as the simulation models are fabricated. The reflectance of assembled panel is measured with a spectrometer (CM-2600d, Konica Minolta). There is some discrepancy of data between the calculated reflectance and measured reflectance. Therefore, only the difference of reflectance between the models of tests 1, 2 and 3 is compared and the relative difference is listed in Table 5. In case of the simulation, the difference between test 1 and test 2 is 16.6% and in case of the measurement, the difference is 21.5%. For test 3, the simulation difference is 10.2% and the measurement difference is 11.8%. The relative differences between the simulation and measurement of each model are well matched.

4. Conclusions

In this study, the optical properties, such as transmittance and reflectance, of PDP are analyzed with 3D optical code (LightTools®). Three different ITO-less structures in the front panel are examined. Except for the structure of bus electrode in the front panel, other structures and optical properties of other structures are the same. In case of the assembled panel study, test 1 shows 16.6% and 10.2% higher reflectance than tests 2 and 3 due to the relatively large bus electrode area in the front panel. The calculated reflective properties of three models are compared to the measured data. Based on the relative reflectance listed in Table 5, the difference between test 1 and test 2 is 4.9 % and the difference between test 1 and test 3 is 1.6 %. The relative differences extracted from the simulation and measurement methods are well matched. The proposed methodology can be applicable to analyze the optical property of PDP and other displays without fabricating a real panel.

Acknowledgements

The present research was conducted by the research fund of Dankook University in 2010.

References

1. S. Mikoshiba, "Color Plasma Displays, Information

Table 5. Comparison of normalized reflectance between simulation and measurement data

	Test 1		Test 2		Test 3	
	Simulation	Measurement	Simulation	Measurement	Simulation	Measurement
Normalized Panel Reflectance [%]	100	100	83.4	78.5	89.8	88.2

Display," J. of SID, **10**, 21-25 (1994).
2. Q. Yan, "PDP Research and Development in China," Proc. of IDW'10, 1929-1931 (2010).
3. Q. Yan, "How can PDP TV meet the Challenges for the Energy Star Requirement," Korea-Japan PDP Forum 2010.
4. S. Jung, H. R. Choi, M. H. Oh and J. Kang, "Optimization of Geometries and Optical properties in PDP Cells," IMID/IDMC'06 DIGEST, 894- 897 (2006).
5. S. Jung, S. H. Eom, M. H. Oh and J. Kang, "Optimization of Geometries in PDP Cells by Optical Simulation," Proc. of ASID'06, 373-375 (2006).
6. S. Jung, H. R. Choi, and J. Kang "Optimization of Geometries in PDP Cell by Optical Simulation," J. of Semiconductor & Display Tech. **5**(2), 7-10 (Apr. 2006).
7. C. W. Eom and J. Kang, "Improvement of Optical Simulation by Using New UV Source in PDP cell," Proc. of IDW '07, 199-201 (2007).
8. H. Park and J. Kang, "A Study on the Optical properties of PDP Cells Using 3D Optical Code," Proc. of IDW'10, PDP p-14L (2010).
9. Y. Amano, "Possibility of New PDP for Less Cost and Less Power," Proc. of ASID'06, 103-106 (2006).
10. J. W. Ok, H. J. Lee, H. J. Kim, H. J. Lee and C. H. Park, "Discharge Characteristics of AC-PDP with Stacked Facing Electrode," SID Symposium Digest of Tech. Papers, vol. 37(1), 1209-1212 (2006).
11. I. C. Song, W. Y. Choi, D. H. Kim, H. J. Lee, H. J. Lee and C. H. Park, "Three-Dimensional Fluid Simulation of an ITO-less PDP Cell," SID Symposium Digest of Tech. Papers, vol. 38(1), 546-548 (2007).

접수일: 2012년 2월 22일, 심사일: 2012년 3월 2일,
게재확정일: 2012년 3월 15일