Optimization of Geometries in PDP Cells by Optical Simulation

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Abstract: *The detailed studies regarding to the front and rear panel geometries and optical properties of composed layers were needed to improve the luminance and efficiency. 3-dimensional optical code can be used to analyze the variation of geometries and the changing of optical properties. The visible light distributions and illuminance results were simulated depending on the bus electrode position, ITO geometries, optical properties of dielectric layer and variation of barrier rib's slope. As the ITO area was decreased and the bus electrode was located at the outer part of cell, the illumination was increased. And we could find quantification which is related between dielectric layer and visible light distribution of PDP cell. Also, the reduction of barrier rib's slope in rear layer was increased cell's brightness.*

Keywords: PDP; optical simulation; cell structure; high brightness

Introduction

Plasma Display Panel (PDP) is display device which is composed of a large number micro-discharge cell. A cell structure in a PDP is changed or designed in order to improve the luminance, luminous efficiency and addressing characteristics. Typically plasma code has been used to design and optimize the PDP cell before the real panel was made [1-2]. Recently the demand of high resolution display having more than 768 scan-lines is increased compared to the demand of common display with 468 scan-lines. It is mainly due to the start of high definition (HD) digital broadcasting. With the same size of panel, as the resolution is increased, the cell pitch is decreased. If the cell pitch is decreased, it is very hard to achieve the high luminance and high efficiency. The detailed studies regarding to the front and rear panel geometries and optical properties of composed layers, such as bus electrode, dielectric layer, ITO (Indium-Tin-Oxide), reflective layer, black matrix, barrier rib and etc. were needed to be performed.

3-dimensional optical code [3] can be used to analyze emission rays from the phosphors on the rear panel. The emitted rays can be reflected, transmitted or absorbed depending on the properties of confronted layers. The variation of geometries, such as height, shape and slope of the barrier rib, thickness of the front dielectric layer, position of the black matrix, and etc. can be simulated with the optical code. Also changing of optical properties, such as reflectance, transmittance and absorbance of each layer can be accounted.

The visible light distribution for change of various parameters made predictions about a real image of cell. and the result of optical code will be a useful data when designing Recent structure of PDP cell.

Model and simulation conditions

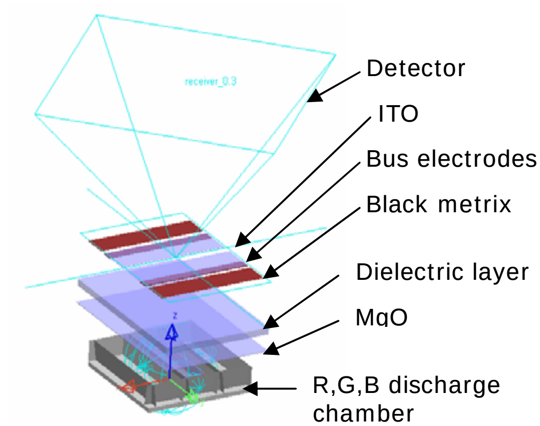


Figure 1. Geometry of Simulated PDP cell

3-dimensional optical code used in this paper is compatible with CAD, and it can be set up optical properties in the made model. It can be measured not only illuminance but also luminance, intensity, color calculation by ray trace of Monte Carlo method. By setting up the detector in the position we want, we can get the similar pattern taken by the actual Iccd camera.

Figure 1. shows a disjointed reference PDP cell used in this study. The cell pitch was selected 0.678 um (H) x 0.300 um (W), and it is same cell pitch of 42" commercial HD PDP. Detailed geometries and optical data of PDP cell were gathered from the published paper, maker's homepage and material's data from the code library. Important geometries and optical properties are shown in Table 1.

Table 1. Material properties of simulation

Components	Width	Transmittance	Reflectance
Barrier Rib	120 um	0%	75%
Electrode	0.5um	0%	98% (bottom)
ITO	1.3 um	90%	0%
MgO	0.5 um	90%	5%
Dielectric layer	38 um	85%	0%

In order to minimize the cross-talk of visible rays between cells, the transmittance of barrier rib was set to 0. and a front glass (2.8mm) is excepted because of cell' height (barrier rib' height : 120um) is relatively low. For the primary light source, we designed source which emit the wavelength of 147nm between two ITOs and it is located under 0.02mm from front layer. The radiated rays excite phosphor which was applied phosphor by 15 um thickness to emit 550nm visible light. The most efficient way to know the characteristic and pattern of the incident ray on the flat board is to compare the illuminance. So we examined relative variation based on this. Also the declination occurs from detector's position, so we measured on the base level of 0.15mm, 0.2mm, 0.3mm high above the surface.

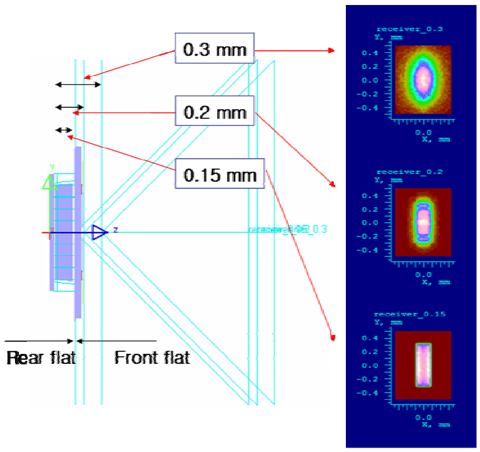


Figure 2. Illuminance chart of various detector positions

Figure 2. is the result from setting detector and ray tracing them above cell's rear flat (0.12mm from discharging cell's bottom), below the front glass and upper all layers (0.2mm) and in the middle of front glass (0.3mm). The detector set above the cell's rear flat (0.12mm) has not yet transmitted front flat has the same value on every experiments. And by observing from the upper all layer's top (0.2mm) that hasn't been transmitted front glass yet, the characteristic's change was the most obvious that we were able to compare.

Results of simulations

Bus electrode at plasma display electrically applied voltage from the driving circuit. It is carrier for the electric current, it also has a character which block and reflect the light. it is used that transparent electrode which transmit visible light such as ITO to reduce loss light following the width of bus electrode. It is determined that luminance of transmitted light by bus position and ITO. Table 2 shows the visible light distributions and illuminance results depending on the variation of bus electrode position [4], and detector position. Due to the changing position of the detector collecting the rays from the PDP cells, the distribution and illuminance could be affected. Case of 0.35mm bus electrode gap with the outer bus position showed the highest illuminance rates (1.162 times) as compared with conventional cell at 0.2mm detector position.

Table 2. Visible light distributions and illuminance results for the different bus electrode gaps and the different detector positions

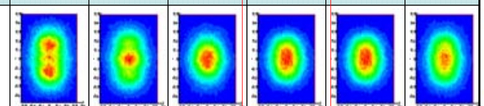
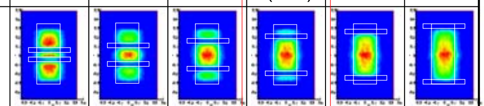
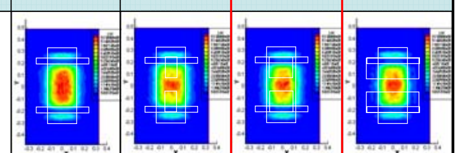
Electrode gap (mm)	0.1	0.15	0.2	0.25	0.3	0.35
Detector position (0.3mm)						
Intensity rate	0.980	0.995	0.998	1(100%)	1.054	1.157
Detector position (0.2mm)						
Intensity rate	0.988	1.005	1.003	1(100%)	1.055	1.162
				reference		

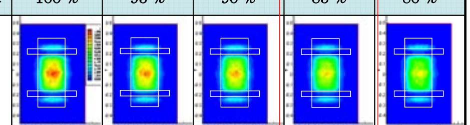
Table 3 shows the variation of distributions and illuminance rates depending on the changing of ITO width. A rectangular on the electrodes to draw the white line is ITO. When the ITO width was zero, the illuminance rate from the cell showed the highest value of rate (1.11 times) at 0.2mm detector position.

Table 3. Visible light distributions and illuminance results for the different bus electrode gaps and the different ITO widths

ITO width (mm)	0	0.1	0.2	0.3
Detector position (0.2mm)				
	1.110	1.054	1 (100%)	0.984

In PDP, a transparent dielectric is formed on a front glass substrate so as to cover bus electrodes. Transmittance and thickness of dielectric layer is effected cell of visible light distribution.

Table 4. Visible light distributions and illuminance results for the different transmittance of dielectric layer

Transmittance	100 %	95 %	90 %	85 %	80 %
Detector position (0.2mm)					
Intensity rate	1.184	1.125	1.066	1(100%)	0.938

Each of the Table 4 and Table 5 shows the results from changing dielectric layer's transmittance and by changing thickness. When the detector's position is 0.2mm, illuminance rate appears up to 1.184 times by increasing transmittance from 80% to 100%.

And with 0.018 mm of layer which is about twice thinner than the reference thickness of 0.038mm, the illuminance increases up to 1.05 times.

Table 5. Visible light distributions and illuminance results for the different dielectric layer thickness

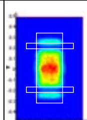
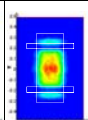
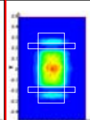
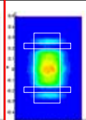
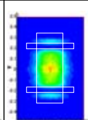
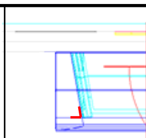
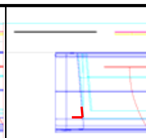
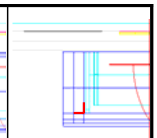
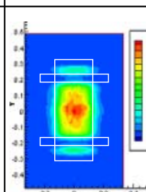
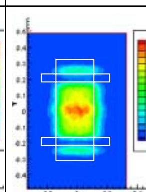
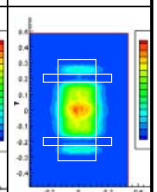
Dielectric layer Thickness (mm)	0.018 	0.028 	0.038 	0.048 	0.058 
Detector position (0.2mm)					
Intensity rate	1.050	1.031	1(100%)	0.982	0.964

Table 6. shows the visible light distributions and illuminance rates depending on the different slopes of the barrier ribs in the rear layer. Case of 80 angle rib slope showed more higher illuminance rates (1.026 times) as compared with conventional cell (85 angle). and when vertical slope, value of illuminance is reduced (0.917 times).

Table 6. Visible light distributions and illuminance results for the different slope of the barrier rib

Rib slope (degree)	 80	 85	 90
Detector position (0.2mm)			
Intensity rate	1.026	1 (100%)	0.917

T-shaped ITO structure proposed by Pioneer [5] was simulated, and the visible light distribution is shown in Figure 3. The ITO shape and the location of bus electrode could be affected to the visible light distribution and luminance of PDP cell. T-shaped ITO structure cell has value of 1.45E+09 lm/mm2 and shows 3% enhancement than the reference PDP cell' illuminance.

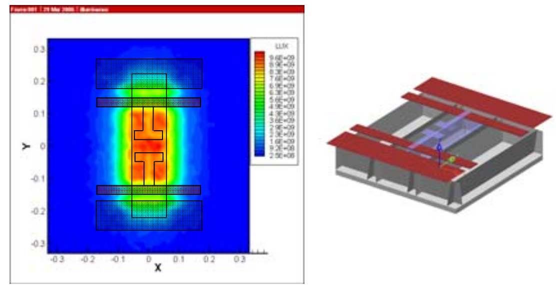


Figure 3. Structure of PDP cell in T-shape ITO

Conclusion

Using the 3-dimensional optical code, we could measure visible light distributions and illuminance rates by changing ITO shape and bus electrode position. We also found about increase or decrease of illuminance and efficiency in differ thickness of dielectric layer and optical properties. When angle of rib set low, illuminance is more higher than the structure with vertical angle. It is needed to research for geometries or optical properties of layers which are composed of cell. This thesis shows that systematic research is possible using optical simulation.

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