Development of High Luminance Plasma Display Panels

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Abstract

High Luminance PDPs have been developed using high efficient electrode structure, discharge gas and fishbone type barrier ribs. New phosphors for the good picture quality were developed. Also, New manufacturing processes such as CPBB were applied in order to reduce processing steps. High Luminance of 1,000 cd/㎡ was obtained in the series of 42 inch, 50 inch and 60 inch PDPs.

1. Introduction

Plasma display panels (PDP) are considered as the best candidate for the high definition digital TV with large panel size and high resolution. LGE has developed 37 inch, 40 inch, 42 inch PDPs with VGA resolution and 50 inch, 60 inch PDPs with XGA resolution.[1]

For a good picture quality, it has been demanded that PDP has higher luminance than CRT TV. CRT TV has ~400 cd/㎡ of peak luminance. In PDP TV, front filter with 40~50% transmittance was used for EMI shielding and anti-reflection, etc. Thus the PDP module should have over 1,000 cd/㎡ of peak luminance to have equal or higher luminance than the CRT TV.

Recently, LGE has developed the series of high luminance PDP modules with the peak luminance of over 1,000 cd/㎡. The cell design and fabrication process to develop the high luminance PDPs will be presented.

2. Cell Design

It is well known that stripe rib has advantages for mass production and fast evacuation. But it has disadvantage of low luminous efficiency. Closed rib gives higher luminous efficiency due to more phosphor area and longer electrodes. However, it demands the process improvement and longer evacuation time.[2][3]

LGE has investigated various rib structures such as fishbone type, semi-box type, embossing type, etc.[4] Fish-bone type rib has the horizontal rib for high luminance and luminous efficiency by increased phosphor area and long electrode length, as shown in Fig. 1(a). Also it has pumping path in the center of horizontal rib to reduce panel evacuation time compared with closed rib. Fish-bone type rib was applied for this work.

We have investigated various transparent electrode structures. Fig. 1(b) shows I-shape patterned ITO electrode. Plasma particles near the ribs collide with rib dielectric and lose their energy or the particles will be lost. To reduce this loss by collision between particles and rib, we removed the ITO electrode area near the vertical rib. By ICCD, we found that the intense part of IR intensity became narrower as ITO width was decreased. When ITO width decreased slightly compared with stripe ITO, decrease of discharge current brought about higher luminous efficiency. As ITO width decreases even more, luminous efficiency decreases due to reduction of luminance. It was found that there was the optimum parameter for high luminance and luminous efficiency.

To obtain high luminance and luminous efficiency, we have also studied the panel characteristics for various gas compositions of Ne-Xe and (He, Ne)-Xe. As Xe partial pressure was increased, luminous efficiency was increased in the mid-margin sustain voltage. However, driving voltages and statistical discharge lag were also increased.[5] As He was added in Ne base gas less than same amount of Ne, luminous efficiency was also increased. But driving voltages were increased and discharge delay time became faster. Optimum gas composition was chosen in condition that drive ICs used were the same as old models.

(a)

(b)

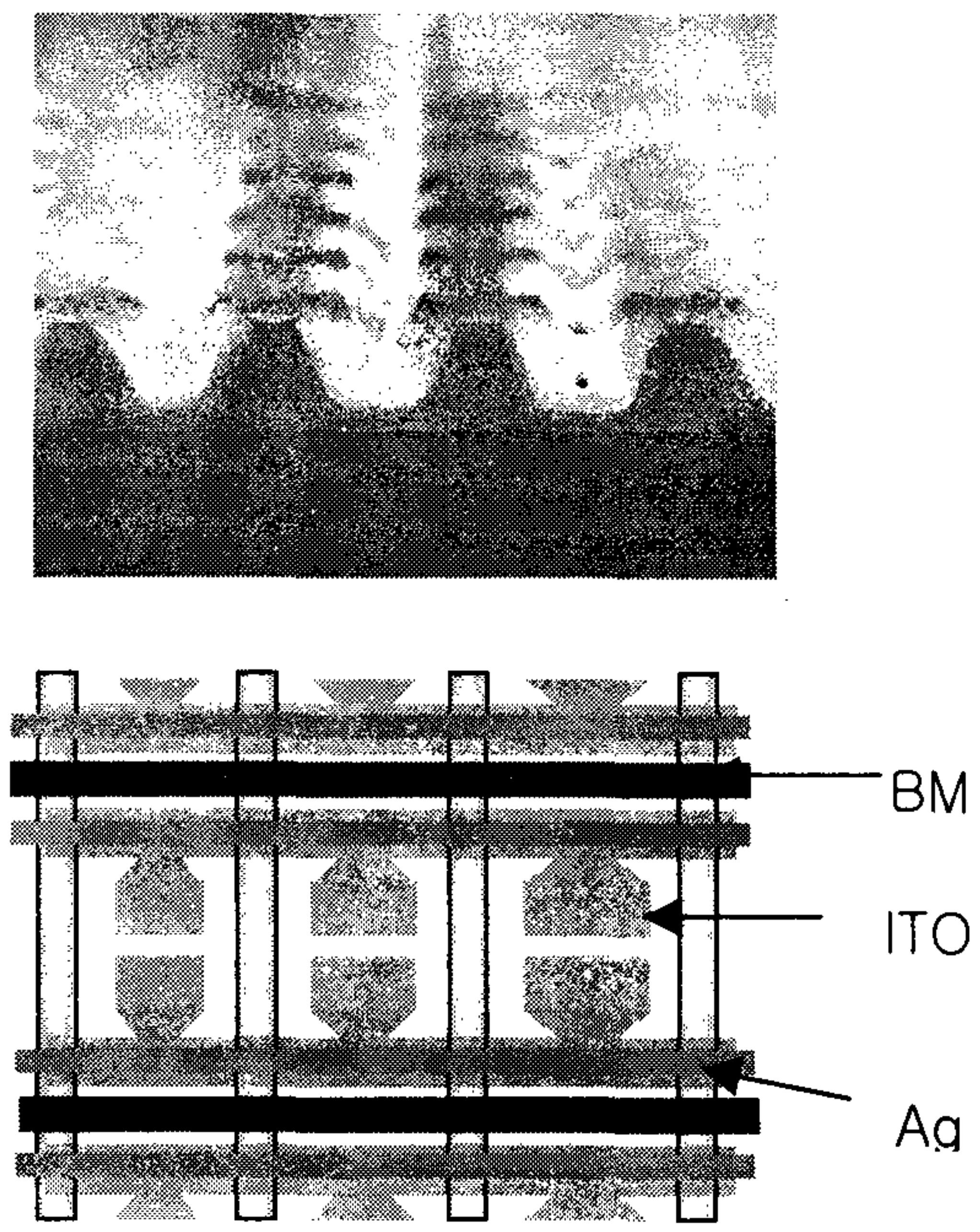


Figure 1. (a) SEM images of rear panel with fish-bone type barrier rib and (b) PDP cell structure with I-shape ITO

3. Manufacturing Process

Fig. 2 shows the flow chart of conventional and new processes making bus electrode, black matrix and transparent dielectric on the front panel.

In the conventional process, after patterning of ITO electrode, black layer and white layer of bus Ag electrode, transparent dielectric and black matrix were made in sequence.

In the new process (CPBB, Co-Processed Bus and Black matrix), black layer of bus electrode and black matrix were patterned simultaneously with non-conducting electrode material. After patterning the bus black layer and black matrix, white layer of bus electrode and transparent dielectric were made. MgO and sealing layer were made to complete the front panel.

By applying CPBB process, printing and drying process steps were eliminated and alignment accuracy between bus electrode and black matrix was also improved. Reduction of process steps contributes to the cost saving. High align accuracy between bus and BM helps the cell design for high luminance.

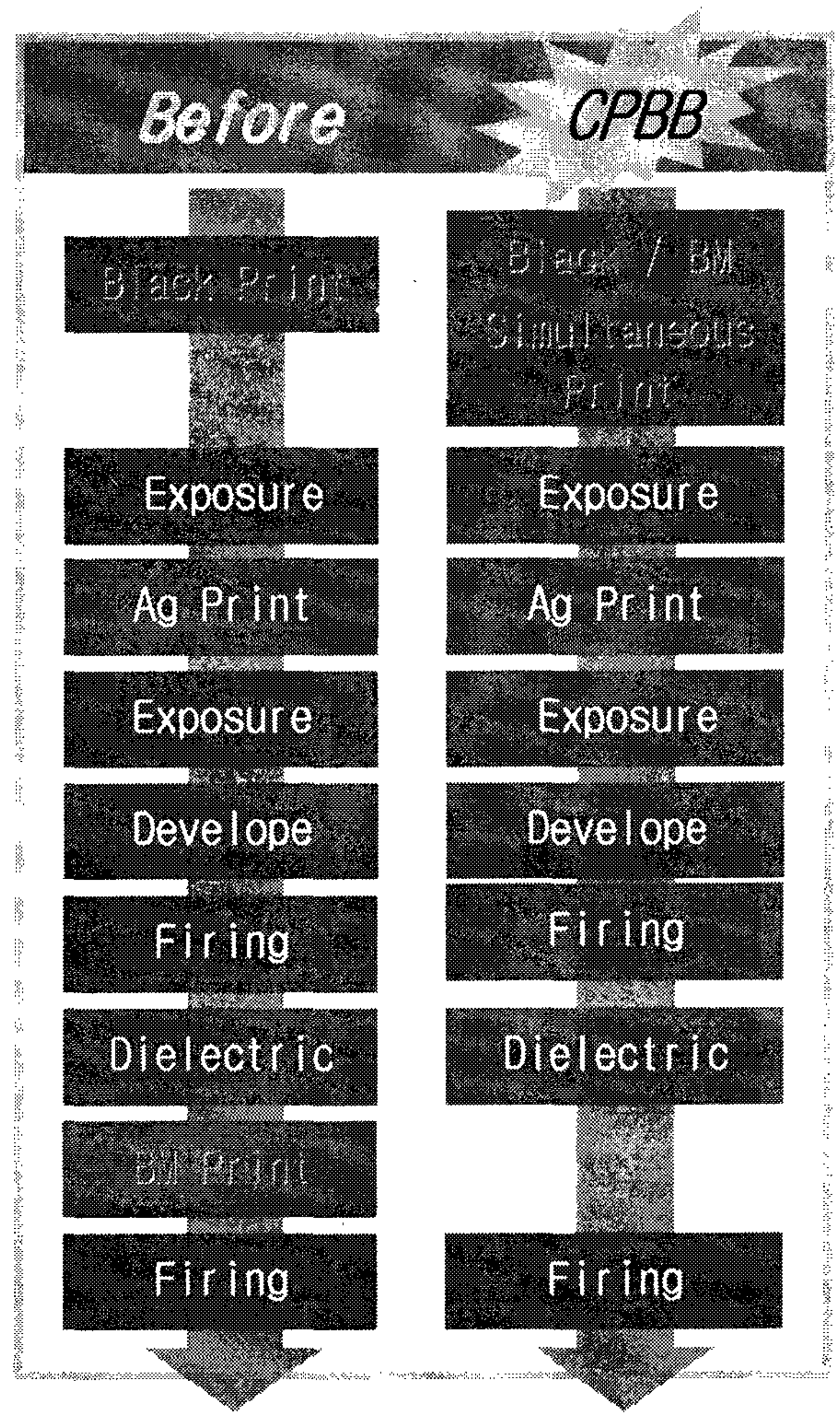


Figure 2 Process Flow Chart of Front Panel

The uniformity of transparent dielectric affects the discharge voltage of each cell around the whole panel. In the case of screen print, thickness uniformity in the large panel was poor and mesh trace of screen mask was observed. These bring about the luminance non-uniformity.

By applying the green sheet method, more uniform surface of dielectric layer was obtained compared with that made by screen print method. In Fig. 3, it is shown that the thickness uniformity of dielectric made by green sheet method was ± 0.9 ㎛, which was smaller than that by screen print method.

In screen print method, 5 times printing and drying and twice firing process were needed to make under dielectric layer and upper dielectric layer. However, in green sheet method, printing, drying and firing for the bottom layer, and laminating and firing for green sheet were needed. By applying the green sheet method, nearly 60% of the process steps were reduced.

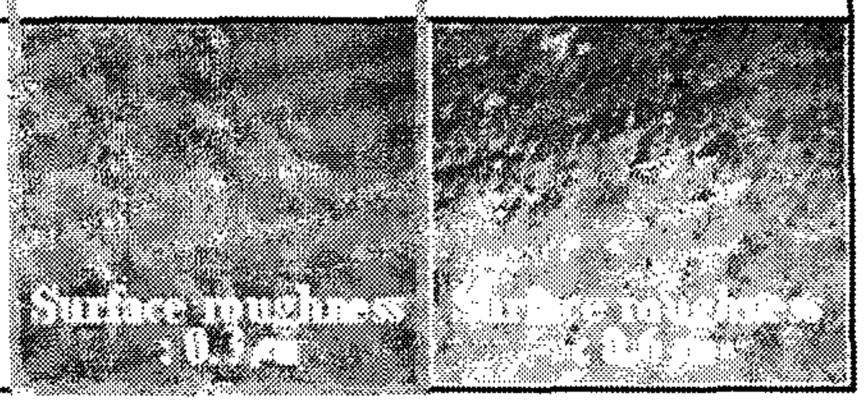
	Green Sheet	Screen Printing
Thickness Uniformity	± 0.9 µm	± 2.5 µm
Breakdown Voltage	5.7KV (@30 µm)	4.3KV (@30 µm)
Transmittance	67 % (@30 µm)	64 % (@30 µm)
Color Change of Electrode	NONE	NONE
Surface Morphology		

Figure 3. Electrical and optical characteristics of transparent dielectric made by screen printing and green sheet method

4. Phosphors

To improve PDP picture quality, it is a key factor to reduce the decay time of green phosphor and to improve the color purity of blue phosphor.

Green phosphor (Zn_2SiO_4:Mn^{2+}) with long decay time brings on the degradation of picture quality. To reduce the decay time of green phosphor, Mn contents of activator were investigated. As Mn content was increased, the decay time was decreased and luminance was also decreased. New green phosphor has around 10 ms of decay time and luminance is a few % smaller than that of old one.

New blue phosphor with high tolerance to PDP manufacturing process and with low y value has been adopted. For BAM blue phosphor, H_2O approaches the Eu^{2+} sites easily and forms the H_2O-Eu complex. Then the variation of electronic energy of Eu^{2+} is increased and emission of low energy is occurred. To reduce the degradation of blue phosphor in the PDP manufacturing process, surface protection layer was used. Fig. 5(b) shows spectra of old and new phosphor after manufacturing process. New phosphor has 30% higher intensity and low y value than those of old one, even though old one has higher intensity at powder condition.

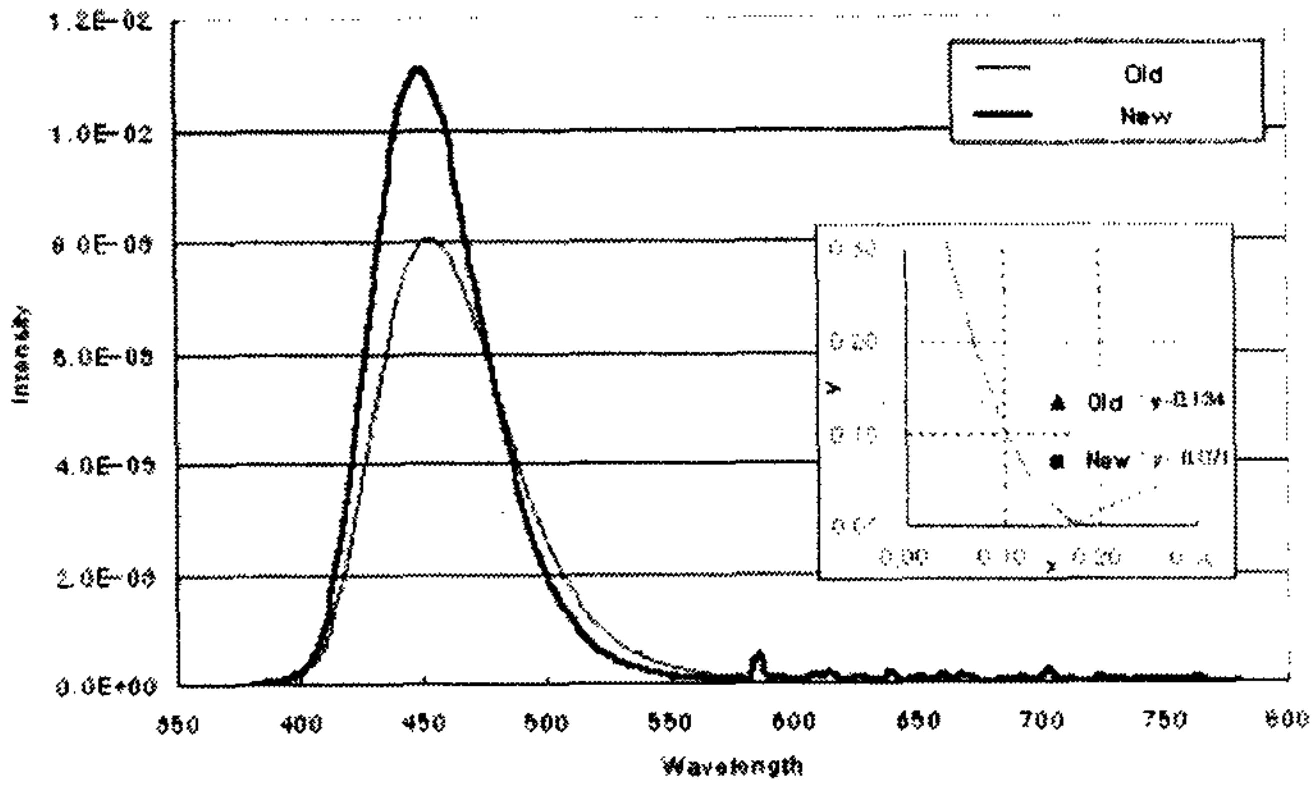


Figure 4. PL spectra and y value of old and new blue phosphor

5. Conclusion

Table 1 shows the main specifications of LGE's high luminance PDP modules. The series of high luminance products have the peak luminance of over 1,000 cd/m², which is equal or better than the CRT. High luminance and luminous efficiency were achieved by applying fish-bone type barrier rib, I-shape ITO and high efficient discharge gas. New green phosphor with short decay time and blue phosphor with high resistance to panel manufacturing process improve the picture quality. High luminance PDPs with 20% higher luminance and 15% lower power consumption than old model have been developed.

6. Reference

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Table 1. Specifications of LGE's high luminance PDPs

		42" SD	50" HD	60" HD
Resolution		852×480	1366×768	1366×768
Cell Pitch		(0.36×3)×1.08	(0.27×3)×0.81	(0.322×3)×0.966
Luminance	Peak (cd/m²)	1,000	1,000	1,000
	F/W (cd/m²)	200	170	160
C/R	Dark Room	1,000 : 1	1,000 : 1	1,000 : 1
	Bright Room	60 : 1	60 : 1	60 : 1
Power Consumption (W) @ Full Screen White		250	350	500