13.5: Research and Development of High Performance 42-inch XGA Plasma Display Panel

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Abstract

High performance 42 inch XGA PDP with high luminance of 1,000 cd/㎡ has been developed using high efficient electrode structure, discharge gas and closed barrier ribs. For high speed addressing with single scan technique, address discharge time lag was reduced over 40% with FAST driving scheme and new materials. High dark room contrast ratio of 5,000 : 1 was achieved and picture quality was improved using new algorithm for eliminating false contour and improving gray level linearity.

1. Introduction

Large area TV market with over 30 inch size grow rapidly due to the spread of digital broadcasting and cost reduction of PDP and projection TV. Plasma display panels (PDP) are considered as the best candidate for the high definition digital TV with large panel size and high resolution. PDP market is expected around 3.5 million unit in this year and grows rapidly over 50% in average per year.

LGE has developed 37 inch, 40 inch, 42 inch PDPs with VGA resolution and 42 inch, 50 inch, 60 inch PDPs with XGA resolution.[1] 71 inch and 76 inch PDPs with full high definition resolution ($1{,}920 \times 1{,}080$) has also been developed.[2]

Low cost and high performance is key factor for development of PDP. For the low cost, reduction of process steps and minimization of driving parts should be needed. Half of data drive IC in XGA PDP could be eliminated by applying single scan technique compared with normal dual scan technique. So single scan technique for XGA resolution is considered as key technology to develop the low cost XGA PDP. For a good picture quality, it has been demanded that PDP has higher luminance than CRT TV. 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 high performance 42 inch XGA PDP modules with the peak luminance of over 1,000 cd/㎡ and applying the single scan technique. The cell design and materials for high luminance and new driving scheme and data processing algorithm for good picture quality to develop the high performance 42 inch XGA PDP will be presented.

2. High Luminance Cell Design

Luminous efficiency of PDP cell consists of 4 steps such as discharge efficiency, UV transport efficiency, UV-Visible conversion efficiency and visible light radiation efficiency.[3] Discharge efficiency is related to discharge electrode shape, discharge gas composition and thickness of transparent dielectric layer etc. UV transport efficiency is connected with gas composition, barrier rib shape and height etc.,[4] and UV-visible conversion efficiency is mainly related to Stoke shift of phosphors. Finally visible light radiation efficiency is related to transmittance of front panel and sub-pixel arrangement.[5] To get the high luminance and high luminous efficiency PDP, electrode shape, discharge gas composition, barrier rib shape and transmittance of front panel were investigated.

We have investigated various transparent electrode structures for the high luminance and luminous efficiency. 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, the ITO electrode area near the vertical rib should be removed.[6] It is well known that luminance is increased as discharge electrode area is increased. So we investigated the optimum parameters of electrode shape and Figure 1 shows conventional stripe shaped ITO and suggested bridge shaped ITO electrodes.

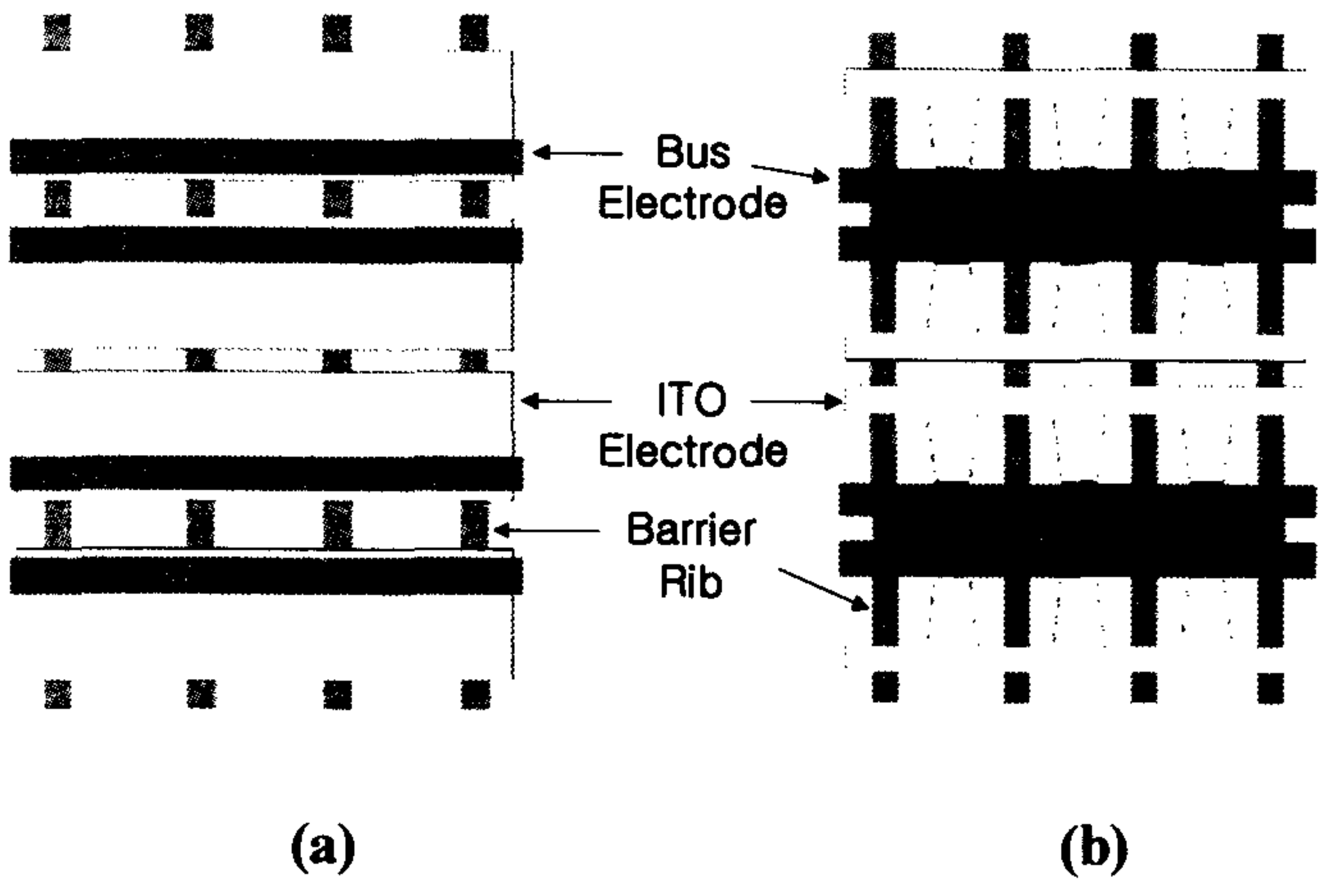


Figure 1. PDP cell structure of (a) conventional and (b) bridge shaped ITO

To increase the UV transport efficiency, phosphor area should be increased. For this purpose, closed barrier rib was applied and figure 2 shows SEM image of closed barrier rib. With respect to stripe barrier rib, closed barrier rib has high luminance and high luminous efficiency by increased phosphor area and long discharge electrode length.

Figure 2. SEM Images of closed barrier rib

To obtain high luminance and luminous efficiency, we have also studied the panel characteristics for Xe partial pressure of Ne-Xe mixture. Figure 3 shows luminance variation with Xe partial pressure. As Xe partial pressure was increased, energy dissipation for ion in gas discharge was increased and Xe excited species for UV generation was also increased. So high luminous efficiency was achieved. Raised sustain voltage of mid-margin in the high Xe content give high luminance shown in figure 3. However increase of Xe partial pressure brings on the long address discharge time lag and high operating voltages. Then new driving waveform and materials for high speed addressing were needed.

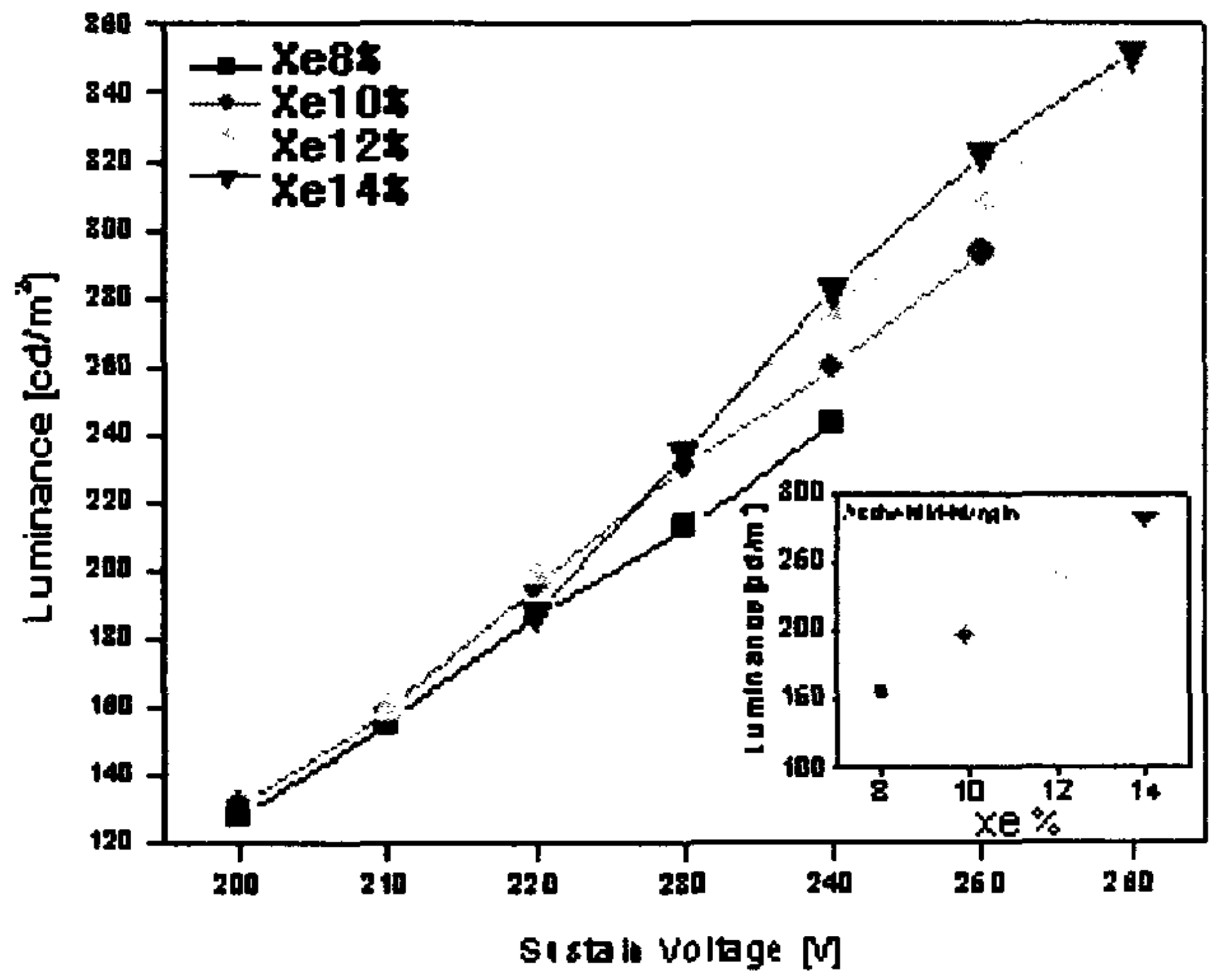


Figure 3. Luminance with sustain voltage with various Xe partial pressure and luminance at mid-margin voltage (small figure)

3. Materials and Manufacturing Process

High transmittance of front panel is essential for high luminance of PDP. For improvement of transmittance of front panel, the position of bus electrode was moved near the horizontal barrier rib and it gave ~15% improvement of visible light radiation efficiency. To get high luminance PDP, new transparent dielectric layer with ~10% higher transmittance than conventional one was developed.

The uniformity of transparent dielectric layer affects the discharge voltage of each cell around the whole panel. In the case of screen print, which is conventional method to manufacturing transparent dielectric layer, thickness uniformity in the large panel was poor and this brings about the luminance non-uniformity.

Figure 4 shows the electrical and optical characteristics of transparent dielectric layer made by screen print and green sheet methods. By applying the green sheet method, more uniform surface of dielectric layer was obtained compared with that made by screen print method. Thickness uniformity and breakdown voltage of transparent dielectric layer was improved by using green sheet 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.

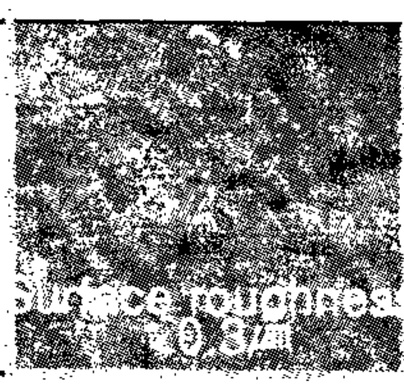
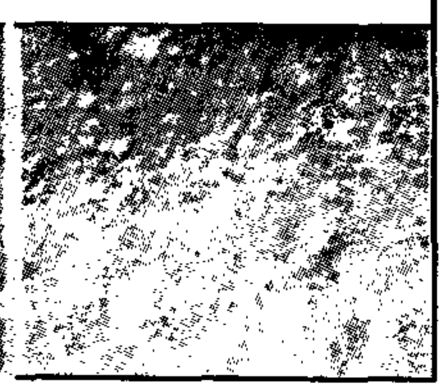
	New Dielectric	Conventional
Manufacturing Method	Green Sheet	Screen Print
Thickness Uniformity	± 0.9 μm	± 2.5 μm
Breakdown Voltage	5.7KV (@30 μm)	4.3KV (@30 μm)
Transmittance	73 % (@30 μm)	64 % (@30 μm)
Color Change of Electrode	NONE	NONE
Surface Morphology		

Figure 4. Electrical and optical characteristics of transparent dielectric made by screen print and green sheet method

4. High Speed Addressing and Picture Quality

To improve PDP picture quality, many number of sub-fields and enough sustain pulse number were needed. As scan lines are increased, the short scan pulse width is essential to reduce the address period. Also to reduce PDP module manufacturing cost, eliminating or reducing the driving parts such as IC, FET etc. is essential. Usually XGA PDP use dual scan technique to address the whole scan line and in this case, data drive IC should be located top and bottom pad lines of PDP panel. Extremely short scan pulse width, which is enough to scan the total scan line with one data pulse can make to eliminate the one side data drive IC of top or bottom pad lines of PDP, then module cost is decreased.

Scan pulse width was decided by address discharge time lag. Therefore, for reducing the this time lag, PDP cell design parameters, such as the shape of the transparent electrode, position of bus electrode in the cell, width of data electrode etc., material characteristics of MgO and phosphor, and driving waveform were investigated.

MgO material and evaporation condition were improved and stable surface and bulk properties of improved MgO material reduce statistical discharge time lag. FAST (Fast Addressing for XGA Single scan with high conTrast ratio) waveform was developed and short address discharge time lag of ~ 1.0 μs was achieved.

Recently discharge threshold voltage curve (Vt close curve) has been used in the understanding and design of the driving waveforms, especially the cell voltage state prior to the address discharge.[7][8] Figure 5 shows the measured Vt close curve of 42-inch XGA panel with high Xe partial pressure and the trajectories of the potential states are illustrated. In the case of conventional SW waveform, the potential state is ready for address discharge after two surface discharges ((1) → (2), (3) → (4)). At high Xe-content panel, the best pre-address point (an angular point of Vt close curve) is hard to be reached with SW waveform. We should increase voltages in order to set the best pre-address point, but it could raise a black brightness problem. When an inappropriate pre-address point is used, the higher address voltage is needed and also the address discharge formation time is inapplicably long. With these reasons, the conventional SW driving scheme isn't suitable for high Xe-content PDPs.

Then, as shown in figure 6, high speed addressing was achieved by setting the cell voltage state prior to the address discharge in the HSA (High Speed Addressing) area, not the SDP (Simultaneous Discharge Point) area. In the SDP area, surface discharge and vertical discharge are occurred simultaneously. However in the HSA area, the vertical discharge is mainly occurred and it maybe gives high speed addressing.

Address discharge time lag with new MgO material and FAST driving waveform was improved nearly 40% shorter than conventional structure and driving waveform shown in figure 7. The detail explanation of FAST driving waveform will be given later. Light intensity in the reset period was also minimized below 0.2 cd/㎡ and high dark room contrast ratio of over 5,000 : 1 was achieved.

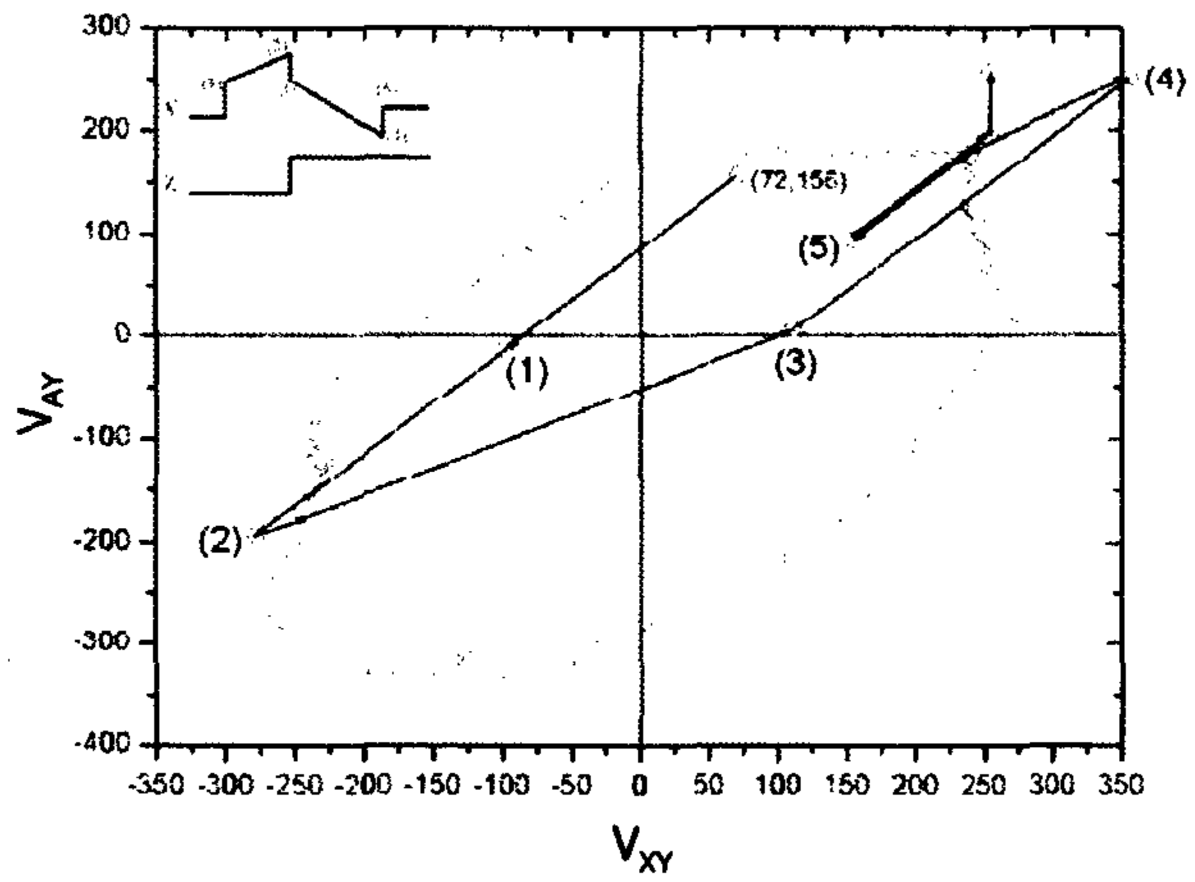


Figure 5. Vt Close Curve and potential trajectories of conventional SW driving

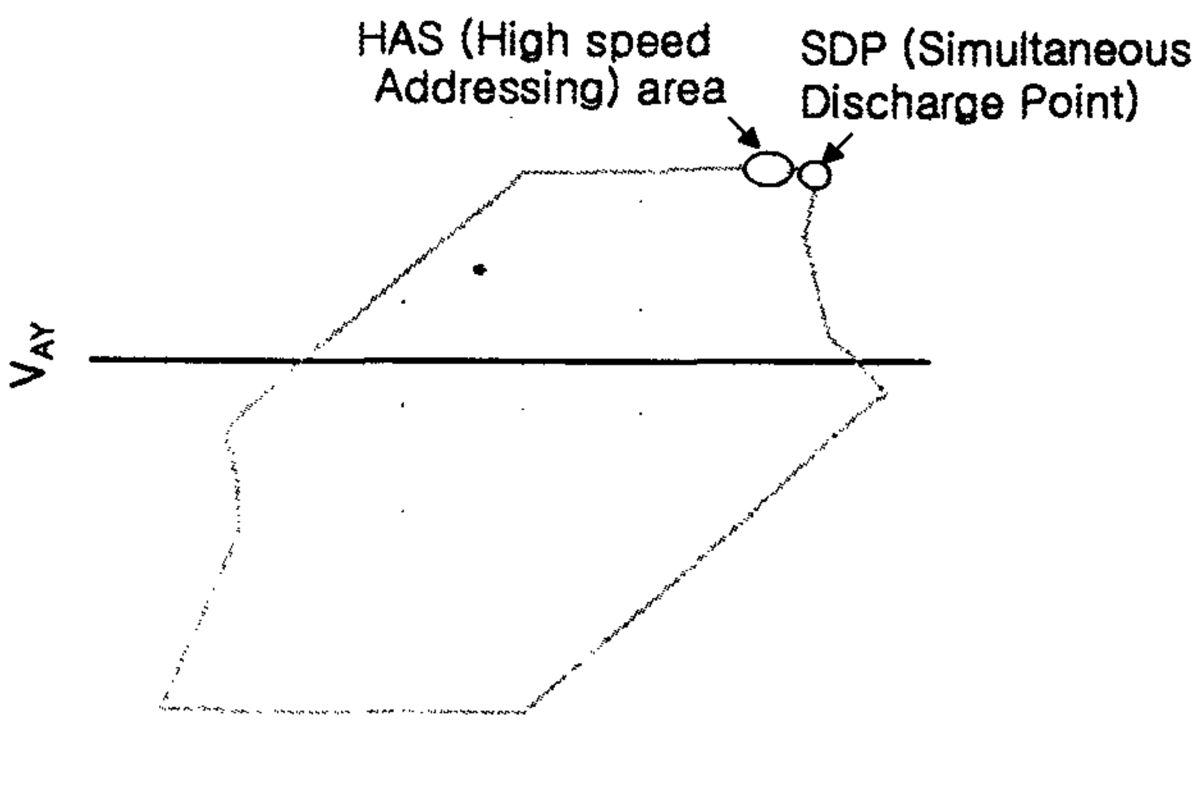
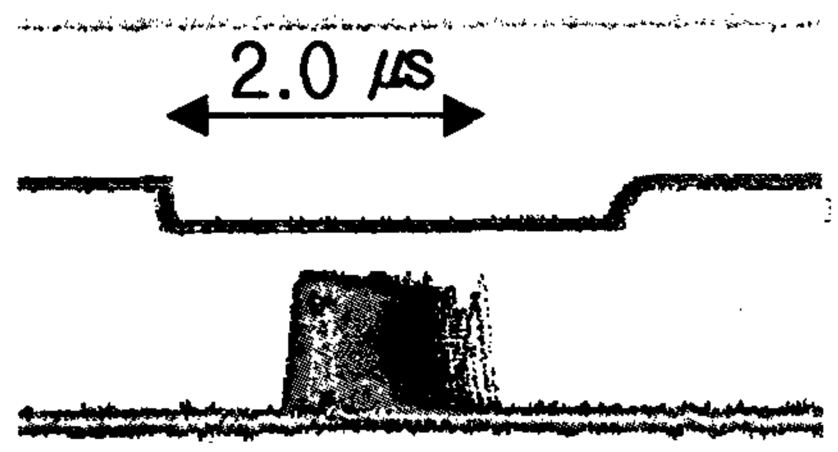
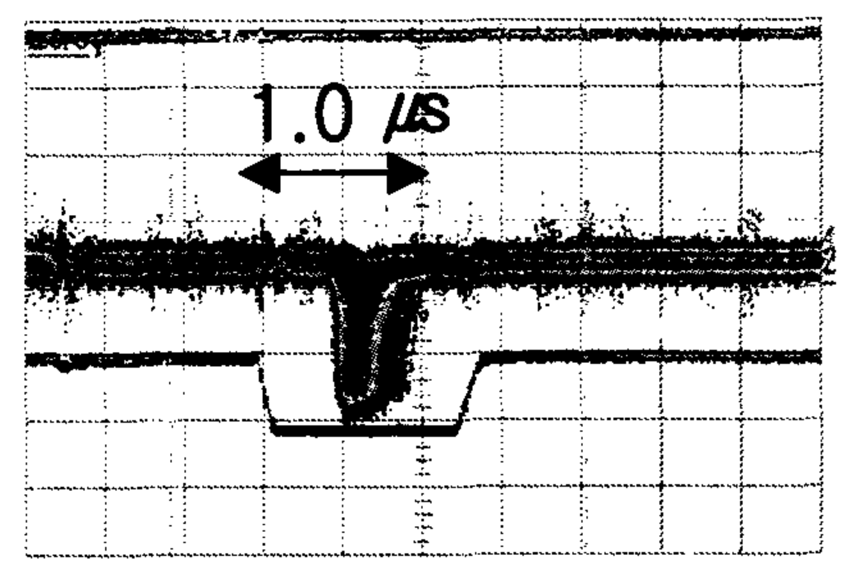


Figure 6. Concept of FAST driving in the Vt Close Curve

Dynamic false contour was considered as the week point of PDP. However we developed new data processing algorithm to eliminate dynamic false contour and picture quality was improved to the range that it is difficult for normal user to recognize about dynamic false contour. In the new algorithm, total gray level was expressed by using the gray level following the light axis in order to minimize the variation of light emission center. Dark image expression was improved and gray level linearity was also improved.



(a)



(b)

Figure 7. Address discharge time lag measurement of (a) old model and (b) new model

5. Conclusion

Table 1 shows the main specifications of LGE's high performance 42-inch XGA PDP modules. The 42-inch XGA PDP has the peak luminance of over 1,000 cd/㎡, which is equal or better than the CRT and high dark room contrast ratio of 5,000 : 1. High luminance and luminous efficiency were achieved by applying closed barrier rib, bridge-shaped ITO and high efficient discharge gas. The short address discharge time lag of ~ 1.0 μs for XGA single scan was achieved by using new MgO material and FAST driving waveform. For good picture quality, dynamic false contour was nearly eliminated and gray level linearity was also improved. By applying these technologies, high performance 42-inch XGA PDP with 25% higher luminance and better picture quality than old model has been developed.

6. Reference

[1] M.H. Park, SID'00 DIGEST, 475 (2000).

[2] K.Y. Choi, J.P. Choi, M.S. Chang, E.H. Yoo, W.T. Kim, J.Y. Kim, E.C. Park, S.T. Park and J.H. Ryu, SID'04 DIGEST, 1022 (2004).

[3] H. Doyeux, IDW'95, 53 (1995).

[4] C. Koshio, H. Taniguchi, K. Amemiya, N. Saegusa and T. Komaki, IDW'01, 781 (2001).

[5] C.K. Yoon, J.H Yang, W.J. Cheong, K.C. Choi and K.W. Whang, IDW'00, 627 (2000).

[6] K.Y. Choi, E.H. Yoo and J.H. Ryu, IMID'03, 343 (2003).

[7] K. Sakita, K. Takayama, K. Awamoto and Y. Hashimoto, SID'02 DIGEST, 948 (2002).

[8] H.J. Kim, J.H. Jung, K.D. Kang, J.H. Seo, I.H. Son, K.W. Whang and C.B. Park, SID'01 DIGEST, 1026 (2001).

		1st Gen.	2nd Gen.
Resolution		1024×768	1024×768
Luminance	Peak (cd/m²)	800	1,000
	F/W (cd/m²)	170	200
C/R	Dark Room	1,000 : 1	5,000 : 1
	Bright Room	60 : 1	80 : 1
Power Consumption (W) @Full Screen White		280	260

Table 1. Specifications of LGE's high performance 42-inch XGA PDP