Research and Development of High Performance 50-inch HD Plasma Display Panel

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Abstract

We are suggesting a new index to represent the performance of PDP, such as Specific Performance Index (SPI) that includes luminous efficacy and panel reflectance.
High Xe gas mixture and low panel capacitance are well known as key factors to improve luminous efficacy of PDP [1]. However, higher driving voltage and longer discharge time lag is an obstacle when applying these technologies. Modified cell design, new materials and driving waveform enable us to overcome these obstacles.
High efficient phosphor is also a key material to improve luminous efficacy. Phosphors coated with pigment are used to reduce panel reflectance.
High performance 50-inch HD PDP with luminous efficacy of 2.3 lm/W has been developed.

1. Introduction

The large size TV market over 30 inch is growing rapidly due to the spread of digital broadcasting and the cost reduction of PDP and LCD TV. Plasma display panels (PDP) are considered the best candidate for the high definition digital TV with large panel size and high resolution.

High luminous efficacy is the key element for high performance of PDP, which allows for higher brightness and lower power consumption.

Luminous efficacy is usually used for defining the performance of plasma display panel. The panel reflectance is also an important factor to define the performance where the watching condition is sufficiently bright enough in places such as the living room.

To generalize the performance of the PDP, including luminous efficacy and panel reflectance, we suggest a new index – Specific Performance Index (SPI).

Figure 1 shows the light flow of emitting light and reflected light from the plasma TV. The plasma TV consists of the PDP module and the optical filter. The luminance of the module decreases as it passes through the optical filter. The incident ambient light passes through the optical filter, reflects from the panel surface, and transmitted to the optical filter again. Reflected light from the PDP TV is a very important factor to define the bright room contrast ratio. Therefore, to compare the performance of the PDP module, we must assume the reflected light of PDP TV is constant.

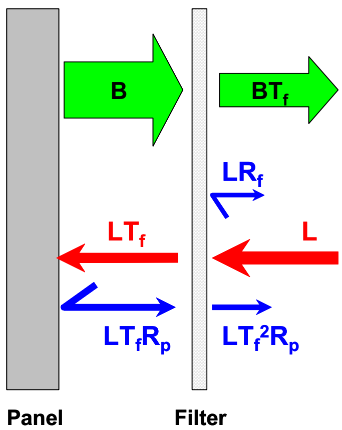

Fig. 1. Light flow of Plasma TV

Then the specific brightness B_{SPI} and efficacy η_{SPI} can be calculated by the following equation.

$$B_{SPI} = \frac{B}{\sqrt{R_p}} \qquad (1\text{-}1)$$

$$\eta_{SPI} = \frac{\pi S B_{SPI}}{P_{dis}} \qquad (1\text{-}2)$$

In the equation (1), B is the luminance [cd/m^2] emitted from panel, R_p is panel reflectance [%], S is screen area [m^2] and P_{dis} represents the power consumption [W] used in gas discharge.

For example, assume that module A has a luminous efficacy of 1.5 lm/W, panel reflectance of 25% and that module B has 1.7 lm/W and 35% respectively. If we use luminous efficacy as the tool of performance comparison, then module B has a higher performance than module A. However, if SPI is used, module A has a higher performance than module B.

To enhance the performance of the PDP, which is described in eq. (1), we have developed new technologies in the fields of discharge gas, materials, driving waveforms, etc.

2. Cell Design

To improve the performance of PDP, high Xe contents and new cell structures have been investigated.

Various Xe contents have been investigated with the conventional cell structure that have contents ranging from 10% to 30%. As the Xe content increases, collision cross-section between electron and discharge gas increases, the electron energy decreases. Xe excitation efficiency increases by the reduction of electron energy, which is verified by the discharge simulation result [2]. Higher Xe contents showed higher luminous efficacy as seen in Figure 2. However, the driving voltage also increased as the Xe content increased. Figure 2 shows the increment of luminous efficacy saturates over 20% of Xe content. In contrast with luminous efficacy, there is no saturation of driving voltage in the range of over 20%. So the saturation of luminous efficacy with high Xe content would be related with the continued increment of the driving voltage.

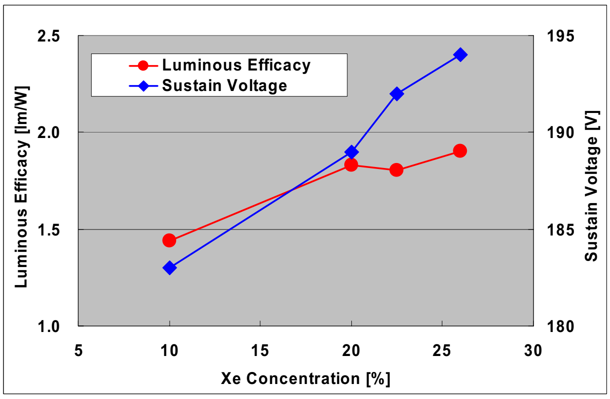

Fig. 2. Luminous Efficacy and Sustain Voltage with Xe content (Conventional Structure)

If the driving voltage becomes higher, it increases the reactive power loss in the circuitry and makes the electrical safety of the circuital devices worse. The longer time lag shortens the sustaining discharge time which is related to the brightness of picture. So, we have modified the cell design and developed new materials and driving waveforms to overcome theses obstacles.

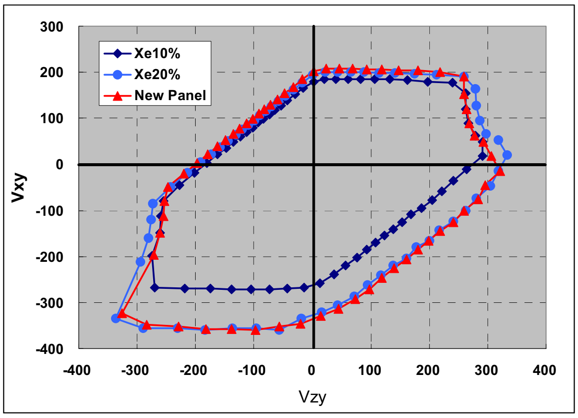

Fig. 3. Vt cutve of various cell design (diamond : Xe 10% with conventional panel circle : Xe 20% with conventional panel triangle : Xe 20% with new panel)

Figure 3 shows the threshold voltage curve of various cell designs. As the Xe content increases from 10% to 20%, the threshold voltage increases in the surface and vertical discharge. To reduce the threshold voltage various design factors are changed, such as the thickness of dielectric, sustain electrode gap, etc. The red curve in Figure 3 represents the threshold voltage of the new panel with 20% Xe, which also shows that the new panel with 20% of Xe content has the same threshold voltage of surface discharge as that of conventional panel with 10% of Xe content. This reduction of sustain voltage gives the improvement of luminous efficacy.

3. Materials

The capacitances of the panel can be separated into electrostatic and electrodynamic. The electrostatic capacitance is related to the reactive power and voltage loss in dielectric materials. The electrodynamic capacitance determines the amount of discharge and wall voltage. These two capacitances influence strongly the discharge formation, the propagation, and the extinguishment. We have optimized the properties and geometries of dielectric materials to maximize the discharge efficacy within a reasonable voltage range.

To investigate the effect of dielectric constant on the discharge property, the wall charge accumulation has been studied with a discharge simulation. The wall charge accumulation in the cell has been achieved with a conventional barrier bib and a new one that has a low dielectric constant. The difference of wall charge on MgO surface after the sustain discharge between conventional rib and the new one is shown in Figure 4. Low capacitance of dielectric gives the widening of the wall charge accumulation near the barrier rib. From the wall voltage transfer curve by simulation, it was found that the transferred amount of wall charge increases in the new panel with the barrier rib of low dielectric constant.

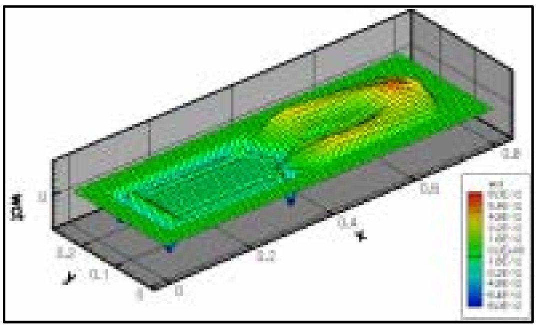

Fig. 4. The difference of wall charge accumulated on MgO between conventional and the low ε barrier rib.

To improve the contrast ratio in the bright room condition, it is important to reduce the reflective light from the panel minimizing the sacrifice of the emitting luminance. We coated red and blue phosphors with pigments of each color and the green phosphor was not coated to prevent the loss of brightness. This technique could lead to the improvement of contrast ratio by 15% [3]. The SEM image of CEP (Contrast Enhanced Phosphor) is given in Figure 5. Red pigment is attached on the surface of the red phosphor powder. When ambient light is incident to the red phosphor, pigment coated areas absorbs the visible light in the range of 400 ~ 550nm wavelength. The intensity of reflected light decreases and the color of the reflected light is changed. The intensity of the red light converted by the phosphor from the VUV slightly decreases. Because the decrement of reduction of reflected light is much larger than that of the converted light by the phosphor, the bright room contrast ratio is improved around 15%.

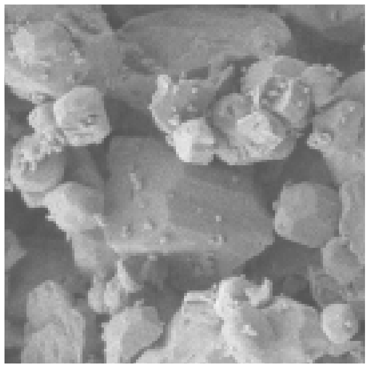

Fig. 5. SEM image of CEP

4. Driving waveform

As the Xe content increases, charge density distribution would be concentrated near the electrode gap and the response time of gas discharge would also become slow. Due to the high driving voltage and large electrodynamic capacitance, the possibility of incoming charges on the data electrode would increase. Therefore instability of wall charge distribution and reduction of wall charge erase capability should be solved.

To guarantee the discharge controllability during the reset and addressing period, a new driving concept was developed. This new driving waveform insured the stable reset discharge and the addressability within the conventional scan time which is the same as that of a low Xe panel.

Figure 6 shows the potential variation and wall charge trace on the threshold voltage domain. The red line represents the wall voltage trace of the proposed reset waveform. The proposed reset consists of the main and trimming reset. The blue line represents the potential variation of the main reset and the green line expresses the potential variation of the trimming reset of on a cell.

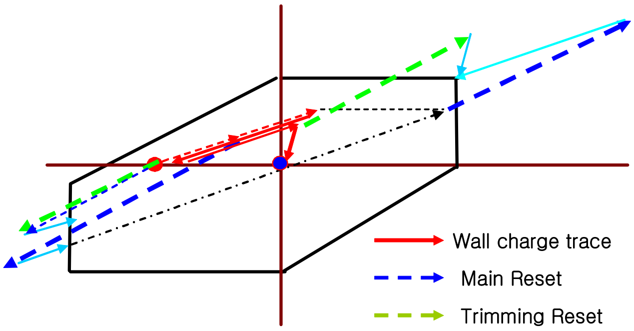

Fig. 6. Potential variation and wall charge trace of proposed waveform

5. Performance

With the stated technologies, we developed high performance 50-inch PDP with luminous efficacy of 2.3lm/W. It also showed luminance of 680 cd/m^2 in 25% display load and power consumption of 280W in a full white condition. This means that this has a higher performance by 80% in terms of SPI than the previous products:

Luminous Efficacy	**2.3 lm/W**
Luminance (25% Load)	**680 cd/m^2**
Power Consumption (F/W)	**280 W**
SPI	**4.5**

6. Conclusion

To represent the performance of PDP in the view point of the TV set, the SPI index is suggested. This index includes the luminous efficacy and panel reflectance.

To improve the performance of the PDP, High Xe gas mixture, new cell structures, low panel capacitance, low reflective phosphor, and a new driving waveform have been investigated.

By adapting the cell structure, the higher Xe gas mixture panel has the same voltage as the previous panels and the luminous efficacy and panel reflectance have improved by the low capacitance panel and the CEP. To hurdle the obstacles due to the high Xe content, a modified waveform has been proposed.

By applying these technologies, High performance 50-inch HD PDP with luminous efficacy of 2.3 lm/W, luminance of 680 cd/m^2 in 25% load and power consumption of 280W in full white has been developed.

7. References

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