Correlation between Sustain Electrode Shape and Luminous Efficiency of ac-PDP with Waffle-type Barrier ribs

Jung-Tae Park, Dong-Hyun Kim, Jong-Ho Sun, Choong-Hee Yoo, Chung-Hoo Park and Jung-Soo Cho

Abstract - In order to improve the luminous efficiency in ac PDP(Plasma Display Panel), we have suggested the new structures of sustain electrodes with waffle-type barrier ribs. In these structures, the light emission area have been enlarged by waffle-type barrier ribs and the discharge current for a given pulse voltage has been decreased by eliminating the electrode area which has nothing to do with visible light emission area compared with conventional structure. As a result, the luminous efficiency was improved about 30% compared with the conventional structure.
Key Words - waffle-type barrier ribs.

1. Introduction

The Plasma Display Panel (PDP) is the leading flat panel display, and is used widely as a large screen TV for home and a public information display. It still has to be improved, however, in terms of cost, brightness, and power consumption. [1] The conventional three electrode stripe-type ac-PDP discharge cell has black stripe band in order not to make the cross-talk between neighbor cells. However, in the ac-PDP with waffle-type barrier ribs, the black stripe of the stripe type ac-PDP is not need, because the ribs suppress the cross-talk instead of the black stripe band. The merit of waffle-type is that it is possible to enlarge the discharge area of sustain electrode(ITO electrode) and the discharge space. If we control the electrode area and the discharge space, the luminous efficiency and luminance of the ac-PDP may be improved.

In this study, we have suggested new sustaining electrode with etching part on ITO electrode. The characteristics of discharge voltage, luminance and luminous efficiency of the ac PDP with the suggested electrodes have been also investigated and compared with conventional electrode.

2. Experimental

Fig. 1 shows the schematic diagram of a typical ac-PDP. In this Figure, we have varied the shapes of sustain electrodes(display electrodes) and barrier rib in order to improve the luminous efficiency.

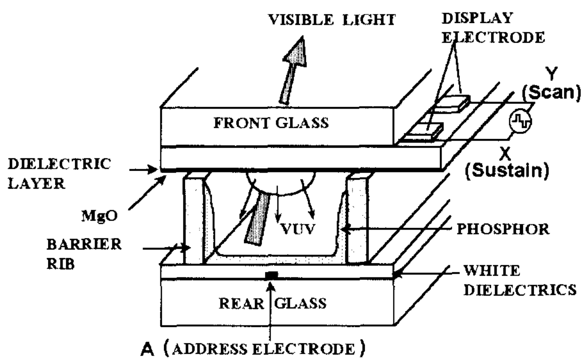

Fig. 1 The schematic diagram of ac PDP

Fig. 2(a) shows sustain electrode arrangement of the conventional three electrodes stripe-type ac-PDP. Fig. 2(b) shows enlarged area of sustain electrode in waffle-rib type ac-PDP. However the discharge cell pitch is the same with Fig 2 (a). Fig. 2 (c)-(e) shows a kind of T-shape electrode suggested by Pioneer except that the ITO is continuous under the vertical ribs.[2] In order to find out the optimum electrode shape showing high luminance and the least discharge current, the size of T-shape was varied and tested. However, one demerit of this T-shape was not align-free type between front and rear plates. In order to meet these disadvantages, the new align-free type sustain electrodes were suggested shown in Fig. 3 (c)-(e). In Fig. 3 (c)-(e), the white part of bullet-shape (BS) is eliminated area on ITO electrode, and at least three BSs are included in one side of ITO electrode in discharge cell regardless of align condition. The heights of BS are varied as shown in Fig 3 (c)-(e) in order to optimize the luminous efficiency. Four types of electrode in Fig. 2 or Fig. 3 are fabricated in

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a 4-inch panel and tested in a same gas, pressure and driving conditions as shown in table 1.

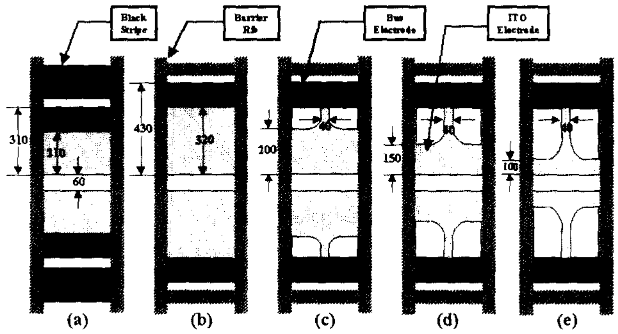


Fig. 2 The schematic diagram of test panel

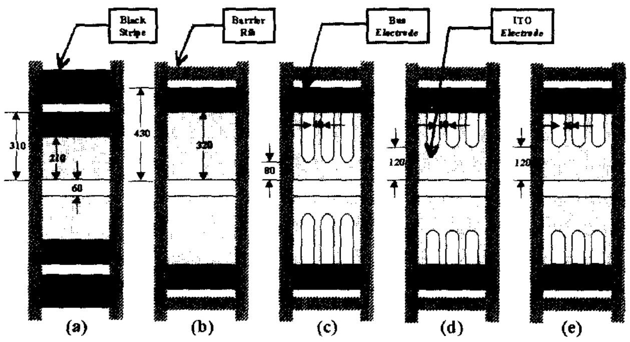


Fig. 3 The schematic diagram of test panel

Table 1 The spec. of 4 inch test panel

ITO electrode gap	60㎛
ITO electrode width	310 ㎛
Bus electrode width	100 ㎛
Dielectric layer thickness	20 ㎛
MgO thickness	5000Å
Barrier rib height	150 ㎛
Barrier rib pitch	360 ㎛
Address electrode width	120 ㎛
Working Gas	He-Ne(30%)-Xe(4%)
Applied sustain voltage	180V
Frequency	50kHz
Duty ratio	0.5

Fig.4 shows the schematic diagram of discharge test chamber and driving circuit used for measuring the electrical-optical characteristics. The vacuum chamber is a cylinder type of 200[mm] diameter and 80[mm] height. The upper part is composed of quartz to investigate the optical characteristics and discharge statement of the samples. The pressure is measured with a pressure transmitter with a digital indicator from atmospheric to 1[Torr].

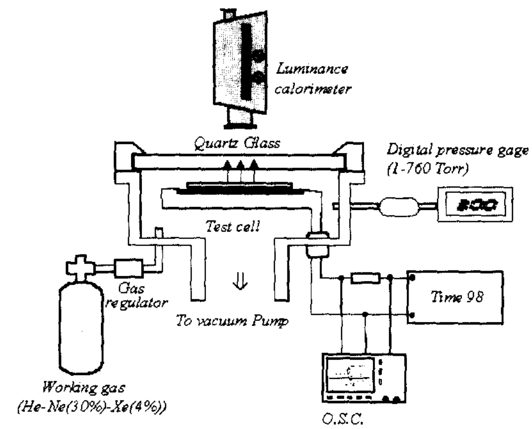


Fig. 4 The schematic diagram of discharge test chamber

The pumping system consists of the rotary pump and the turbo pump. In this study, the test samples were prepared by assembling the front and back panel with clip. And then, the test samples are installed to this chamber. It is first exhausted up to ~10^{-7} [Torr] not to be affected by the residual gases. After that, the He-Ne(30%)-Xe(4%) gas is filled to a given working pressure. The characteristics of samples are tested after 1hr aging process. The electrical measurements consist of obtaining the firing voltage (V_f), the sustaining voltage (V_s), and the current waveform from the test samples operating with 50[kHz] square wave voltage driver.

The luminance of the samples is measured by the luminance colorimeter (BM-7). The method used for calculating the luminous efficiency is as follows.

$$\text{Luminous efficiency (lm/W)} = \frac{\pi \times \text{Luminance (cd/m}^2) \times \text{Display Area (m}^2)}{\text{Power consumption (W)}} \quad \cdots\cdots (1)$$

$$\text{Power consumption (W)} = 2fD \int_0^{T/2} V_s(t)\,(i_{on}(t) - i_{off}(t)) \quad \cdots\cdots (2)$$

(where, D is pulse duty ratio , f is frequency and T is period)

3. Results and Discussion

Fig. 5 and Fig. 6 show the discharge voltage characteristics as a parameter of gas pressure for the panel with Fig. 2 and Fig. 3 type of sustain electrode, respectively.

From fig. 5 and fig. 6, the firing voltage(Vf) and sustain voltage(Vs) characteristics is almost the same regardless of electrode shape. It is considered that the discharge voltage characteristics are not influenced by the parameter of another electrode shapes except the sustaining electrode gap under the conditions that the parameters of dielectric layer and working gas were all fixed.

In the surface discharge structure, an electric field is concentrated on the electrode edges. The discharge voltage characteristics mainly depend on the distance between the electrodes. So, they have the same characteristics.

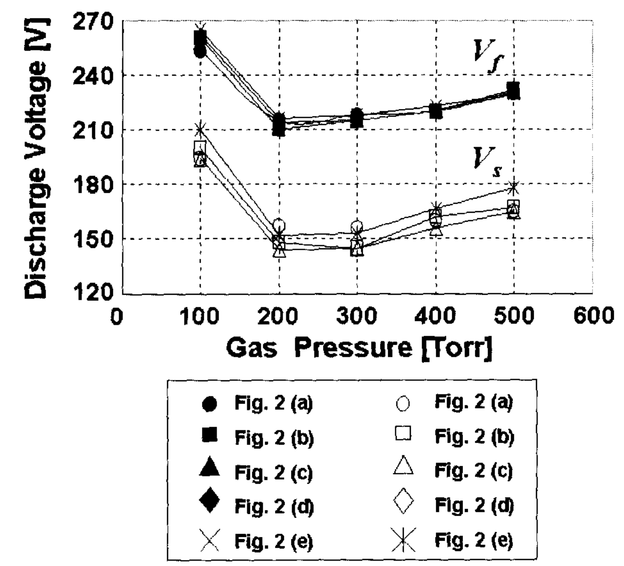


Fig. 5 Discharge voltage as a parameter of gas pressure with samples shown in Fig. 2

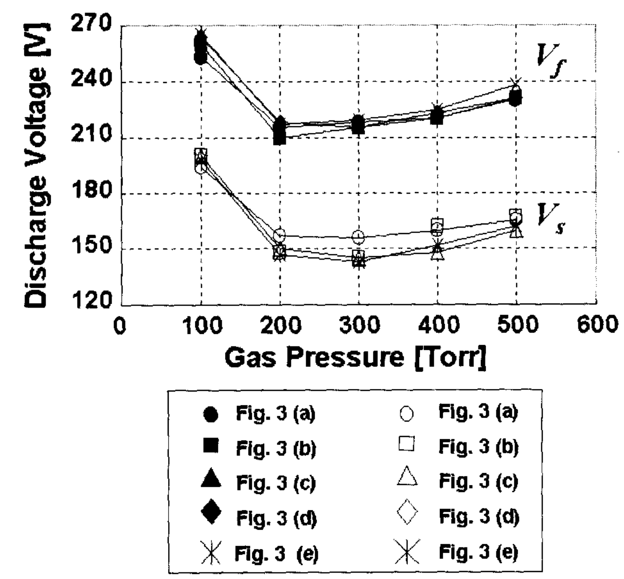


Fig. 6 Discharge voltage as a parameter of gas pressure with samples shown in Fig. 3

Fig. 7 shows the luminance and luminous efficiency for the test panel as shown Fig. 2. The two reasons of designing the test panel as shown Fig. 2 are as follows.

Since the part of maximum electric field is the gap part between the sustain electrodes, the discharge is initiated in the edge of gap. Moreover, the maximum generation spot of VUV in ac-PDP cells is also the edge of sustaining electrode [3]-[4]. After the discharge initiating at the edge

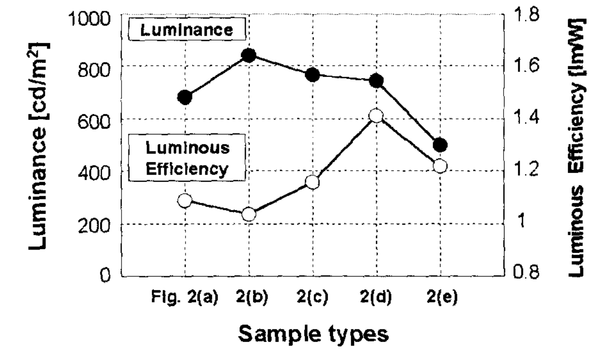


Fig. 7 The luminance and luminous efficiency as samples shown in Fig.2

of gap, ions and electrons start moving toward the cathodes and anodes, respectively. The leader of the ion flux with weak discharge is gradually moving to the cathode bus electrode and barrier ribs due to their lower mobility than the electrons.

In case of Fig. 2 (b)-(e), the shape of initial discharge is the same characteristic as that of Fig. 2 (a). In the latter discharge, however, the direction of ion spreading is centralized for the influence of the electrode shape. It is expected that the latter discharge of Fig. 2 (b)-(e) is more intense than that of Fig. 2 (a) type. It is considered that the luminous efficiency could be improved due to the decrement of diffusion loss of ions, electrons and metastable particle absorbed in barrier ribs and the increment of a discharge path resistance by eliminating the electrode area nearby the barrier ribs [5].

The luminance of Fig. 2(b)-(d) types except Fig. 2(e) type is higher than that of Fig. 2(a) type. In case of Fig. 2(e) type, because the part showing the maximum electric field is smaller than that of the conventional type, it is considered that the luminance of Fig. 2(e) type is lower than that of Fig. 2(a) type. However, it is because the power consumption of Fig. 2(e) is lower than that of Fig. 2(a) that the luminous efficiency of Fig. 2(e) is higher than that of Fig. 2(a).

In case of Fig. 2(d), it has the higher luminance than Fig. 2 (a) and the luminous efficiency of Fig. 2 (d) is about 30% higher than that of Fig. 2(a).

Fig. 8 shows the luminance and luminous efficiency for the test panel with the electrode with Fig. 3. All panels with the electrode of Fig. 3(b)-(e) has the higher luminance than Fig. 3(a) and the luminous efficiency of Fig. 3(c)-(e) is higher than that of Fig. 3(a). In case of Fig. 3(d), the luminous efficiency is about 25% higher than that of Fig. 3(a). The most merit of the Fig. 3(c)-(e) proposed in this study is free alignment between the front and the rear glass.

Fig 9 shows the discharge current waveform of Fig. 2(a) and Fig. 2(d) and power consumption of cell types suggested in Fig. 2(a)~(e). From Fig. 9(a), the first peak part shows the displacement current. There is a little

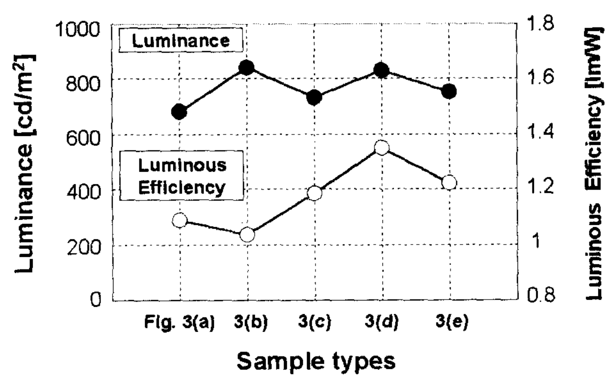
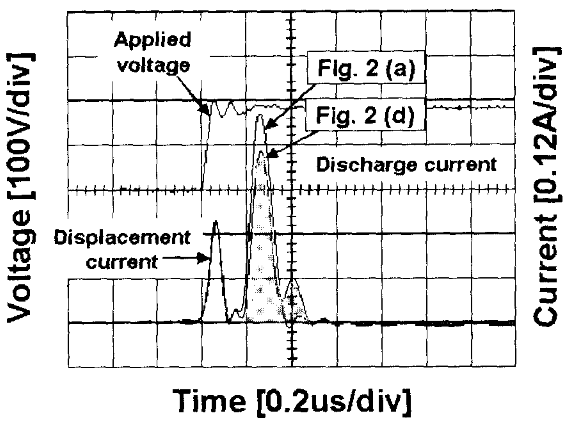
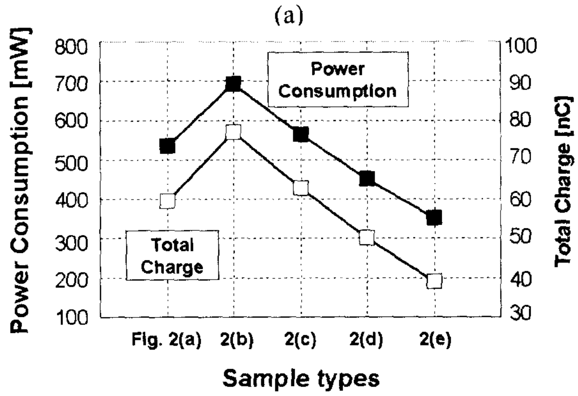


Fig. 8 The luminance and luminous efficiency as samples shown in Fig.3



(a)

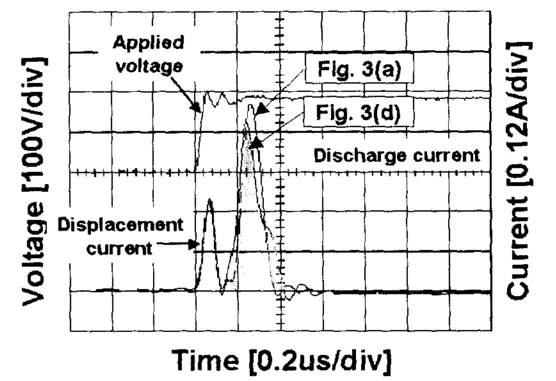


(b)

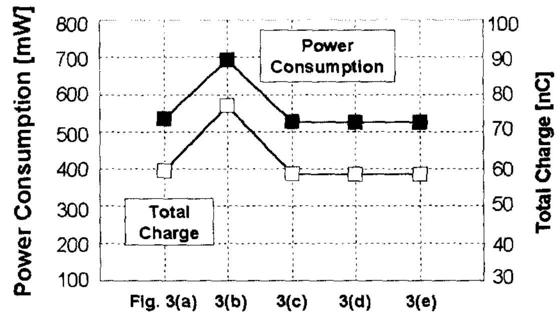
Fig. 9 The current waveform of Fig. 2(a) and Fig. 2(d) and power consumption of Fig. 2(a)-(e) types

difference in the displacement current between Fig. 2(a) and Fig. 2(d). The second peak part shows the discharge current. The discharge current of Fig. 2(d) decrease in about 20% compared with Fig. 2(a). It is considered to be due to the reduction of an electrode area in Fig. 2(a). As shown Fig. 9(b), the power consumption decreases as the discharge current decrease.

Fig.10 shows the current waveform of Fig. 3(a) type and Fig. 3(d) and power consumption of cell types suggested in Fig. 3(a)~(e). The discharge current and power consumption of Fig. 3(d) are similar to those of Fig. 3(a). It is because the luminance of Fig. 3(d) is about 20 % higher than Fig. 3(a) that the luminous efficiency of Fig. 3(d) is higher than Fig. 3(a)



(a)



(b)

Fig. 10 The current waveform of Fig. 3(a) and Fig. 3(d) and power consumption of Fig. 3(a)-(e) types.

4. Conclusion

Two new type of sustain electrode are suggested in order to improve the luminous efficiency in the ac-PDP with waffle-type ribs. The luminance of the ac-PDP with the suggested electrodes in Fig. 2 (d) and Fig. 3(d) are increased compared with conventional type cuased by increasing light emission area, but the power consumption are decreased or same with the conventional one caused by increasing the path resistance of discharge current. As a result the luminous efficiency was improved by up to 30% compared with conventional stripe type electrodes.

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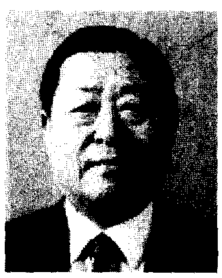

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