A Study on New-Shaped Sustaining Electrode Showing High Luminous Efficiency in AC PDPs

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Abstract

In order to improve the luminous efficiency in ac PDP(Plasma Display Panel), we have suggested a new bridge type sustaining electrode which makes it possible to have free alignment between front and rear panels. The luminous efficiency of the ac PDP with suggested new sustaining electrode is improved by about 28 % compared with that of conventional sustaining electrode. However, the luminance of the ac PDP with the suggested electrode is kept the same with the conventional ones.

Keywords : Ac PDP, addressing time

1. Introduction

Plasma display panel (PDP) is one of the most promising technological devices for large flat-panel display, especially color high-definition television (HDTV). There have been various intensive efforts made to improve the luminance and luminous efficiency.

For example, ac PDP with T- shaped sustaining electrodes, as shown in Fig. 1(a), showed that the luminous efficiency was improved by about 15% compared with the conventional type, as shown in Fig. 1(b)[1-2]. However, it is very difficult to align between the rear and front panel with T-shaped electrodes because of the distortion of the panels in thermal process[1]. Therefore, new free-alignment sustaining electrode type with high luminous efficiency has been required.

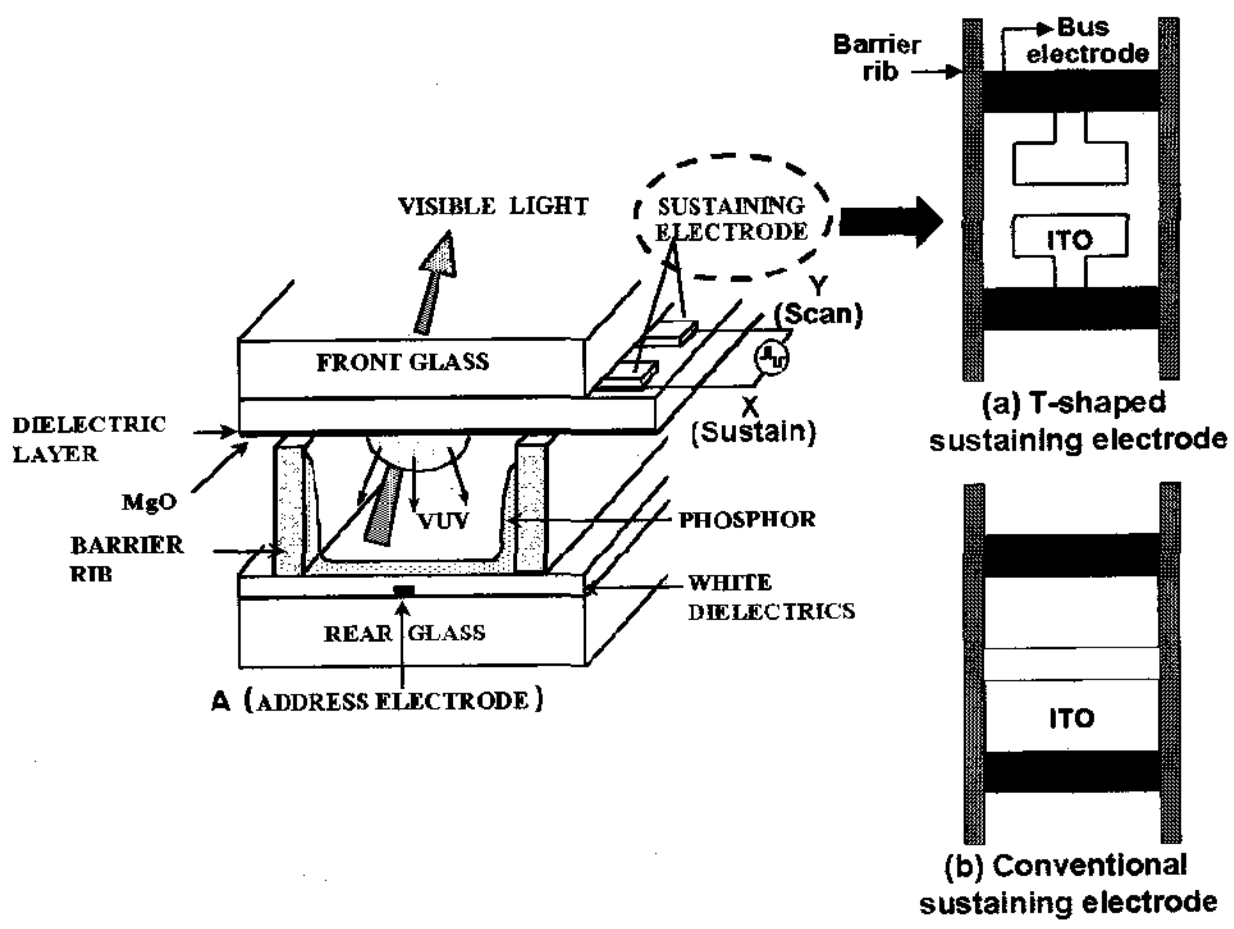

Fig. 1. Schematic diagram of ac PDP and structure of the sustaining electrodes.

In this study, we have suggested new align-free type sustaining electrode with bullet-shaped (BS) etching part. The characteristics of discharge voltage, luminance and luminous efficiency of the ac PDP with the suggested electrodes have also been investigated and compared with conventional electrodes.

2. Experimental

The specification of 4-inch ac-PDP and driving conditions used in this study are shown in Table.1. Fig. 2

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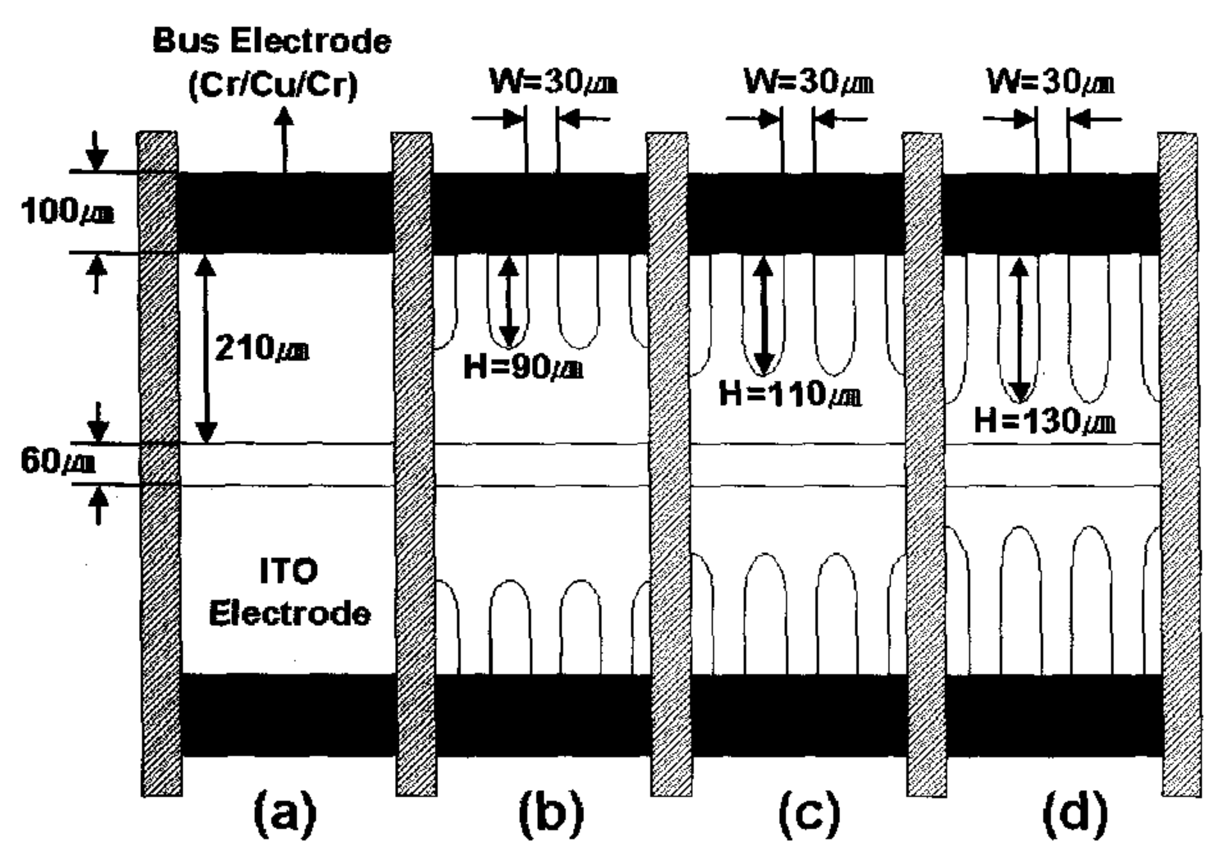
TABLE 1. Specification of 4inch test panel and driving conditions.

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



(a) : Conventional eletrode
(b)-(d) : Suggested electrode

Fig. 2. Various kinds of sustaining electrodes between the barrier ribs.

shows the typical shapes of sustaining electrodes in a stripe-type barrier rib. Fig. 2(a) shows the conventional sustaining electrodes and Figs. 2(b)-(d) show the suggested bridge-type electrodes in order to improve luminous efficiency of ac PDP by controlling the discharge current. In Figs. 2(b)-(d), it is designed that at least three BS are included on one side of the ITO electrode in a discharge cell, which leads to free alignment. The height and pitch of the BS are varied, as shown in Figs. 2(b)-(d), in order to find out the correlation between the size of BS and the luminous efficiency of AC PDP.

Fig. 3 shows the schematic diagram of discharge test chamber and driving circuit used for measuring the electrical and optical characteristics. The vacuum chamber is a cylindrical type of 200 mm in diameter and 80 mm in height. The upper part is composed of quartz view-window for investigating the optical characteristics. The test samples are installed in this chamber. It is first exhausted up to ~10^{-7} Torr by molecular pump. The firing voltage, the sustaining voltage, the luminance and the discharge current waveform for the test panels are measured. The luminance of the samples is measured by the luminance colorimeter (BM-7). The luminous efficiency is calculated from the measured values. That is,

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

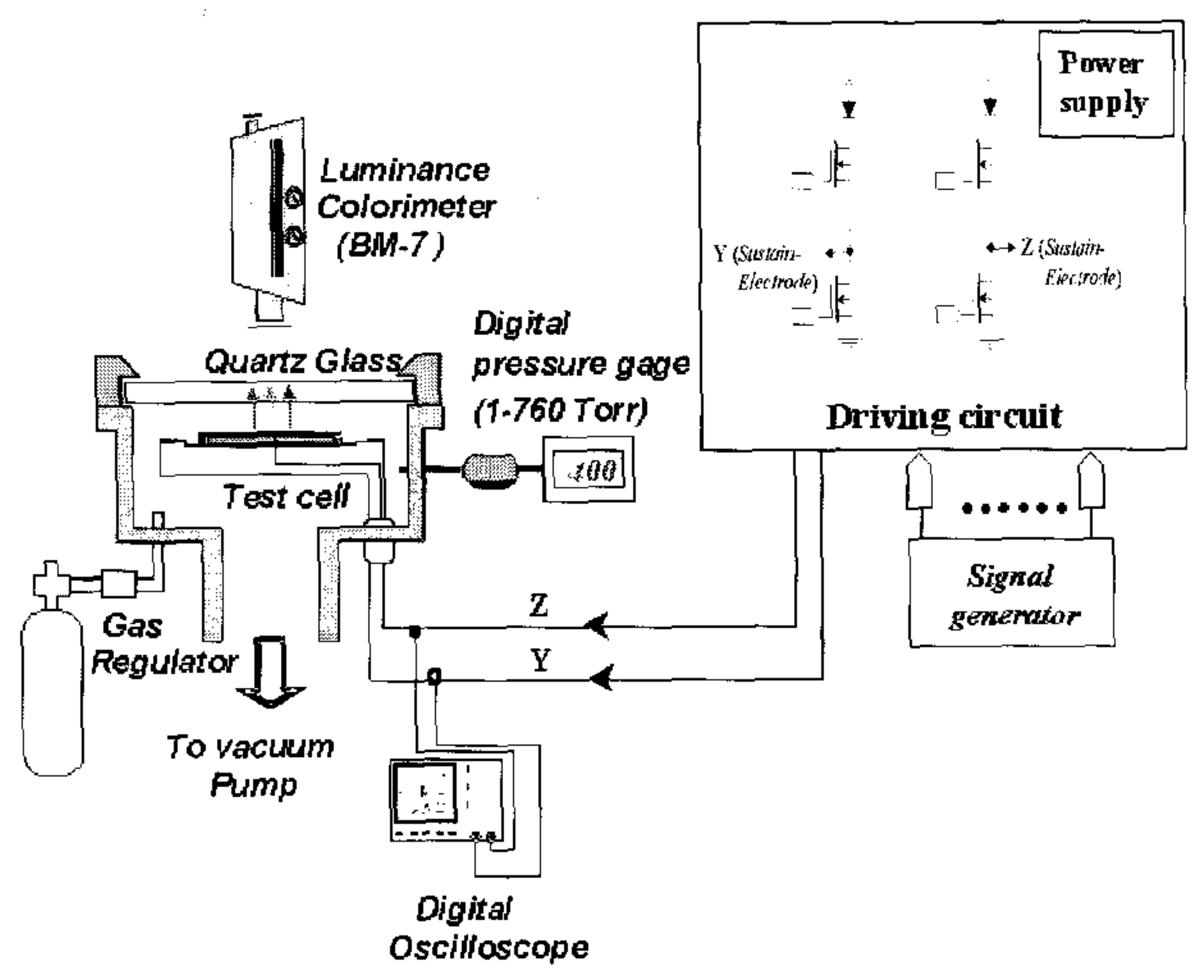


Fig. 3. Schematic diagram of experimental setup

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

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

3. Results and Discussion

Fig. 4 shows the discharge voltage characteristics as a parameter of gas pressure for the types shown in Fig. 2. From Fig. 4, the firing voltage and sustain voltage characteristics are almost the same regardless of the electrode shapes. In the surface discharge structure, it is well known that an electric field is concentrated on the electrode edges[3-5]. And the discharge voltage characteristics mainly depend on the distance between the electrodes[6-7]. Therefore, it is considered that almost the same voltage charateristics in Fig. 4 may be due to the same sustaining electrode gap .

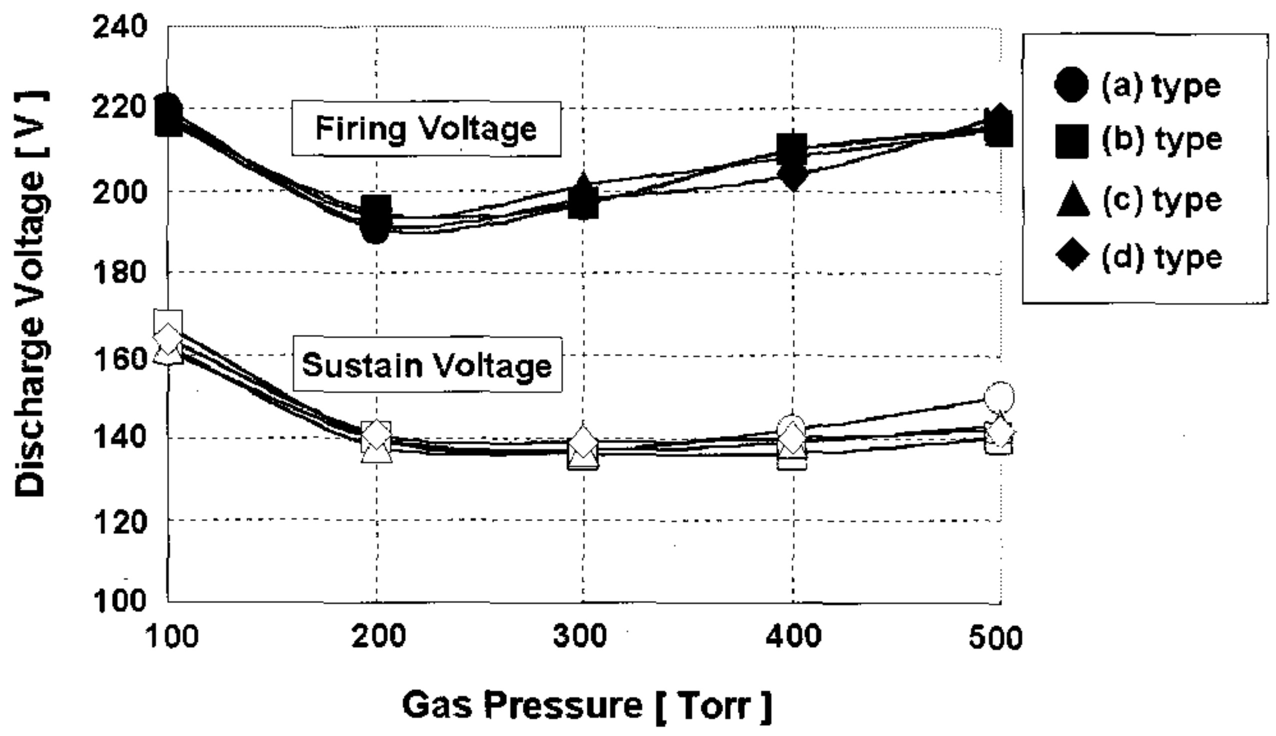


Fig. 4. Discharge voltage characteristics as a parameter of gas pressure and the kind of sustain electrode as shown in Figs. 2(a)-(d).

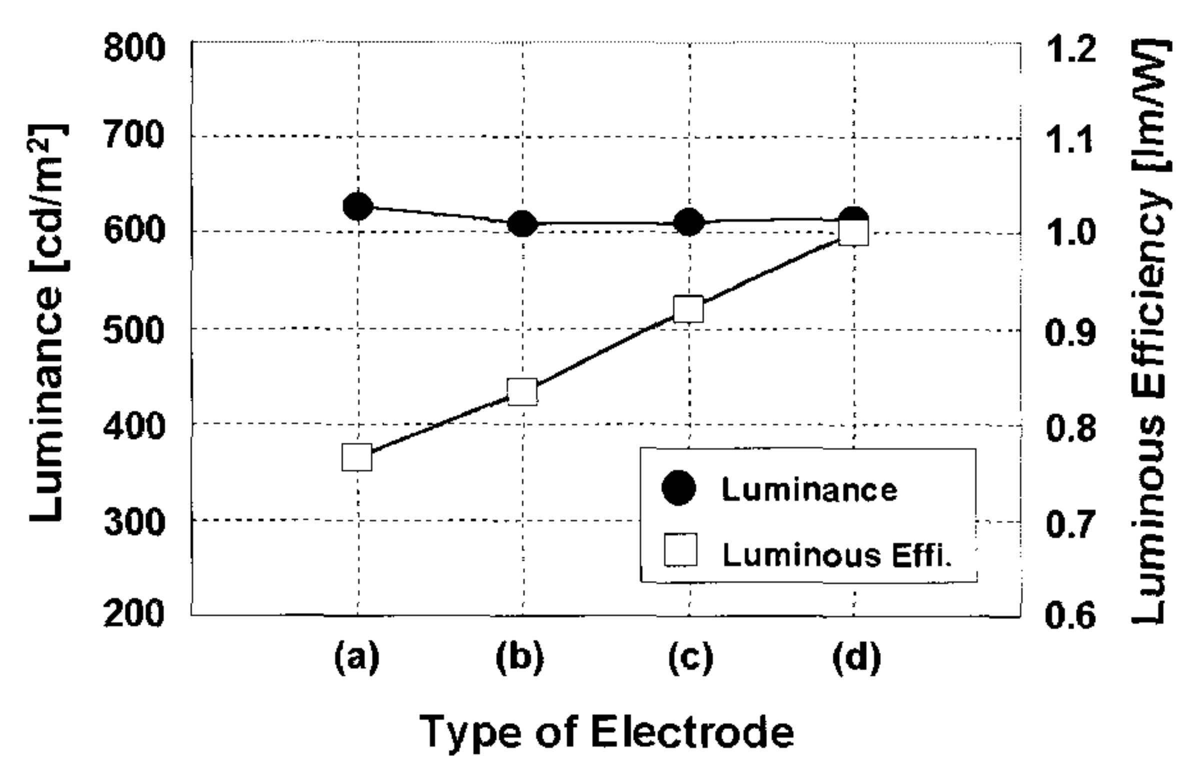


Fig. 5. Luminance and luminous efficiency characteristics as a parameter of a kind of sustaining electrode shown in Figs. 2(a)-(d).

Fig. 5 shows the luminance and luminous efficiency charateristics as a parameter of the kind of sustaining electrode, as shown in Figs. 2(a)-(d). From this figure, it can be deduced that although the bullet-type electrode areas in Figs. 2(b)-(d) are eliminated, the luminance of the AC PDP does not vary so much because the main visible light emission part is around the sustaining electrode gap[8-10].

The luminous efficiency is, however, increased with the bullet-type etching area until the height H of the bullet is about 130 ㎛, as shown in Fig. 2. Moreover, the efficiency is decreased if height H is higher than 130 ㎛ or if the leg width W of the bridge-type electrode is wider than 30 ㎛.

If the leg width W is thinner than 30 ㎛, it is difficult to realized the width exactly in the laboratory level, and there is a tendency to decrease the luminance and the luminous efficiency. From Fig. 5, the peak luminous efficiency is obtained for the sample with electrode shape of Fig. 2(d), and the luminous efficiency is improved by about 28 % compared with the conventional electrode of Fig. 2(a). The improvement in the luminous efficiency may be attributed to the following reasons. The luminous efficiency for a given panel is correlated with the luminance and power consumption, as shown in equation (1). From Fig. 5, the luminance of the test panel is almost the same regardless of the kind of given electrodes in Fig. 2. However, the power consumption is very different from the kind of electrodes. It is well known that the discharge current is increased with the area of the discharge electrodes. Therefore, for a given pulse voltage, the discharge current can be decreased with the increase in the bullet height H, as shown in Fig. 2, because the higher the height, the smaller the electrode area. Furthermore, the decrease in the discharge current for a given pulse voltage leads to a decrease in the power consumption.

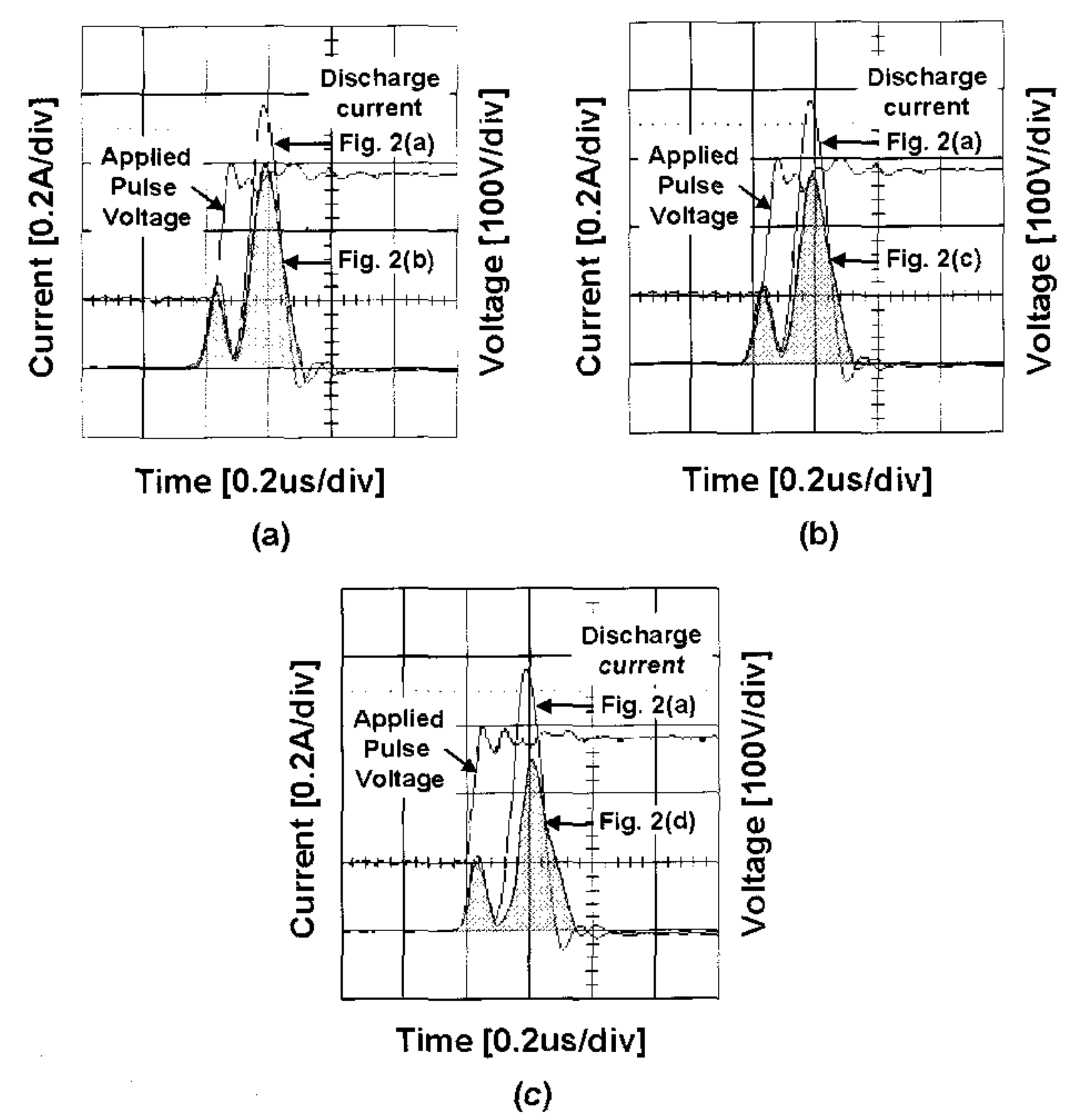


Fig. 6. Discharge current waveforms for the model ac PDP with the electrodes of Figs. 2 (a), (b), (c) and (d)

Another reason for decreasing in the power consumption is to control or suppress the discharge current by controlling the leg width W as shown in Fig. 2, because the narrower the leg width, the higher the discharge current path resistance[11-12].

Fig. 6 shows the current waveform characteristics for the conventional and suggested electrode. The current waveforms have two peaks. The first peak shows the displacement current which charges the stray capacitance of PDP cells, and the second peak of the waveform shows the discharge current. For Fig. 6(c), comparing the two current waveforms for the conventional electrode of Fig. 2(a) and the suggested electrode of Fig. 2(d), the displacement current is almost the same. However, the average discharge current for the suggested electrode is decreased by about 28 % compared with the conventional electrode, which leads to an improvement of luminous efficiency by about 28 % compared with the conventional electrode, as shown in Fig. 5.

4. Conclusion

In order to improve the luminous efficiency of ac PDP, a bridge type sustaining electrode has been suggested. For the suggested type, the luminous efficiency is improved by about 28 % compared with conventional stripe type electrodes. This type has also a merit of align free between front and rear panel.

The improvement in luminous efficiency may be due to the following reasons. Since the new type has the same sustain electrode gap as the conventional electrode type, the discharge voltage characteristics are almost the same. However, this type has eliminated some parts of the transparent electrode that have no effecd on the peak luminance but in turn increases the path resistance of discharge current, leading to improvement of the luminous efficiency.

References

[1] T.Nishio and K. Amemiya, "High-Luminance and High Definition 50-in.-Diagonal Co-Planar Color PDPs with T-Shaped Electrodes," SID digest, pp. 268-271, 1999.

[2] K. Amemiya, "Surface Discharge AC Plasma Display Apparatus and Driving Method Therefor," US patent, US6037916, 2000.

[3] Shahid Rauf and Mark J. Kushner, "Dynamics of a coplanar-electrode plasma display panel cell. I. Basic operation," Journal of Applied Physics, vol. 85, no. 7, pp. 3460-3469, 1999.

[4] Shahid Rauf and Mark J. Kushner, "Dynamics of a coplanar-electrode plasma display panel cell. II. Cell optimization," Journal of Applied Physics, vol. 85, no. 7, pp. 3470-3476, 1999.

[5] C. Punset, S. Cany and J. P. Boeuf, "Addressing and Sustaining in alternating current coplanar palsma display panels," Journal of applied Physics, vol. 86, no. 1, pp. 124-133, 1999.

[6] M. Makino, T. Yoshioka and T. Saito, "Influence of Non-Uniform Electric Field on the Firing Voltage of Surface Discharge AC-PDPs," IEICE Trans. Electron, vol. E80-C, no. 8, pp. 1086-1090, 1997.

[7] J. Rosenkranz, S. Pekarek and M. Zacek, "Breakdown Voltage of the Surface Glow Discharge," IEEE Trans. On Electron Devices, vol. 44, no. 1, pp. 58-61, 1997.

[8] M. Sawa, H. Uchiike, S. Zhang and K. Yoshida, "Direct observation of VUV rays for surface-discharge ac plasma displays by using an ultra-high-speed electronic camera," SID 98 DIGEST, pp. 361-364, 1998.

[9] R. T. McGrath, R. Veerasingam, J. A. Hunter, P. D. Rockett and R. B. Campbell, "Measurements and Simulations of VUV Emissions from Plasma Flat Panel Display Pixel Microdischarge," IEEE Trans. on Plasma Science, vol. 26, no. 5, pp. 1532-1542, 1998.

[10] H. S. Jeong, B. J. Shin and K. W. Whang, "Two-Dimensional Multifluid Modeling of the He-Xe Discharge in an AC Plasma Display Panel," IEEE Trans. On Plasma Science, vol. 27, no. 1, pp. 171-181, 1999.

[11] M. Sawa, T. Tsutsume, K. Yoshida and H. Uchiike, "Effects of Barrier Ribs on Discharge Characteristics of Surface-Discharge ac Plasma Displays by Direct Observation of Vaccum Ultraviolet Ray," SID 99 digest, pp. 284-287,1999.

[12] R. Veerasingam, R. B. Campbell and R. T. McGrath, "Two-Dimensional Simula- tions of Plasma Flow and Charge Spreading Across Barrier Pixels in AC Plasma Display," IEEE Trans. on Plasma Science, vol. 24, no. 6, pp. 1411-1421, 1996.