Efficiency Counter Electrode Discharge Cells of PDP – a macro-cell experiment

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Abstract
In this study, new types of counter electrode discharge cells for PDP were designed. The counter electrode discharge cells were designed to realize long-gap discharge mode, low firing voltage and moderate conductance for evacuation and sealing process of the panel. In order to test the concept of the design, macro discharge cells were prepared and the discharge characteristics were evaluated. The results indicate that discharge behavior may be modified significantly by changing the morphology of discharge cells.

1. Introduction
In recent years, developments of high definition PDP TVs of 40~50 inch in diagonal are required as LCD TVs expand their market to larger sizes. Increase in resolution of PDP, however, reduces volume of discharge cells and that leads to decreased luminance and luminance efficacy of PDP. Various research efforts have been directed to improve the luminance efficacy of PDP, including the development of discharge cells with counter electrode [1]. In the discharge cells, sustaining and scan electrodes are embedded inside barrier ribs such that the discharge occurs between opposite barrier ribs. This arrangement of electrodes makes full use of discharge volumes inside the cells and therefore, the luminance and luminance efficacy of high resolution TVs may be enhanced. In addition, ITO sustaining and scan electrodes, dielectric layer, and MgO protective coating on front plate are not required with this structure, making the panel much more economical compared with conventional coplanar electrode panel.

Recently, Mori et. al. [1] developed a processing route for the discharge cells with counter electrode using green sheet technologies. They reported a decent luminance efficiency of 2.5 lm/watt and a peculiar phenomenon that its firing voltage does not depend on the thickness of dielectric layer sensitively. The cells used for their study were rectangular cells with 230μm in height, which are ideal for preventing cross-talk between neighboring cells. Evacuation of air from such discharge cells during sealing and tip-off process, however, is problematic since the height of barrier ribs is much higher than conventional PDPs. In addition, the glow discharge between the sustaining electrodes was induced between the surfaces of short axis of the rectangular cells due to high firing voltage. For higher discharge efficiency, it is preferably to have discharge along long axis of the rectangular cells to utilize its discharge volume fully.

2. Experimental Page
Figure 1 shows schematic illustrations of semi-closed counter electrode discharge cells used in this study. Main idea of the design was to initiate glow discharge at narrow channels formed between barrier ribs and let the glow discharge propagate towards wider section of the channels, resulting long-gap discharges. In addition, the continuous channels should facilitate the evacuation process of the panel.

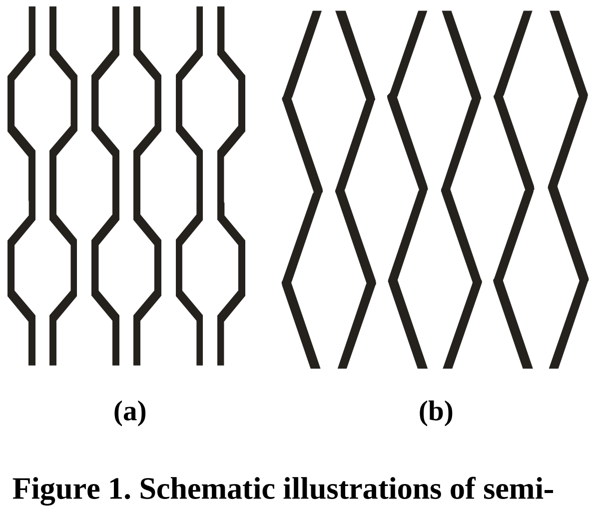
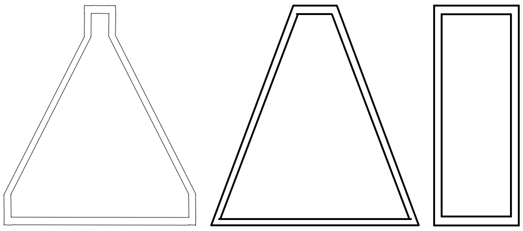


Figure 1. Schematic illustrations of semi-closed counter electrode discharge cells: (a) meander type and (b) serpentine type.



(a) (b) (c)

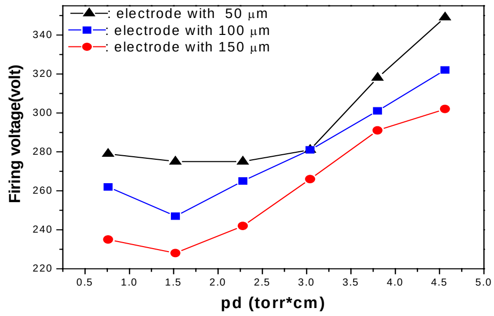
Figure 2. Shapes of macro discharge cells prepared: (a) meander type, (b) serpentine type, and (c) rectangular type.

To test the feasibility of such cell designs, macro-cells were prepared by using glass plate as barrier ribs. The scaling factor of the macro-cells was 58.7 and the model cell was VGA grade of 40 inch panel. Fig. 2 shows the macro-cells prepared for this study. For comparison, rectangular macro discharge cells were also prepared with the same scaling factor. Paschen curves of such cells were determined to evaluate the firing voltage and cross-talk of the cells. In addition, effects of gas compositions and sustaining electrode thickness were evaluated using such cells.

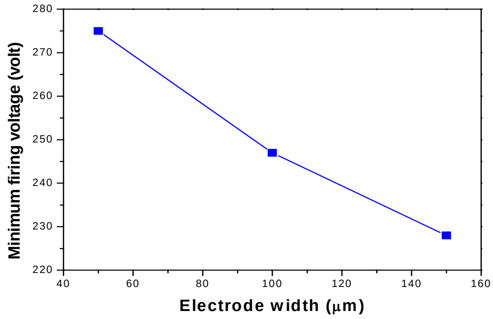
3. Result and discussion

3.1. Effect of sustaining electrode width on firing voltage of rectangular discharge cells with counter electrode

Using rectangular type macro-cells, the effect of electrode width on the firing voltage of discharge cells were investigated. The electrode width was varied from 50, 100, and 150 µm. The electrode gap of counter electrode arrangement was 130µm and discharge gas used was Ne-4%Xe. Discharge within the rectangular cell was investigated since its behavior may be used as references for meander and serpentine type cells. As shown in Fig. 3(a), the firing voltage of the cells followed the Paschen curves of gas glow discharge, showing a minimum at certain 'pd' value. The firing voltage, however, was affected by the width of the counter electrode very significantly. The minimum firing voltage of the Paschen curves decreased monotonically with the increase in the width of sustaining electrode. Increase in the width of electrode from 50µm to 150µm reduced the firing voltage from 275 volts to 228 volts (Fig. 3(b)). This suggests that unlike the coplanar discharge cells, there is additional parameter, i.e., width of electrode, which may be capable of reducing firing voltage of counter electrode discharge cells.



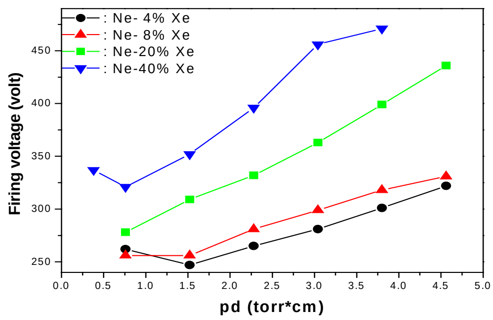
(a)



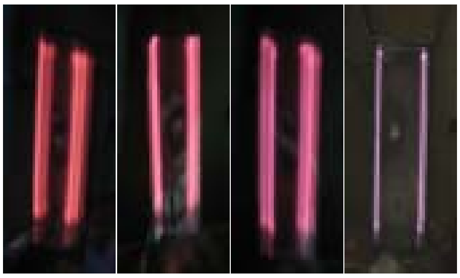
(b)

Figure 3. (a) Effect of electrode width on firing voltage and (b) minimum firing voltage.

Using the same rectangular type macro discharge cell, effect of Xe content on the firing voltage was examined (Fig. 4(a). As expected, the firing voltage increased with the increase in Xe content in discharge gas. The rate of firing voltage increase with pd value appeared to be similar to that of coplanar discharge cells. One of interesting phenomena observed during the macro-cell experiment was that color of the glow discharge changes from red to blue with the increase in Xe content in the discharge gas (Fig. 4(b)).



(a)



Xe 4% Xe 8% Xe 20% Xe 40%

(b)

Figure 4. (a) Paschen curves and (b) color of glow discharge of counter electrode macro discharge cells with different Xe content in discharge gas.

3.2. Glow discharge characteristics of semi-closed discharge cells with counter electrode

Glow discharge characteristics of the serpentine type macro cells (Fig. 1(b)) were examined. With this cell type, once the applied voltage reached the firing voltage, the discharge was initiated entirely over the walls of barrier ribs, irrespective of the distance between the glasses. The initiation was not confined to narrow gap formed between the barrier ribs as we initially expected. As shown in Fig. 5, a typical Paschen curve was obtained with the cells. The firing voltage of the cells, however, was slightly higher than that of the rectangular cells.

Once the glow discharge is initiated with the discharge cell, the region of glow discharge decreased gradually as we decrease the sustaining voltage until it completely distinguished at the narrow gap. Fig. 6 show the glow discharge formed at various sustaining voltages. As noted from the photographs, the volume of glow discharge reduced rather smoothly with the decrease in sustaining voltage. Fig. 7 shows the firing voltage, medium voltage at which the volume of glow discharge is reduced to a half, and minimum sustaining voltage. The firing voltage was always larger than the medium voltage and minimum sustaining voltage. The difference between the firing voltage and minimum sustaining voltage was increased with the increase in pd product value and Xe content (Fig. 7(b)). This suggests that the discharge might be confined to the discharge cell without propagating to neighboring cells if the sustaining voltage is selected to be less than the firing voltage. Therefore, with this cell design, it may not required to have crossing ribs like the one formed in rectangular discharge cells to prevent the cross-talk between the cells.

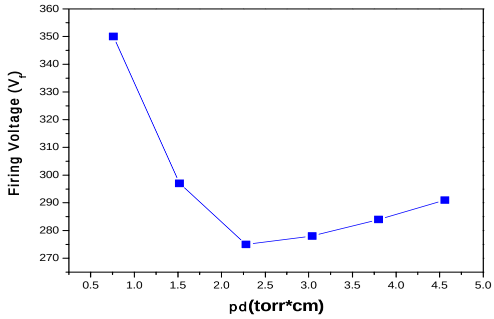
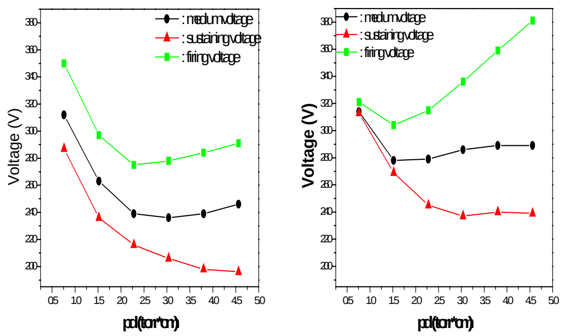


Figure 5. Paschen curve of serpentine type discharge cell.

319V 325V 334V 341V 350V 363V

Figure 6. Volumes of glow discharge in serpentine type micro-cells at different sustaining voltages.



(a) **(b)**

Figure 7. Discharge characteristics of serpentine type discharge cells (a) Ne-4%Xe (b) Ne-20%Xe.

With the meander type discharge cell (Fig. 1.(a)), a completely different type of discharge behavior was observed. With this structure, the discharge is initiated initially at the narrow channel and propagated towards wider channel area as the sustaining voltage was increased. In other words, the firing voltage was lower than that of the sustaining voltage, making the cells absolute stable against cross-talk between neighbouring cells. Fig. 8 shows the discharge characteristics of meander type micro-cells. As shown in the figure, the full firing voltage ($V_{f\ full}$), at which the glow discharge occurs over the entire cell, was measured to be higher than firing voltage (V_{f1}), at which the discharge is initiated at the narrow gap. As the sustaining voltage is reduced from the full firing voltage, the discharge was distinguished at the minimum sustaining voltage (V_s), which is lower than the first firing voltage. This phenomenon is believed mainly due to increased area of sustaining electrode at the narrow gap region of the meander type discharge cell. As noted in Fig. 3, the increase in electrode area leads to decreased firing voltage.

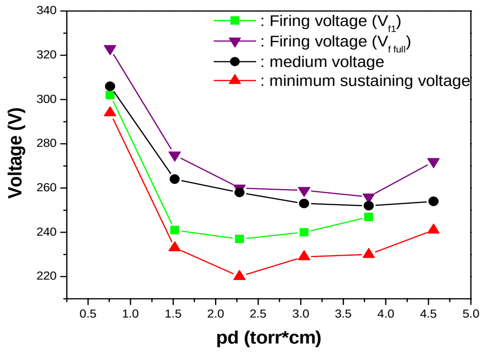


Fig. 8. Discharge characteristics of meander type discharge cells. The discharge gas was Ne-4%Xe.

This behavior, lower firing voltage compared with sustaining voltage, is somewhat contradictory to conventional PDP driving scheme, but may be useful for the development of new driving scheme of PDP.

4 Conclusion

The possibility of using semi-closed discharge cells with counter electrode structure was explored using macro-cell experiment. The results indicated that the width and geometry of discharge cell affect the firing voltage and discharge behavior very significantly. The increase in width of electrode from 50 to 150 μm reduced the firing voltage from 275 volts to 228 volts. In addition, the length of narrow gap in the semi-closed cell was found to influence the discharge behavior dramatically, making the firing voltage lower than the sustaining voltage. With the meander type discharge cell, the firing voltage was lower than sustaining voltage by 20~30 volts.

5. References

[1] S. Mori, S. Ajisaka, A. Oku, K. Ikesue, S. Mori, K. Tanaka, H. Asai, N. Kikuchi, and S. Sakamoto, "Discharge Characteristics of a New Structure AC-PDP using Thick Film Ceramic Sheet Technoligy ", IDW'04 Digest, pp937-940(2004).

[2] S.D.Park, N,H,Shin, J.H.Lee, B.J.Shin, K.C.Choi "Luminance and luminance efficiency of AC-PDP with coplanar long gap and high Xe content gas mixture", SID 04'

[3] Sang-Soon Oh, Do-Young Park, Tae-Jeong Chang and Yong-Seog Kim, "Luminance Improvements of PDP using Reflection Layers Formed via Osmotic Coating Process", SID'04 Digest, Vol.35, pp. 499-501