

New Electrode Shape for High Xe-content Gas in AC PDP

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Abstract

One of the most important issues in AC PDP is the improvement of luminous efficiency. One possible method for achieving this aim is by increasing Xe partial pressure in discharge gas mixture. The increase of Xe ratio, however, causes the driving voltage to rise, even if brightness is increased. In this study, a new electrode shape is proposed. A test panel fabricated by using a new electrode shows that efficacy has improved by 25 % and sustain voltage has decreased by 20 % compared with the conventional structure.

Keywords : ac PDP, luminous efficiency, Xe ratio, ITO electrode, sustain voltage

1. Introduction

Display technology is steadily evolving to towards a flat and largen surface are a and that which can be easily hung on walls. The alternating current plasma display panel (AC PDP), which has been continuously developed for almost 30 year, has been improved remarkably in the past several years and is expected to open up a new and large display market. The most essential aspect of the AC PDP, that must be achieved to be accepted in the relevant market, is the improvement of its luminous efficiency [1-3]. The white light efficiency in the present PDP which is currently about 1.5 lm/W, is relatively low in comparison with CRT (5 lm/W) and the brightness is apparently limited. Furthermore, even though luminous efficiency improved, such improvement shall need to tetain low cost manufacturing process, including low voltage driving.

The luminous efficiency in PDP is given by the following elemental efficiencies: (1) efficiency of the production of vacuum ultraviolet (VUV) in plasma; (2) efficiency of the transportation of VUV from the discharge volume to the phosphor surface in a discharge cell; (3) efficiency of the transformation of VUV to visible light (phosphor efficiency); and (4) efficiency of the utilization of the visible light. Among these elemental efficiencies, the VUV production efficiency is expected to make the largest contribution in increasing the luminous efficiency[4]. Based on the foregoing, many research groups and panel makers have challenged themselves into achieving high efficiency PDP using gas mixture system with high Xe partial pressure. However, increasing Xe partial is pressure generally induces high driving voltage, which is not desirable in overall stability of the system, power efficiency of the driving circuit, electromagnetic interference and cost effective production. High firing voltage of high Xe panel is believed to come from low secondary electron emission coefficient of Xe and low electron temperature due to the increase in collision probability.

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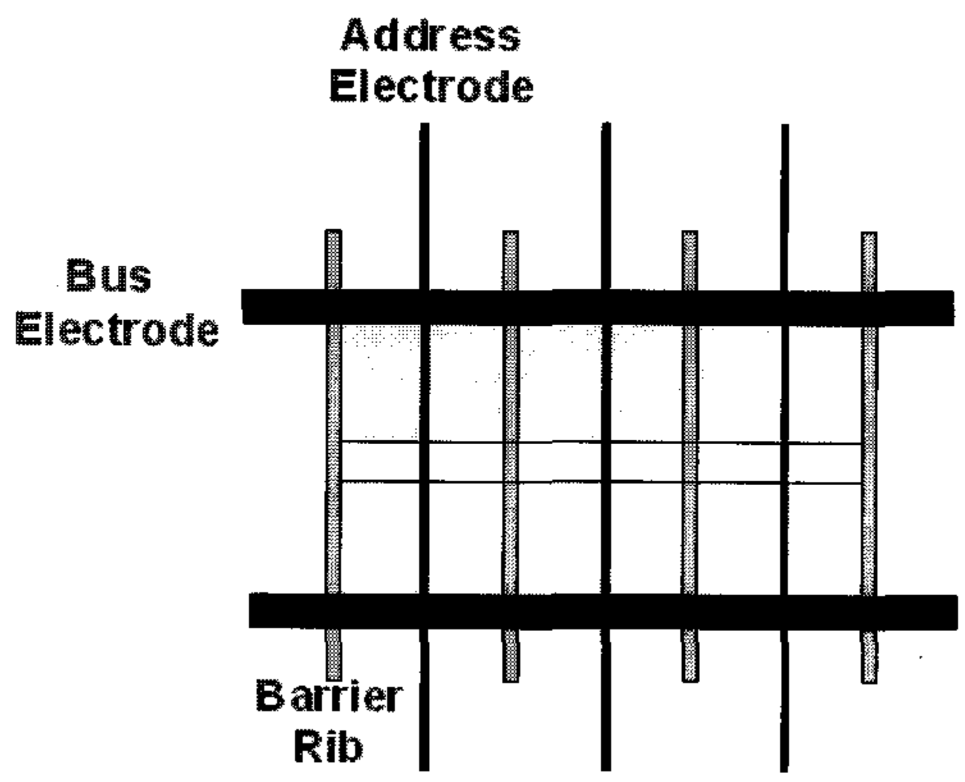
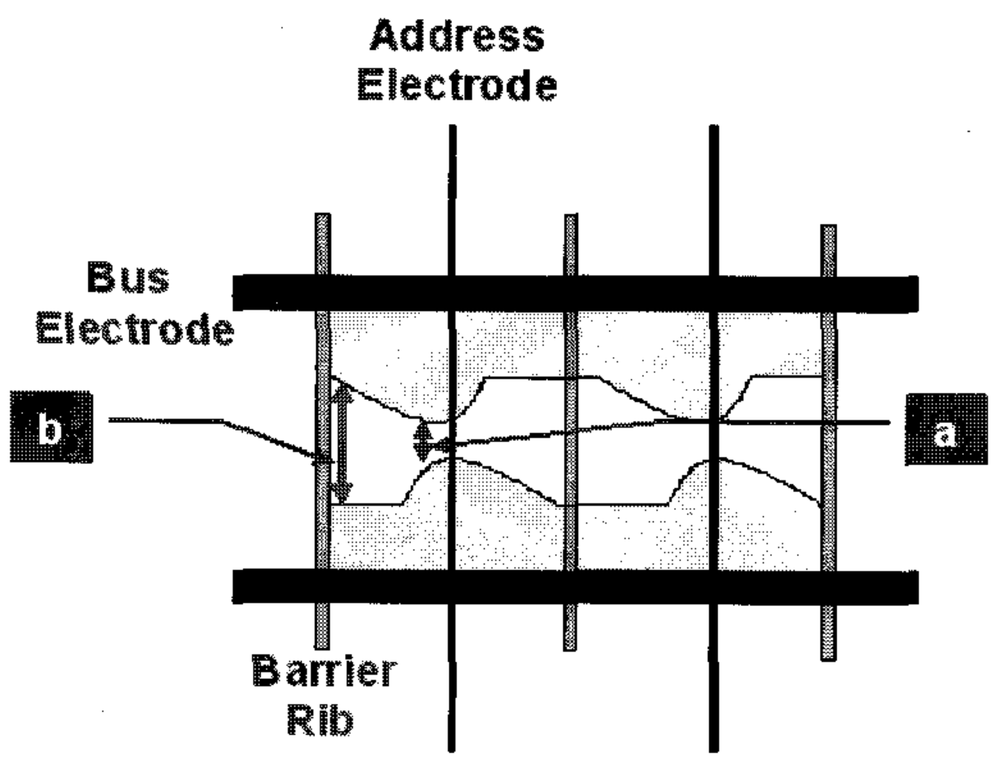
In this paper, a new ITO electrode shape suitable for high Xe PDP is proposed. Particular interests are put on the low voltage driving with high efficiency. The feasibility of the proposed electrode was verified by experiments.

2. Experiments

Fig. 1(a) shows the conventional stripe-type electrode used as reference. Fig.1(b) shows the schematics of the suggested electrode to realize low voltage driving and high luminous efficiency in PDP with high Xe partial pressure. The key feature of the suggested electrode is the variable gap distance. The important parameters that need to be optimized are the minimum and maximum gap lengths ***a*** and ***b***.



(a) Conventional Structure



(b) Proposed Structure

Fig. 1. Schematic diagram of conventional and proposed structures.

Table 1 shows the specification of test panel, that corresponds to VGA grade in a 42" panel.

Fig. 2 shows the manufacturing process of the front and rear panel of an AC PDP. First, the front panel is made to go through the patterning of ITO electrodes by the photolithography methods. Then, the bus electrodes, conductivity layer (Ag paste), are formed by the photolithography. Dielectric layers are made by screen-printed method on bus electrodes. Sealing glass layers are applied to the perimeter of the display area and pre-fired. This sealing glass causes the front and rear plates in the assembly of the panel to adjoin and cauising a protective layer, MgO, to evaporate on the front panel.

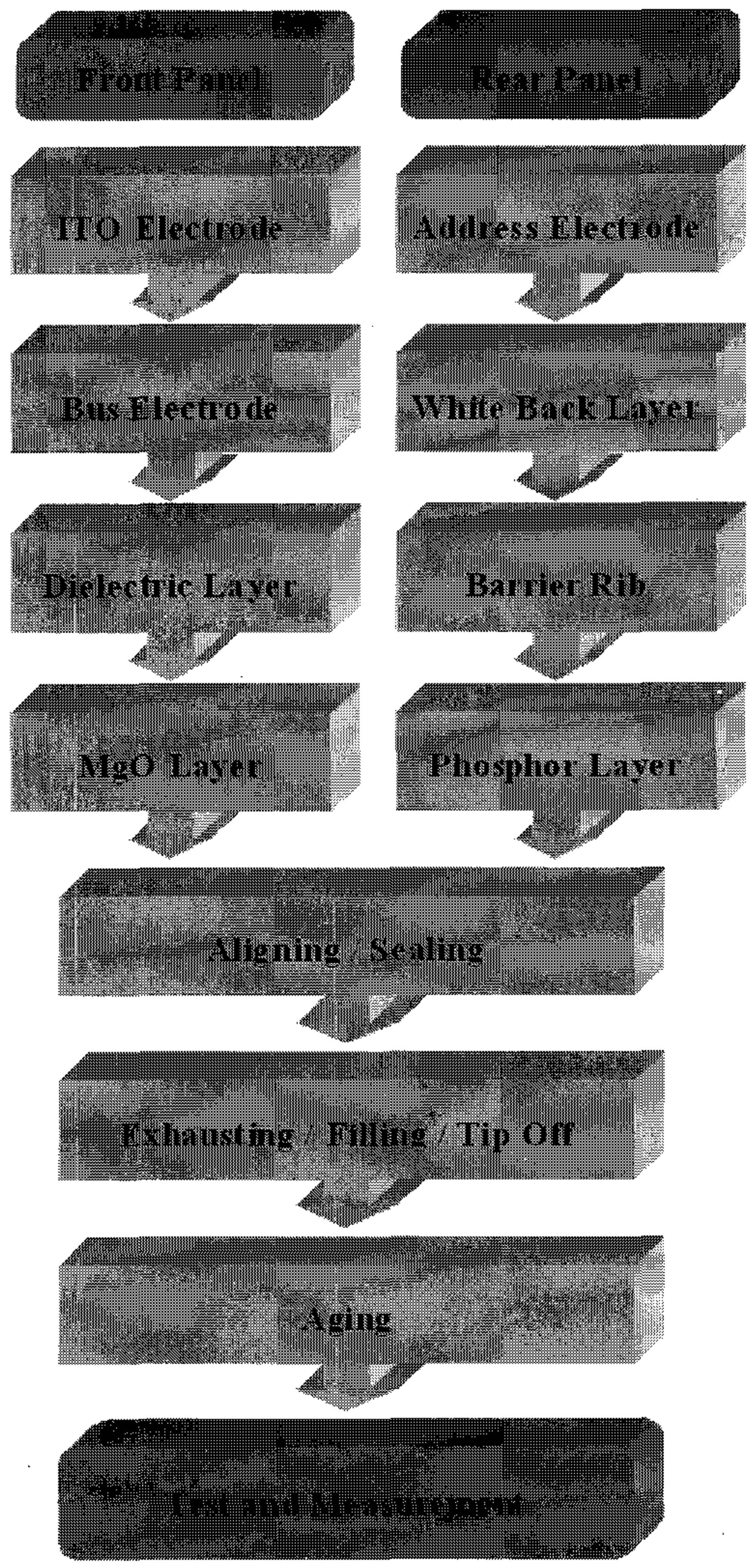


Fig. 2. Flowchart of manufacturing process of test panel.

The manufacturing process of the rear panel is slightly different from that of the front panel. A small hole is first made at the corner of the rear plate to connect to the vacuum system. Address electrodes (Ag

Table 1. Specifications of test panels

		Conventional structure	Suggested structure
Front Glass	ITO Gap	60 μm	a: 30~40 μm b: 50~80 μm
	ITO Width	310 μm	310 μm
	Dielectric Thickness	30 μm	30 μm
	MgO Thickness	5000 Å	5000 Å
	Bus Electrode Width	100 μm	100 μm
Rear Glass	White Back Thickness	15 μm	15 μm
	Barrier Height	130 μm	130 μm
	Phosphor Thickness	30 μm	30 μm
	Address Electrode Width	100 μm	100 μm
Gas	Ne+Xe(10 %)		

Table 2. Static characteristics

	Vf_n[V]	Vf_l[V]	Vsm_n[V]	Vsm_l[V]
Conventional	269	240	178	149
S3050	197	176	133	126
S3060	205	184	139	129
S3070	225	215	159	131
S4060	208	200	159	131
S4070	218	216	156	146
S4080	237	216	161	149

paste) are first printed, followed by the dielectric layers. The barrier ribs are formed by sandblast method and fluorescent material is printed among the ribs.

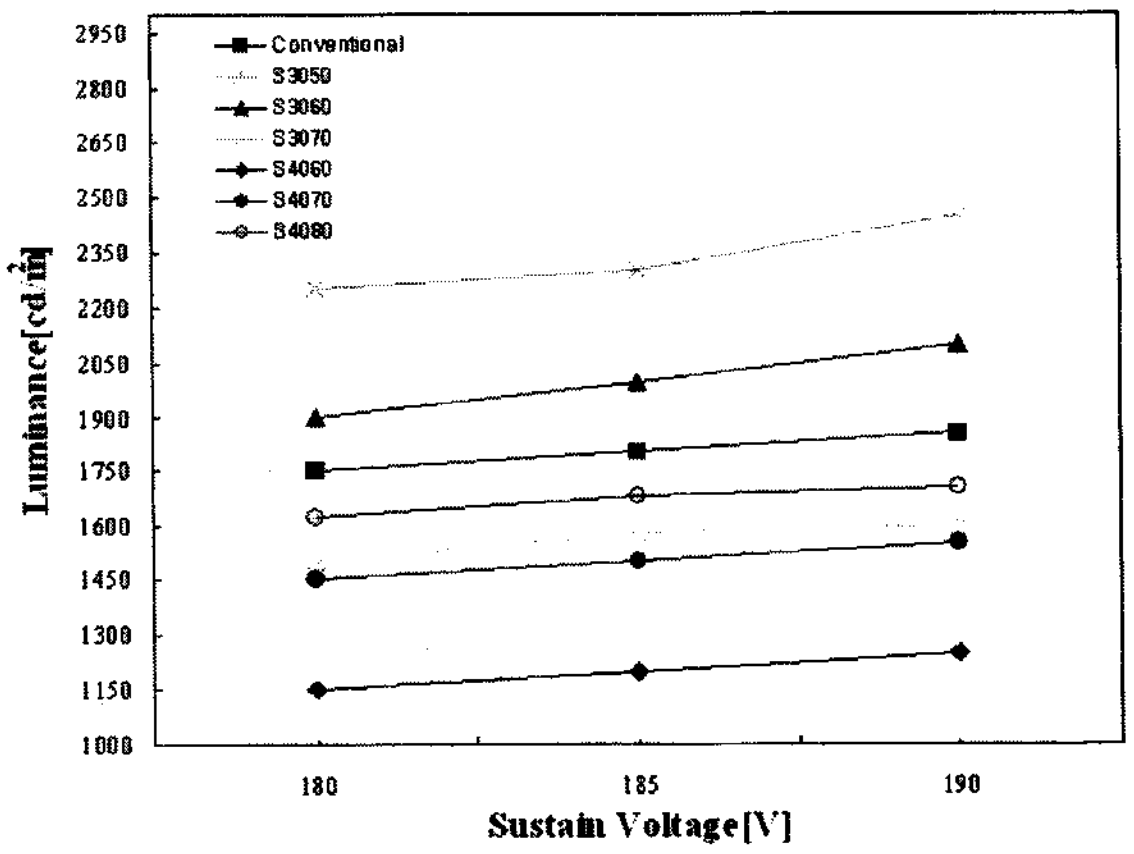
After assembling the front and rear plates, the panel under goes a firing process as the frit glass of low-melting point seals the plates together. Baking process under vacuum is carried out to remove the contaminations adsorbed on the inner surface of the panel and to activate the protective layer. Finally, Penning mixture gas is admitted into the panel.

The panel is then operated under the condition of a a somewhat higher voltage than firing voltage. This in turn, aging operation cleans and activates the protective layer. This in turn, lowers the operating voltage and increases the uniformity on account of reducing the differences of the operating voltage over several regions of the panel[5-7].

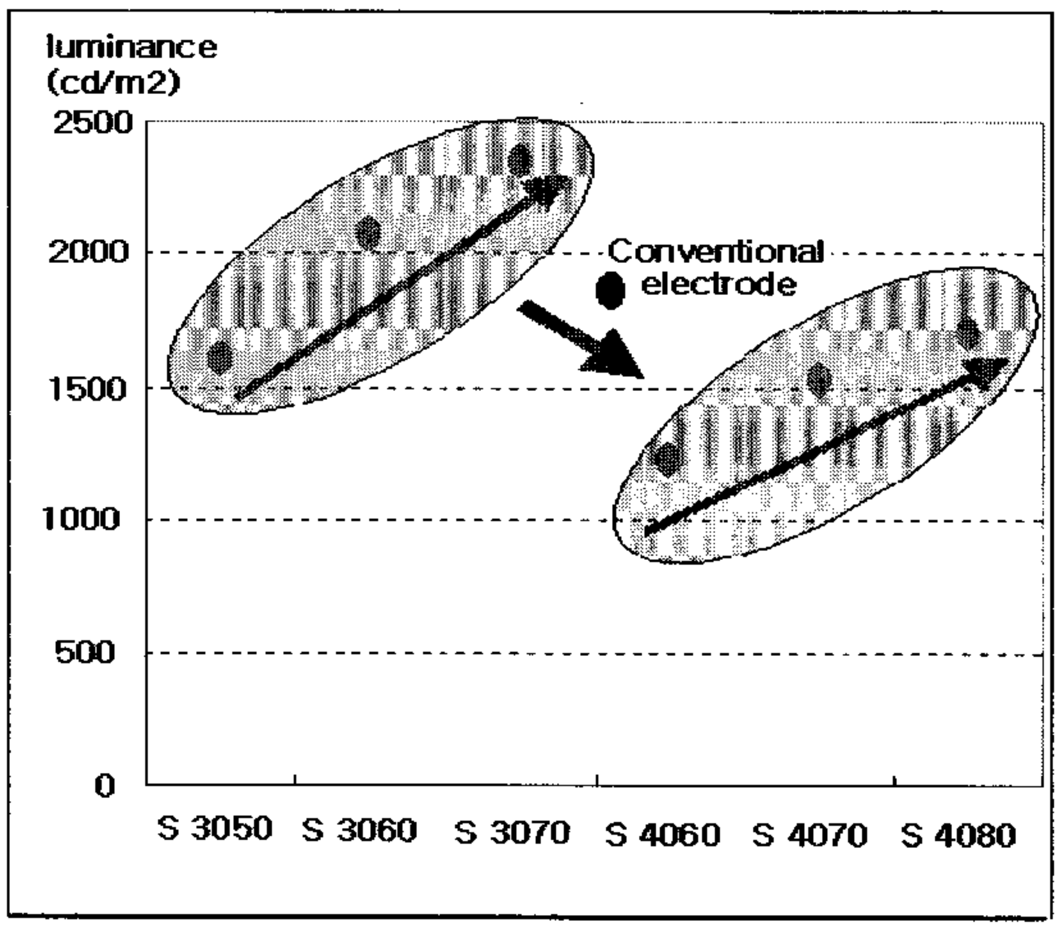
3. Results and Discussion

Table 2 shows the static characteristics of the conventional and suggested electrode. The sample name indicates the gap distance of ***a*** and ***b***. ***S3060***, for example, has the shortest gap of 30 μm and the longest gap of 60 μm. The static voltage characteristics of all suggested electrode shapes, especially, the first-on(Vf_l) and first-off(Vsm_n) voltages, are lower than that of the conventional type. The sample group of S30xx has relatively low firing voltage than the S40xx group. The firing voltage is also dependent on the longest gap length. It tend to increase with the increase of the longest gap length.

Fig. 3 shows luminance changes of each structure as a function of sustain voltage at 50 KHZ. Luminance increases with sustain voltage for all samples, which is quite an obvious result. Luminance also increases with the longest gap length for both S30xx and S40xx groups. However, S30xx group shows a higher luminance than S40xx group. It is interesting to note that the shortest gap ***a*** and the longest gap ***b***, shows different dependency in terms of luminance characteristics. Although the exact mechanisms behind this result cannot be explained in simple manner, this implies that space-time evolution of



(a)



(b)

Fig. 3. (a) Luminance changes as a function of sustain voltage, (b) Luminance changes as a function of gap length (Vs= 190 V).

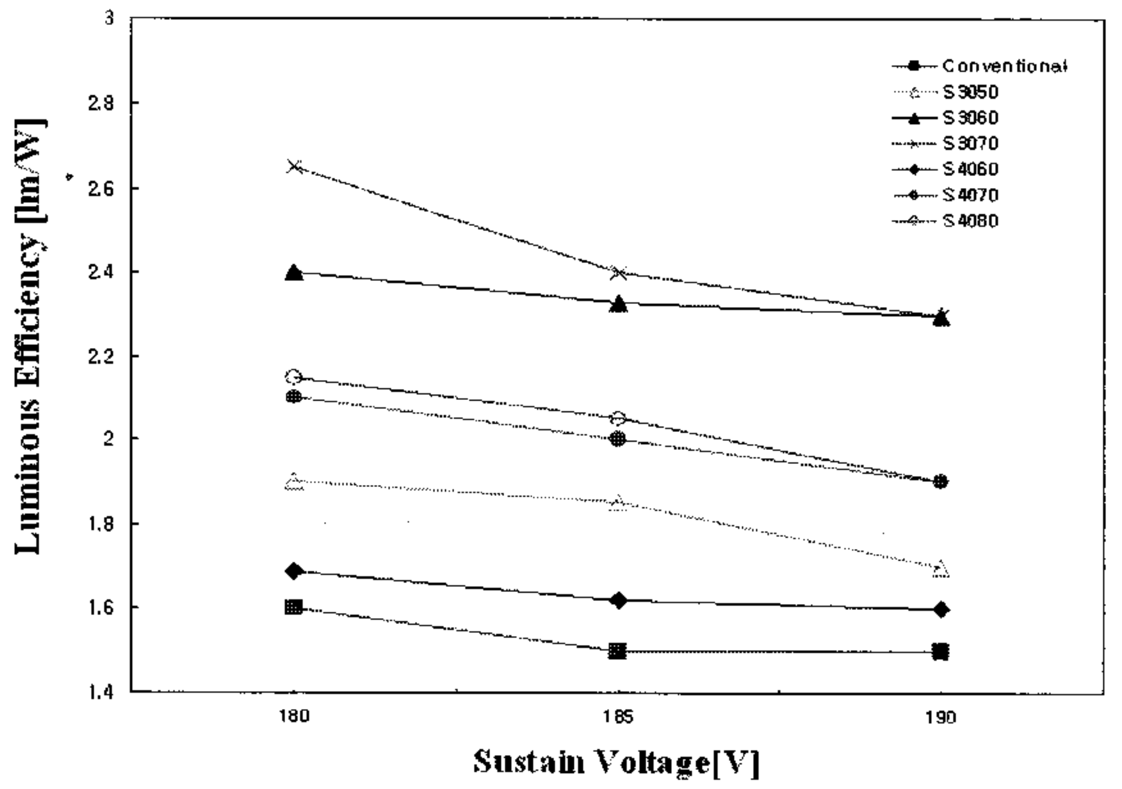
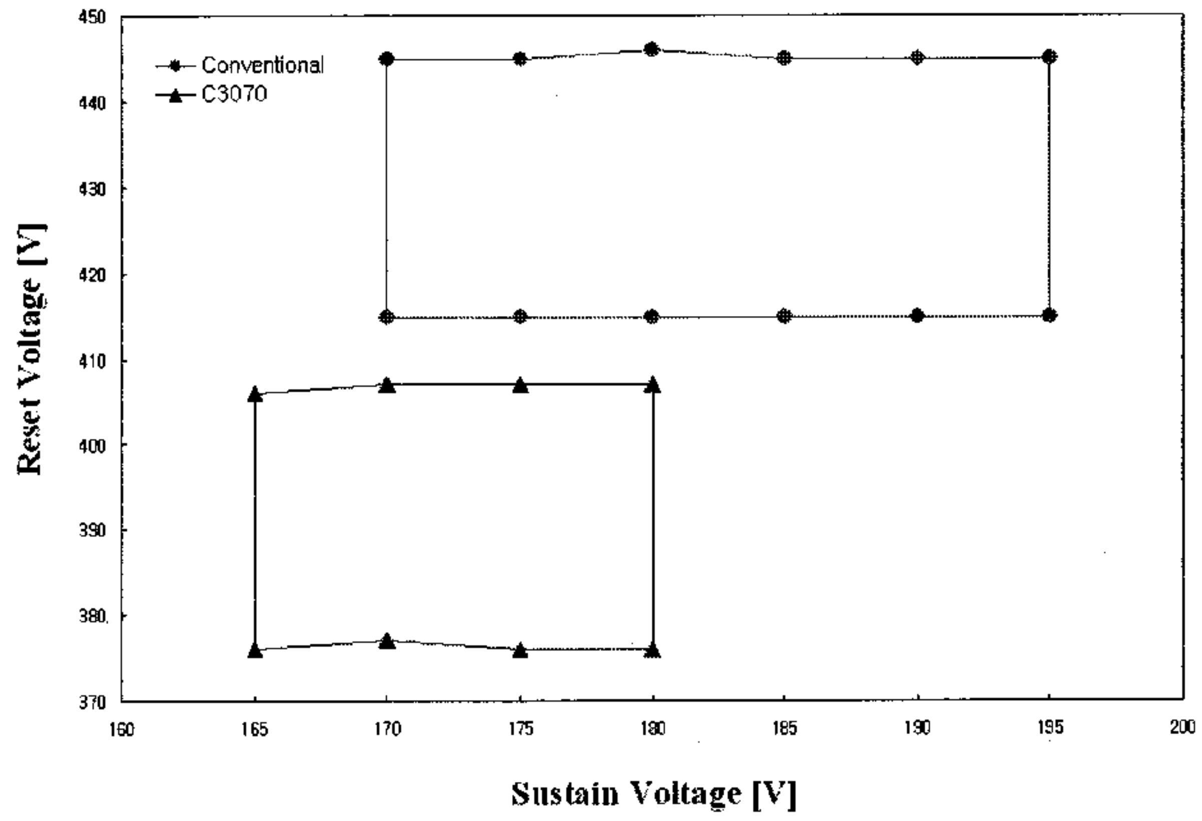
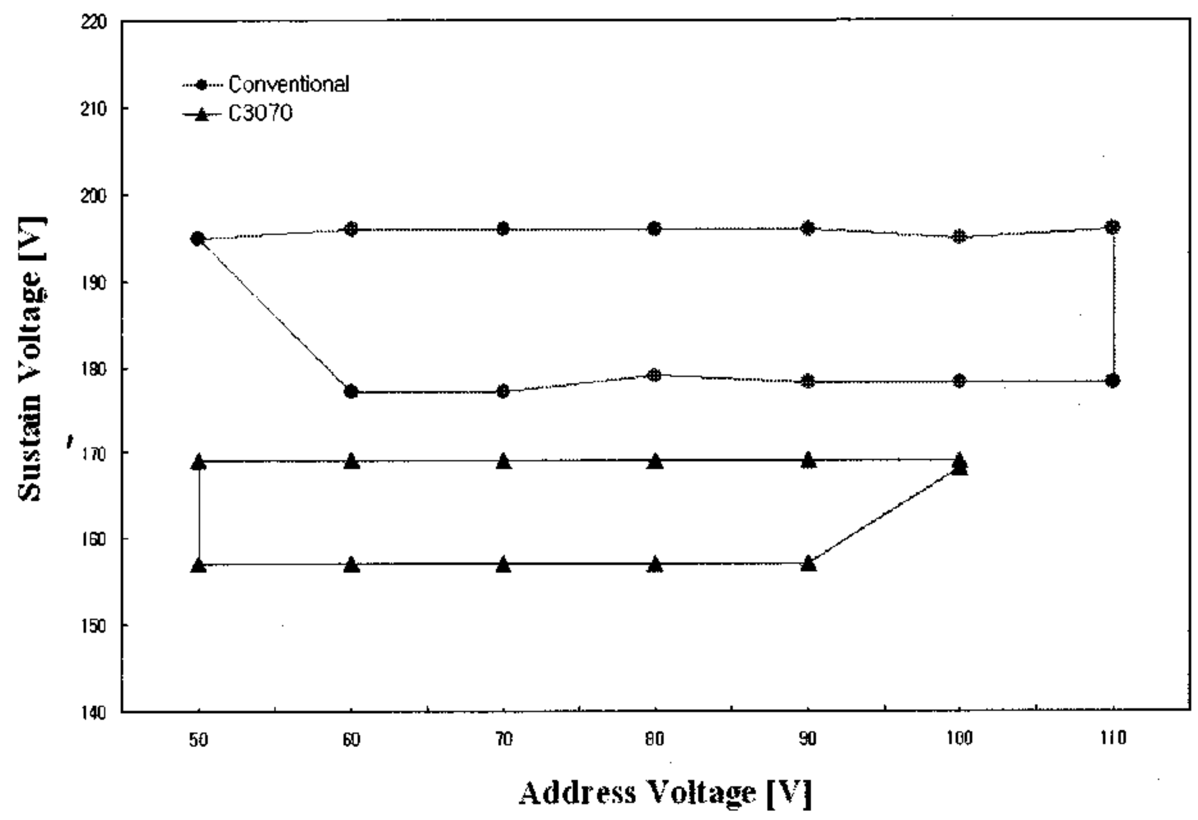


Fig. 4. Luminous efficiency changes as a function of sustain voltage.

the micro plasma in the non-uniform field to the luminance characteristics is important. It should also be noted that if the gap length ***a*** becomes too short, self-erasing occurs and if the gap length ***b*** becomes too long, we have high driving voltage would be high. These are the limiting factors to consider in the design of ITO electrode with variable gap length. For convenience, luminance characteristics are re-plotted in Fig 3(b), which shows clear dependency on the gap length.



(a) Reset voltage versus Sustain voltage



(b) Sustain voltage versus Address voltage

Fig. 5. Dynamic characteristics.

Fig. 4 shows luminous efficiency changes of each structure as a function of sustain voltage at 50 KHz. Efficiency decreases with sustain voltage and increases with longest gap length ***b***, for both S30xx and S40xx groups. These tendencies suggest that high efficiency is achieved at relatively weak electric field. Under the experimental conditions applied in this experiment, it can be assumed that the reduction of ionization energy loss due to the decrement of electron energy is responsible for efficiency improvement. However, group S30xx is found

Table 3. Operating Voltage

	Vreset [V]	Vblk [V]	Vscan [V]	Vadd [V]	Vsus [V]
Conventional	430	190	90	80	185
C3070	395	180	70	60	170

to show more efficient than S40xx group. This is most likely not due to weak-field effect. It resembles luminance results. A more detail analysis is needed. From a practical point of view, improvement of both luminance and luminous efficiency would be the most desirable.

Fig. 5 shows the dynamic margin characteristics of sample S3070 that shows the best luminous efficiency and luminance. Fig. 5(a) shows the relationship between the erasing (Reset voltage) versus the displaying (Sustain voltage). The effects of changing the amplitudes of both the reset and the sustain voltages are also presented. The part within a window shows the satisfactory operation area. In other words, this area is the region between the maximum and the minimum dynamic sustain/reset voltage limits where addressing is performed correctly under the condition of actual driving. Fig. 5 (b) shows the relationships between the writing (Address voltage) and the displaying (Sustain voltage). As can be seen from the figure we were able to drive the panel having proposed electrode shape substantially low voltage compared with the conventional one.

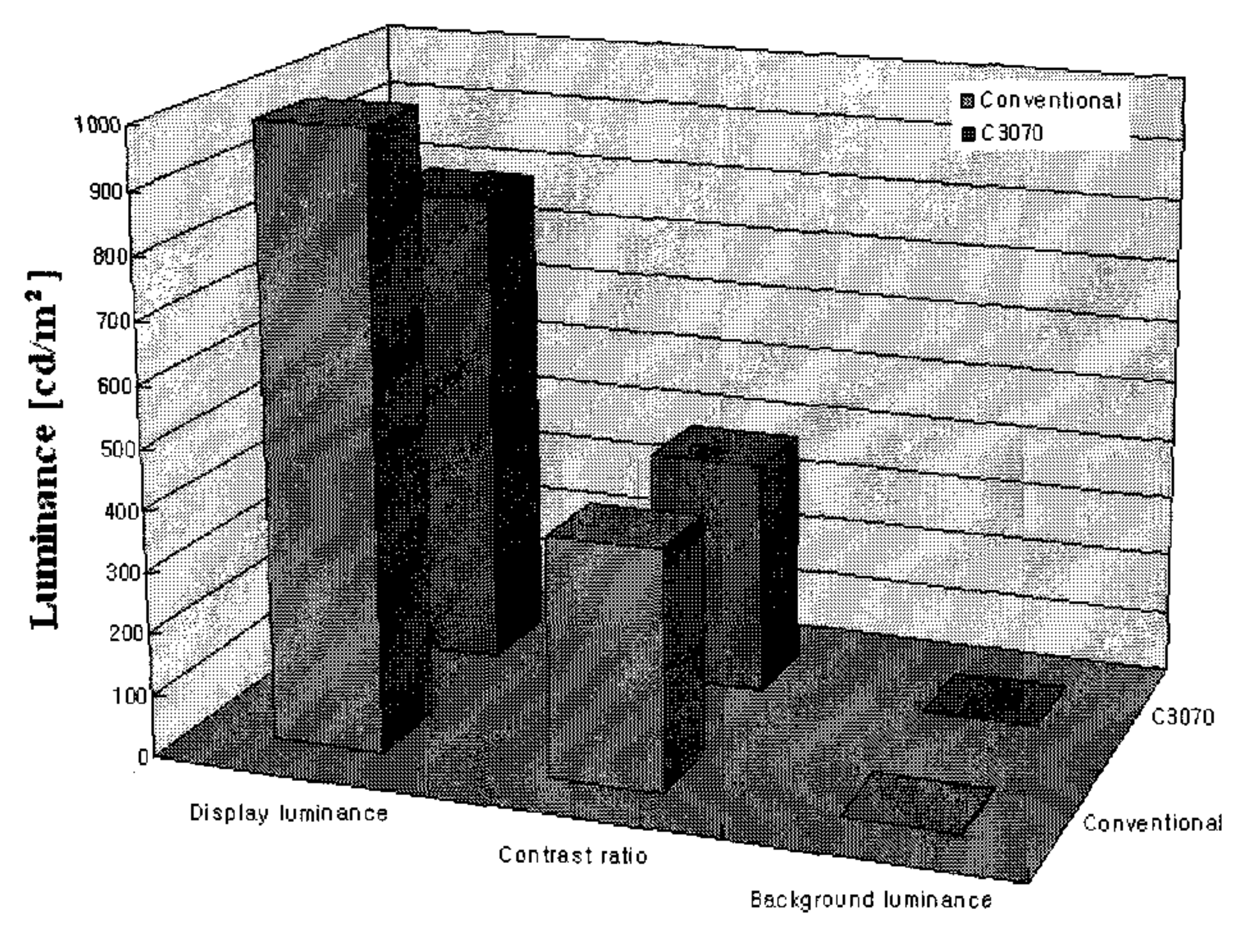


Fig. 6. Display and background luminance and contrast ratio.

Fig. 6 shows the display and background luminance and contrast ratio of reference and S3070 sample for ADS driving situations. The driving conditions for each sample are shown in Table 3. Those conditions, which are determined based on the dynamic margin characteristics, show the most stable ADS driving for each panel. The display luminance and background luminance of conventional structure (992[cd/m$_2$], 2.58[cd/m$_2$]) are seen to be higher than that of ***S3070*** due to the different operating voltages, there appear to be no meaningful differences in contrast ratio between the two samples.

4. Conclusion

In this paper, a new ITO electrode is proposed in order to improve luminous efficiency and to reduce the driving voltage of AC PDP having relatively high Xe ratio. The key feature of the new electrodes is the non-constant gap length. Intensive experimental study has been performed to optimize the minimum and maximum electrode gap length, ***a*** and ***b*** that oexist in a single cell. The performance of the proposed electrode structure has been investigated in terms of luminance, luminous efficiency, dynamic margin and contrast ratio. These characteristics were compared with the conventional stripe-type ITO electrode. The results can be summarized as follows:

(1) Luminance and luminous efficiency were increased with increase in the maximum gap of the sample group having same minimum gap size. The sample group with shorter minimum gap showed better luminance and luminous efficiency. (2) For all characteristic voltage in ADS driving such as reset, address and sustain voltage, the suggested electrode structure provided much lower value. (3) The contrast ratio showed no meaningful difference between conventional and the proposed electrode structures.

Considering these experimental results, we expect the sample ***S3070*** will be a good reference for new cell design in connection with the future development of low voltage-high efficiency driving of high-Xe PDPs.

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