

An Electrical and Optical Characteristics of the Color ac Plasma Displays with a New Cell Structure

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Abstract

New types of ac plasma display panel (PDP) cells are designed and tested electro-optically. We proposed two types of sustaining electrode to improve the luminous efficiency. One is the meander electrode, which has longer discharge path length and smaller electrode area than conventional type. The other is the bridge-shaped electrode, which eliminates the transparent electrode near the barrier ribs. They show higher luminous efficiency and lower power consumption than conventional type.

Keywords : Ac PDP, new cell structure

1. Introduction

Full color plasma displays have received great attention as a possible candidate for large area flat panel displays. It has advantages over conventional display technologies in terms of screen size, thickness, durability and wide viewing angle. The usual method of achieving color in the plasma displays is to excite the phosphors for the three primaries R, G, and B with the VUV radiation produced in the gas discharge[1-3]. The present stage of the development of ac PDP, however, is not satisfactory with regard to the luminance and the luminous efficiency.

In the present study, in order to increase in the luminous efficiency and decrease in the power consumption of the plasma display panels, we have suggested new types of ac PDP cells. One is the meander type-sustaining electrode, which has longer discharge path length and smaller electrode area than conventional type. The other is the bridge-shaped sustaining electrode, which is eliminated the transparent electrode near the barrier ribs. The structure of bridge type is similar to that of T-shaped electrode suggested by T. Nishio and K. Amemiya[4]. However, in the bridge type cells, the transparent electrode is connected with neighborhood cells in order to increase the tolerance of alignment, whereas in the case of T-shaped electrode, mis-alignment have close relationship with panel characteristics, such as in voltage margin, contrast ratio and driving conditions[4]. And, the bridge type cell was designed so that the luminance is almost the same as the conventional type through generation of the initial discharge same with the conventional type.

In this paper, 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 schematic diagram of a typical ac PDP is shown in Fig. 1. Its characteristic features are that the sustaining and addressing electrodes are coated with dielectric layer, and the display is operated by the surface discharge mode. In the panel, the front glass bears two sets of parallel sustaining electrodes. Addressing electrodes are placed orthogonal to the sustaining electrodes, on the opposite rear glass. In the front glass, there is a

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protective film of MgO to prevent deterioration of the dielectric layer caused by ionic impacts. MgO has a deterioration-preventing effect, and has favorable

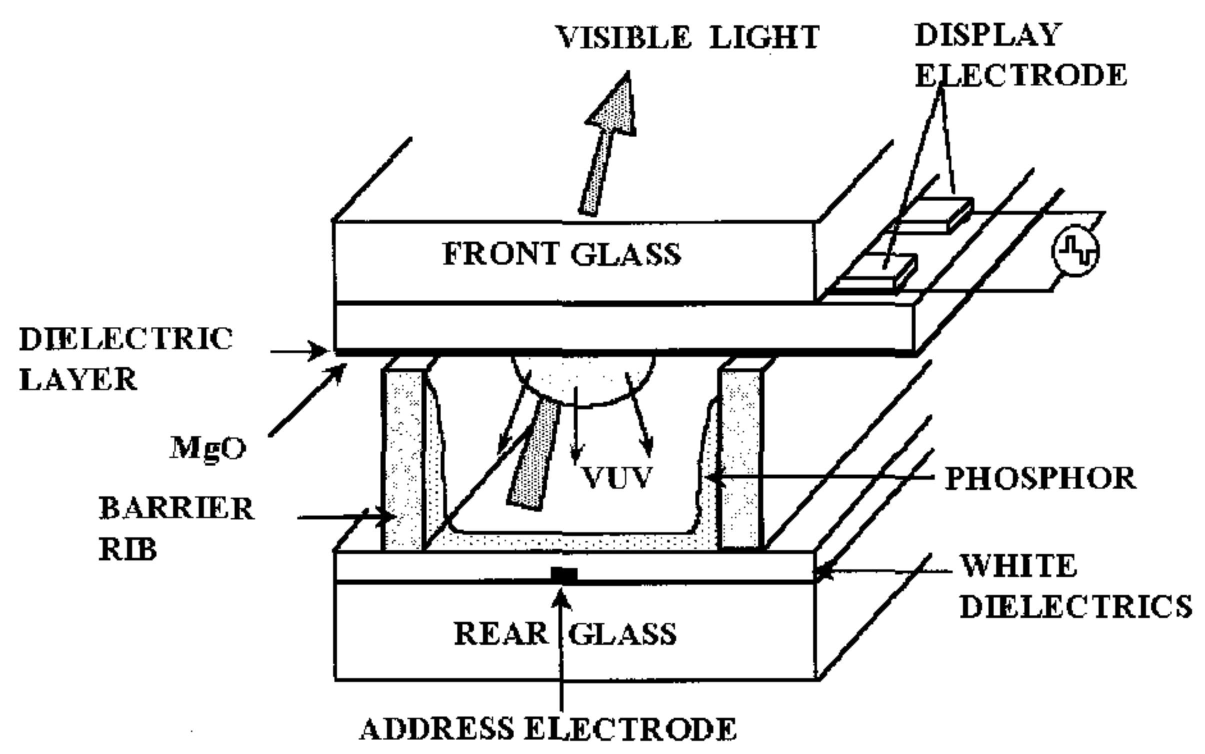


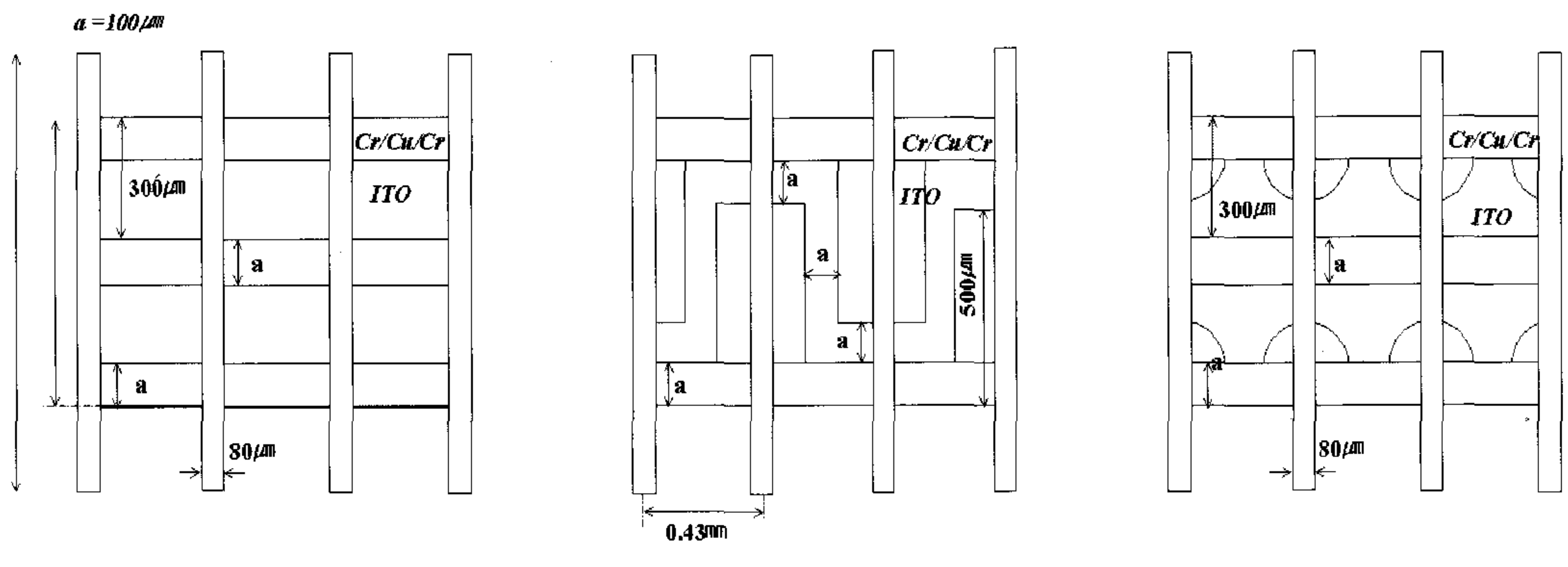
Fig. 1. The schematic diagram of model ac PDP.

characteristics in that its discharge voltage is low, thanks to a high 2nd electron emission coefficient. And, the rear glass has a phosphor layer for converting the VUV to visible light for color displays, and barrier ribs to control the discharge gap, which is usually ~200 ㎛, and to separate the cells[1-3].

Fig. 2 shows the construction of conventional and new type sustaining electrodes. The characteristic feature of new type sustaining electrode shown in Fig. 2(b) is the meander electrode gap. These cells have longer discharge path length and smaller electrode area than conventional ac PDP cells. The reasons for taking this structure are as follows. Since the maximum electric field is shown in gap of the sustaining electrode, the discharge is initiated at the edge of the gap. Moreover, the maximum generation spot of VUV in ac PDP cells is the edge of a sustaining electrode[5-6]. The other structure shown in Fig. 2(c) has a small electrode area because we eliminated the transparent electrode on both sides of the ribs with half circle shape to avoid diffusion loss. Besides, it maintains its discharge path length as that of conventional ac PDP. To compare with the electrical and optical characteristics, three kinds of cells, as shown in Fig. 2, are made on a panel and have tested. The sustaining electrodes are made of a transparent conductive thin film (ITO) with the Cr/Cu/Cr bus electrode on the ITO that leads to lower electrode resistance. Fig. 3 shows the manufacture flowchart of the test ac PDP[7-8].

Fig. 4 shows the schematic diagram of discharge test chamber used for measuring the electrical and optical characteristics. The vacuum chamber is a cylinder type of 200 ㎜ in diameter, and 80 ㎜ in height. The upper part is made of quartz view-window to investigate the optical characteristics. The pressure is measured with a pressure transmitter (Setra co., Model 280E) with a digital indicator (GLA co., MD-100) from atmospheric pressure to 1 Torr. An ac square pulse, which can be controlled with the frequency range of 5 to 50 ㎑ and within the voltage range of 0 V to 300 V, is applied to the cells.

In this study, the test samples are prepared by assembling the rear and front panel with clip. And then the test samples are installed to the discharge test chamber. It is first exhausted up to ~10^{-6} Torr so as not to be affected by the residual gases. Thereafter, the He-



(a) conventional **(b) meander type** **(c) bridge shaped**

Fig. 2. Construction of conventional and new type sustain electrode.

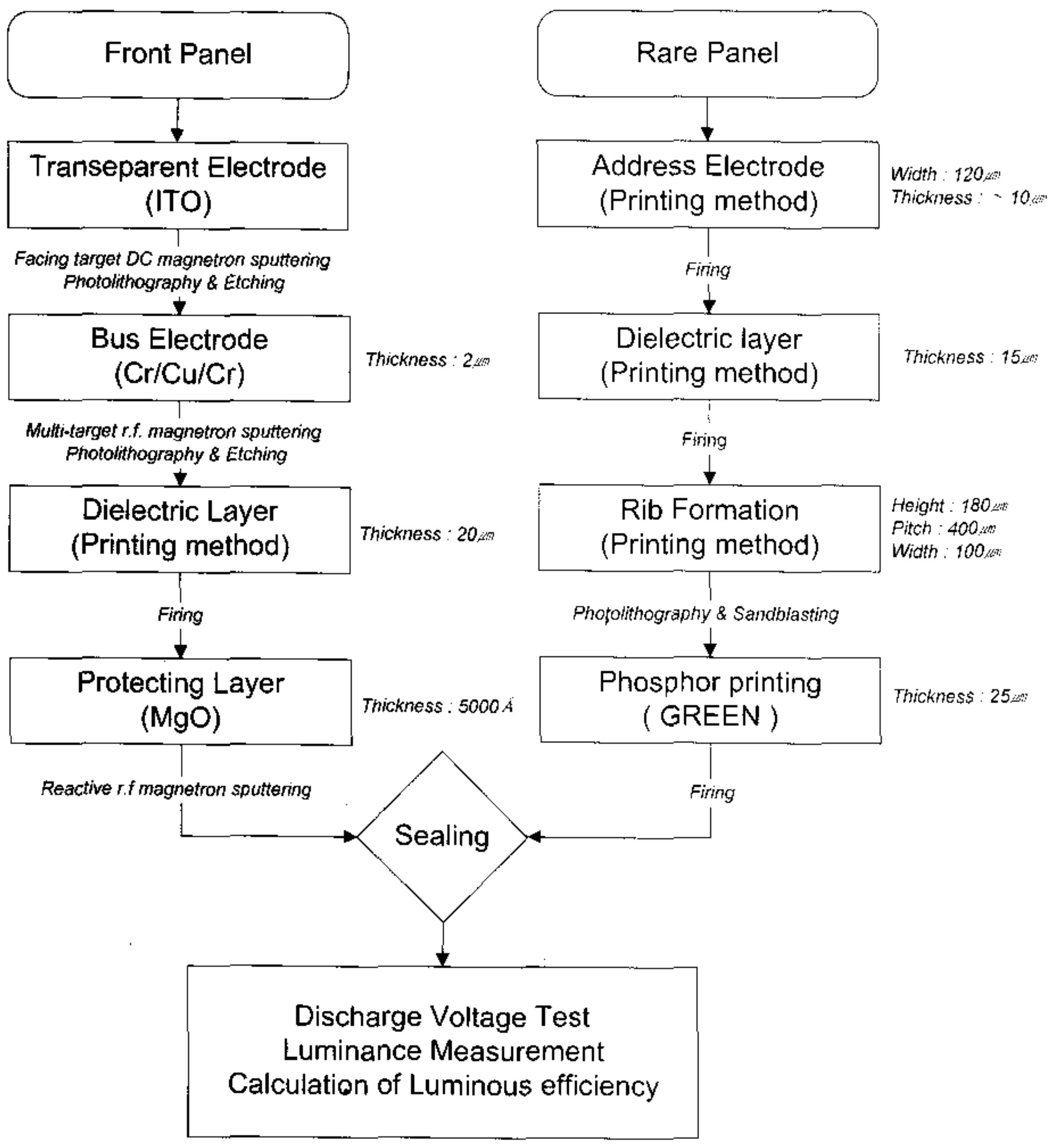


Fig. 3. Manufacture flowchart of the test ac PDP

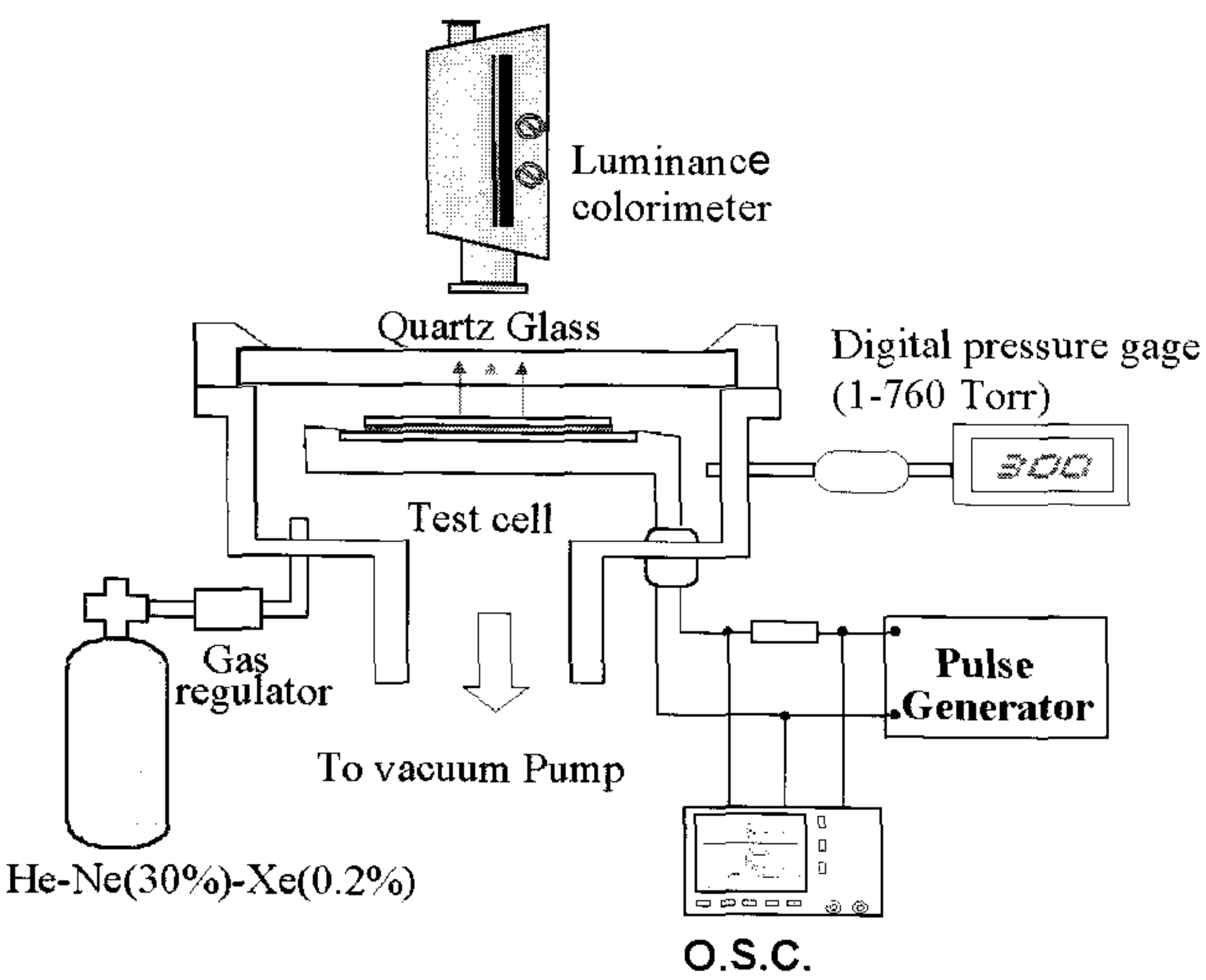


Fig. 4. The schematic diagram of discharge test chamber.

Ne(30%)-Xe(0.2%) gas is filled to a given workable pressure. The characteristics of samples are tested after 1hr aging process. The electrical measurements include obtaining the firing voltage (V_f), the sustaining voltage (V_s), and the current waveform for the test ac plasma display panels operating with 50 ㎑ square wave voltage drive. The firing voltage is measured by progressively increasing applied voltage to initiate the discharge, and then the sustaining voltage is measured by reducing their applied voltage to the point at which the ON cells begin to extinguish. The luminance of the samples is measured by the colorimeter (BM-7).

The method used for calculating the luminous efficiency is as follows [9-10].

$$Lu\min ous\ efficiency = \frac{\pi \times lu\min ance(cd/m^2) \times Area(m^2)}{Power\ consumption(W)}$$

3. Results and Discussion

Fig. 5 shows the discharge voltages (firing voltage V_f and sustain voltage V_s) for the test samples operated with He-Ne(30%)-Xe(0.2%) penning gas. The frequency and duty ratio of the sustain pulses are 50 kHz and 50 %, respectively. The discharge voltages had little differences among conventional, meander and bridge shaped electrode. The discharge voltages were not influenced by parameters of another electrode except the electrode gap under the conditions that the parameters of dielectric layer and working gas were all fixed. The firing voltage decreased as the gas pressure increased to 250 Torr and then increased above 250 Torr. But, the pressure point that represents the minimum sustain voltage was shifted to the right side compared with firing voltage characteristics curve.

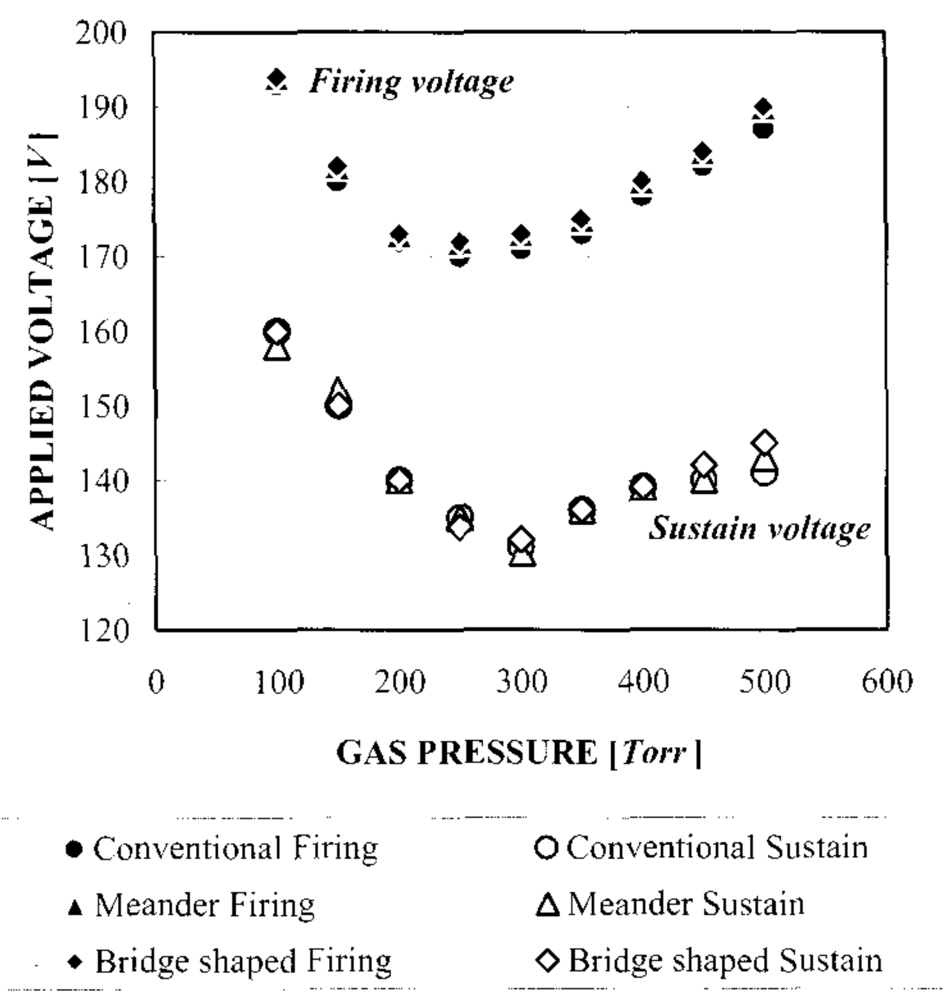


Fig. 5. Discharge voltage as a parameter of gas pressure(He - Xe 0.2% - Ne 30% mixture gas).

Fig. 6 shows the luminance of the test samples as a parameter of applied voltage. The pressure is 400 Torr of He-Ne(30%)-Xe(0.2%) mixture gas. It is interesting to note the differences in these curves. In the lower region (160 V~190 V) it is seen that the luminance of meander electrode is about 5cd/m^2 smaller than that of the conventional electrode. In the middle region (190V~

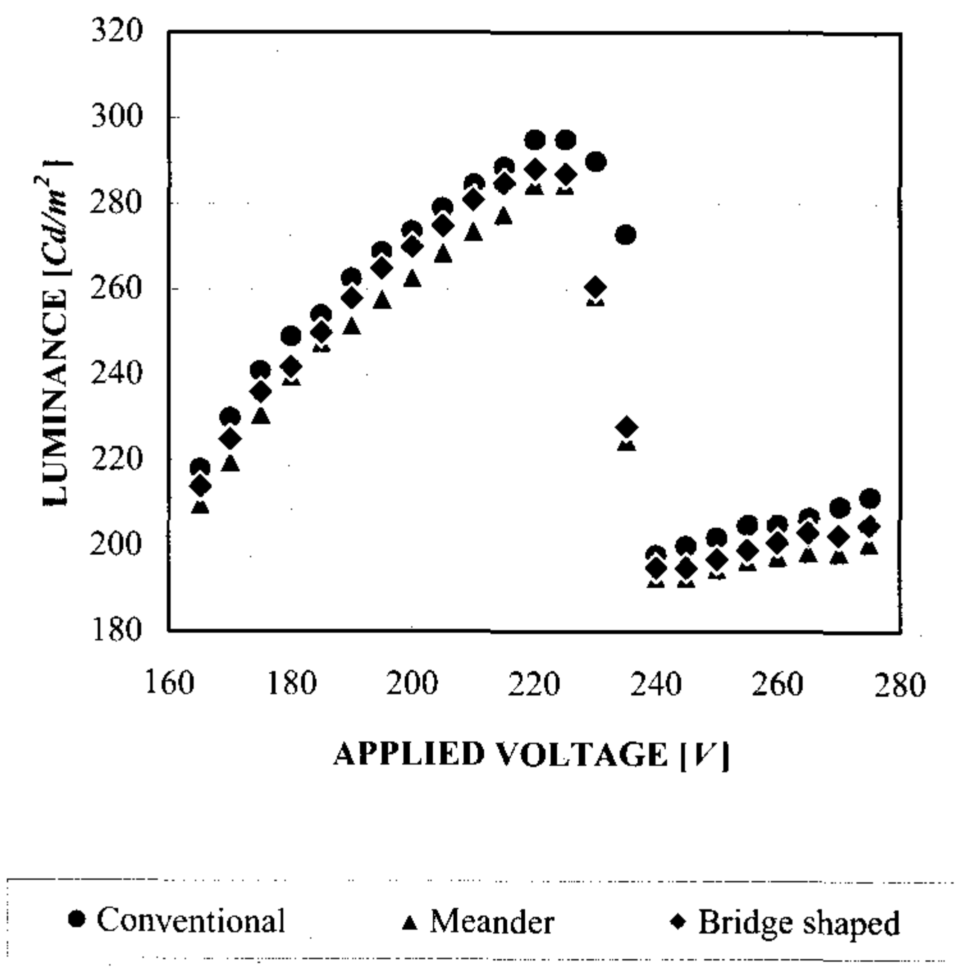


Fig. 6. Luminance as a parameter of applied voltage.

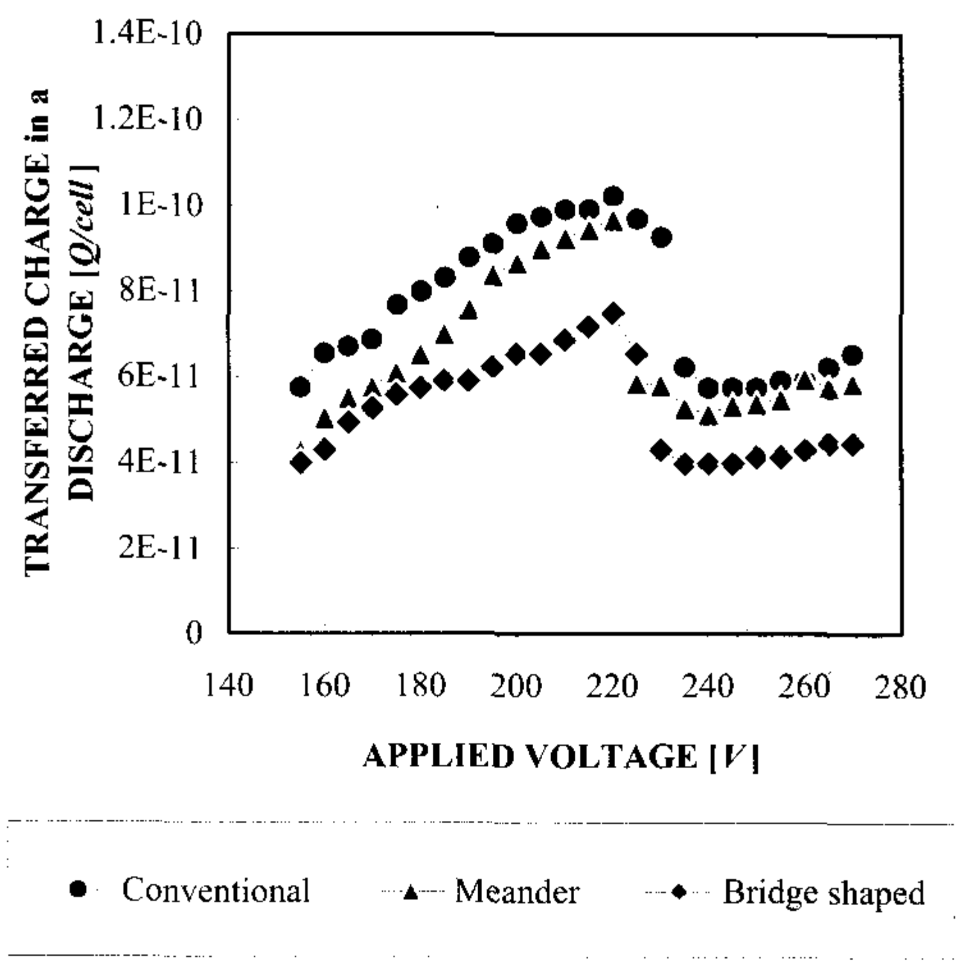


Fig. 7. Charge quantity as a parameter of applied voltage.

220 V) of the curve the differences between meander and conventional electrode were even greater. The increase of differences is caused by the expansion of discharge toward the barrier ribs because the discharge particles were being absorbed at the surface of barrier ribs. Also, these curves show steep falls over the 230 V. The reason for the steep fall can be explained by reverse discharge. When the applied voltage falls to zero, there is a reverse discharge that causes the wall voltage to decreases. The reverse discharge effect will cause a reduction in wall voltage and thus cause the luminance to decrease sharply.

Fig. 7 shows the transferred charge which is obtained by the current in a discharge as a parameter of applied voltage. The operation of test cells sustained in He-Ne(30%)-Xe(0.2%) at 400 Torr. When the applied voltage amplitude is increased, while the breakdown voltage and self-sustain voltage do not change, more current is required to charge the dielectric layers before the gap voltage is reduced below the minimum for discharge sustenance[14-17]. And, the transferred charges were nearly proportional to the electrode area as shown in Fig. 7. In the case of meander electrode, the transferred charge in the lower region (160 V~180 V) is similar to that of bridge-shaped electrode because of reduction of electrode area. But, in the middle region, below the reverse discharge starting point the transferred charge is increased as much as that of conventional electrode because of the increase in diffusion loss to the barrier ribs.

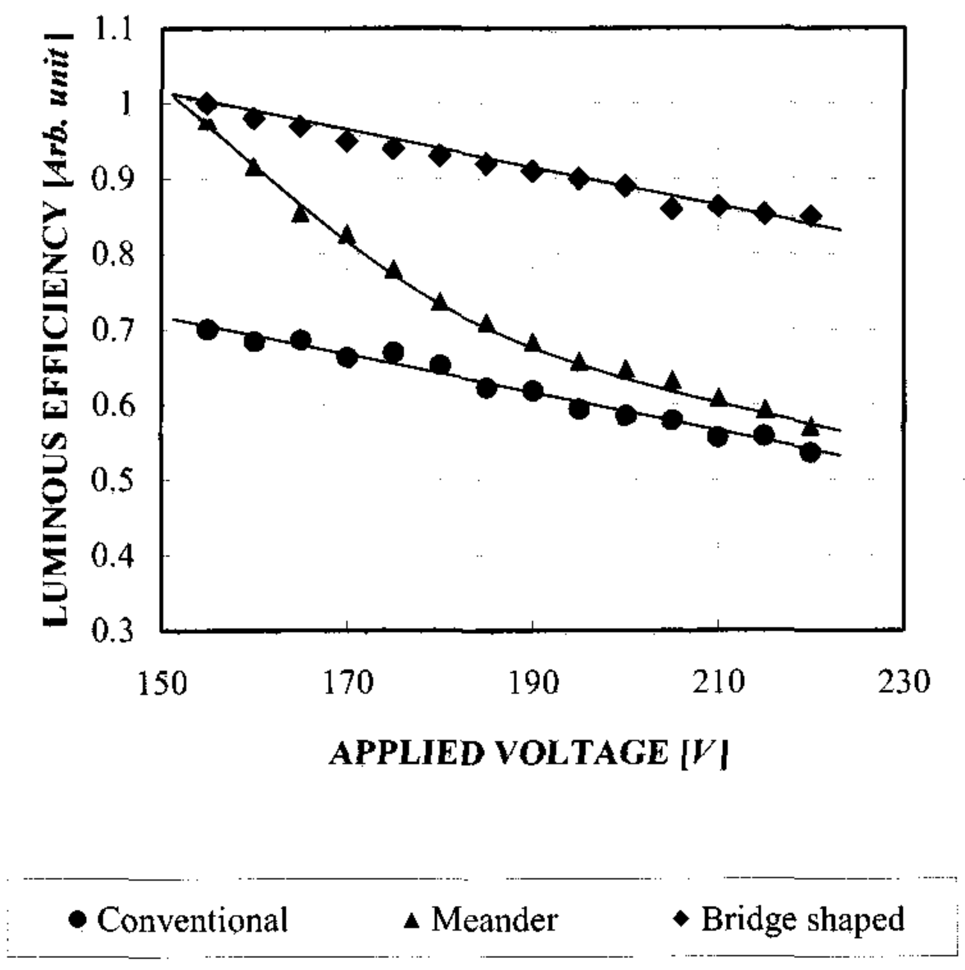


Fig. 8. Luminous efficiency as a parameter of applied voltage.

Fig. 8 shows the luminous efficiency as a parameter of applied voltage. For a bridge-shaped electrode, luminous efficiency was about 30 % higher than that of conventional electrode. And the luminous efficiency of meander electrode was also greater than that of conventional electrode. But, the luminous efficiency of the meander electrode seems to bend over whereas those of conventional and bridge shaped type do not. The reason for the bending can be explained by the increase of diffusion loss for the high-applied voltage region.

4. Conclusion

A meander electrode with the longer discharge path length and the smaller electrode area than the conventional electrode and the bridge-shaped electrode with eliminating the transparent electrode near the barrier ribs were suggested. The discharge voltages were not influenced by electrode shape except the electrode gap under the conditions that the other parameters were all fixed. The luminance of the suggested electrodes and conventional electrode had little differences except for the region between firing voltage and reverse discharge starting point in case of meander electrode. The amount of transferred charge for suggested electrodes was nearly proportional to electrode area. As a result, the luminous efficiency of the bridge-shaped electrode was about 38 % higher than that of the conventional electrode over all voltage regions. In the case of meander electrode, the luminous efficiency was at maximum 36 % higher than that of conventional one. However, the improvement of the luminous efficiency to conventional electrode was reduced as the applied voltage was increased.

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