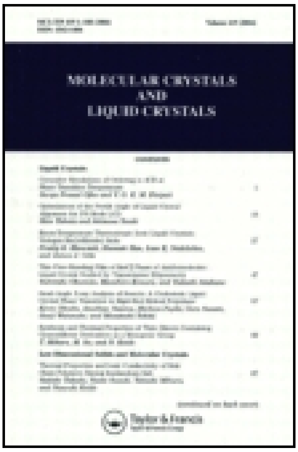

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Reduction of Power Consumption of Counter Electrode Structure in AC-PDP

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The low capacitance in the panel contributes to a reduction of power consumption in a Plasma Display Panel system. In this paper, the capacitances of the counter and coplanar electrode structures are compared on the basis of the measurement of discharge and displacement current. The sustain gap of the counter structure is wider than that of the coplanar structure under the same discharge volume. Furthermore, the sustain electrode area of the counter structure is smaller than that of the coplanar structure. Accordingly, the capacitance of the counter structure is lower than that of the coplanar structure for the same discharge volume and sustain gap.

Keywords AC PDP; counter electrodes; capacitance

Introduction

The counter sustain electrode structures have been suggested to improve the luminous efficiency of an ac-plasma display panel [1, 2]. The surface discharge-type coplanar structure employed in the current PDP structure with three electrodes has difficulty in the improvement of luminous efficiency due to the limitation of sustain gap distance, if the cell size is reduced further [3, 4]. However, the counter electrode structure has advantage to guarantee the large sustain gap in the small cell size due to the sustain electrodes in the barrier-ribs. These types such as the counter electrode structure has shown a high luminous efficiency due to the large gap discharge distance, the improvement of the transmittance and the low capacitance caused by the small area of the sustain electrodes on the front panel. In particular, low capacitance in the panel is an important factor for reduction of power consumption in PDP [5–7]. In this paper, the capacitances of the counter and coplanar electrode structures are analyzed by comparing the discharge current and the displacement current waveform in the same discharge volume and sustain gap, respectively.

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Table 1. Comparison of specifications between counter and coplanar sustain electrode structure

	Counter sustain electrode structure		Coplanar sustain electrode structure	
	Discharge Volume (HD grade)	Discharge Gap (400 μm Gap)	Discharge Volume (HD grade)	Discharge Gap (400 μm Gap)
Discharge Gap	483 μm	400 μm	80 μm	400 μm
Pixel Dimension	693 × 304 μm	400 × 304 μm	693 × 304 μm	693 × 304 μm
Barrier-rib Height	120 μm			
Dielectric Layer Thickness	40 μm			
Gas Composition	Ne-Xe (4%) 450 Torr			

Experimental

Figures 1(a) and (b) show the schematic diagram of the proposed counter and coplanar sustain electrode structures used in the current study, and the detailed specifications for both structures are listed in Table 1. For both structures, identical fabrication conditions are employed with respect to the barrier rib height, dielectric layer, and MgO protective layer thickness. The coplanar sustain electrodes consist of an opaque bus electrode made from Ag paste and transparent ITO (Indium Tin Oxide) sustain electrodes. In contrast, for the counter sustain electrode, opaque sustain electrodes made from Ag paste are embedded within the barrier ribs with a fine groove fabricated by a sandblasting method, as shown in Fig. 1.

The capacitances of the both structures are analyzed by the same discharge volume of HD grade and discharge gap with 400 μm conditions, respectively. In the case of the HD grade cell, for both structures, the vertical and horizontal cell pitches for a single subpixel are 693 and 304 μm, respectively. As shown in Table 1, the cell dimentions of the counter and coplanar electrode structures are 400 × 304 μm and 693 × 304 μm respectively, in the 400 μm discharge gap condition. The height of the barrier rib was 120 μm and the thickness of the dielectric layer was 40 μm. An MgO protective layer with a thickness 0.7 μm was then deposited on the dielectric layer. The gas mixture of Ne-Xe (4%) was filled under a pressure of 450 Torr in the 6-in. test panel. Figure 2 shows a schematic diagram of the experimental setup for measuring the panel capacitance of the both structures. The measurement system consists of two 6-inch test panels (i.e., a test panel with counter sustain electrode structure, and a test panel with coplanar electrode structure), the driving circuit system consists of the driving circuit, power supply and signal generator and the oscillocope, as shown in Fig. 2. The sustain electrodes, X and Y are supplied by the electrical pulses generated from the driving circuit, and the resultant sustain pulses, Vx and Vy are alternately applied at a driving frequency of 100 kHz with a duty ratio of 40%.

Results and Discussion

The capacitance is determined as following equation (1),

$$C = \varepsilon \frac{A}{d} \tag{1}$$

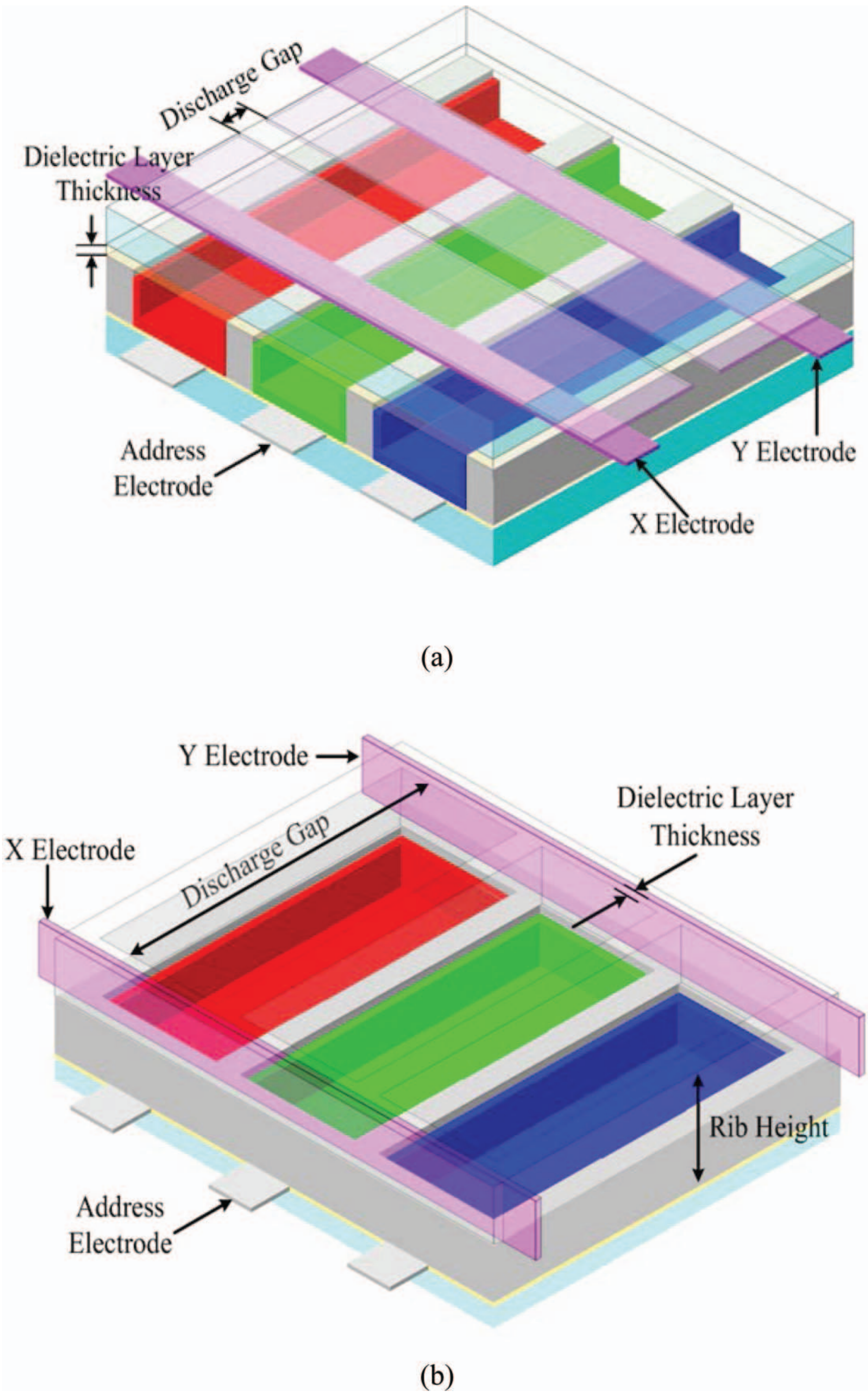

Figure 1. Schematic diagram of 6-in. test panels with: (a) coplanar sustain electrode structure and (b) proposed counter electrode structure.

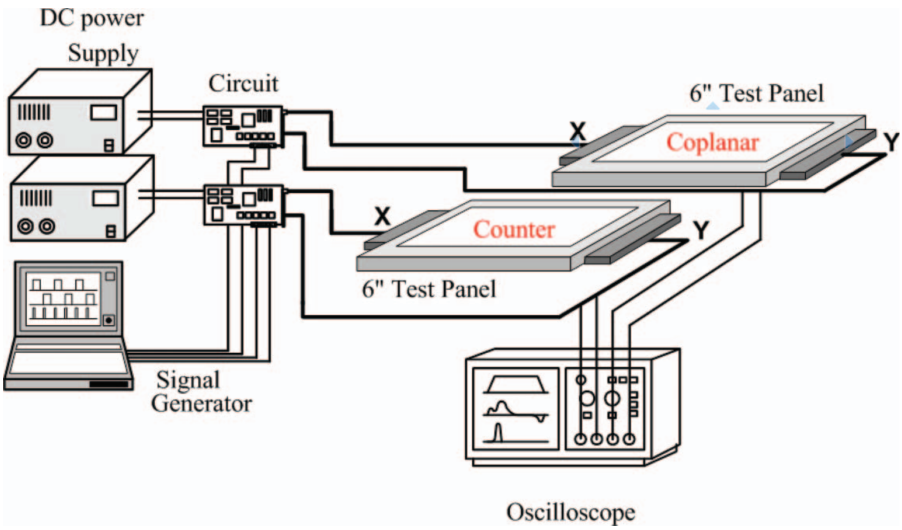

Figure 2. Schematic diagram of experimental setup.

where ε is the permittivity of the dielectric layer, d is the distance between two sustain electrodes, and A is the electrode area. In case that the distance between two sustain electrodes are fixed, the sustain electrode area determine the panel capacitance.

Figures 3(a) and (b) show the discharge and displacement current characteristics in the 42-inch HD grade test panel. The firing and sustain voltages of the counter structure are 290 and 240 V, respectively. On the other hand, the firing and sustain voltages of the coplanar structure are 210 and 170 V, respectively. This discrepancy is due to the sustain electrode gap of the counter structure being about 413 μm wider than that of the coplanar structure. The large sustain gap yields a low discharge current under the weak electric field, and thus the discharge current of the counter structure is lower than that of the coplanar structure, as shown in Fig. 3(a). The sustain electrode area per unit cell of the coplanar structure and counter structure is 140,400 μm^2 and 23,400 μm^2, respectively. The large sustain gap and the small sustain electrode area provide a weak electric field and a low displacement current even with high discharge voltage. The displacement current of the counter structure is lower than that of the coplanar structure, as shown in Fig. 3(b). Figure 3(c) shows the changes in the effective discharge current. The effective discharge current (J) is obtained from the following equation (2):

$$J = \frac{I_{on} - I_{off}}{A} \quad (2)$$

where I_{on} is a discharge current, I_{off} is a displacement current, and A is a displayed area. The power consumption is calculated by subtracting the displacement current from the discharge current, and thus the effective discharge current is not related to the displacement current. The effective discharge current of the counter structure is lower than that of the coplanar structure, and therefore the low capacitance of the counter structure contributes to attaining high luminous efficiency.

Figures 4(a) and (b) show the discharge and displacement current characteristics for both structures with a 400 μm electrode gap. The firing and sustain voltages of the counter structure are lower than those of the coplanar structure for the same sustain electrode gap. In

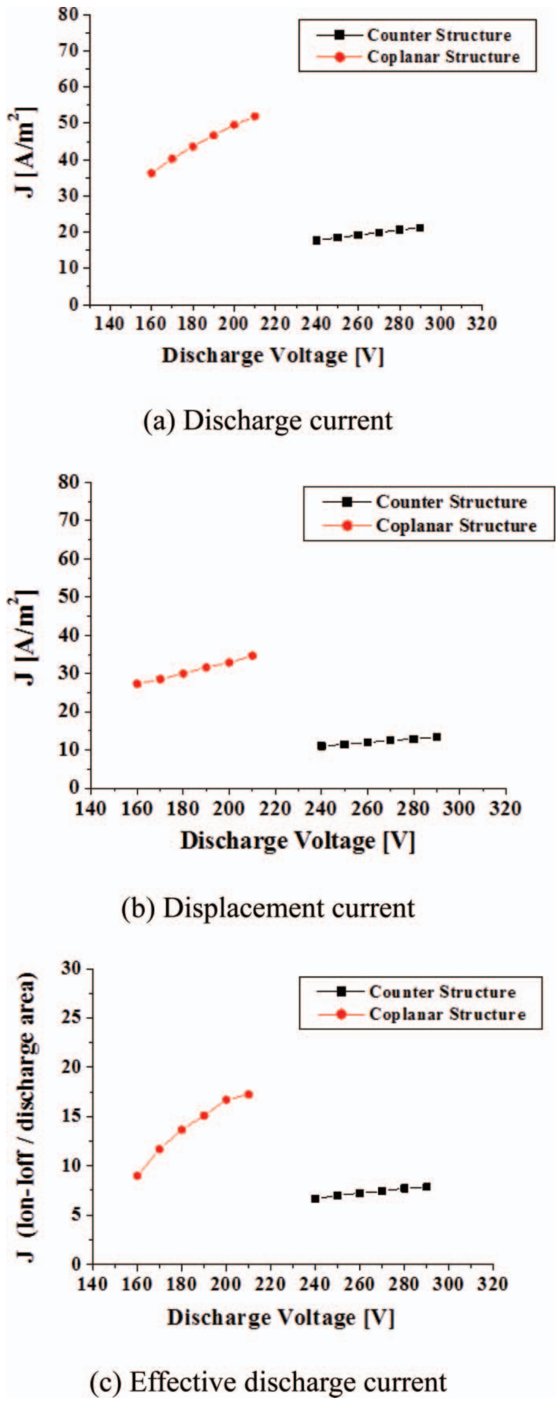

Figure 3. The discharge and displacement current characteristics in 42-inch HD grade cell.

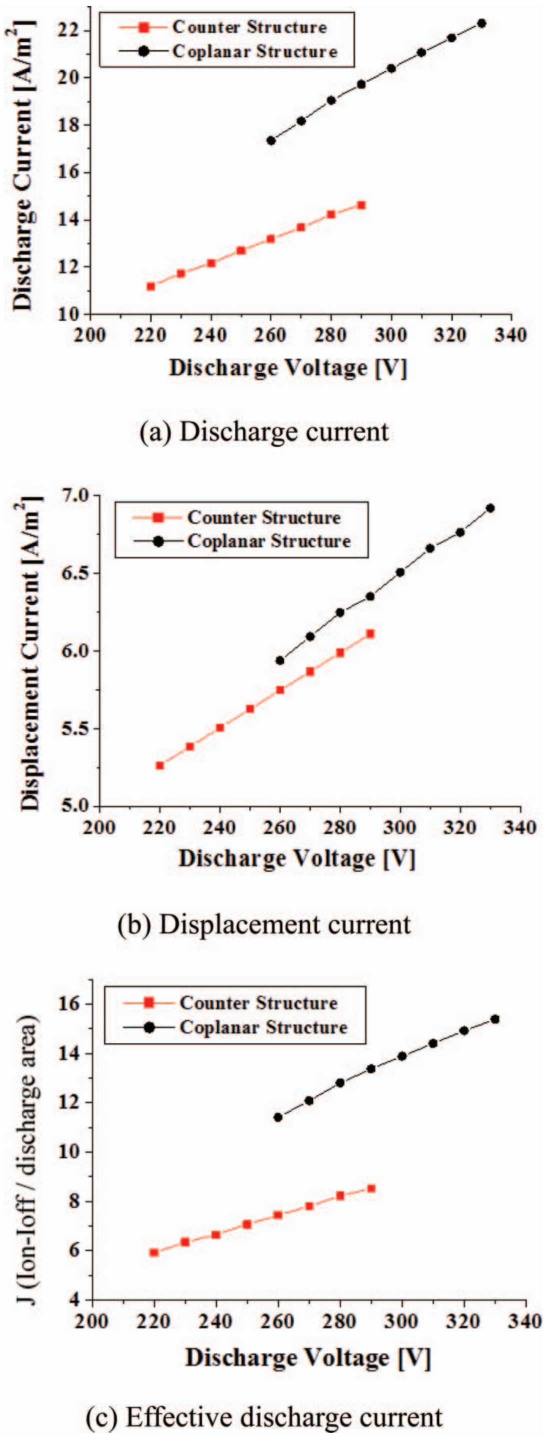

Figure 4. Current characteristics of test cell with 400 μm electrode gap.

the case of the counter-type discharge, the electric field between the X and Y electrodes has uniform characteristics, and thus the discharge voltage between these electrodes is lower than that of the coplanar-type discharge. As noted previously, the sustain electrode area of the counter structure is smaller than that of the coplanar structure, and thus the discharge and displacement current of the counter structure has a low value even at the same sustain

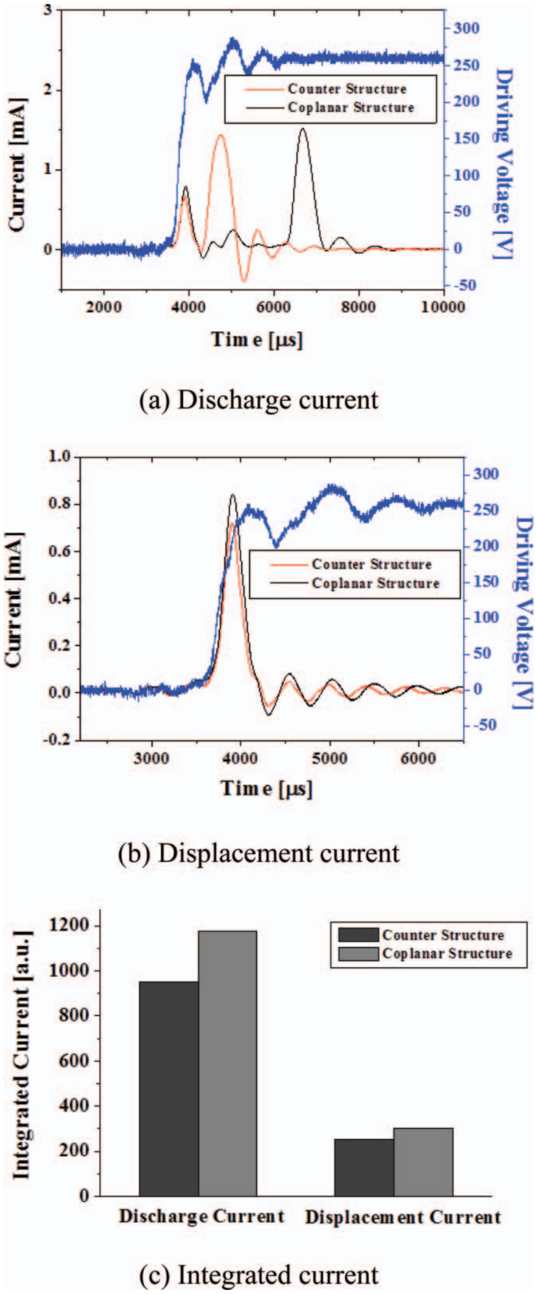

Figure 5. Current waveform under the floating condition.

voltage. However, the minimum sustain voltage of the counter structure can be much lower than that of the coplanar structure. Accordingly, the discharge current, displacement current and the effective discharge current of the counter structure are lower than those of the coplanar structure for the same sustain electrode gap, as shown in Fig. 4. Therefore, the small sustain electrode area provides low discharge and displacement current, and therefore the capacitance of the counter structure is lower than that of the coplanar structure for the same discharge gap.

In the floating condition, the electric field is applied to the two sustain electrodes. Thus, the discharge and displacement current under the floating condition influence only the sustain electrodes without affecting the address electrode.

Figure 5(a) shows the discharge current waveform of both structures under the floating condition at 260 V. The counter structure has a weak electric field environment compared with the coplanar structure in the minimum sustain region with the same sustain gap. Thus, the breakdown time of the counter structure is faster than that of the coplanar structure, and the amount of discharge current of the counter structure is also lower, as shown in Fig. 5(a). Figure 5(b) shows the displacement current waveform of both structures under the floating condition. The displacement current of the counter structure under the floating condition is lower than that of the coplanar structure due to the small sustain electrode area. Figure 5(c) shows the differences in the integrated discharge and displacement current for one sustain pulse. The discharge and displacement current of the counter structure are lower than those of the coplanar structure for one sustain pulse. For this reason, a greater reduction of the discharge and displacement current of

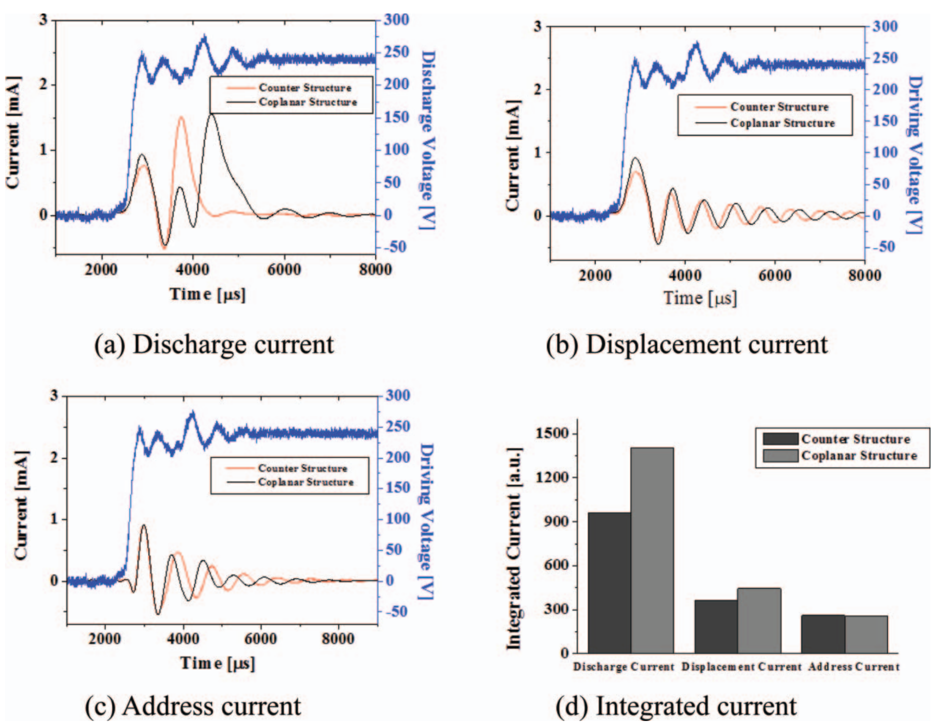

Figure 6. Current waveform under the ground condition.

the counter structure can be achieved with a large number of sustain pulses and a large discharge area.

In the ground condition, the electric field between the two sustain electrodes is affected by the address electrodes. A comparison of current among the three electrodes is required, since the actual driving condition of the PDP is the ground condition. Figure 6(a) shows the discharge current waveform of both structures under the ground condition at 260 V. Compared with the coplanar structure, the discharge current of the counter structure is shifted to the left direction not only under the floating condition but also the ground condition. The discharge current of the counter structure is lower than that of the coplanar structure, as shown in Fig. 6(a). Figure 6(b) shows the displacement current waveform of both structures. The displacement current of the counter structure is lower than that of the coplanar structure. Figure 6(c) shows the address current of both structures. Although the oscillation times of both structures are different, the overall address current of the counter structure is similar to the coplanar structure. Figure 6(d) shows the integrated discharge current, the displacement current, and the address current. The address currents of both structures are similar, but the discharge and displacement currents of the counter structure are lower than those of the coplanar structure. The small sustain electrode area of the counter structure contributes to low discharge current and displacement current without affecting the address electrode. As a result, the capacitance of the counter structure is lower than that of the coplanar structure under the same sustain electrode gap.

Conclusions

The counter structure achieves high luminous efficiency through a reduction of the power consumption by low capacitance, because the sustain gap of the counter structure is wider than that of the coplanar structure for the same discharge volume. Moreover, the sustain electrode area in the counter structure is smaller than that in the case of the coplanar structure. As a result, it is found that the counter structure is a more suitable structure for realizing high luminous efficiency due to the reduction of the displacement current and power consumption.

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