P-17: Analysis on Discharge Modes in AC-PDP with Sustain Gap of 200 μm

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Abstract

The Vt close curve measurement shows that there exists the X-Y discharge contour in the large sustain gap of 200 μm (> a barrier rib height of 125 μm). This indicates that there are two different discharge modes: one mode is that the discharge is produced only between the sustain electrodes, and the other mode is that the discharge is initiated between the address and sustain electrodes, thus producing the main discharge between the sustain electrodes. The two discharge modes are confirmed and analyzed based on Vt close curve movement on cell voltage plane after the strong discharge. The two discharge modes show the different discharge characteristics such as a sustainable region, Vt close curve behavior, and luminance. Furthermore, it is observed that the discharge characteristics induced by applying the short address pulse are different according the discharge mode.

1. Introduction

The plasma display panel using a micro-cell discharge has already grown up to take a large area in the display market. However, the luminous efficiency of the current ac-PDP using a micro-discharge cell structure is still low. Thus, over the past few years, a considerable number of studies have been tried to improve the luminous efficiency of a PDP. Among various researches, two types of very interesting results are presented where one is to increase Xe content [1] and the other is to extend the discharge path [2]. These two methods could be a breakthrough to improve the luminous efficiency of the micro-discharge, respectively. Our previous works showed the effort to extend the discharge path under the low sustain voltage level [3]. Even though the large sustain gap structure has an advantage of the long discharge path, it has also a disadvantage under the high Xe content. Under the low Xe content, the weak field generated by the large sustain gap structure promotes the excitation processes efficiently, whereas under the high Xe content, the weak field has a difficulty in driving the efficient discharge due to increase in the heavy xenon particles. Accordingly, in the case of increasing the Xe content, it seems that the proper dimension of the micro-discharge cell is about 200 μm. Nonetheless, the intense investigation on the discharge characteristics of this type of cell structure, *i.e.*, the large sustain gap of 200 μm slightly larger than the barrier rib height of 125 μm has been neglected so far. Our previous experimental result of the large sustain gap (> 400 μm) structure has shown that the main discharge can be produced between the sustain electrodes only when the trigger discharge is produced between the address and sustain electrodes, since the sustain discharge can not be produced directly between the two sustain electrodes. Our current experimental result of the large sustain gap of 200 μm shows that the sustain discharge can be produced directly between the two sustain electrodes and also the sustain discharge can be produced through the face discharge generated between the address and sustain electrodes. In this paper, the two different discharge modes that exists in the large sustain gap structure of 200 μm are investigated by different pulsing conditions, and also explained by using the Vt close curve analysis. Furthermore, the effects of the short address pulse of the two discharge modes also examined in a view point of the discharge characteristics, such as a sustainable region and luminance.

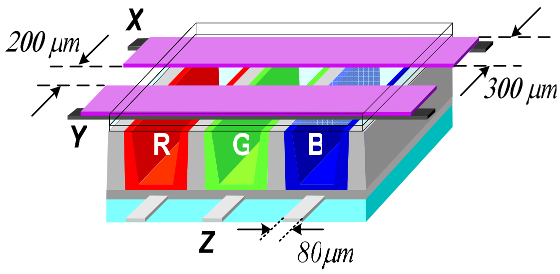
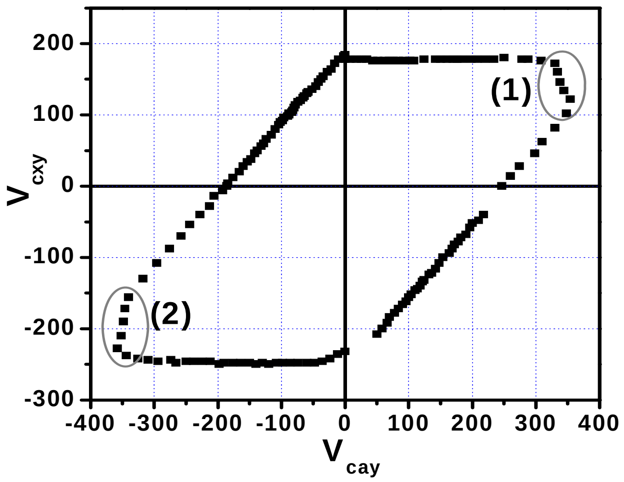


Fig. 1. Discharge cell structure for this experiment (sustain gap=200 μm).

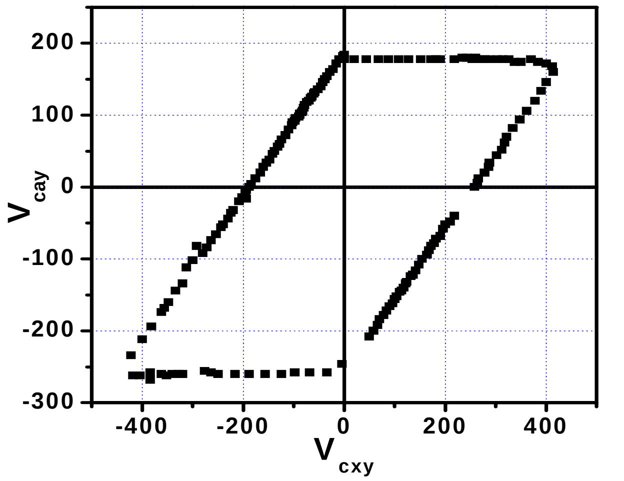
2. Cell Spec. & Possibility of Discharge Mode Separation

Fig. 1 shows the discharge cell structure for this experiment and the gap between the sustain electrodes of 200 μm. The width of the sustain electrode is 300 μm and the height of the barrier rib is 125 μm. The thicknesses of the front dielectric layer and MgO layer are 30 μm and 5000 Å, respectively. The R, G and B phosphor layers are deposited between the barrier ribs on the rear panel. The red, green, and blue phosphor layers are $(Y,Gd)BO_3:Eu$, $(Zn,Mn)_2SIO_4$, and $(Ba,Eu)MgAl_{10}O_{17}$, respectively. The gas pressure is 500 Torr and its mixture is Ne-Xe (5 %).

Figs. 2 (a) and (b) show the Vt close curve [4, 5] measured from the 7-in. test panel with the sustain gaps of 200 and 400 μm, respectively. In Fig. 2, the X-Y threshold voltage contours (1) and (2) are observed in the sustain gap of 200 μm, whereas the X-Y threshold voltage contour is not observed in the sustain gap of 400 μm. The existence of the X-Y threshold voltage contour in the sustain gap of 200 μm implies that the sustain discharge can be produced directly between the two sustain electrodes in the high threshold voltage over 300 V of the cell voltage. Thus, the case that the initial wall voltage prior to the sustain discharge is located in the position on the Vt close curve, as shown in Fig. 3. The two different discharge modes can exist according to a different driving condition. As shown in Fig. 3, the mode 1 is that the initial discharge is produced between the two sustain electrodes, whereas the mode 2 is that the initial discharge is produced between the address and sustain electrodes. In mode 1, the high sustain voltage is needed, but in mode 2, the discharge is produced under the low sustain voltage due to the application of the address voltage. The two different discharge modes are evaluated based on the control of voltage



(a)



(b)

Fig. 2. Vt close curve measured from 7-in.test panel in cases of (a) sustain gap of 200 µm, and (b) sustain gap of 400 µm.

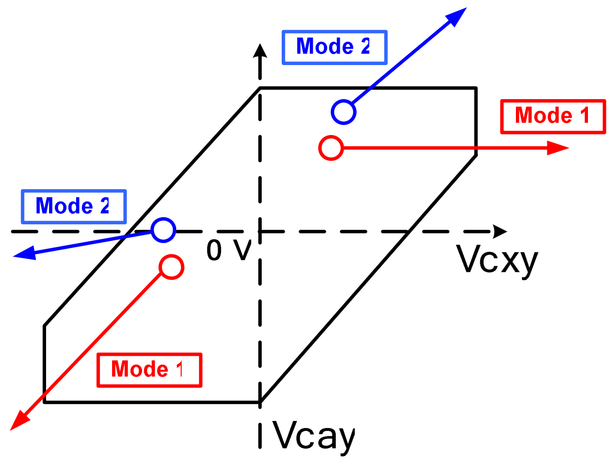


Fig. 3. Supposition of two different discharge modes based on Vt close curve from test panel with sustain gap of 200 µm.

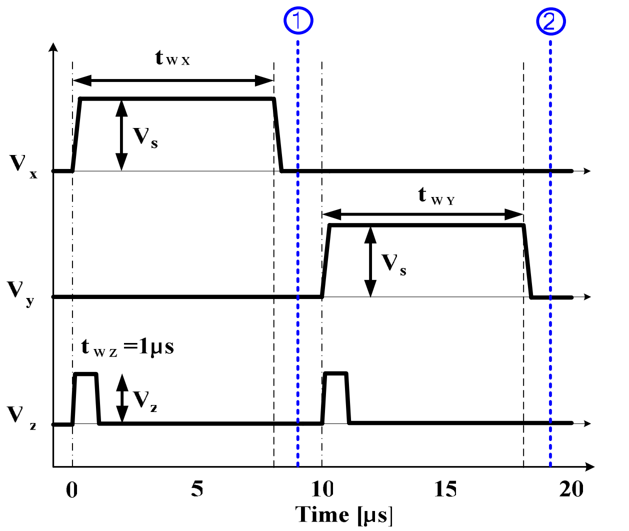


Fig. 4. Sustain voltage waveforms applied to three electrodes during sustain-period.

distribution among three electrodes in the 200 µm sustain gap structure.

3. Experiments and Results

3.1. Observation of two different discharge modes

Fig. 4 and Fig. 5 show the voltage waveforms applied to the three electrodes in this study and the discharge mode separation by the different voltage condition among the three electrodes, respectively. As shown in Fig. 4, the voltage waveforms V_x, V_y, and V_z, applied to the sustain electrodes, X, and Y, and address electrode, Z, at a frequency of 50 kHz. The width of the sustain pulse ($t_{WS} = t_{WX} = t_{WY}$) was 8 µs. The address pulse had a width of 1 µs and its position was coincided with a rising point of the sustain pulse. In Fig. 5 (a), the firing discharge is produced by applying the voltages 300 and 250 V to the sustain (X or Y) and address (Z) electrodes, respectively. After firing the cells, the discharge of mode 1 is produced by decreasing only the voltage applied to the address (Z) electrode from the firing condition, whereas the discharge of mode 2 is produced by decreasing only the voltage applied to the sustain (X or Y) electrode or by decreasing both the voltages applied to the sustain (X or Y) and address (Z) electrodes. The voltage distribution conditions (V_x = 190 V, V_y = 0 V, and V_z = 250 V) of mode 2 in Fig. 5 (c) should satisfy the following discharge pathway: prior to the main X-Y discharge, the trigger discharge is initiated between one of the sustain electrodes and the address electrode [process (1) of Fig. 5 (c)], thus extending toward the other sustain electrode along the address electrode, and producing the main discharge [process (2) of Fig. 5 (c)].

Fig. 6 shows the sustainable regions for the two discharge modes as a function of the address voltage. As mentioned in Fig. 5, the discharge mode 1 exist in the high sustain voltage region as the address voltage decreases from 250 to 0V. On the other hand, the discharge mode 2 exists in the low sustain voltage region thanks to the address voltage. The detailed descriptions of this phenomenon are discussed by the Vt close curve analysis in next subsection.

3.2. Vt close curve properties at two different discharge modes

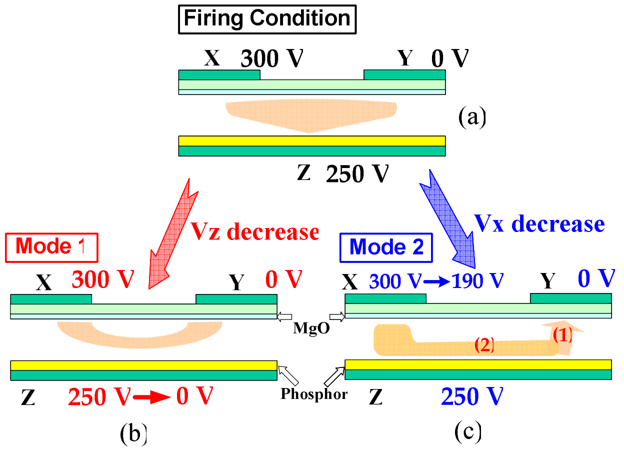


Fig. 5. Two different discharge modes depending on voltage distributions among three electrodes where (b) mode 1 is produced by decreasing only voltage on address electrode from (a) firing condition, and (c) mode 2 is produced by decreasing only voltage on sustain (X) electrode from (a) firing condition.

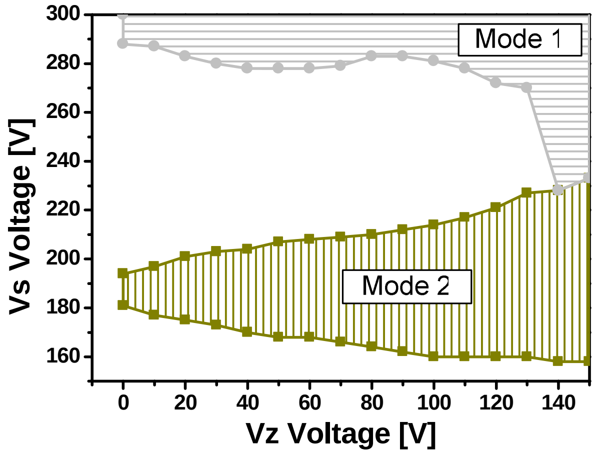


Fig. 6. Sustainable regions in two different discharge modes (gap=200μm).

Fig. 7 shows the movement of the cell voltage in the sustain period on the cell voltage plane. In case (a) of Fig. 7 corresponding to mode 1, the amplitudes of V_s and V_z of the applied wave form are 300 V and 0 V, respectively, whereas in case (b) of Fig. 7 corresponding to mode 2, the amplitudes of V_s and V_z are 190 V and 100 V during the sustain period. Each case was measured at and of Fig. 4. As shown in Fig. 7, the Vt close curve does not much move on cell voltage plane in case (a). It can be explained that the self erasing discharge, that is observed as shown in Fig. 8, may erase lots of the wall charges on the X and Y electrodes. Thus, the higher voltage needs to sustain the surface discharge. While, it is observed the peculiarity of Vt close curve in case (a). The surface discharge contour is enhanced toward helping the next discharge. This is why the surface discharge can be sustained in spite of a little wall charge. However, in case (b) of Fig. 7, the Vt close curve moves to near by AX contour or AY contour for an advantage of the next facing trigger discharge. The Vt close curve at represent that, the AX discharge will be produced more easily. In same manner, the AY discharge will be produced easily in the cell voltage condition of ② in a cell voltage plane. These Vt close curve behaviors are in conformity with the discharge process of Fig. 5 (c).

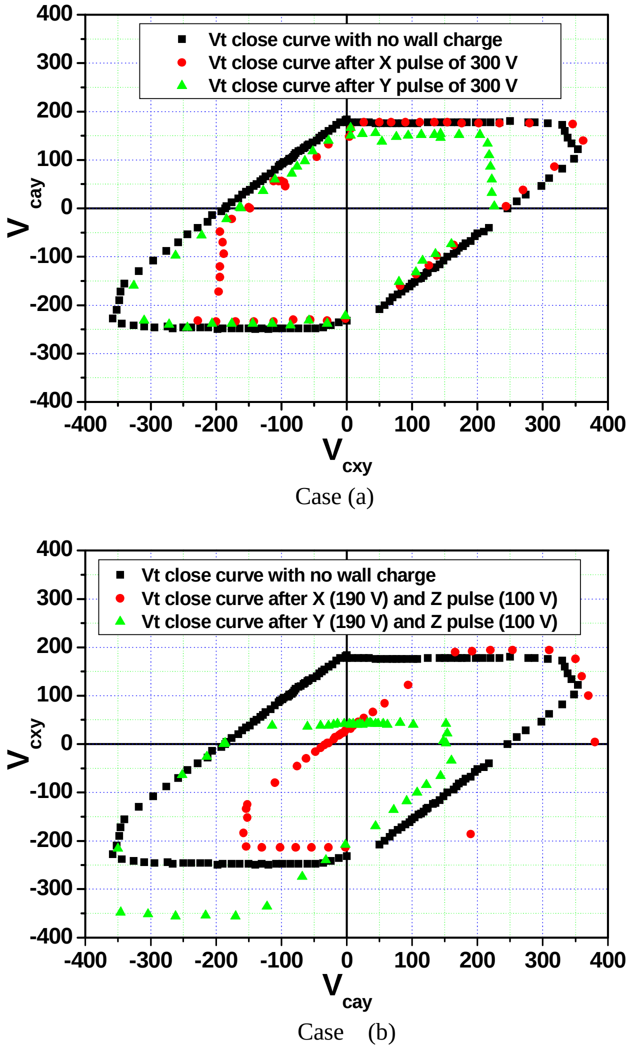


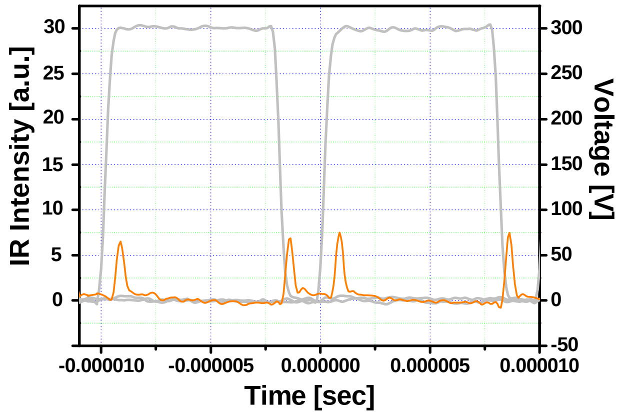
Fig. 7. Movements of Vt close curves after the strong discharge in two different discharge modes of case (a) corresponding to mode 1 (Vs is 300 V and Vz is 0 V) and case (b) corresponding to mode 2 (Vs is 190 V and Vz is 100 V), respectively.

Fig. 8 shows temporal IR profiles in two different discharge modes of case (a) and (b). As mentioned above, it is observed the self erasing discharge in case (a). In addition, the IR profile of case (b) is more intensive than that of case (a). Thus, the luminance of case (a) is higher than case (b) during the sustain period. The luminance according to the different discharge modes are discussed in next subsection, intensively.

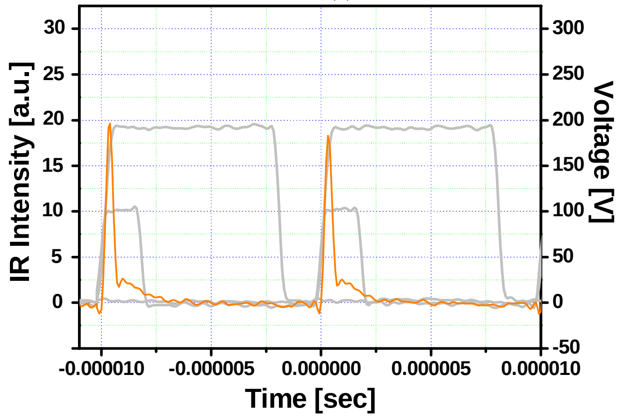
3.3. Role and effect of address short pulse

Fig. 9 shows the changes in the luminance with increasing V_z at different discharge modes. The sustain pulses are fixed for 190 and 300 V for both modes, respectively. At $V_z = 0$ V, the mode 1 shows the lower luminance even if the sustain voltage is high. Moreover, the mode 1 shows the improvement of the luminance only when applying the high address voltage greater than 100 V. This phenomenon can be explained as follows:

since the main discharge is produced directly between the two sustain electrodes, the address voltage does not participate in producing the main discharge. Consequently, the address voltage contributes to improving the luminance, only if it is high



Case (a)



Case (b)

Fig. 8. Temporal IR profiles in two different discharge modes of case (a) corresponding to mode 1 (Vs is 300 V and Vz is 0 V) and case (b) corresponding to mode 2 (Vs is 190 V and Vz is 100 V), respectively.

Enough to pull the charged particles toward the address electrode. On the contrary, at the mode 2, the address voltage plays a significant role in generating the discharge since the discharge is initiated between the sustain and address electrodes. Even though the address voltage at about 50 V enhances the luminance slightly, the application of the address voltage over 50 V reduces the luminance. *i.e.*, when the address voltage is about 50 V, the discharge produces most efficiently at Vs of 190 V in mode 2.

Conclusion

The discharge characteristics are examined with the variation of

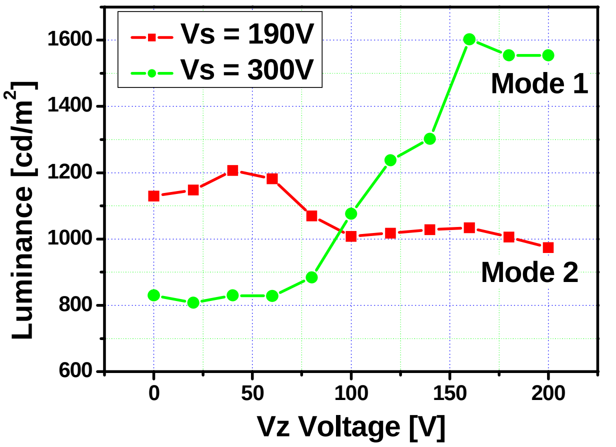


Fig. 9. Changes in luminance as function of Vz at different discharge modes.

the voltage distribution among three electrodes in ac PDP cell with a sustain gap of 200 μm. It is observed that the two different discharge modes in the same structure exist based on Vt closed curve analysis and the discharge characteristics of the two discharge modes are examined experimentally.

References

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