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Variation of the Discharge Characteristics in single-sustainer Driving of an AC PDP

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Abstract

Single-sustainer driving is an AC PDP driving scheme to reduce the circuitry by maintaining the sustain electrode at ground level. To date, however, the research on the discharge characteristics in such driving scheme is insufficient. In this study, the panel performance and discharge characteristics of the single-sustainer driving scheme were observed while varying the address electrode condition. In single-sustainer driving, the address electrode is strongly involved in the sustain discharge when the former is maintained at ground level, and the dependence of the luminous efficacy on the sustain voltage is different from that in the conventional driving scheme. The dependence of the luminous efficacy on the sustain voltage appeared similar, however, to that in the conventional driving scheme when the address electrode was floated in single-sustainer driving. In the investigation of the temporal evolution of the sustain discharge using an IICCD camera, it was found that the sustain discharge in single-sustainer driving with a floating address electrode is similar to that in the conventional driving scheme, and the strong plasma formation region was located in the vicinity of the MgO surface, which seems to be related to the lifetime of a PDP with single-sustainer driving. In the investigation of the operation characteristics, the PDP that was operated with a floated address electrode showed a narrower dynamic operation margin, but a longer lifetime was expected..

Keywords: plasma display panel (PDP), single-sustainer driving, discharge characteristics

1. Introduction

A plasma display panel (PDP) has the merits of a large size and a high image quality as a flat-panel display. For it to become the most competitive display device in the market, however, it needs a low-cost driving scheme and improved luminous efficacy [1, 2]. Recently, high luminous efficacy was reported in a research that was done on PDPs with the gas conditions of high Xe content and a cell geometry with a long sustain electrode gap [3]. The conventional PDP provides driving circuits for three kinds of electrodes: sustain (X), scan (Y), and address electrodes. From the viewpoint of the improvement of cost effectiveness, a new driving technology was introduced to simplify the circuit structure [4-5].

In the conventional sustain driving method, monopolar pulses were alternately applied to the X and Y electrodes, and symmetric sustain discharges were then induced in the two electrodes. Sustain pulses with both positive- and negative-going voltage levels were alternately applied to the Y electrode while the X electrode was maintained at ground level. The maintenance of a constant voltage level for the X electrode will lead to the exclusion of the driving board, and bipolar sustain pulse driving can achieve cost effectiveness. Some practical researches that were conducted to adopt single-sustainer driving suggested that the voltage level of an address electrode can be varied in time, with the application of sustain pulses [5-6]. In this study, the panel performance was observed while varying the address electrode condition during sustain discharge. Moreover, the infrared (IR) emission images were investigated using an image-intensified charge-coupled device (IICCD) camera, to verify the variation of the discharge characteristics.

2. Experiment and Results

A test panel with a 42-inch WVGA format and utilizing a monochrome green phosphor (Zn_2SiO_4: Mn) was used in the experiment. The detailed panel specifications are shown in Table I. The total gas pressure was fixed at 53.3

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kPa, and Ne-Xe gas mixtures were used with 4% Xe. A 50-kHz square pulse with a 25% duty ratio was alternately applied to the X and Y electrodes to sustain the discharge in the conventional driving. In the single-sustainer driving, the 50-kHz square pulse with both positive- and negative-going polarities was applied only to the Y electrode, as shown in Fig. 1.

Fig. 2 shows the panel performances in the conventional and single-sustainer driving. The luminance of the panel increased with the increase in the sustain voltage, regardless of the driving scheme that was used, because an increased electric field will increase the gas reaction, including the Xe atom excitation. Luminous efficacy, however, shows a different dependence on the sustain voltage.

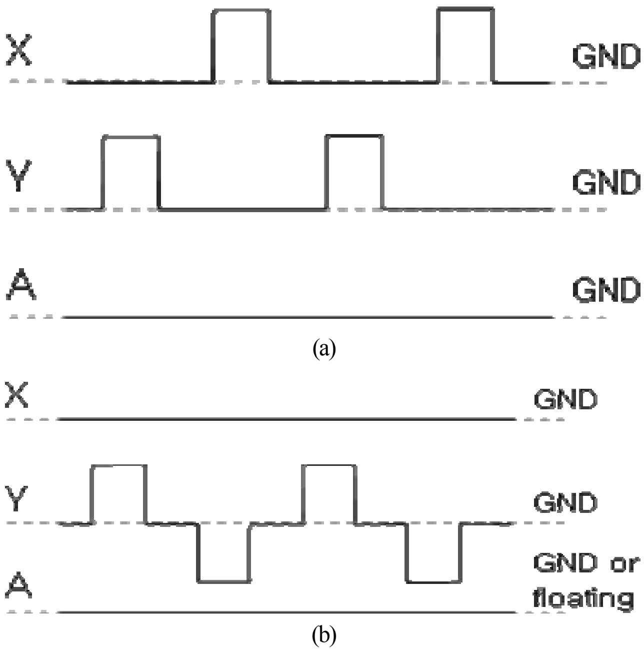

Fig. 1. Sustain waveforms in the (a) conventional driving and (b) single-sustainer sustain driving.

Table 1. Specifications of the cell structure that was used in the experiment

Parameter	Value [μm]	Parameter	Value [μm]
Length of the sustain electrode (ITO)	340	Thickness of the phosphor layer	20
Width of the address electrode	100	Thickness of the dielectric layer	40
Gap of the sustain electrode	80	Thickness of MgO	4000 [Å]
Height of the barrier rib	160	Width of the barrier rib	80

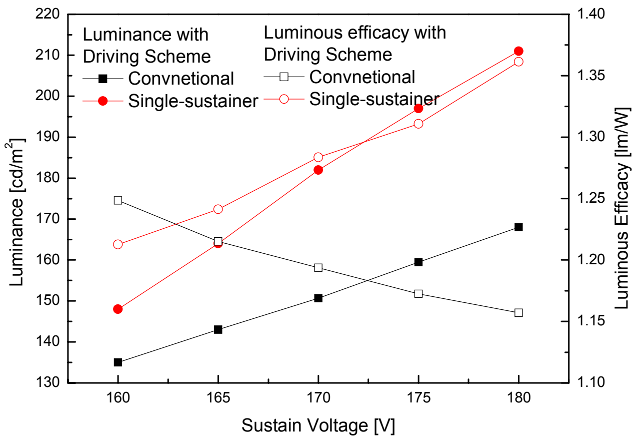

Fig. 2. Variation of the luminance (solid symbol) and luminous efficacy (hollow symbol) in the conventional and single-sustainer driving.

The aforementioned phenomenon was studied in [4], along with the investigation of the discharge characteristics, via IR emission observation and numerical-discharge simulation. In sustain discharge with conventional driving, where surface discharge is dominant, the luminous efficacy will decrease with increasing sustain voltage because the increased electric field will decrease the ratio of the Xe excitation to the ionization reaction. In single-sustainer driving, the address electrode with a low secondary electron emission coefficient plays a more important role in the discharge than the X electrode does, as an anode, when the negative-going pulse is applied to the Y electrode. In addition, this kind of discharge along the vertical direction, which shows a sustain voltage dependence different from that shown by surface discharge, affects the dependence of luminous efficacy on the sustain voltage. The luminous-efficacy variation with regard to the sustain voltage may not have any effect on the feasibility of single-sustainer driving. The increased participation, however, of the address electrode (where the phosphor layer is located) in the sustain discharge can serve as a hurdle to the industrial adoption of single-sustainer driving because the phosphor crystal can be degraded by the ions impinging on it during the discharge. Hence, the feasibility of single-sustainer driving may deteriorate.

Based on the results of the previous observation, controlling the potential of the address electrode was considered. At any given potential, however, the address electrode will be a major electrode due to the nature of an AC discharge in a PDP, where the wall charge cannot be controlled by a constant potential. Instead of applying a fixed voltage level, the voltage level of the address electrode was maintained in a floating condition. Fig. 3 shows the variation of the luminance and luminous efficacy as a function of the sustain voltage. The variations of the luminance show the same dependence on the sustain voltage, but the sustain voltage dependences of the luminous efficacy became different with the change in address condition. The luminous efficacy decreased with increasing sustain voltage when the address electrode was maintained in a floating condition during sustain pulse application to the Y electrode, while it appeared to have the opposite tendency when the address electrode was fixed at ground level, which is the same tendency as that of the conventional driving.

To investigate the discharge characteristics, the three-dimensional IR emission of 823- and 828- nm wavelengths from a surface-discharge-type AC PDP cell was observed during sustain discharge in a real discharge cell. The discharge sample cell had a mirro-polished glass in the position of the barrier rib, and the side and top views of the discharge evolution could be observed [7]. Fig. 4 shows the side-view discharge images of the PDP (which was integrated during the sustain period) in the single-sustainer driving when positive- and negative-going pulses were applied.

In the upper discharge image in Fig. 4, with positive-going pulse application to the Y electrode, the address electrode does not appear to play an important role in the discharge because it has a lower secondary electron emission

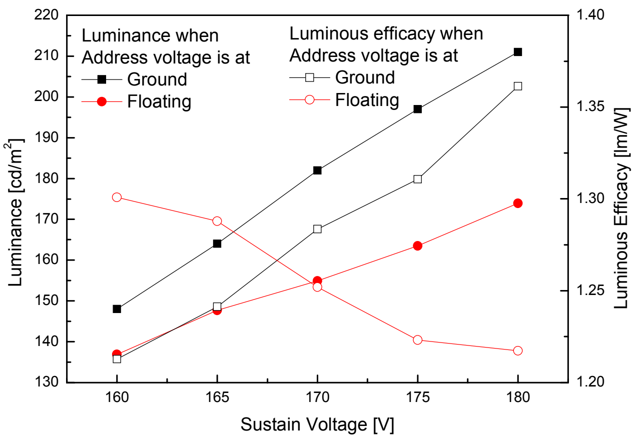

Fig. 3. Variation of the luminance (solid symbol) and luminous efficacy (hollow symbol) in the single-sustainer driving when the address electrode was maintained at ground or floating level.

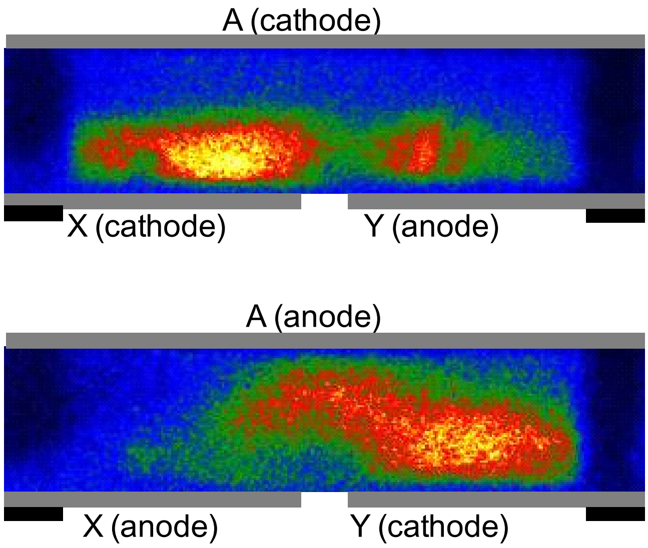

Fig. 4. Cross-sectional discharge image of the PDP in the single-sustainer driving when a positive-going pulse was applied (top) and when a negative-going pulse was applied (bottom).

coefficient than the X electrode does. Moreover, the surface discharge in the vicinity of the MgO thin film appears to be the main path of the discharge. On the contrary, with negative-going pulse application to the Y electrode, the address electrode plays the role of an anode, where the secondary electron emission coefficient is not important, and a strong discharge can be found in the vicinity of the phosphor layer. This implies that the possibility of ions impinging on the phosphor layer can increase. A detailed discussion of the discharge characteristics in single-sustainer driving with an address electrode at ground potential can be found elsewhere [4].

When the address electrode that was floated during the application of bipolar pulses was applied to the Y electrode, the discharge appeared to be different from that when the address electrode was maintained at ground voltage level. Fig. 5 shows the discharge evolution image in the single-sustainer driving with a floating address electrode, and in the conventional driving. The left column of Fig. 5(a) shows the time evolution of the sustain discharge when a positive-going pulse was applied to the Y electrode. Plasma was formed around the inner edge of the anode electrode and expanded towards the outer-cathode surface. Striation can also be observed. Even when the negative-going pulse was applied, as shown in the right column of Fig. 5(a), a similar but symmetric phenomenon can be observed, with a slight time delay. This can be clearly compared with the

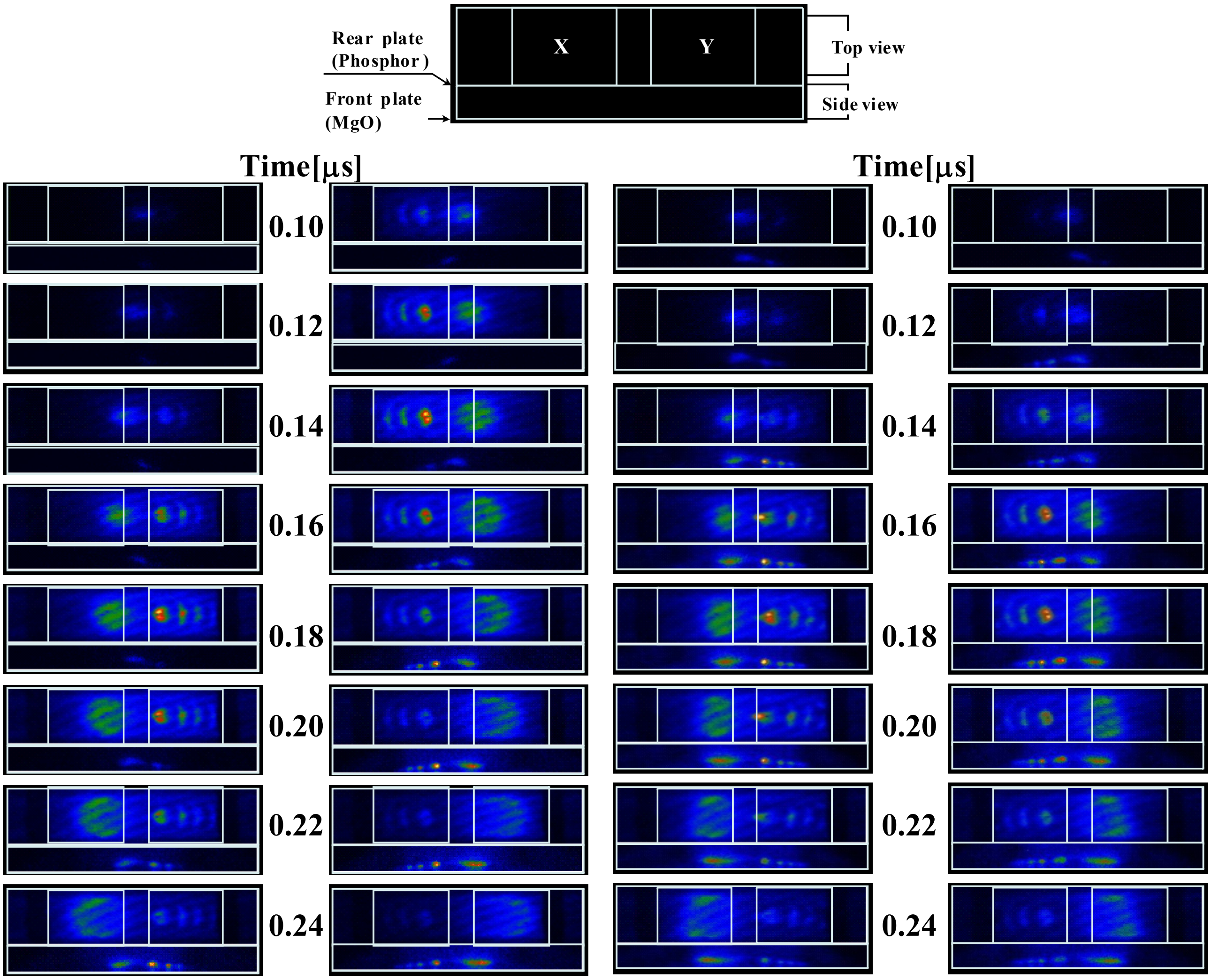

Fig. 5. The temporal discharge evolution images of the top and side views of the discharge cell in the (a) single-sustainer driving when the address electrode was floated (polarity of the pulse applied to the Y electrode: left - positive; right - negative) and in the (b) conventional driving (left: pulse applied to the Y electrode; right: pulse applied to the X electrode).

time evolution of the sustain discharge in the conventional driving, as shown in Fig. 5(b). From the observation of the cross-sectional image of the discharge, it was found that the location of the strong plasma region was near the MgO surface. The discharge evolution characteristics well coincide with the luminous-efficacy tendency as a function of the sustain voltage shown in Fig. 2 and 3. To verify the operation characteristics, the dynamic operation margin of the panel was observed. Fig. 6 shows the driving waveforms for the observation of the operation margin of the driving scheme. A ramp pulse was applied to set up the stable wall charge during the reset period. A scan pulse of 500 μsec was applied after the reset period, with a 5 μsec duration. The addressing voltage was observed while varying the sustain voltage. The maximum address voltage was varied up to 100 V, however, due to the limitation of the driving circuit. Fig. 7 shows the operation margin of the address voltage as a function of the sustain voltage. single-sustainer driving showed a wider address voltage margin when the address electrode was maintained at ground level than when the address electrode was floated.

The other operation characteristic to be considered is the temporal variation of the luminance, which is related to the lifetime. During the observation, the test panel was continuously operated with 50-KHz bipolar single-sustainer pulses. Fig. 8 shows the change in the relative brightness of the panel as a function of the sustain discharge time. Even up to the operation time of 300 h, the difference in the tem-

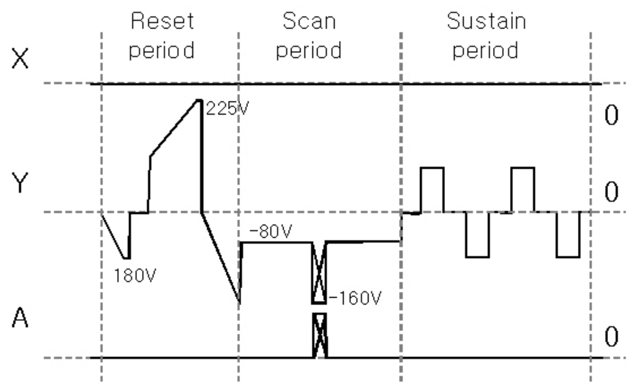

Fig. 6. Driving waveforms for the observation of the dynamic operation margin.

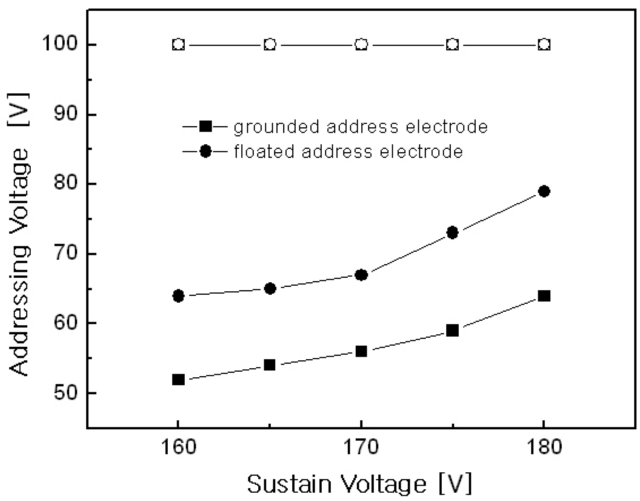

Fig. 7. Operation margin of the address voltage as a function of the sustain electrode with varying address electrode conditions in the single-sustainer driving.

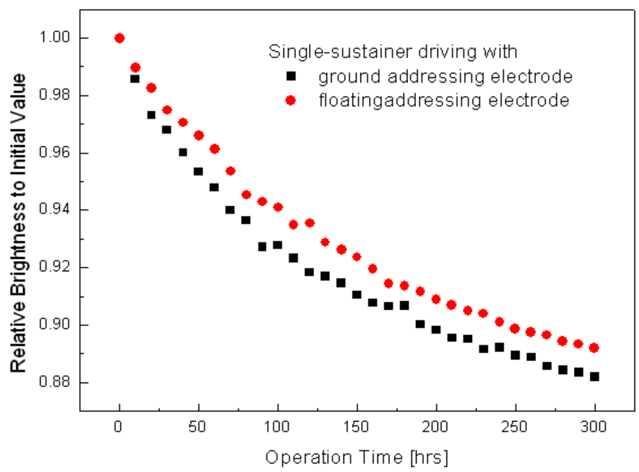

Fig. 8. The temporal variation of relative brightness as a function of the operation time under different address electrode conditions.

poral tendency of the luminance can be clearly seen. It is expected that the panel with a floating address electrode during the sustain discharge will have a longer lifetime when the single-sustainer driving scheme is adopted. It is estimated that this phenomenon is closely related to the change in the discharge characteristic observed in Fig. 3 and 4. The ions during the discharges may cause greater damage to the panel's phosphor layer when the address electrode is maintained at ground level because the strong plasma region is located in the vicinity of the phosphor layer.

3. Summary

single-sustainer driving was suggested to reduce the circuit cost by maintaining the X electrode at ground level. This circuitry scheme, however, gave rise to different discharge characteristics. Especially, the address electrode is strongly involved in sustain discharge. For the investigation of the discharge characteristics in single-sustainer driving, the panel performances and discharge characteristics in single-sustainer driving were observed while varying the address electrode voltage level. The luminous efficacy decreased with increasing sustain voltage when the address electrode was floated during the sustain discharge, while the opposite tendency was observed when the address electrode was maintained at ground potential. The temporal evolution of the sustain discharge also appeared differently with the change in address condition. Especially, the strong plasma formation region was varied, which seems related to the lifetime of the PDP with single-sustainer driving. The PDP with a floated condition showed a smaller dynamic operation margin than that with a grounded address electrode during the sustain period. Even with the narrowed operation voltage margin, it is supposed that the method of maintaining the address electrode in a floating condition is worth adopting in single-sustainer driving from the viewpoint of lifetime, and that the further investigation of the feasibility of single-sustainer driving is needed.

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