Observation and Analysis of Address and Sustain Discharges and Related Wall Voltage Characteristics in AC-PDP

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Abstract

The address and sustain discharge characteristics in plasma display panels (PDPs) are investigated and compared by the optical emission spectroscopy using the ICCD and Vt close-curve analysis. The observations on the xenon (Xe) emission show that the spatial and temporal evolutions in the first sustain discharge are quite different from those in the address and the other sustain discharges. The striation found in the conventional sustain discharge doesn't occur in the first sustain discharge. These different discharge behaviors are explained by employing the Vt close-curve.

1. Introduction

In the address-display-separated (ADS) driving method [1], the on-cells are addressed by applying the scan and address voltages to the Y and A electrodes, respectively. Only the selected cells are sustained with a help of the wall voltage set up in the address step while the same voltage is applied to all cells [2, 3]. It is important to guarantee the successful address for the stable driving especially in the full HD-PDPs. In this sense, the better understanding of the address and sustain discharge characteristics is needed for the successful addressing.

In this study, the address and sustain discharge characteristics are examined and compared using the optical emission spectroscopy. In particular, the behavior of the first sustain discharge is explained by measuring the wall voltage relative to the number of sustain pulse.

2. Experimental setup

The test panel used in this work was a 6-in. AC-PDP with a box-type barrier rib. The unit cell size was 0.270 × 0.810 mm^2, equivalent to that of 50-inch commercialized PDPs with 1366 × 768 pixels. The gas mixture and pressure were Ne-He-Xe (11 %) and 450 Torr. The gap between the coplanar electrode and the barrier rib height are fixed at 70 μm and 110 μm, respectively. The temporal evolutions of discharge current and infrared emission are measured by using an oscilloscope (Lecroy WavePro 7100) and an optic scope (PSI Trading Co., Ltd). The spatial and temporal

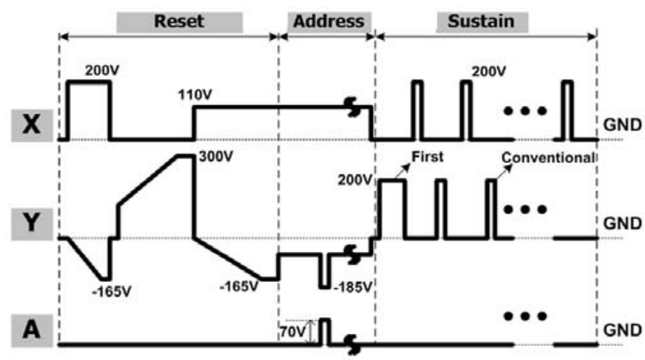


Fig. 1. Schematic diagrams of driving waveforms employed in this current study.

discharge behaviors are analyzed using a gated intensified charge coupled device (ICCD) camera (Roper Scientific) with an optical filter centered at 828 nm. The Vt close-curves are measured to estimate the wall voltages formed after the reset, address, and sustain pulses, respectively. Fig. 1 shows the schematic diagrams of the driving waveforms employed in this work. The driving scheme adopts the address-display-separated (ADS) method that consists of three sequential steps, such as the reset, address, and sustain. The former two pulses in the reset period have a function of writing the wall voltage on the electrodes, whereas the last pulse causes the extra wall charges to be erased. By this method, the wall charge states can be successfully initialized in all cells regardless of the on- and off-states in the previous stage.

3. Results and discussion

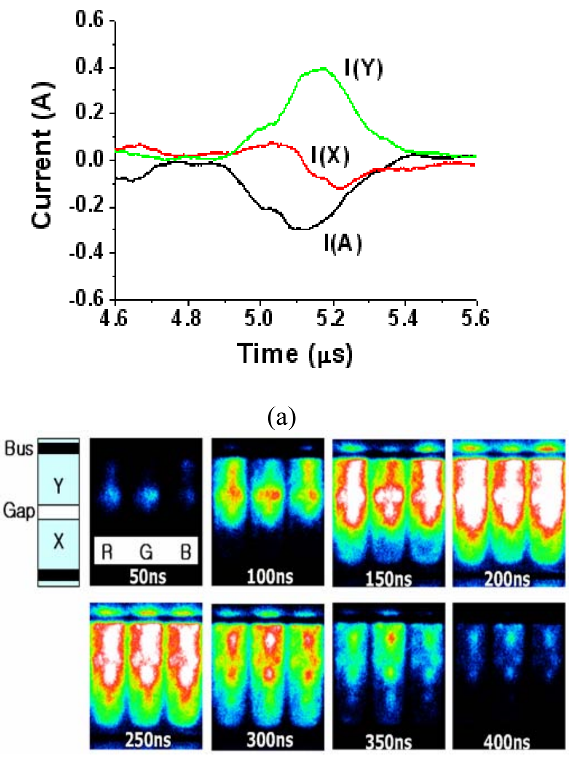
3.1. Comparisons among Address, First Sustain, and Other Sustain Discharges

Fig. 2 (a) shows the discharge currents flowing through the three electrodes during the address discharge. The main discharge is produced between the A and Y electrodes, followed by the weaker discharge between the X and Y electrodes, which means that the wall charges on the A and Y electrodes are changed considerably via the address discharge. The ions and electrons are accumulated on the A and Y electrodes, respectively. On the other hand, the variation in the wall charge quantity on the X electrode is relatively small in comparison with that on the A and Y electrodes. The electrons are accumulated on the X electrode as a result of an address discharge. The spatial and temporal behaviors of the IR emission during an address discharge are measured in Fig. 2 (b) by using an ICCD with an infrared filter (828 nm). The images are taken with an exposure time of 50 ns, and the total measurement time is 400 ns, equivalent to the maintenance time of address discharge current in Fig. 2 (a). The discharge initiation in the X electrode is retarded by about 100 ns in comparison with that in the Y electrode, and the strong emissions are not extended to the edge of the X-electrode. That is, as shown in Fig. 2 (b), the A-Y discharge is initiated near gap between the Y-A electrode, extending toward the bus electrode on the Y electrode. The resultant wall charges accumulating on the A and Y electrodes experience a great change, so that the ions and electrons are accumulated on the Y and A electrodes, respectively. On the other hand, some of electrons are accumulated near the gap on the X electrode. The experimental results of Figs. 2 (a) and (b) indicate that the address discharge is dominantly produced only between the A-Y electrodes.

Fig. 3 shows the address discharge procedure (i.e., A-Y discharge) based on the Vt close-curves measured prior to an address discharge.

Figs. 4 (a) and (b) show the ICCD images measured during (a) conventional sustain discharge and (b) first sustain discharge. The ICCD images in Fig. 4 shows the spatial and temporal behaviors of the Xe emission during the sustain discharges. In the conventional sustain discharge shown in Fig. 4 (a), the discharge starts at a specific region, i.e., near the gap between the X and Y electrodes where the high electric field is concentrated. After that, the discharge spreads gradually toward the electrode edge i.e., the bus electrode. In other words, for the conventional sustain discharge, the discharge starting points are located near the gap region. Accordingly, the ions produced near the gap region are accelerated toward the cathode region, whereas the electrons produced near the gap region are accelerated toward the anode region. As shown in Fig. 4 (a), therefore, the distribution of plasma density bunches, that is, the striation phenomenon, occurs along the anode electrode. On the other hand, in the first sustain discharge shown in Fig. 4 (b), the discharge starts in the entire region of electrode, which means that the electric field induced by the applied sustain voltage is more or less uniform within the cell. The subsequent discharge is intensified gradually in the entire region. Consequently, unlike the phenomenon of Fig. 4 (a), no striation phenomenon is observed during the first sustain discharge. To check the reason for showing the different discharge phenomena for both cases, the wall charges that have already been accumulated on the three electrodes prior to the sustain discharge are measured by using the Vt close-curve method.

Figs. 5 (a) and (b) show the measured Vt close-curves prior to the (a) conventional and (b) first sustain discharges, respectively. As shown in Fig. 5 (a), the sustain discharge is produced only in the Y-X discharge region under the MgO cathode condition. On the other hand, the first sustain discharge is produced at the simultaneous discharge region such as the Y-X discharge under the MgO cathode condition and the Y-A discharge under phosphor cathode condition. From this analysis, it is thought that the



(a)

(b)

Fig. 2. (a) Discharge currents flowing on three electrodes during address discharge, and (b) spatial and temporal discharge behavior during address discharge using ICCD with infrared filter (828 nm).

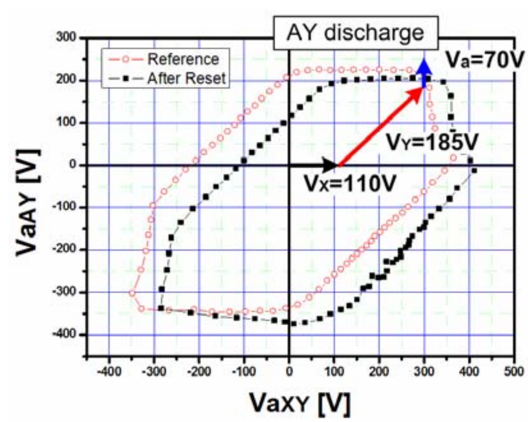
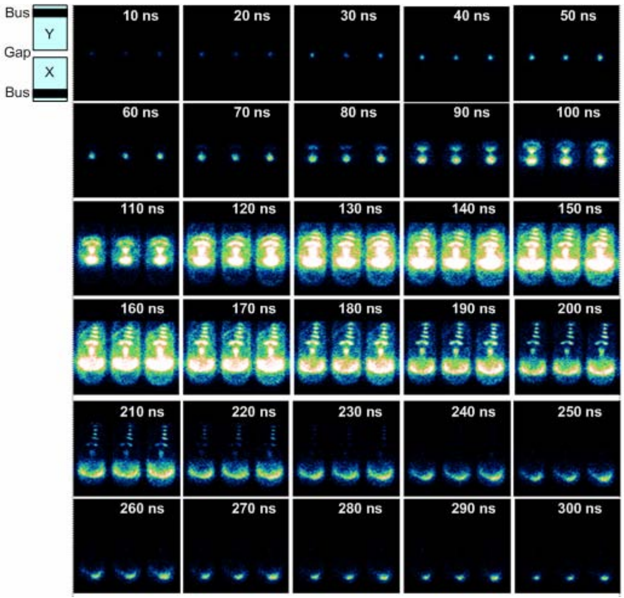
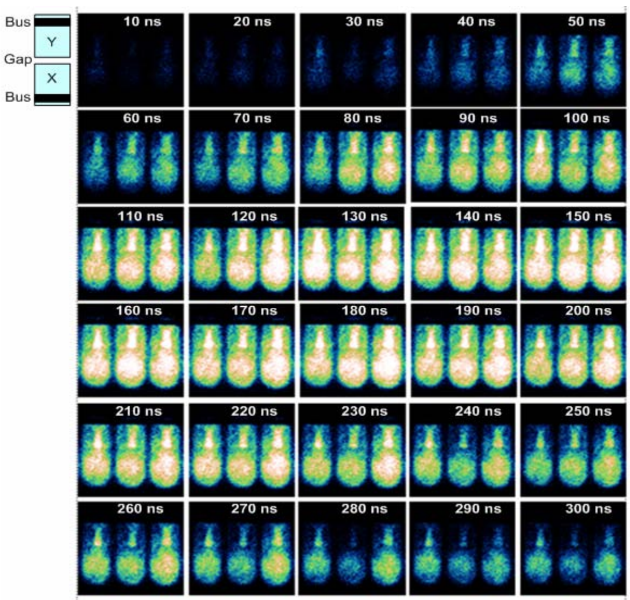


Fig. 3. Voltage vector applied to three electrodes for address discharge on Vt close-curve where reference means Vt close-curve measured in cells with no wall charges.



(a) Conventional sustain discharge



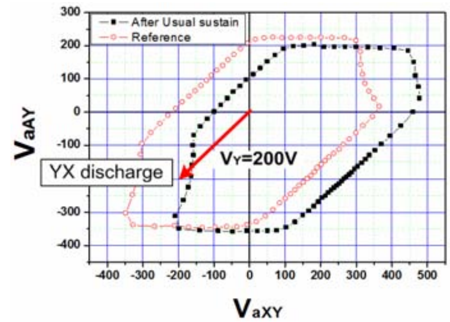
(b) First sustain discharge

Fig. 4. ICCD images during (a) conventional sustain discharge and (b) first sustain discharge.

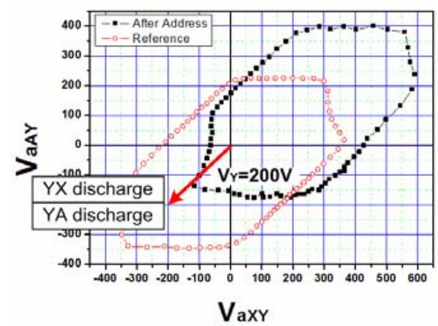
wall charge distribution accumulated by only the Y-X discharge (i.e, sustain discharge) would induce the non uniform electric field, especially near the gap, whereas the wall charge distribution accumulated by the simultaneous Y-X and Y-A discharge (i.e., address discharge) would induce the relatively uniform electric field within the cell.

3.2. Saturation Characteristics of Wall Voltage during Iterant Sustain Discharge

Fig. 6 shows the IR emissions during the iterant sustain



(a) Conventional sustain discharge



(b) First sustain discharge

Fig. 5. Comparison of discharge modes for both cases[(a):conventional sustain discharge and (b) first sustain discharge] by measuring Vt close-curve.

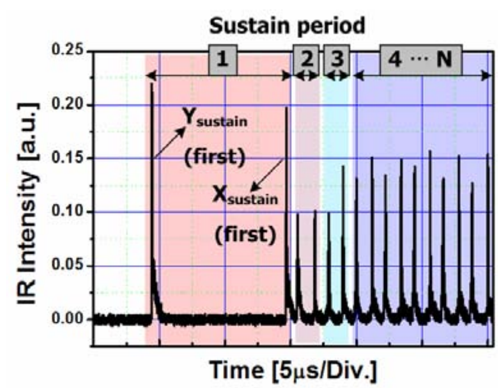
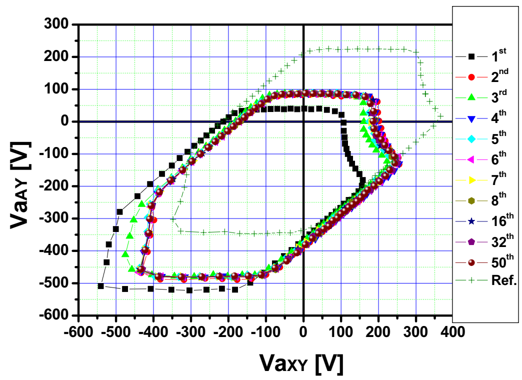
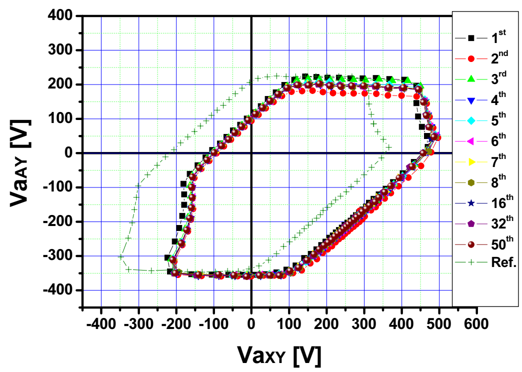


Fig. 6. IR emissions during iterant sustain discharge when applying alternately sustain pulses to Y and X electrodes in sustain period.

discharge in a sustain period. The IR intensities emitted during the first Y and X sustain discharges are observed to be stronger than those emitted during the other sustain discharges. Meanwhile, the IR intensities during the 2^{nd} and 3^{rd} sustain discharge are observed to be weaker than those of other sustain discharges. On the other hand, the IR emission intensities after the 3^{rd} sustain discharge (i.e., the 4^{th} ~ N^{th} sustain discharges) have almost the same. This means that the wall voltage set-up during the iterant sustain discharge shows the saturation tendency with an increase in the number of the applied sustain pulses. The related wall voltage on the three electrodes are measured using the Vt



(a) After Y sustain discharge

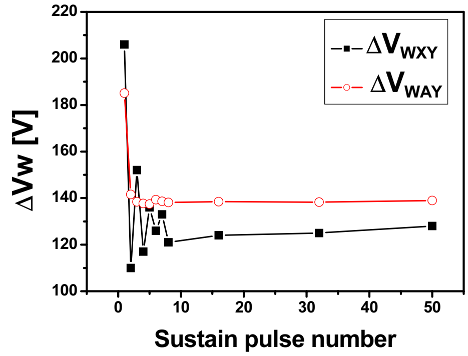


(b) After X sustain discharge

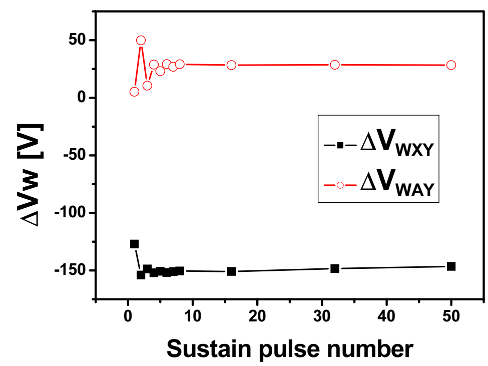
Fig. 7. Vt close-curves measured relative to number of Y and X sustain discharges.

close-curve method. Figs. 7 (a) and (b) show the Vt close-curves measured relative to the number of Y and X sustain discharges. The Vt close-curve measurement shows that the Vt close-curves are coincided with an increase in the sustain discharge number. The resultant wall voltage differences between the X-Y electrodes and between the A-Y electrodes are shown in Figs. 8 (a) and (b).

As shown in Fig. 8 (a), the wall voltage difference, ΔV_{WXY} and ΔV_{WAY} are 206 and 185 V after the first Y sustain pulse, respectively. The initial wall voltage difference, ΔV_{WXY} was decreased with an increase in the Y sustain pulse number and finally saturated to 125 V after the 8 sustain pulses. The wall voltage difference, ΔV_{WAY} was decreased with an increase in the sustain pulse number and finally saturated to 138 V after the 8 sustain pulses. Similarly, Fig. 8 (b) shows that the wall voltage differences, ΔV_{WXY} and ΔV_{WAY} are -127 and 5 V after the first X sustain pulse, respectively. The initial wall voltage difference, ΔV_{WXY} was decreased with an increase in the X sustain pulse number and finally saturated to -150 V after the 8 sustain pulses. The wall voltage difference, ΔV_{WAY} was decreased with an increase in the sustain pulse number and finally saturated to 28 V after the 8 sustain pulses. This means that in order to obtain the larger dynamic voltage margin for the stable sustain discharge, the selective reset waveform needs to be changed depending on the number of the applied sustain pulse.



(a) After Y sustain discharge



(b) After X sustain discharge

Fig. 8. Wall voltage differences obtained by Vt close-curves measured relative to sustain pulse number.

4. Summary

This paper provides the better understanding of the relation between the address and sustain discharge or the relation between the first sustain and subsequent sustain discharge characteristics for the successful addressing in the ADS driving scheme. The address and sustain discharge characteristics are compared using the optical emission spectroscopy. The Xe emission observation shows the different discharge characteristics between the address and sustain discharges such as discharge initiation and discharge propagation characteristics. The spatial-temporal evolution for the first sustain discharge shows the different discharge characteristic for the conventional case, especially for the non-existence of striation. Furthermore, the saturation characteristics of the wall voltage are observed with an increase in the number of the applied sustain pulse, especially, after the 8^{th} sustain pulse.

5. References

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2. Woo Joon Chung, Jeong Hyun Seo, and Ki-Woong Whang, *IEEE Transactions on Plasma Science*, Vol. 30, No. 2, pp.665-672, April 2002.
3. Joon Young Choi, Dong Hyun Kim, Hae June Lee, Ho Jun Lee, Chung Hoo Park, Sung-Hyun Lee, and Sung-Nam Ryu, *SID Technical Digest*, pp.626-629 2005.