6.1: A Study on Wall Charge Behavior of Single Sustain Waveform Based on Vt Close Curve Analysis in AC-PDP

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Abstract

The wall charge behavior of the conventional and two types of single sustain waveforms are investigated based on a simulated result and Vt close curve analysis. The single sustain waveform means that the sustain voltage was alternately applied to the negative and positive voltage level on the single side electrode, that is, the scan (Y) electrode in this paper, where the common (X) electrode remains grounded. In the single sustain waveforms, the address discharge characteristics were improved during an address-period and an asymmetric intensity of the IR emission waveform was produced during a sustain-period compared with the conventional driving waveform. It was found that the improved address discharge characteristics was caused by the effect of the higher external applied voltage during an address-period than the accumulated wall charges during a reset-period, and an asymmetric IR intensity during a sustain-period was due to the simultaneous discharge including the plate gap discharge between Y and A electrode when applying the negative sustain pulse to the Y electrode.

1. Introduction

The plasma-TVs have been considered to be the most promising candidate for digital television due to such conspicuous features as a slim-type large area (> 40-in.), self-emitting-based good color reproduction capability, wide dynamic contrast ratio, and fast visible conversion response by the phosphor layer per sustain pulse [1]. Thus, to capture the TV consumer market and maintain a lead over other flat panel display devices, the development of a low-cost driving technology for plasma TVs has become a critical issue. Most recent efforts have focused on reducing the address voltage [2], a single scan method [3], and decreasing the number of electrical parts. On the other hand, the PDP was driven by applying the driving waveforms to the sustain (X), scan (Y), and address (A) electrodes. Especially, the sustain waveform was alternately applied to the X and Y electrodes. If the two sustain pulses were merged to one sustain pulse with positive and negative polarity on the Y electrodes without applying sustain driving waveform to the X electrodes (hereinafter, this waveform is called the single sustain waveform), the driving circuit cost could be considerably reduced due to the elimination of the sustain driving circuit block on the X electrodes. Previous research called an EX driving waveform has already been reported [4]. However, the discharge characteristics and wall charge behavior of the single sustain waveforms were not discussed intensively. In this paper, the wall charge behavior of the conventional and two types of single sustain driving waveforms including EX driving waveform are investigated and studied based on the simulated result and Vt close curve analysis [5].

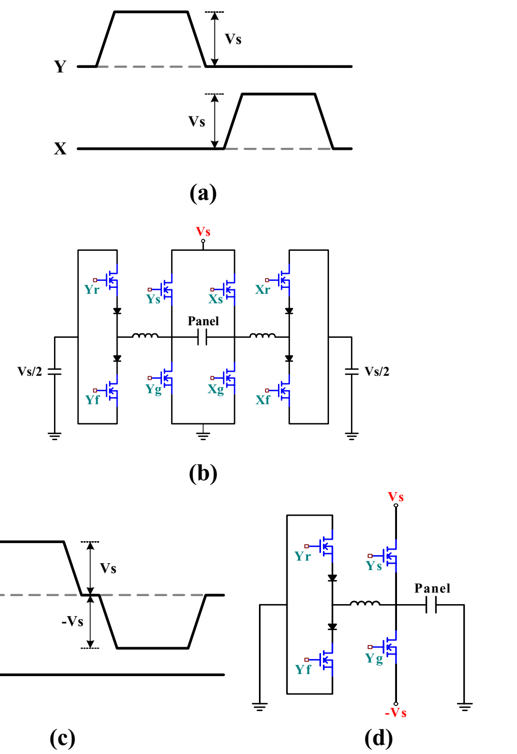

Fig. 1. (a) Conventional sustain pulses applied alternately to Y and X electrodes, (b) corresponding sustain driving circuit with energy recovery circuits, (c) single sustain driving waveform with positive and negative polarities applied only to Y electrode, and (d) corresponding sustain driving circuit with energy recovery circuits.

2. Single sustain waveform

Figs. 1 (a) and (b) show the conventional sustain driving waveform applied alternately to the Y and X electrodes and corresponding sustain driving circuit with energy recovery circuit, respectively. Figs. 1 (c) and (d) show the proposed single sustain driving waveform with positive and negative polarities applied only to the Y electrode and corresponding driving circuit with energy recovery circuits [6]. As shown in Figs. 1 (b) and (d), the conventional sustain waveform needs the main sustain and energy recovery switches 2 times in comparison with the switch number required for the single sustain driving circuit. On the other hand, the maximum voltage level for the single sustain waveform requires the higher level than that for the conventional sustain

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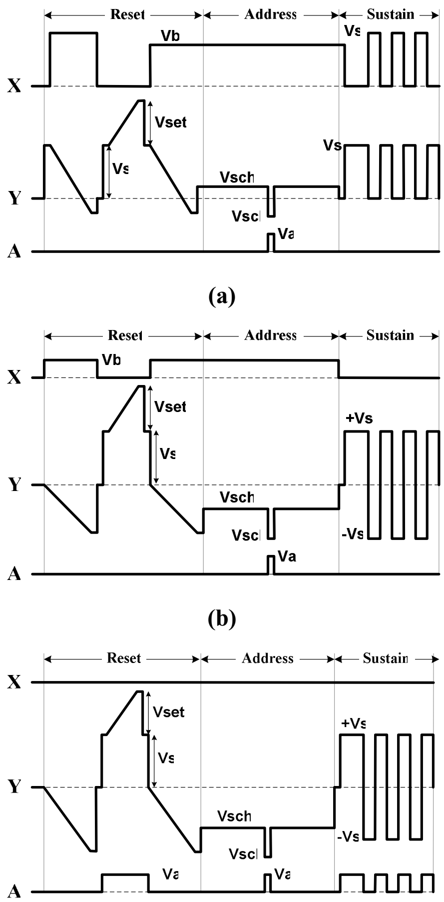


Fig. 2. (a) Conventional, and two types of single sustain waveform employed in this study: (b) case 1 and (c) case 2.

waveform. Nonetheless, it is expected that for the single sustain waveform, the circuit cost would be reduced because the cost reduction effect induced by the reduction of the driving switches is higher than that induced by the lowering of the voltage level.

Fig. 2 shows the (a) conventional, and two types of single sustain waveforms [(b): case 2, and (c): case 3] including the reset-, address-, and sustain-periods for the conventional 42-in. panel structure with a Ne-Xe (7 %) gas mixture. In the proposed driving waveforms in Figs. 2 (b) and (c), the falling ramp waveform was applied at the zero voltage and the Vscl (=scan low voltage) during the address-period was lower than that in the conventional driving waveform. In addition, the single sustain waveform was adopted as a sustain waveform during a sustain-period. In case 1, a small bias voltage was applied to erase the wall charges between the X and Y electrodes on the common (X) electrode during an address-period. However, because the falling ramp voltage on Y electrode in case 2 was lower than that in both the conventional and case 1, the wall charges between the Y and A electrodes was accumulated to the opposite polarity: that is, the ions were accumulated on the Y electrode and the electrons were accumulated on the A electrode, when compared with the wall charges by the conventional method, which induces the misfiring discharge during a sustain-period. Accordingly, the address bias voltage during a sustain-period in case 2 plays a significant role to prevent the misfiring discharge [4].

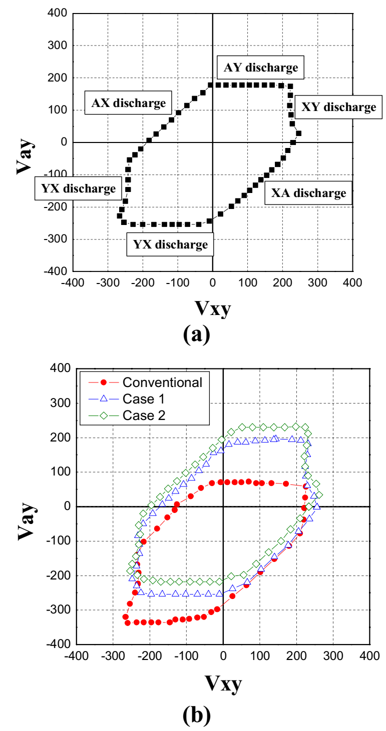


Fig. 3. (a) Vt close curve on the applied voltage plane measured from 42-in. panel before applying driving waveform and (b) Vt close curves on applied voltage plane measured after reset-period when applying three driving waveforms.

3. Analysis of three driving waveforms

3.1 Reset waveform

Fig. 3 (a) shows the Vt close curve on the applied voltage plane measured from the 42-in. panel without the accumulated wall charges before applying the driving waveform. The horizontal axis indicates the threshold voltage between the X and Y electrodes, whereas the vertical axis indicates the threshold voltage between the A and Y electrodes. The typical Vt close curve shape in the conventional panel structure is a hexagon with six sides indicating the threshold voltage. Thus the inner region of the V_t close curve in Fig. 3 (a) means a non-discharge region, while the outer region means a discharge region [5]. Fig. 3 (b) shows the three different V_t close curves on the applied voltage plane measured after a reset-period when applying the three driving waveforms of Figs. 2 (a), (b), and (c). Fig. 3 (b) indicates that the wall charges between the X and Y electrodes were redistributed to the same amount irrespective of the types of the sustain waveforms, but the wall charge distribution between the A and Y electrodes were changed considerably depending on the types of the sustain waveforms. As shown in Fig. 3 (b), for the conventional case, the ions were accumulated on the address electrode. The shape of the measured Vt close curve in case 1 of Fig. 3 (b) was almost similar to that in Fig. 1 (a), which meant that for the 1st single sustain (case 1), the wall charges were almost erased on the three electrodes. For the 2nd single sustain (case 2), the wall charges with the opposite polarity were accumulated on the address electrode. Fig. 4 illustrates the simulated results of the wall charge accumulation among the three electrodes after a reset-period for the three cases: (a) conventional, (b) 1st single sustain

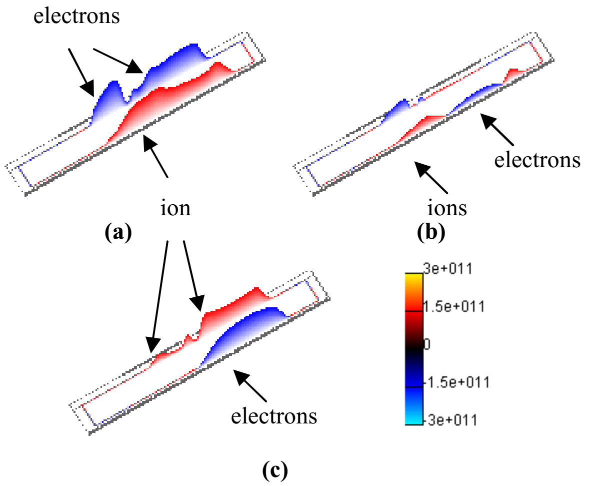


Fig. 4. Simulated results of wall charge distributions accumulating among three electrodes after reset-period: (a) conventional, (b) case 1, (c) case 2.

(case 1) and (c) 2nd single sustain (case 2) waveforms. The simulated result of Fig. 4 validates the analysis result of the Vt close curves in Fig. 3.

3.2 Address discharge characteristics

Fig. 5 (a) shows the address discharge probability of three cases with the times after applying the scan pulse for the three different types of driving waveforms. The 1st single sustain waveform (case 1) shows the best address discharge probability, and the 2nd single sustain waveform (case 2) shows the better address discharge probability. These results are based on the fact that the address discharge time lags for the single sustain waveforms were shorter than those of the conventional case. For the conventional case, the address discharge strongly depends on the wall charge accumulated on the three electrodes prior to the address discharge. However, for the cases 1 and 2, the address discharge strongly depends on the applied voltage during the address-period because the wall charges accumulated on the three electrodes, especially the X and Y electrodes have been erased considerably. This wall charge-erasing condition enables the lower scan low voltage (Vscl). Since the PDP has millions of micro-discharge cells, the fast and stable address discharge using the wall charge accumulated on the three electrodes is difficult to produce because of the inherent non-uniform characteristics. The address discharge time lag of the case 1 was slightly shorter compared with the case 2 because the inversion phenomenon of the wall charge polarity occurred in case 2. Figs. 5 (b) (c) and (d) show the scan pulse applied to the Y electrode and the corresponding IR emission waveforms during an address-period when applying the (a) conventional, and two types of single sustain waveforms [(b): case 1, and (c): case 2]. As shown in Fig.5, the address discharge in the single sustain waveform was produced earlier than that of the conventional case.

3.3 Sustain discharge mode

Figs. 6 (a) and (b) show the measured Vt close curves on the applied voltage plane (a) after applying the X sustain pulse for the conventional case and the negative sustain pulses for two single sustain cases and (b) after applying the Y sustain pulse for the conventional case and the positive sustain pulses for two single

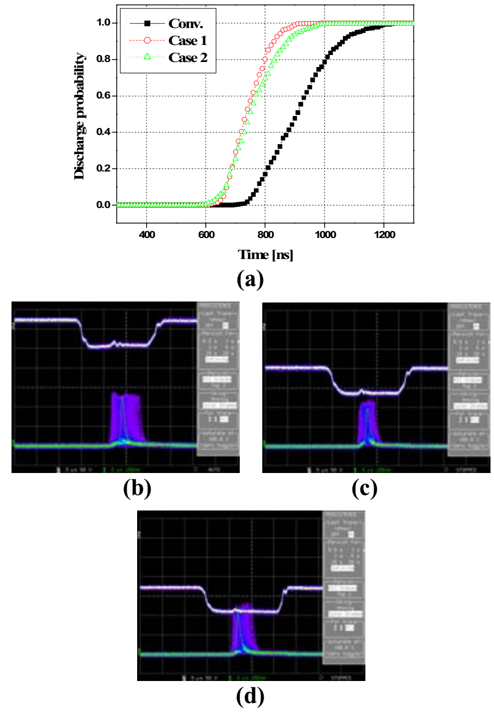


Fig. 5. Address discharge probability of three cases after applying scan pulse (a), and IR emission waveforms during address-period in cases of (b) conventional, (c) case 1, (d) case 2.

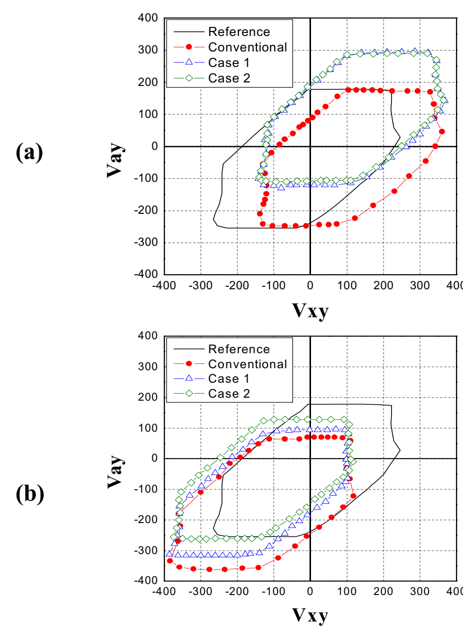
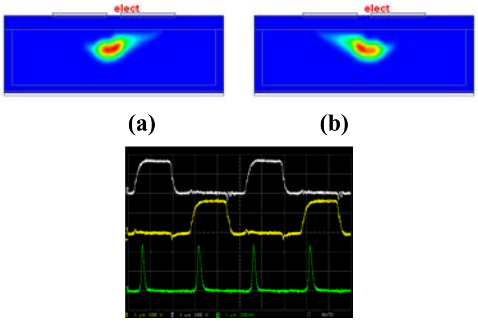


Fig. 6. Measured Vt close curve on applied voltage plane: (a) after X sustain pulse in conventional case and negative sustain pulse in single sustain case, (b) after Y sustain pulse in conventional case and positive sustain pulse in single sustain case.

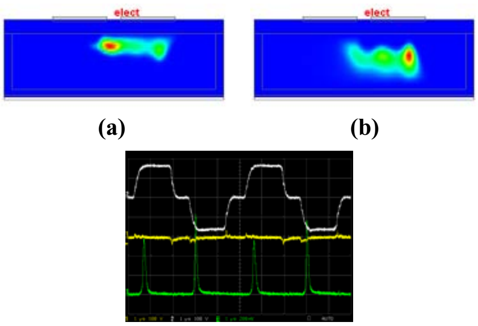
sustain cases. The reference in Figs. 6 (a) and (b) means the Vt close curve before applying the driving waveform, *i.e.*, no wall charge or the same wall charge amount among the three



(a) (b)

(c)

Fig. 7. Simulated result of electron density profile among three electrodes when applying conventional sustain waveform on Y electrode (a), X electrode (b), and applied sustain waveform with corresponding IR (828 nm).

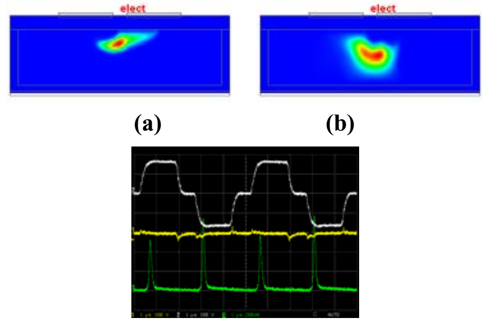


(a) (b)

(c)

Fig. 8. Simulated result of electron density profile among three electrodes when applying sustain waveform of case 1 on Y electrode (a), X electrode (b), and applied sustain waveform with corresponding IR (828 nm).

electrodes. As shown in Fig. 6 (a), for the conventional case, the Vt close curve after applying the X sustain pulse was shifted to the right side compared with the reference curve, which meant that the wall voltage was changed dominantly between the X and Y electrodes instead of between the A and Y electrodes. The resultant wall charge distributions were as follows: the electrons on the X electrode and the ions on both the Y and A electrodes. For the conventional case of Fig. 6 (b), the Vt close curve was shifted to the lower left side after applying the Y sustain pulse, which meant that the wall voltages were changed between the X and Y electrodes, and between the Y-A electrodes, but the wall charge did not change between the A-X electrodes. That is, in this case, the electrons were accumulated on the Y electrodes, and the ions were accumulated on both the X and A electrodes. Accordingly, for the conventional case, the sustain discharge was produced between the X and Y electrodes because the ions were always accumulated on the A electrodes. However, for the single sustain case, the Vt close curve after applying the negative Y sustain pulse was shifted to the upper right side compared with the reference curve, which meant that the wall voltage was changed dominantly between the X and Y electrodes and between the A-Y electrodes instead of between the X and A electrodes. The resultant wall charge distributions were as follows: the ions on the Y electrode and the electrons on both the X and A electrodes. This Vt close curve analysis provides information about the



(a) (b)

(c)

Fig. 9. Simulated result of electron density profile among three electrodes when applying sustain waveform of case 2 on Y electrode (a), X electrode (b), and applied sustain waveform with corresponding IR (828 nm).

simultaneous discharge between the X-Y electrodes and between the A-Y electrodes. Fig. 7 shows the simulated result of electron density profile among three electrodes when applying conventional sustain waveform on (a) Y electrode, (b) X electrode, and applied sustain waveform with corresponding IR (828 nm). Figs. 8 and 9 show the simulated result of electron density profile among three electrodes when applying the single sustain waveforms (cases 1 and 2), respectively. Comparing the electron density profile and IR emission of Fig. 7 with that of the conventional sustain pulse, the more strong sustain discharge was produced when applying the negative sustain pulse instead of the positive sustain pulse in both cases 1 and 2. This result was due to the simultaneous discharge (X-Y and A-Y discharges) produced when applying the negative sustain pulse.

4. Conclusion

This work focused on the wall charge behavior of the conventional and the two types of single sustain waveforms are investigated based on the simulated result and Vt close curve analysis. It was found that the improved address discharge characteristics was caused by the effect of the higher external applied voltage during an address-period than the accumulated wall charges during a reset-period, and an asymmetric IR intensity during a sustain-period was due to the simultaneous discharge including the plate gap discharge between the Y and A electrode when applying the negative sustain pulse to the Y electrode.

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