New Self-Erasing Discharge Mode for Improvement of Luminous Efficiency and Color Purity in AC Plasma Display Panel

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Abstract

This paper presents a new self-erasing discharge mode for the improvement of luminous efficiency and color purity of an AC plasma display panel (AC PDP). A new self-erasing discharge mode is produced between successive sustain pulses by simultaneously applying the auxiliary short pulses at the falling edge of the sustain pulses without cross-talk during a sustain period. As a result, the luminous efficiency and color gamut are improved by 16% and 5%, respectively.

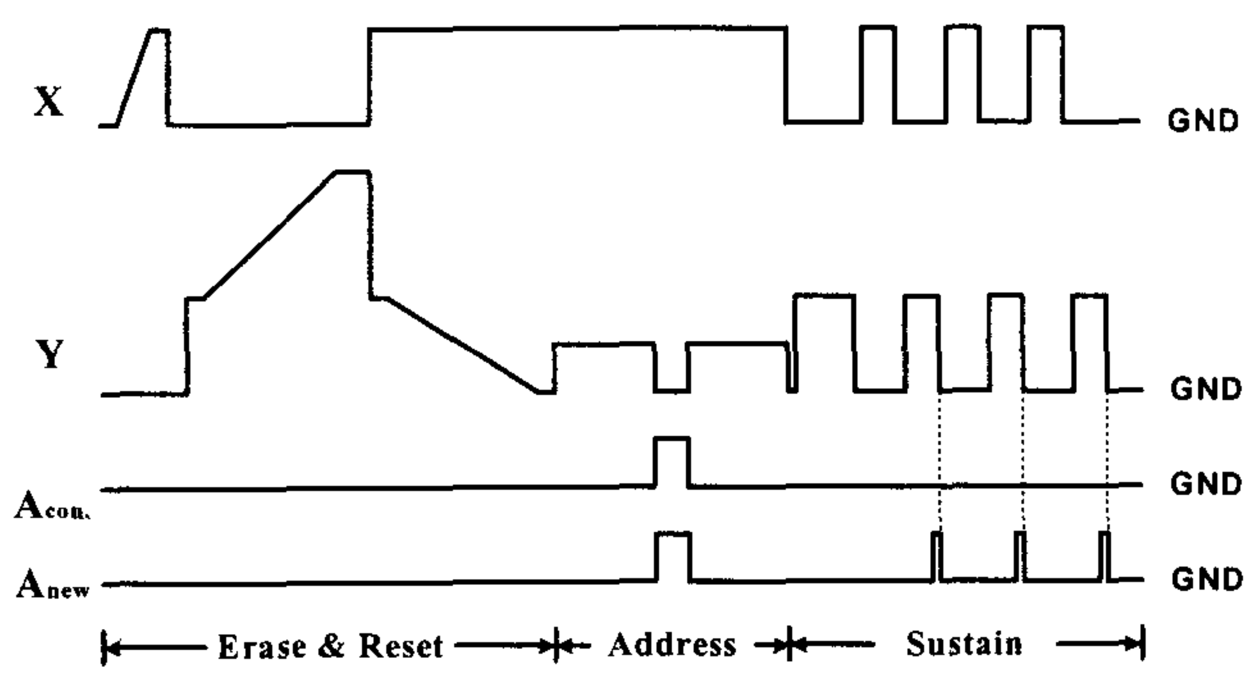
1. Introduction

This work focuses on an improvement of luminous efficiency and color purity of an AC PDP using a self-erasing discharge produced by applying short pulses to the address electrodes during a sustain period. Most previous research has focused on improving luminous efficiency and color purity using the new cell structure [1], optical filter[2], or using the optimization of the gas chemistry[3]. In a sustain period, once the plasma discharge is produced in the cell, the corresponding wall charges are formed abruptly from the space charges such as electrons and ions. These wall charges play an essential role in the next sustain discharge for a stable discharge. However, if the part of wall charges is utilized to produce the priming particles such as space charges, it is expected that the luminance efficiency will be improved. In this sense, a new sustain discharge mode using a self-erasing discharge has been suggested to improve the luminous efficiency [4].

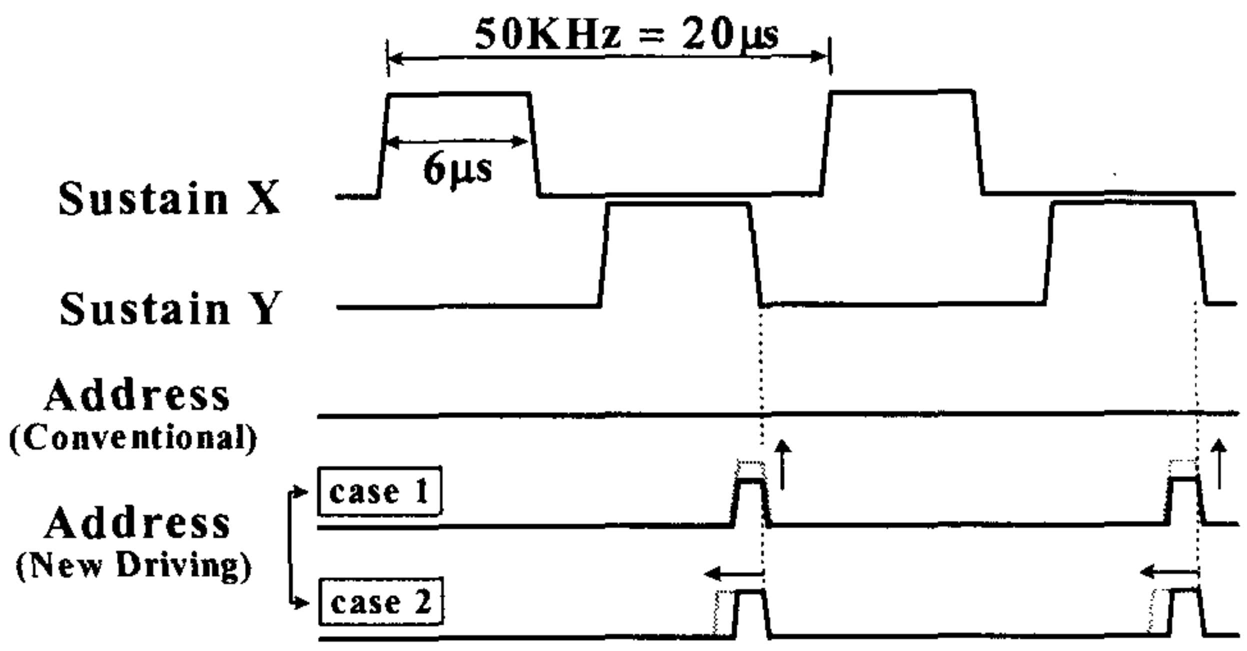
In this work, we suggest a new driving technique to induce the self-erasing discharge without reducing the luminance of an AC PDP. The auxiliary short pulses are simultaneously applied to the address electrodes at the falling edge of the sustain pulses so that the strong electric field is not applied to the sustain electrodes where the wall charges are accumulated. The effects of the amplitudes and pulse widths of the auxiliary short pulses on the luminous efficiency and color purity of 4-inch AC PDP test panel are examined.

2. Experiment

Fig. 1 shows the conventional and new driving waveforms in the case of adopting of ADS method (a) and new driving scheme for a self-erasing discharge using an auxiliary short address pulse during a sustain period (b). No address pulse is applied in the conventional driving scheme, however, the proposed driving scheme applies an auxiliary short pulse to the address electrode simultaneously at the falling edge of only sustain Y pulse to prevent cross-talk between sustain Y and address A electrodes. The driving conditions are a sustain voltage of 170V, a sustain frequency of 50KHz, a sustain pulse width of 6μs. In order to produce a self-erasing discharge between successive sustain pulses, the auxiliary short pulses



(a) Ramp-reset ADS driving waveform



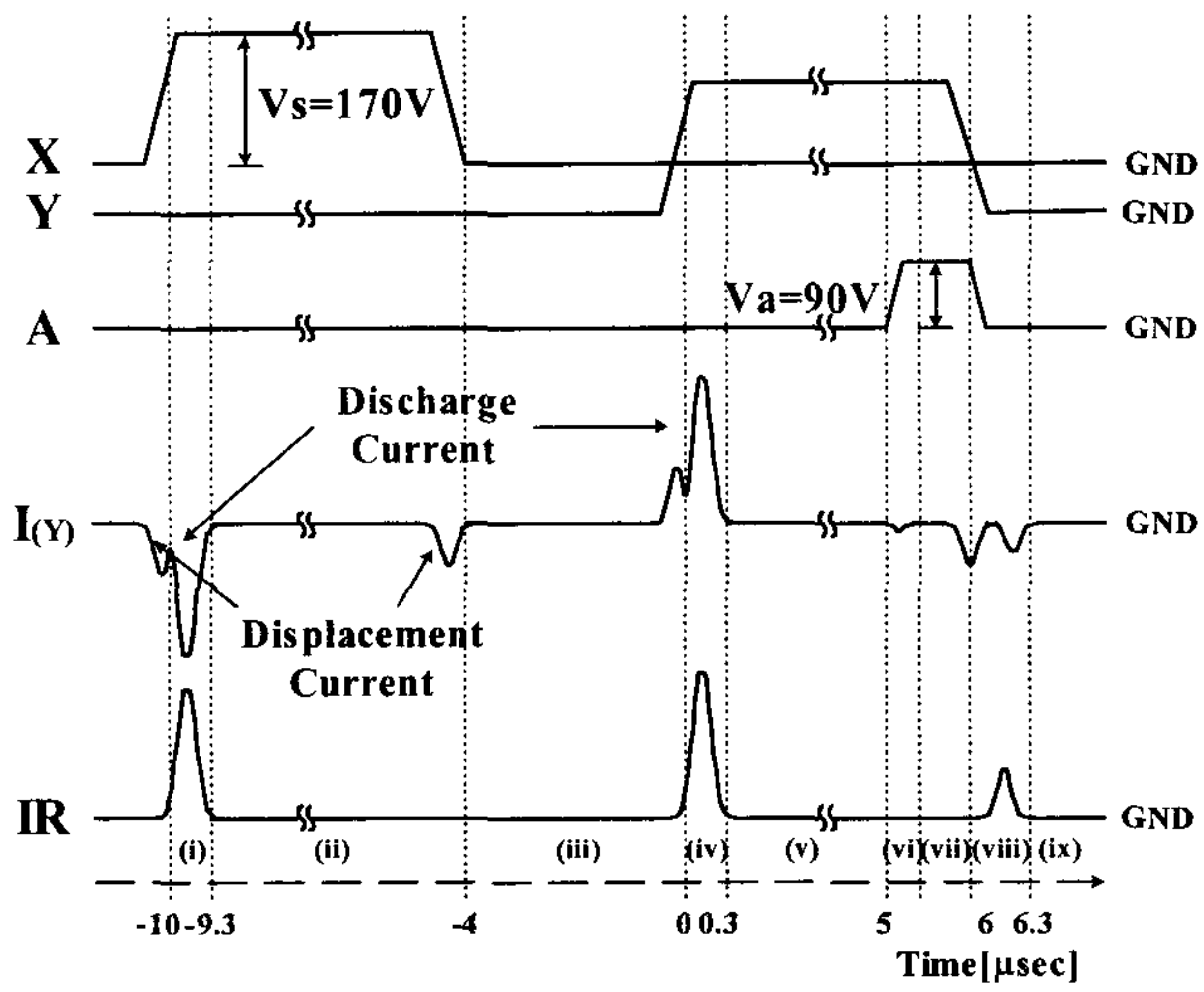
(b) New driving scheme during sustain-period

Figure 1 New driving scheme for inducing a self-erasing discharge

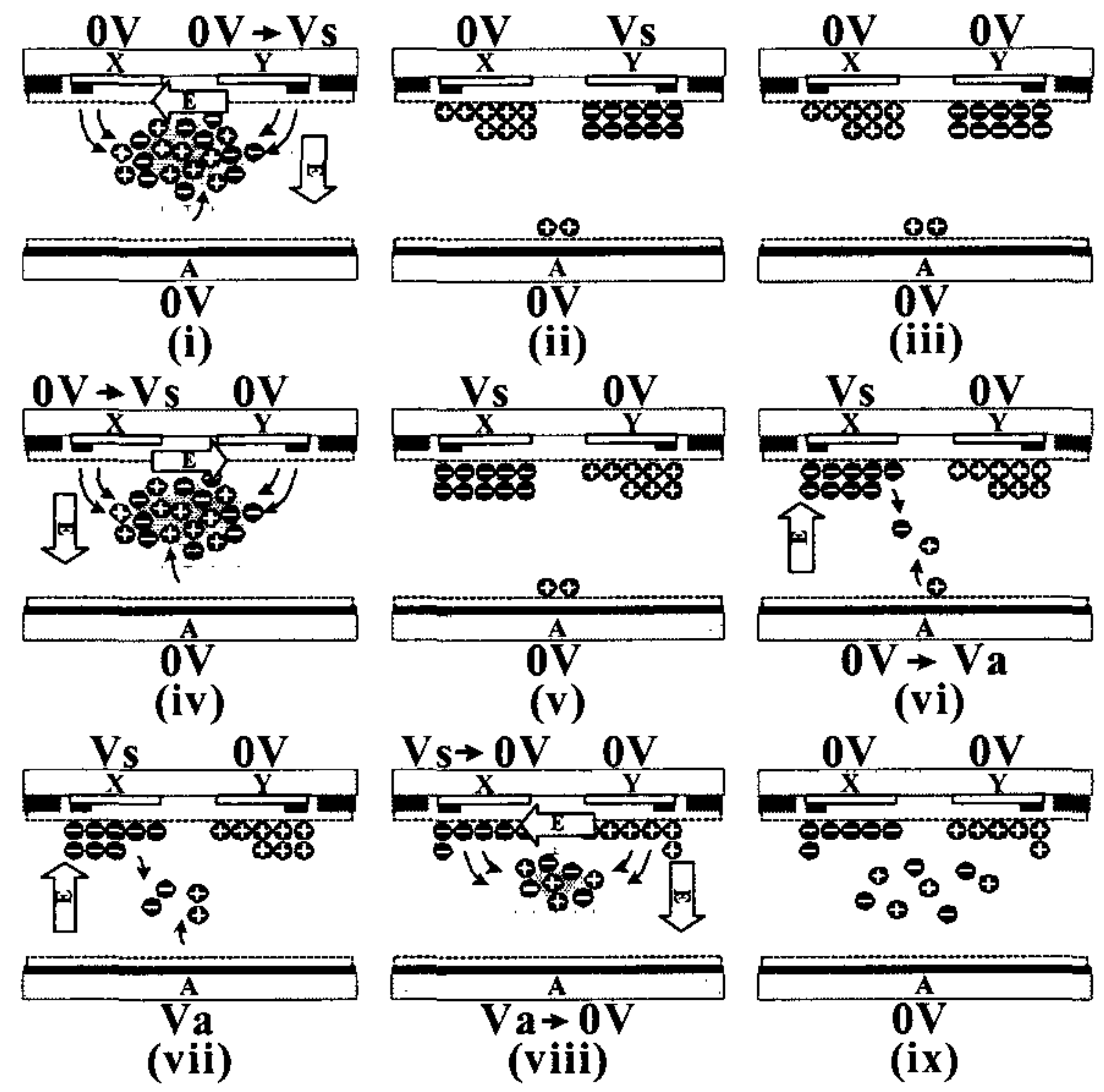
are applied to the address electrodes so that their falling edges coincide with those of the sustain pulse, thereby producing a self-erasing discharge between two successive sustain pulses when the all voltages applied to the three electrodes are zero. To prevent cross-talk between sustain Y and address A electrodes, auxiliary short address pulses are applied when the sustain voltage is applied on Y electrode. In addition, the amplitudes and pulse widths of auxiliary short pulses were varied to investigate their influence on the self-erasing discharge.

3. New Self-Erasing Discharge Mode Triggered by Auxiliary Short Pulse

Fig. 2(a) illustrates the schematic waveforms of the sustain and auxiliary short address pulse applied to the three electrodes along with the corresponding sustain current and IR (823 nm) based on the actual waveforms measured from the 4-in. ac-PDP test panel during a sustain period in the case of adopting the new driving scheme for a self-erasing discharge. The corresponding temporal behavior model of the wall and space charges within the PDP cell relative to the variations in V_s and V_a is also shown in Fig. 2(b). When the sustain voltage is applied to the sustain electrode, this produces the plasma, as shown in Fig. 2(b)-(iv), due to the accumulated wall charges. As soon as the plasma is produced, the electrons and ions accumulate on the sustain electrodes X and Y with the opposite polarity, respectively, and a small amount of ions also accumulate on the address electrode with 0V [Fig. 2(b)-(v)]. After about 6μs, the auxiliary short pulse V_a with an amplitude of 90V and a pulse width of 1000ns is applied to the address electrode A. The electric field caused by this abrupt short positive pulse plus a small amount of positive wall charges removes a small amount of the positive wall charges accumulated on the address electrode, and also eliminate the part of the negative wall charges accumulated on the sustain electrode X [Fig. 2(b)-(vi)], which is verified by detecting the small displacement current flowing through the sustain electrode X [Fig. 2(a)-(vi)]. These wall charges removed from the sustain and address electrodes act as space charges. However, in this case, the energy of the space charges, especially electrons is not so high as to excite the atoms for generating the IR emission. Thus, these space charges play a significant role as priming particles in producing a self-erasing discharge at the falling edge of the sustain pulse. As shown in Fig. 2(b)-(viii), when both the sustain voltage and the auxiliary voltage abruptly fall to a zero



(a) New driving scheme for self-erasing discharge



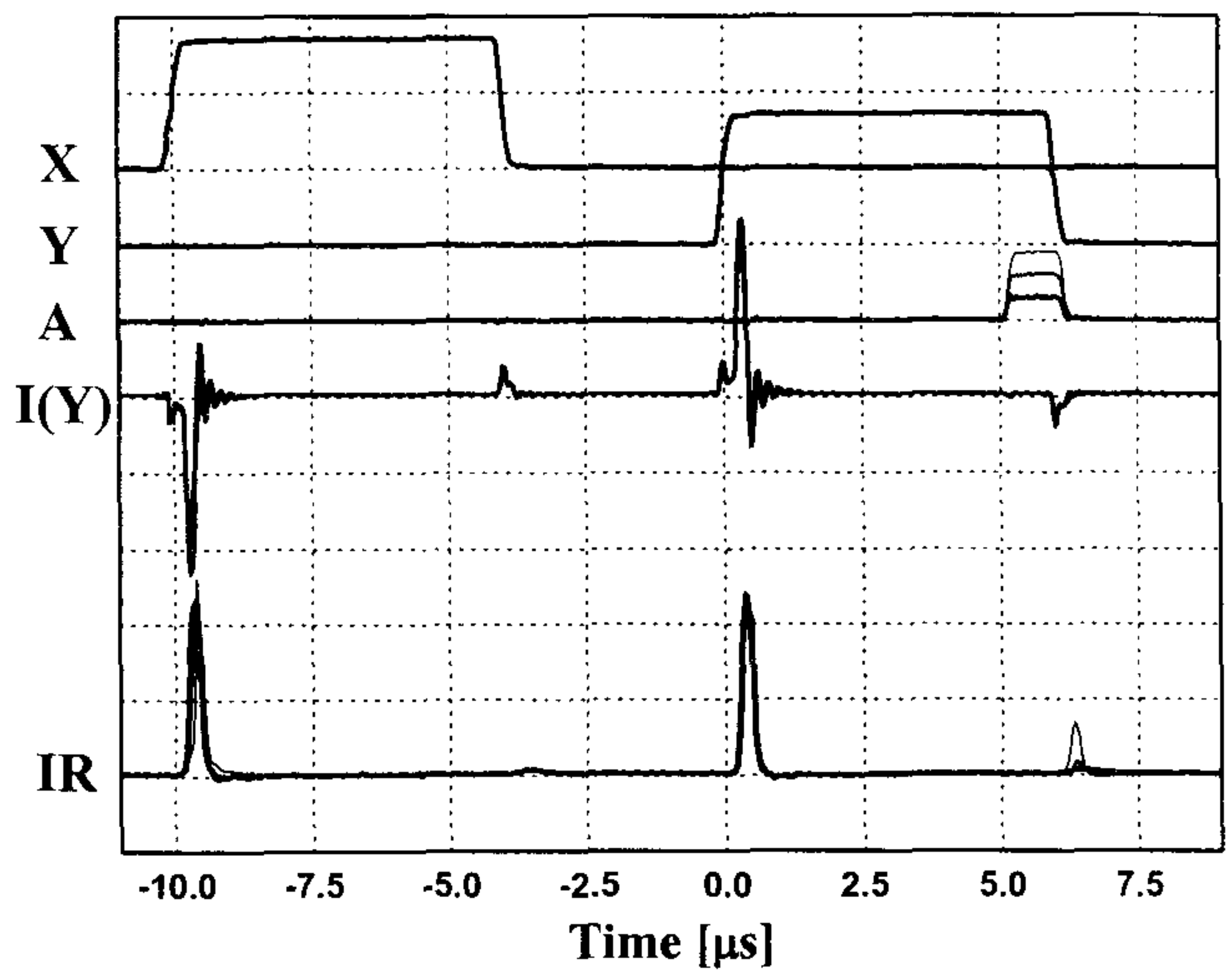
(b) Temporal behavior of wall/space charges

Figure 2 Voltage, current and IR (a) and schematic model for temporal behavior of wall/space charges within the PDP cell(b)

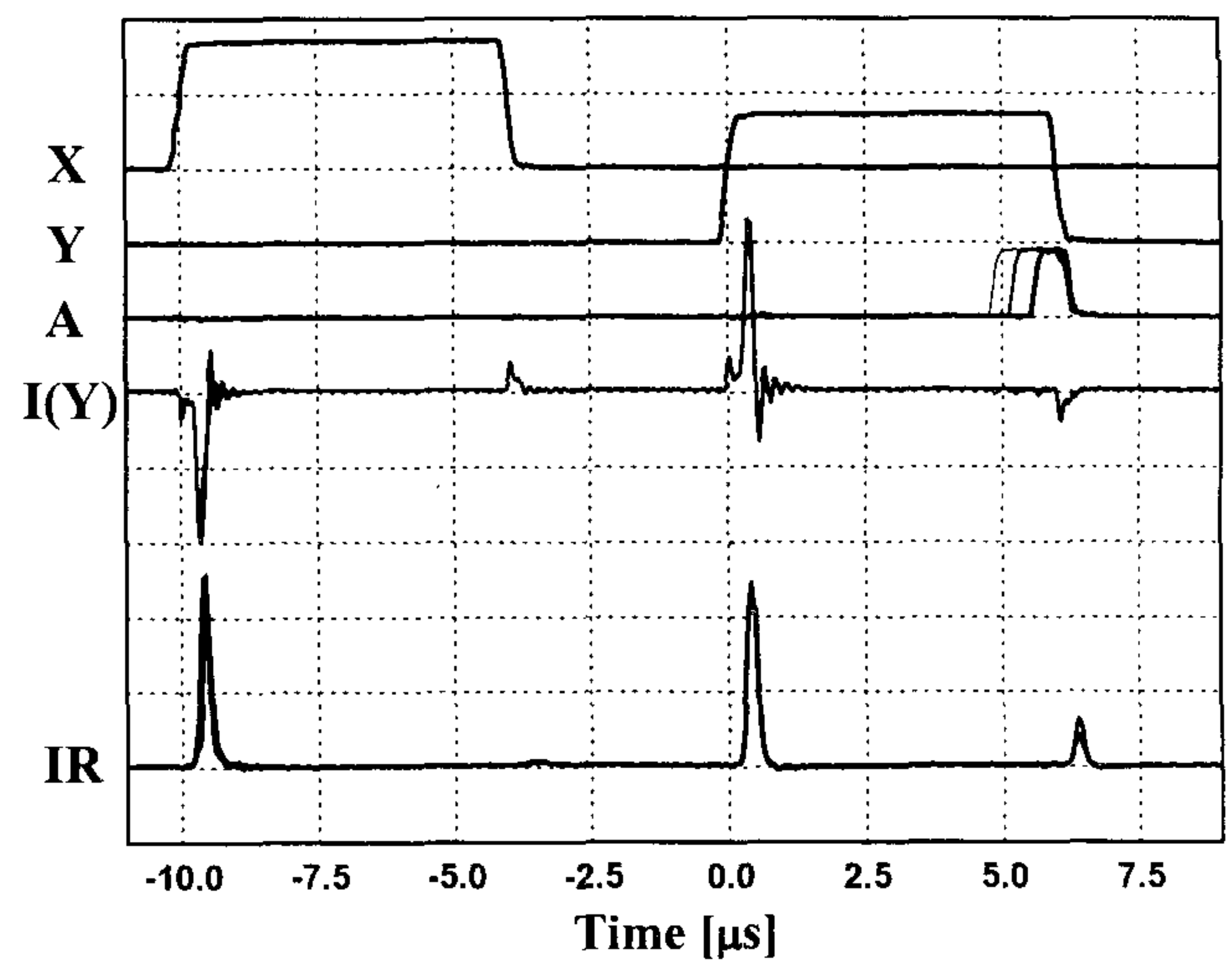
simultaneously, another small discharge, *i.e.*, a self-erasing discharge is induced. In this case, the abrupt falling of both sustain and address voltages plus the wall voltage caused by the wall charges on the sustain electrodes induces the electric field between two sustain electrodes as well as between sustain and address electrodes to the direction shown in Fig. 2(b)-(viii). The application of this electric field causes the conversion of the part of wall charges into the space charges in addition to the remaining space charges, thereby resulting in producing a self-erasing discharge, as shown in Fig. 2-(viii). Accordingly, this self-erasing discharge can be produced even under a weak electric field condition due to the presence of space charges, implying that the discharge current is decreased due to the reduction of the ionization, but the corresponding IR emission is increased by means of the efficient excitation. That is why the self-erasing discharge contributes to improving the luminous efficiency. The space charges produced during the self-erasing discharge also participates in the next main sustain discharge as the priming particles. The presence of the space charges at the initiation of the ensuing main discharge can contribute to improving the luminous efficiency of the main discharge because the space charges at the beginning of the discharge can promote efficiently the excitation instead of the ionization.

3. Effects of Amplitude and width of Auxiliary Short Pulse on Luminous Efficiency

Fig. 3 illustrates the sustain current and IR (823 nm) waveforms measured from the 4-in. ac-PDP test panel in the case of adjusting the amplitudes (a) and pulse widths (b) of the auxiliary short pulses. In Fig. 3(a), the pulse widths of the auxiliary short pulses were fixed at 1000ns, whereas the amplitudes ranged at intervals of 30V from 30V to 90V. When the amplitude of the auxiliary short pulse was 30V, there was no self-erasing discharge, indicating that this amplitude was too low to produce the space charges for a self-erasing discharge. When the amplitude was increased from 60V to 90V, the self-erasing discharge intensity was increased and the main discharge current was decreased. However, the main IR intensity remained almost constant, as shown in Fig. 3(a). This result shows that the higher the amplitude of the auxiliary pulse, the stronger the self-erasing discharge intensity, implying that the high amplitude of the auxiliary pulse can contribute to producing more space charges necessary for the strong self-erasing discharge at the falling edge of the sustain pulse. In Fig 3(b), the pulse widths of the auxiliary short pulses were increased at intervals of 400 ns from 600 ns to 1400 ns at a constant address voltage of 90V. As the pulse widths were increased to the direction shown in Fig 3(b), the IR intensity emitted during the self-erasing discharge was increased, while the IR intensity emitted during the main discharge was decreased a little and the main discharge current was decreased. As the pulse width of the auxiliary short pulse at a constant address voltage is wider, the self-erasing discharge intensity become slightly strong, thereby resulting in better the luminous efficiency. Like the case of the variation in the amplitude, the wide width of the auxiliary pulse can contribute to producing more space charges necessary for the strong self-erasing discharge at the falling edge of the sustain pulse.



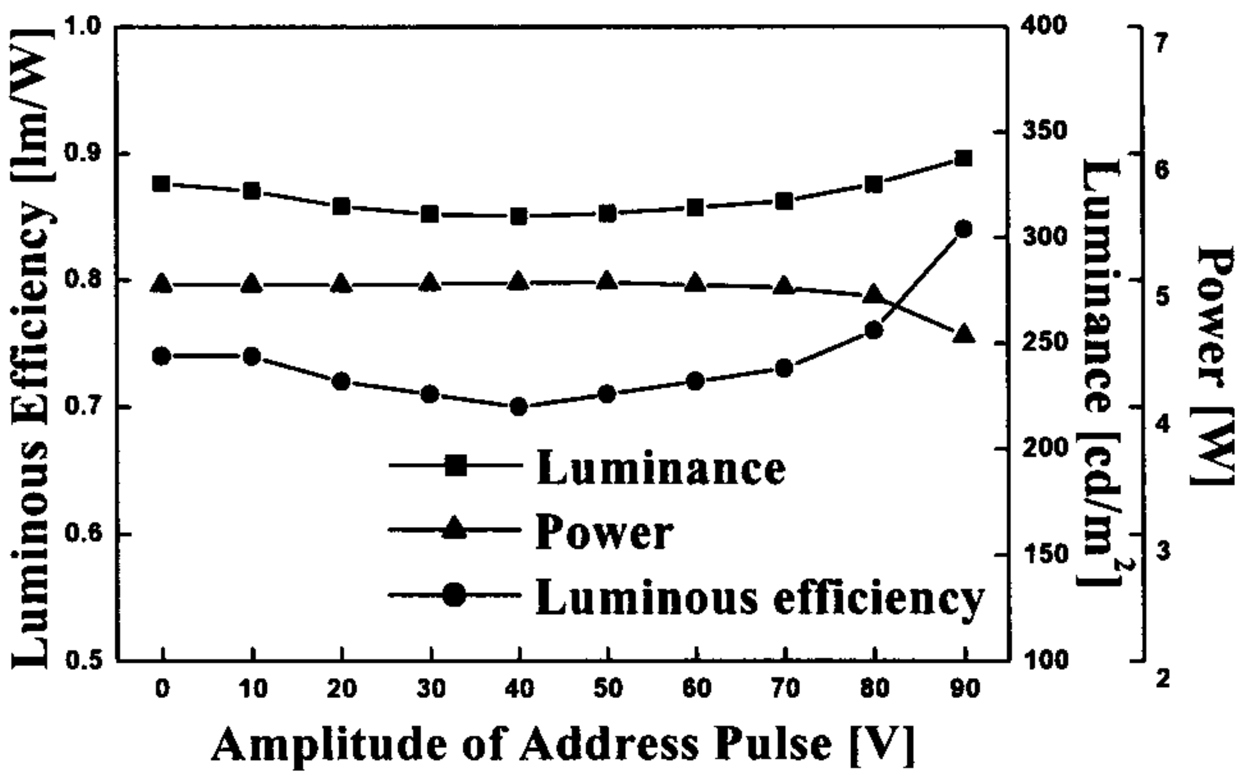
(a) Variations of amplitudes of short address pulse



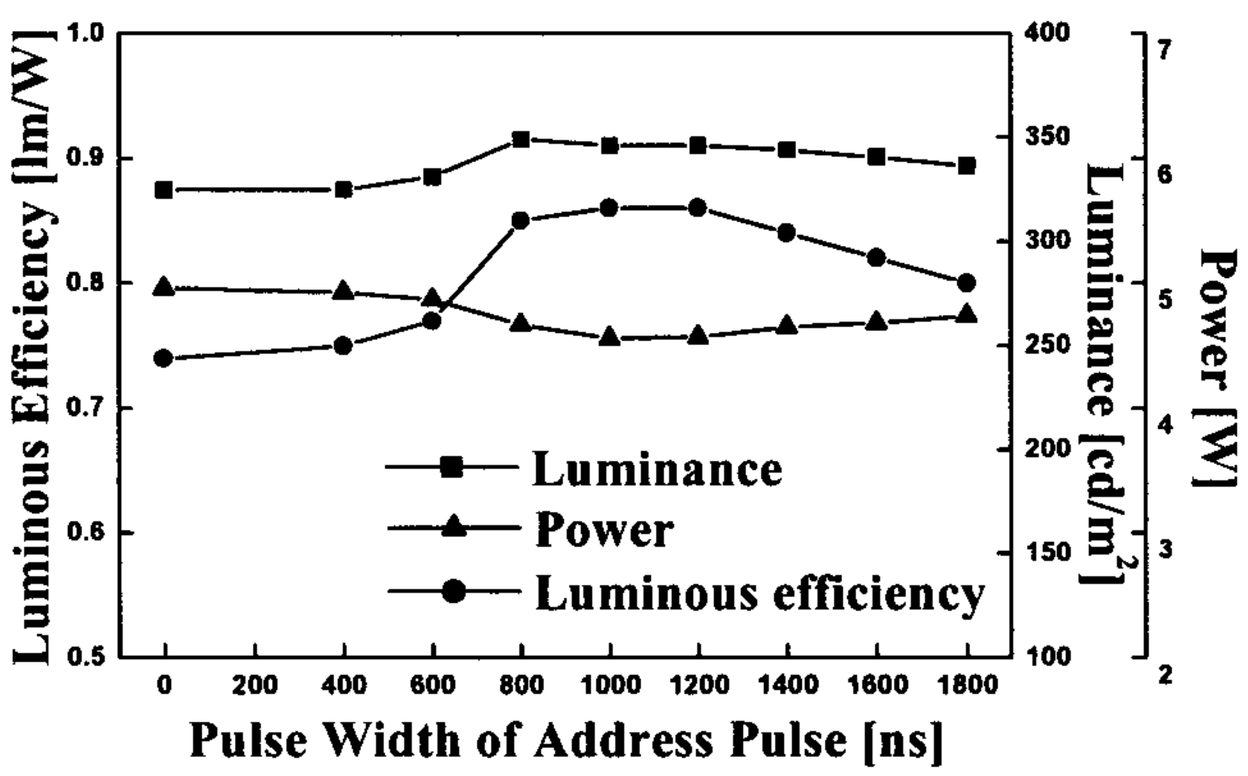
(b) Variations of pulse width of short address pulse

Figure 3 Current and IR waveform measured from 4-inch AC PDP panel with new driving scheme.

Figs. 4 illustrate the changes in the luminous efficiency, luminance, and power consumption relative to an increase in the amplitude (a) and pulse width (b) of the auxiliary short pulse in the new driving scheme. The pulse width in Fig. 4(a) was 1000 ns, whereas the pulse amplitude in Fig. 4(b) was 90V. Fig. 4(a) shows that a short pulse voltage of less than 60V did not induce a self-erasing discharge but disturb the main discharge. However, when the short pulse voltage became higher than 60V, the self-erasing discharge intensity increased such that the luminous efficiency increased. In addition, the power consumption during the main discharge was also reduced, as shown in Fig. 4(a), because the following main discharge became weak due to the previous self-erasing discharge. Fig. 4(b) shows that as the pulse width of an auxiliary short pulse with a constant voltage of 90 V increased at intervals of 200ns from 0 to 1800ns. The maximum luminance efficiency increase rate of about 16% was obtained at amplitude of 90V and pulse width of 1000 ns. As in Fig. 4(a), the luminance remained almost constant or was increased slightly, and the power consumption was reduced. Accordingly, it is anticipated that the proper control of the auxiliary short pulse used to trigger a self-erasing discharge can contribute to a high luminous efficiency without reducing the luminance of an AC PDP.



(a)



(b)

Figure 4 Luminance, luminous efficiency, and power consumption with variations of amplitudes (a) and pulse width (b) of short address pulses in the new driving scheme.

4. Effects of New Mode on Color purity

This phenomenon is attributed to the weakening of the main discharge caused by a self-erasing discharge. As a result, the expanded color gamut was obtained in the new self-erasing discharge mode, as illustrated in Fig. 5 [5]. In particular, the color purities of the blue and green visible emissions were improved, thereby resulting in enlarging the color gamut area by about 5% in the new self-erasing discharge mode.

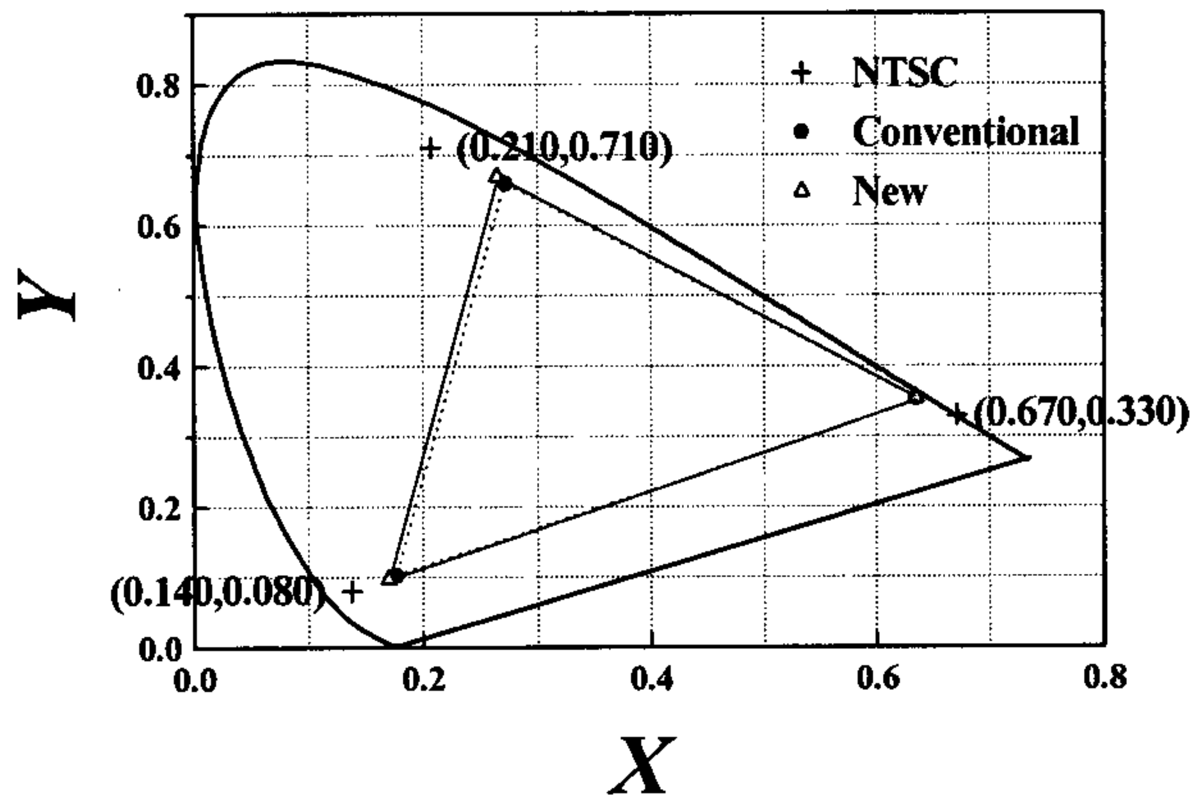


Figure 5 Changes in color gamut area in CIE Chromaticity Diagram(1931)

5. Conclusion

The significance of this work is that the luminous efficiency and the color purity can be improved simultaneously using the new self-erasing discharge mode during a sustain-period. The new self-erasing discharge mode was found to improve the luminous efficiency by 16% and the color gamut area by about 5%, when compared with the conventional discharge mode of an AC PDP.

6. References

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