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Study on Address Discharge Characteristics Using Wall Charge on Three Electrodes during an Address Period in AC PDP

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A modified driving waveform in AC plasma display panel is proposed to improve the address discharge characteristics applying the additional pulses on the sustain electrode during an address period. After a reset period in the driving scheme of an AC PDP, the electrons are accumulated on two front electrodes and the ions are accumulated on the address electrode. Among the accumulated wall charge on three electrodes, the electrons on the scan electrode and the ions on the address electrode are mainly used for the address discharge triggering when the scan and address pulses are applied simultaneously during an address period. Meanwhile, since the constant bias voltage on the sustain electrode is only maintained during an address period, the wall charge on the sustain electrode a little contribute to an address discharge triggering. In this sense, if the electrons on the sustain electrode during an address period are utilized, the improvement of the address discharge characteristics is expected. Therefore, in this study, the additional negative going pulses are applied to the sustain electrode while the scan and address voltages are changed during an address period. In addition, the address discharge characteristics are investigated in accordance with the various voltage height and pulse applying time. Consequently, the production time of an address discharge can be reduced approximately 200 ns under the optimal driving condition compared with the conventional driving waveform.

Keywords Address discharge; wall charge; sustain electrode; plasma display panel; PDP

1. Introduction

Nowadays, AC plasma display panel (AC PDP) device is faced with a difficult situation in the television or monitor market compared with the other display devices. However, AC PDP is still considered to be a suitable display device for a large area and the 3D digital high definition television because it has some merits such as an easy manufacture

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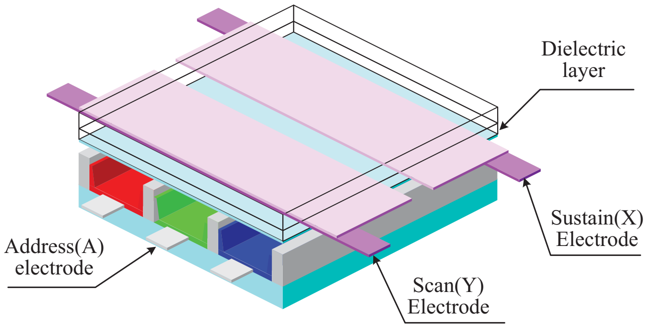

Figure 1. Fundamental three-dimensional AC PDP structure with surface type.

for a large area, a cheap manufacturing cost, a high speed response characteristics, and so on [1, 2]. Especially, AC PDP has a large advantage for the 3D TV due to high speed response time among the other display devices. However, in spite of high speed response characteristics in AC PDP, the luminance is decrease in realization of the 3D TV and it is difficult to improve the luminance because the sustain time for generating the visible light by the plasma discharge is limited by the long address period during one-TV frame [3]. The address method in AC PDP is that the scan and address pulses are applied line-by-line from the first to the last vertical scan lines during an address period. If the number of lines are increased in the case of the full-HD or Ultra-HD resolution, the sustain time for displaying will be relatively decreased under the constant one TV frame because the addressing time is increased as the number of lines [4].

The scan pulse indicate the applying pulse to the scan (Y) electrode, whereas the address pulse indicate the applying pulse to the address (A) electrode. Since the address time is determined by the scan and address pulse widths during an address period – one pulse width was normally over 1μs, a reduction in a pair of the scan and address pulse can decrease not only one pulse applying time but also the total address time. This result contribute to increase the sustain time to produce the visible light. However, it is difficult to reduce the scan and address pulse width due to the address discharge time lag when adopting the conventional driving method. Therefore, the new high speed address method during an address period should be proposed to reduce a scan and address pulse width and decrease in the total address time. The previous studies for a high speed address method has been reported on the driving method to increase in address voltage gradually with an address time, using the priming effect by the adjacent cell, using priming particle produced by the reset discharge, and so on [5–7]. However, the discharge misfiring occurred in some methods and the realization for the driving circuit was difficult for a large area.

Normally, AC type plasma display panel is composed of three electrodes – the sustain (X), scan (Y), and address (A) as shown in Figure 1 [8]. The Y electrode for the scan action and the X electrode for the sustain discharge are on the front plate with parallel lines to horizontal direction, while the address electrode is located on the rear plate with vertical direction on the contrary to two front electrodes. The wall charge in AC type PDP is accumulated on the dielectric layer in a cell between the electrode and discharge space when the plasma discharge is produced by application of the external voltages, otherwise the electrodes in DC type PDP are directly exposed to the discharge space without the dielectric layer. Heating a gas ionized its molecules or atoms, thus turning it into plasma, which contains charged particles – positive ions and negative electrons [9]. The wall charge is known to ions and electrons located on the dielectric layer in a cell of an AC PDP. After the

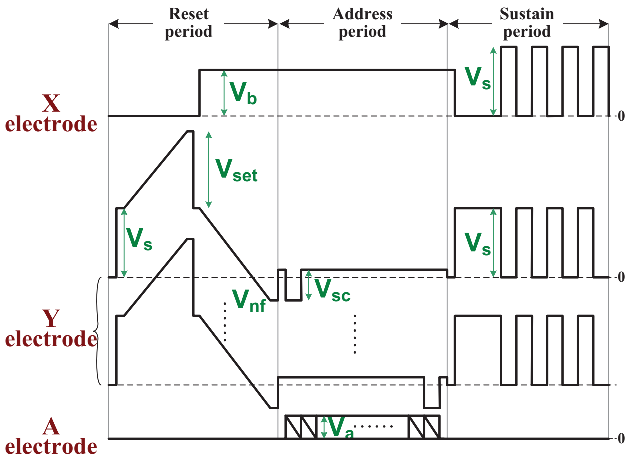

Figure 2. Conventional driving waveform to apply three electrodes including reset, address, and sustain period during one subfield time.

plasma discharge is produced by applying the external voltage to three electrodes, electrons are accumulated on the electrode at relatively positive voltage and ions are accumulated on the electrode at relatively negative voltage or ground.

Therefore, the cell voltage in an AC PDP is determined by the sum of the external applied voltage and the wall voltage generated by the accumulated wall charge after occurring the plasma discharge. During a reset period, the wall charge is accumulated on three electrodes to help easily produce an address discharge by the reset waveform – the electrons are accumulated on the X and Y electrodes of the front plate, whereas the ions are on the A electrode of the rear plate. The address discharge is produced when a scan pulse on the Y electrode and an address pulse on the A electrode are applied to the panel at the same time. Thus, the wall charge on the Y and A electrodes is mostly used for triggering the main address discharge. If the wall charge on all electrodes including the X electrode is utilized for an address discharge, the address discharge characteristics will be improved.

In this study, the address discharge characteristics were investigated when additional pulses were applied to the X electrode for utilizing the wall charges on the X electrode as well as the Y and A electrodes. In particular, the optimum condition was considered by the experimental results with changes in the voltage height and the pulse applying time on the X electrode under the conventional the scan and address driving waveform.

2. Experiment

2.1 Conventional Driving Method

Figure 2 shows the conventional driving waveform applied to three electrodes in Figure 1 during a reset, address, and sustain periods in one TV subfield. The X waveform applied to the sustain electrode with horizontal line on the front plate, the Y waveforms applied to the scan electrodes line-by-line, and the A waveform applied to the vertical address electrode. During a reset period, the wall charge was accumulated on three electrodes and redistributed to facilitate the production of the address discharge in a cell. When a scan pulse on the Y

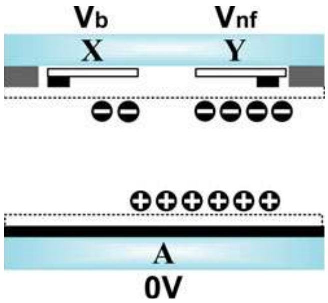

Figure 3. Schematic diagram of accumulated wall charge on three electrodes after reset period.

electrode and an address pulse on the A electrode were applied simultaneously during an address period, an address discharge was produced and the wall charge distribution changed at a selected cell for displaying [10]. In the sustain period, the square pulses alternately applied to the X and Y electrodes and the sustain discharge were produced in succession at the selected or an address discharged cell [11].

Figure 3 shows the schematic diagram of the accumulated wall charge on three electrodes in a cell after a reset period. Considering the conventional driving waveform after a reset period in Figure 2, the applied voltage on three electrodes were V_b, V_{nf}, and 0 V, respectively. The V_b was the positive bias voltage on the X electrode through the reset to the address period, and the V_{nf} indicated the negative falling voltage on the Y electrode during a reset period. While the slowly increased positive going ramp reset waveform for producing the weak plasma discharge was applied to the Y electrode, electrons were accumulated on the Y electrode and ions were accumulated on the X and A electrodes. When the negative going ramp waveform on the Y electrode and the bias voltage (V_b) on the X electrode were applied during a reset period, the weak plasma discharge was also produced between the X and Y electrodes by the difference in the cell voltage. Thus, after a reset period, the electrons were accumulated on two front electrodes and the ions were remained on the A electrodes as shown in Figure 3. Once a scan pulse on the Y electrode and an address pulse on the A electrode were applied simultaneously during an address period, the address discharge was produced by the external applied voltage and the wall voltage with the wall charge in a cell. However, the address discharge was not produced immediately when applying the scan and address pulses, and the production time of the address discharge was normally delayed – the address discharge time lag. Hence, it was difficult to reduce the scan and address pulse widths.

2.2 Proposed Address Driving Method

It was certain that the reduction of the scan and address pulse width was the biggest issue in the AC PDP driving scheme. If the address time would be reduced, the sustain time for displaying the screen could increase. In the conventional driving method, the address discharge triggering was mainly produced using the wall charge on the Y and A electrodes when the scan and address pulses were applied. In this sense, the modified driving method was proposed to reduce the address discharge time lag by utilizing all wall charge on three electrodes during an address period as shown in Figure 4. Since the electrons were accumulated on the X electrode after a reset period, the negative going pulses ($V_b \rightarrow V_{nb}$) for utilizing the electrons were applied to the X electrode when the scan and address pulses

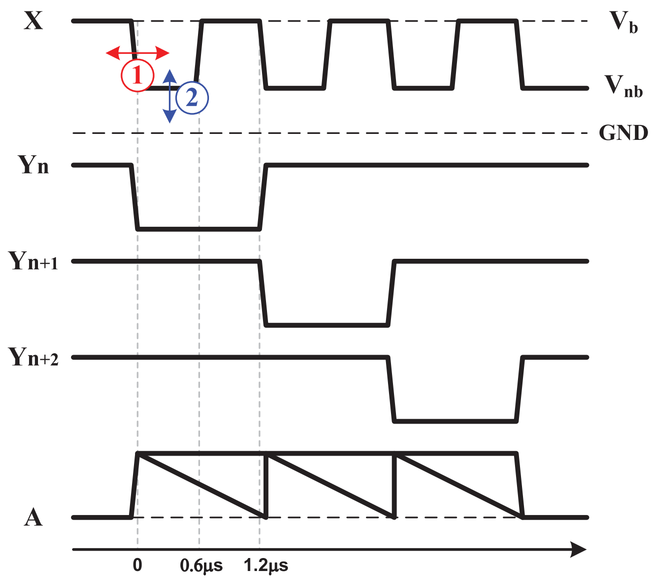

Figure 4. Proposed driving waveform applying negative going pulse to X electrode during address period.

was applied. Meanwhile, in the sustain period, the first sustain discharge when applying the first sustain pulse was produced by electrons on the X electrode and ions on the Y electrode after occurrence of an address discharge. The electrons utilized during an address period should be accumulated once more on the X electrode, therefore the negative going pulses was applied for a half time in the scan and address pulse width and the additional applied voltage (V_{nb}) was returned to the bias voltage (V_b). To put it concretely, if the scan and address pulse width was 1.2 μs in this experiment, the V_{nb} on the X electrode was applied from 0 to 0.6 μs and returned to the V_b after 0.6 μs. This V_b voltage fulfilled the wall charge accumulation from the negative priming particle and the free space charge on the X electrode for preventing from the weak sustain discharge. In this study, two kind experiments were accomplished for the V_{nb} height (j) and pulse applying time (k) on the X electrode, respectively.

3. Results and Discussion

3.1 Changes in V_{nb} Height

Figure 5 shows the discharge start and end time of an address light waveform by change in the V_{nb} height from 150 V to 0 V when the scan and address pulses were applied during an address period. The horizontal axis indicated the V_{nb} height and the time in the vertical axis indicated the address discharge start and end time after applying the scan and address pulses. The V_{nb} of 150 V meant that there was no pulse on the X electrode during an address period because the V_b was 150 V. The V_{nb} of 100 V meant that the negative going pulse was applied with 50 V height from 150 V to 100 V, and the V_{nb} of 0 V meant that the pulse from 150 V to 0 V was applied to the X electrode during one scan and address pulse width. As shown in Figure 5, when the V_{nb} height was decreased or the difference of the pulse amplitude was increased, the production of an address discharge could be fast started and

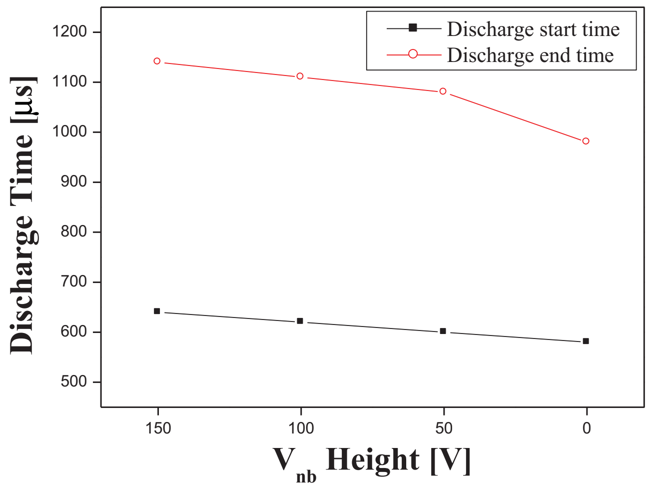

Figure 5. Discharge start and end time on address light waveform by changes in V_{nb} height when scan and address pulses were applied during address period.

the end time also could be reduced. By these result, it was found that the more the pulse amplitude was increased, the more the address discharge characteristics were improved.

3.2 Changes in Applying Time of V_{nb}

Figure 6 shows the discharge start and end time of an address light waveform by changes in the applying time of the V_{nb} from 0.2 to -0.4 μs under the voltage condition of the $V_{nb} = 0$ V on the X electrode when the scan and address pulses were applied during an address period. In Figure 6, the horizontal axis indicated the pulse applying time with the

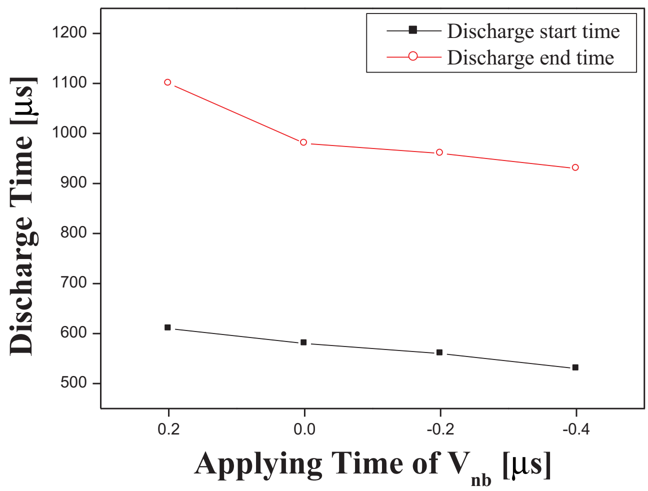

Figure 6. Discharge start and end time on address light waveform by changes in applying time of V_{nb} when scan and address pulses were applied during address period.

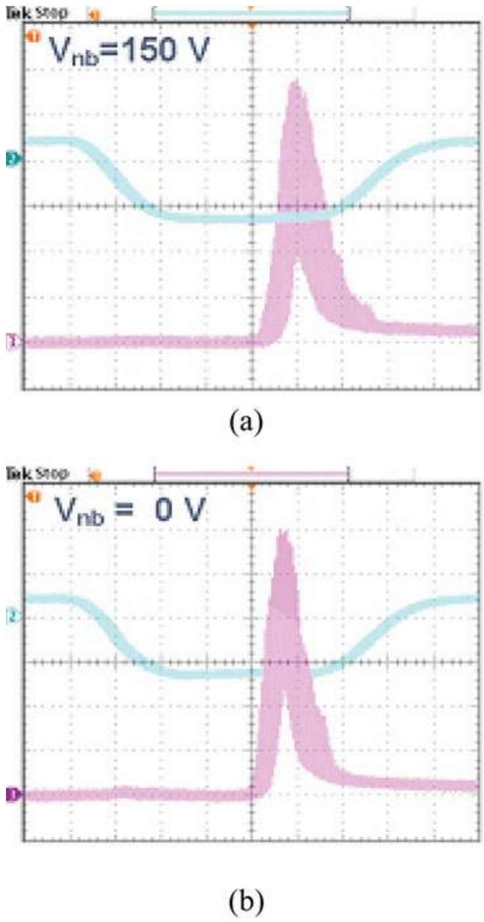

Figure 7. Comparison of address discharge waveforms when the V_{nb} height is (a) conventional 150 V and (b) proposed 0 V under the applying time of -0.4 μs during address period.

V_{nb} and the vertical axis indicated the address discharge start and end time as mentioned above. The time of 0.0 μs at the horizontal axis in Figure 6 meant that the V_{nb} was applied at the same time when applying the scan and address pulses as shown in Figure 4. The time of 0.2 μs meant that the applying time of the V_{nb} was delayed for 0.2 μs after applying the scan and address pulses. That was, the negative going pulse on the X electrode was moved to the right direction for 0.2 μs in the waveform of Figure 4. When the applying time of the negative going pulse was 0.2 μs, the address discharge start and end time was more delayed compared with the conventional driving method without the negative going pulses. On the contrary to 0.2 μs, the pulse applying time of -0.2 and -0.4 μs meant that the negative going pulse was applied to the X electrode before the scan and address pulses were applied. In other words, the negative going pulse on the X electrode was moved to the left direction. In this case, the early applying negative going pulse before the scan and address pulses contributed the fast and stable triggering discharge production and the priming particle generation. Therefore, the address discharge characteristics could be improved compared with the conventional driving waveform.

3.3 Optimum Condition of V_{nb}

The optimum condition could be arrived at the height of 0 V and the applying time of $-0.4\ \mu$s through investigating the height and the applying time of the V_{nb} on the X electrode during an address period. Figure 7(a) and 7(b) compared address discharge waveforms when the V_{nb} height was the conventional 150 V without any pulse (a) and proposed 0 V under the pulse applying time of $-0.4\ \mu$s (b) on the screen of the oscilloscope. Adopting the proposed driving waveform, the start and end time of the address discharge were shown a tendency to produce fast and the discharge time lag could be reduced about 200 ns as shown in Figure 7.

Conclusion

The modified driving method was proposed to reduce the discharge time lags using the wall charge on the X electrodes by applying the negative going pulses at a time of appliance of the scan and address pulses during an address period. After a reset period in the driving method of an AC PDP, the electrons were accumulated on the front X and Y electrodes, and the ions were accumulated on the rear A electrode. While the conventional address discharge was produced by using only the triggering discharge between the Y and A electrodes, the electrons on the X electrode were additionally utilized by applying the negative going pulse in the proposed driving method. Consequently, the address discharge time lag could be reduced approximately 200 ns under the optimum voltage height and pulse applying time conditions comparing with the conventional driving method without the negative going pulse during an address period.

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