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ISSN: 1542-1406 (Print) 1563-5287 (Online) Journal homepage: https://www.tandfonline.com/loi/gmcl20

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MOLECULAR CRYSTALS AND LIQUID CRYSTALS
2017, VOL. 651, 189–195
https://doi.org/10.1080/15421406.2017.1338084

Simulated results of plasma discharge in AC plasma display panel with asymmetric electrode

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ABSTRACT
The cost of the driving circuit could be reduced in the AC type plasma display if one of the two electrodes on upper plate was grounded and the driving circuits were used at only the other electrodes. However, when this new driving waveforms were applied to the conventional panel structure, it had been found that the misfiring discharge occurred during the sustain period even though the address signal was not applied. Since the misfiring discharge during the sustain period occurred between the scan electrode at the upper plate and the address electrode at the lower plate, it is possible to prevent the misfiring discharge by applying the additional voltage to the address electrode at the time of applying the positive sustain voltage. On the other hand, since the application of the address voltage during the sustain period causes the power loss of the drive circuit and the shortening of the lifetime in the circuit component, a panel having the asymmetric electrode structure in which the width of the scan electrode on the upper plate is narrower than other electrodes has been proposed. The reason for only reducing the width of the scan electrode on the upper plate is to prevent the misfiring discharge area with the facing address electrode on the lower plate. As a result, it could be confirmed that the misfiring discharge was prevented by the asymmetric electrode structure using the discharge and wall charge simulations.

KEYWORDS
Asymmetric electrode; discharge; driving circuit; misfiring discharge; simulation

1. Introduction

One of the important issues in the driving circuit of an AC plasma display panel is the low cost [1]. Until now, to reduce the price of the drive circuit to date, the method of lowering the price of each driving component or simplifying the driving waveform has been applied, but the technology and effort have reached the limit [2]. In general, the panel structure of an AC type plasma display panel is composed of three electrodes, two electrodes are on the upper plate and one electrode is on the lower plate [3]. The two electrodes on the top plate are arranged in parallel and are divided into a scan and a sustain electrode, respectively. On the other hand, one electrode of the lower plate is formed as an address electrode in a direction perpendicular to the two electrodes of the upper plate. Since the driving waveform is applied to each of the three electrodes, three driving circuits are also required [4]. If the driving waveform is

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modified to make one electrode of the top plate grounded and only the remaining two electrodes constitute the driving circuit, the cost of the AC plasma display panel can be reduced [5–6]. In the conventional driving method, the driving waveforms is divided into reset, address, and sustain periods for one sub-frame time, and driving waveforms are applied to three electrodes, respectively. The reset period initializes the wall charge in the cell, the address period selects the cell to display the screen, and the sustain period alternately applies the positive voltage to the two upper plate electrodes to continuously apply the plasma discharge and determine the intensity of the light by the number of pulses. Among the three electrodes, waveforms of the scan and address electrode cannot be grounded because the cell must be selected and only the sustain electrode can be grounded. If the sustain electrode is grounded, the waveform applied to the sustain electrode should be added to the scan and address electrodes in the opposite direction, but the voltage modification of the address electrode is limited to a positive voltage. In the reset and address period for the driving time, no serious problem was caused by the adjustment of the voltages of the two electrodes. However, in the sustain period, it has been found that misfiring discharge occurs when positive and negative voltages are alternately applied only to the scan electrodes in the state where the sustain and the address electrodes are grounded. The misfiring discharge in the sustain period is generated when positive and negative voltages are alternately applied to the scan electrodes because the wall charges are accumulated in the scan and address electrodes in the address period in the previous time. In the address period, since the function of selecting the cell is performed, it is almost impossible to correct the driving circuit and the waveform. While, in the sustain period, only the positive and negative voltages are applied to the scan electrodes, which makes it easy to correct.

When the driving waveforms are applied to the scan and address electrodes in the cells selected under the grounded state of the sustain electrodes in the address period, plasma discharge occurs and sustain discharge in the sustain period also normally produces. Meanwhile, in the non-selected cell, since the address pulse is not applied (in the case where the address discharge does not occur), the sustain discharge should not occur in the normal case. However, in the case of driving with only two electrodes, when the address discharge does not occur, the wall charge state inside the cell does not change after the reset period. In this case, when the positive and negative voltages are applied to the scan electrodes during the sustain period, a misfiring discharge occurs between the scan and the address electrodes, although the cells are not selected. In the previous research, it was solved by continuously applying the address voltage to the address electrodes during the reset and sustain periods during the sub-frame of the driving time. But, applying the address voltage continuously causes power loss of the drive circuit and shortening the life in the circuit component.

In this paper, an asymmetric electrode is proposed to prevent erroneous discharge in the sustain period without causing power loss and shortening the lifetime of the part in the drive circuit. Since the misfiring discharge during the sustain period occurs between the scan and the address electrode, it is simulated that the misfiring discharge with the address electrode can be prevented by adjusting the width of the scan electrode, and the result is confirmed [7–8].

2. Single sustain waveform

Figure 1 shows a single sustain driving waveform applied to three electrodes during reset, address, and sustain periods for one sub-frame time. In the figure, X is the sustain electrode in the top plate of AC PDP, Y is the scan electrode in the top plate, and A is the address electrode

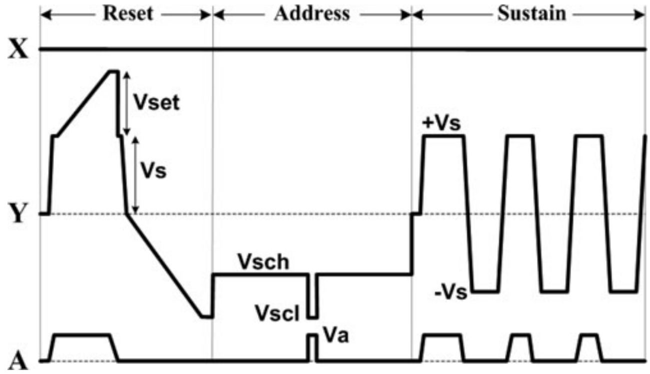
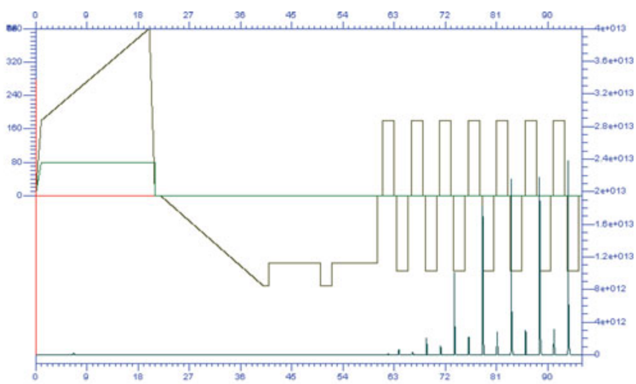
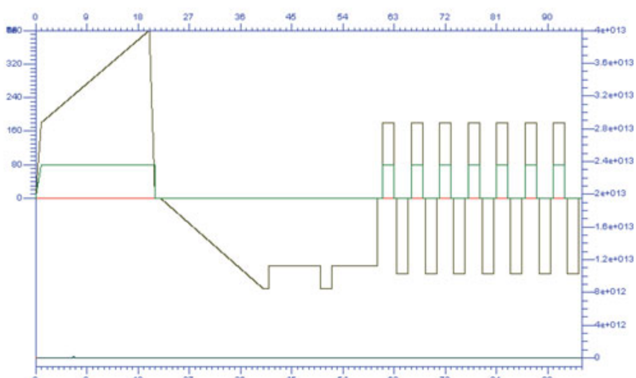


Figure 1. Single sustain driving waveform including reset, address, and sustain period during one sub-frame time.

in the bottom plate. In the single sustaining drive waveform, the X electrode is grounded. In the reset period, the positive and negative voltages in the form of the ramp type waveform are applied to the Y electrodes to initialize the wall charges in the cells. In the address period, when pulses are applied in the opposite directions to the Y and A electrodes, A discharge is generated to select the cell, and in the sustain period, the positive and negative square



(a)



(b)

Figure 2. Simulated results of discharge when pulses were not applied (a) and pulses were applied to address electrode during sustain period in single sustain driving waveform.

waveforms are alternately applied to the Y electrode to generate the light in the selected cell. If the cell is not selected in the address period (cells where address discharge has not occurred), the discharging should not occur in the sustain period. However, in the sustain period of a single sustain driving waveform, an misfiring discharge occurs when the positive and negative voltages are applied. Therefore, the positive pulses are applied to the A electrode during the time when the positive voltage was applied to the Y electrode, thereby preventing the generation of the misfiring discharge as shown in Fig. 1.

Figure 2 shows the results of a discharge simulation when there are no pulses (a) and when there are pulses (b) on the address electrode during a sustain period in a single sustain drive waveform. In each figure, the upper waveforms represent the driving waveforms applied to the three electrodes, and the lower line represents the plasma discharge. Figure 2 (a) shows that misfiring discharge occurs during the sustain period when the address pulse is not applied. However, if the address pulses are applied to the A electrodes during the positive pulse time of the Y electrode as shown in Fig. 2(b), the misfiring discharge are disappeared. In Fig. 2 (a), due to many wall charges were accumulated inside the cell by the high positive and negative voltages on the Y electrode during the reset and address period, the misfiring discharge occurred between the Y and A electrodes during the sustain period. When the address pulses are applied to the A electrode during the sustain period at the time of applying the positive voltage on the Y electrode, the misfiring discharge do not produced because the voltage difference between Y and A electrodes can be reduced. However, as mentioned in the introduction, the continuous application of the address voltage during the sustain period causes the power loss of the driving circuit and induce shortening of the life of the component. Therefore, it is necessary to prevent the misfiring discharge by changing the structure of the panel without applying the address voltage during the sustain period in the driving waveform.

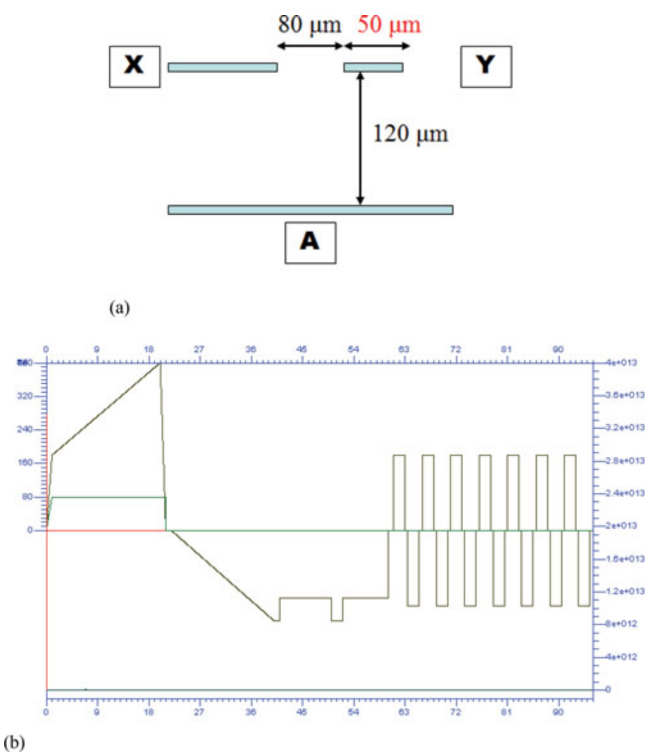
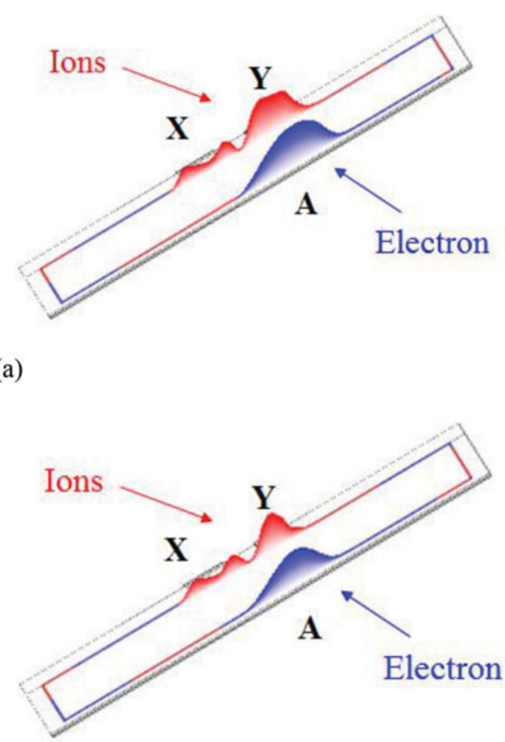


Figure 3. Schematic diagram showing a cross-section of a three-dimensional cell of an asymmetric electrode structure (a) and result of discharge simulation.

3. Simulation of discharge and wall charge in asymmetric electrodes

Generally, the intensity of the plasma discharge between the electrodes is proportional to the area of the electrodes. That is, as the area increases, discharge occurs at a low driving voltage and the discharge intensity increases. In the single sustain driving waveform, the misfiring discharge in the sustain period occurs between the Y and A electrodes, so if the width of the Y or A electrode is designed to be narrower than the conventional one, the possibility of misfiring discharge can be reduced. If the width of the A electrode is narrow, a high voltage is needed to generate a discharge in the reset and address period. This is because the sustain discharge can be weakened if the interval between the X and Y electrodes is distant.

Figure 3 (a) is a schematic diagram showing a cross-section of a three-dimensional cell of an asymmetric electrode structure. The X and Y electrodes of the upper plate are horizontal to each other and the A electrodes of the lower plate are arranged perpendicular to the upper plate electrode. The plasma discharge in the sustain period occurs between the X and Y electrodes arranged in parallel, and the discharge in the address period occurs between the Y electrode of the upper plate and the A electrode of the lower plate. In general, the discharge between the upper plate electrodes arranged in parallel is less likely to occur than the facing electrode, so that the distance between the parallel X and Y electrodes is designed to be closer to the distance between Y and A electrodes facing each other. In the single sustaining drive waveform, the width of the Y electrode is reduced as shown in Fig. 3 in order to prevent misfiring discharge between the Y and A electrodes. However, since the sustain discharge must occur in the same manner as in the prior art, the interval between the X and Y electrodes is designed to be the same as the conventional one. As a result, when the address discharge was



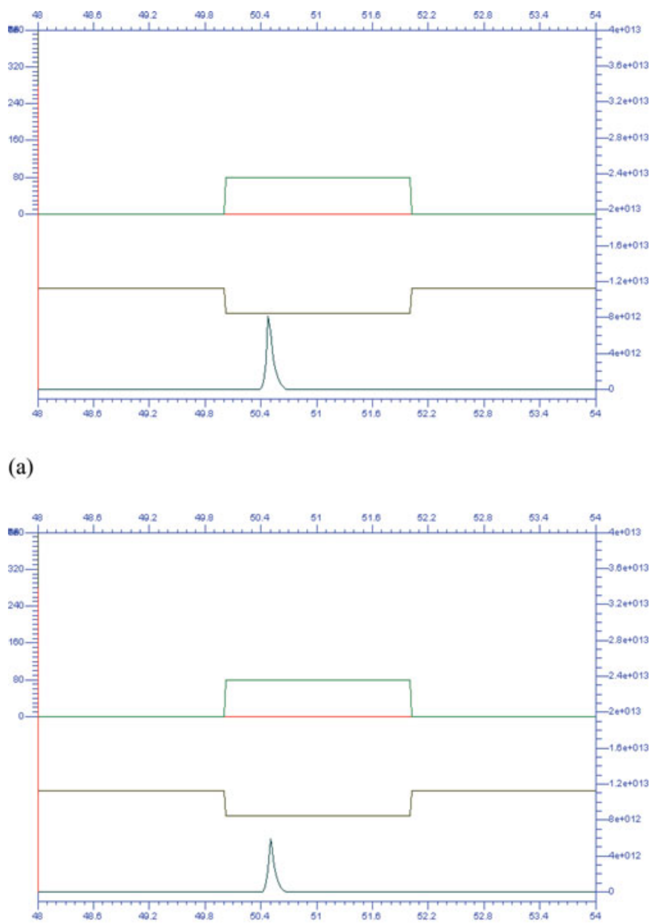
(a)

(b)

Figure 4. Wall charge distribution in cell after reset period: (a) conventional, (b) asymmetric electrode structure.

not generated in the single sustain driving waveform, it was confirmed from the discharge simulation result in Fig. 3 (b) that the misfiring discharge did not occurred in the sustain period even when the address pulses were not applied in the sustain period.

The simulation of the wall charge distribution after the reset period in the conventional and the asymmetric electrode structure is shown in the fig. 4. In a general three-electrode driving method other than a single sustain driving waveform, since the positive high voltage is applied and the magnitude of the negative voltage is small during the reset period, negative charges are accumulated in the upper plate and positive charges are accumulated in the lower plate. On the other hand, in the case of the single sustain driving waveform, the magnitude of the negative voltage during the reset period is very large, so that the wall charge distribution is reversed as in the conventional case. Therefore, as shown in Fig. 4 (b), positive charges are accumulated on the top plate and negative charges are accumulated on the bottom plate. In addition, it can be seen that the amount of the wall charges of the Y and A electrodes in the asymmetric electrode of Fig. 4 (b) is reduced in comparison with the conventional structure of Fig. 4 (a). This is because the width of the Y electrode in the asymmetric electrode is small, so that the amount of wall charge accumulated after the discharge in the reset period is reduced.



(a)

(b)

Figure 5. Simulation result of address discharge in conventional (a) and asymmetric electrode structure (b).

The intensity of the discharge is determined by the wall voltage due to the difference between the externally applied voltage and the wall charge inside the cell. In the asymmetric electrode structure after the reset period, the amount of wall charge inside the cell is small compared with the conventional one. As can be seen from the address discharge simulation result in Fig. 5, the intensity of the address discharge in the asymmetric electrode structure is weakened compared with the conventional structure.

4. Conclusions

The previous single sustain driving method in which one electrode was grounded and the driving waveforms were applied to only two electrodes was used at the conventional structure of the AC type plasma display panel. However, when the positive and negative voltages were applied to the scan electrode during the sustain period, the misfiring discharge occurred between the Y electrode of the upper plate and the A electrode of the lower plate due to the accumulated wall charges in the reset period. When the positive voltage is applied to the Y electrode during the sustain period, the address voltage is applied in order to lower the potential difference with the A electrode, thereby preventing the misfiring discharge. However, continuously applying the address voltage causes a power loss of the driving circuit and a shortening of the life in the component. Since the misfiring discharge occurred between the Y and A electrodes, if the width of the Y electrode was reduced, the overlapping areas of the opposing Y and A electrodes would be reduced and the misfiring discharge could be prevented. The panel having an asymmetric electrode structure was designed in which the distance between the X and Y electrodes was kept the same but the width of the Y electrode was reduced. The discharge and wall charge simulation results showed that misfiring discharge did not occurs. However, since the discharge area is narrow between Y and A electrodes, the amount of wall charge accumulated during the reset period was small and the address discharge was also weakened. Therefore, the research on techniques to enhance the address discharge will be a challenge in the future.

Acknowledgement

This work was supported by a Research Grant of Pukyong National University (2017 year).

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