# 11.3: Logically Addressable Surface Discharge ac Plasma Display Panels with a New Write Electrode

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## 1. INTRODUCTION

Micro-computer development increases the need for a flat panel display. An AC-Plasma display panel is one of the most appropreate devices, however, development of a low cost unit with a color presentaion is necessary.

One of the authors has shown that surface discharge type color AC-PDPs (SD-PDPs) have a potential to realize a flat color display [1]-[3]. The color SD-PDPs have other merits over two-substrate discharge types, such as a longer life, higher brightness, higher luminous efficiency, and a simpler production process. But some problems remain.

(1) The life is not long enough due to dielectric degradation at the intersections of X and Y electrodes, where the electric field is concentrated, if the panel is made with thin film techniques. This problem can be solved by decreasing the electric field intensity by increasing the dielectric thickness. However, in making a thick film with a thin film technique, such as evaporation or sputtering, a problem of cracking occurs. On the other hand, with a thick film printing technique, precise control of the baking temparature is necessary [4].

(2) To make a color panel, a pixel is made with three primary color dots. The driving complexity doubles with each added electrode.

(3) Higher driving voltage.

The last two problems increase the circuitry cost.

To solve the problems, a new type of surface discharge AC-PDP is proposed in this paper. The panel structure and the operating principle are extremely different from conventional AC-PDPs. This panel has the following features.

(1) Three types of electrodes. One is a writing electrode for pre-fire , and the others are a set of parallel sustaining electrodes for display and addressing.

(2) The writing electrodes are covered by only a thin MgO protecting layer. This produces a single-layer dielectric structure. Thus, the thick dielectric layer printing technique can easily be used.

With this new idea, a low cost color AC-PDP will be realized.

In this paper, the principle of the new surface discharge AC-PDP is discussed using a mono-color panel. We call this new plasma display the three-electrode surface plasma display (TSPD).

## 2. PRINCIPLE

Figure 1 shows the panel structure and electrode pattern. Two sets of parallel sustaining electrodes with projection are placed on the glass substrate. The electrodes are covered with a dielectric layer. Writing electrodes are placed on the dielectric layer on one side of the projection and perpendicular to the sustaining electrodes below. Floating separators, which are isolated from any other electrodes, are placed between the writing electrodes and the adjacent projection of the sustaining electrodes. These are covered by only the MgO layer. This simple structure permits the easy use of the thick film printing technique, because a sink or swim problem with the upper electrode, which sometimes occurs in firing with upper dielectrics and electrodes in conventional thick film surface discharge AC-PDPs [4] does not occur. The cover glass is assembled to the substrate with a 100 μm gap.

This panel has another feature to reduce the complexity of the driving circuit. Figure 2 shows the principal electrode connection for a 9X9 dot matrix panel (a) and the magnified electrode pattern (b). X sustaining electrodes are divided into 3 blocks. Each block has 3 connected lines. The K-th Y lines in each X block ( K=1,2,3 ) are connected to each other too. Thus, we can drive the M x N dot panel with $2\sqrt{N}$ sustaining drivers and M writing drivers.

Figure 3 shows the driving waveforms and the light outputs. There are three steps in TSPD operation; pre-fire, selection, and sustain. Input of information for display is done at the pre-fire and selection steps in the input cycle. There are three kinds of pulses. One is a plus pulse applied to the writing electrode (Ww pulse), and the others are minus pulses applied to the sustaining X and Y electrodes (Wx and Wy). If we want to write the point D in Fig.2, the Ww and Wx are applied at the same time in the selected W3 line and X2 block, respectively. Then, the discharges ignite at the three intersections ( d1, d2, and d3 (call the points pre-fire cells.)) at time A in Fig.3. In the unselected X1 and X2 blocks, the Wx pulse is not applied. Next, the Wy pulse is applied in the selected Y2 line at the same time as the fall of the Ww pulse and the rise of the Wx pulse. When the Ww and Wx pulses are eliminated, the discharge by the self induced field of the accumulated charge near the writing electrode occurs at time B in Fig. 3. In this paper, this discharge is called an "avalanche". This phenomena is discussed detail with experimental results in the next section. This discharge (avalanche) helps ignition of the selecting discharge between the projections of the selected sustaining electrodes (call this point the display cell). At the unselected display cells in the X2 block, the Wy pulses are not applied and the avalanches eliminate the wall charges accumulated by Ww and Wx, automatically. Next, although both the sustaining pulses, Sx and Sy, are applied between all of the X and Y electrodes, only the selected discharge is maintained at the selected display cell, D. These sustaining discharges accumulate wall charges on the dielectric layer on the projections as in ordinary AC-PDPs. To erase the discharges, the same pulses as the writing Ww and Wx pulses are applied at the same time in the selected W and X lines. With these pulses, discharges are ignited in the writing cells not only of the displayed cells where discharges are maintained but also of the non-displayed cells. However, as the Wy pulses are not applied on all of Y lines, the accumulated wall charges are eliminated and the discharges are erased.

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1. Pre-fire

the pre-fire step, we found an interesting ıe phenomena which is unique to the TSPD. ıtionships between the avalanche and the Ww was investigated. Figures 4 (a),(b), show the relationships between the light and the width of Ww. The width of Wx is 8 all photographs. When Ww and Wx were the first discharge occured 0.6 μs ıe rise of the pulses and was the same for tographs. When the width of Ww pulse was than that of Wx, the second discharge ( e) occured at the end of Wx. When Ww was han that of Wx, the second discharge at the end of Ww. This phenomena is d as follows.

ure 5 shows the qualitative avalanche m. The bottom figure shows the cross at the intersection of the write electrode X electrode. Figures 5 B(a) through B(e) e surface potential. The solid lines show ntial made by the accumulated charges and nes show the potential when the charges ored. The upper figure shows the applied ls and light outputs. Figures 5A (a) (e) correspond to the potential distri- B(a) through B(e), respectively. The l of the MgO surface when Ww and Wx are is shown in B(a). If the potential r than Vf, the first discharge ignites and s and ions accumulate on the MgO surface V and X electrodes to compensate for the ls. At this time, some of the electrons low into the W electrode due to the layer. Then, the potential is compensated he solid line shown in B(b). At time though the applied voltage of Ww is d, the potential of the sustain X the wall charges as shown in Fig. B(c). applied voltage is eliminated at time strong field made by the accumulated wall makes an avalanche. This eleminates the ges because the Wy pulses in Y-electrode applied. It is important that the ed charges never be eliminated at time shows that whenever the electric field W and X is maintained, the charges stably e near the intersection of W and X. , the reason why the avalanche occurs at of Ww when the Ww pulse width is wider of Wx is easily understood. In practical Ww and Wx have the same pulse width.

select and sustain

re 6 shows the spot shapes of the pre- display. When the writing pulses are the upper discharges in Fig.6(a) occur riting cell first, then spread in the where opposits the separator to the display cell. Next, at the end of Ww and Wx, avalanches occur. When Wy is t this time, the selecting discharges are i at the selected display cell as shown (b). When we compare the light outputs [illegible] of the single pulse is almost same as the first of the double pulses. Thus, the single pulse and the first of the double pulses show light output of the avalanche and the second of the double pulses shows the selecting discharge. The selected discharge is maintained by the following sustaining pulses applied to the X and Y sustaining electrodes.

3-3. Reliability

The degradation problems of the dielectric layer in SD-PDPs should essentially be solved in the TSPD. The two sustain electrodes are separated by about 40 μm at the projections and the electric field between the projections should be about 3 or 4 times weaker than that at the intersection of SD-PDPs. This reduces damage by ion bombardment on the MgO surface in the display cell. The life of the pre-fire cell should be long for the following reasons. The reliability is due to the Ww always being plus and Wx, Wy, and the sustaining pulses being minus. As the writing electrodes are covered by only a thin MgO layer, if minus pulses are applied, a high energy ion bombardment of the MgO surface on writing electrodes occurs and destroys the surface. The minus pulse allows only electron bombardment. This reduces surface damage by discharge. The requirment for the writing cell to operate for a long time is not as critical as that for the display cell. The display cells are usually operated with a 40 kHz square wave. However, we can set the writing frequency less than 40 kHz, depending on the applications. If we use the device in the TV mode, about a 30 Hz writing frequency is selected, which is a thousand times less than the sustaining frequency. As the chance of damage depends on the frequency, this is one advantage of this device to improve life.

3-4. Sample display

Figure 8 shows the sample displays on an experimental panel. The 24 x 16 lines was driven with 14 (12+2) sustaining drivers and 16 writing drivers. The filling gas was Ne + Xe(0.2%) and the gas pressure was 600 torr. The firing voltage was approximately 130 volts, which was about 30 volts higher than the two-substrate AC-PDPs. However the memory margin was 25 volts and the memory coefficient was 0.4, corresponding to the ordinary two-substrate AC-PDPs. The dynamic sustain margin was more than 10 volts and the writing margin was more than 15 volts.

4. CONCLUSION

In this paper, the authors have proposed a new type of surface discharge AC-PDP with the following features.

(1) Surface discharge. This allows a color display.

(2) Three types of electrodes; two parallel sustaining electrodes and writing electrode. This allows a reduction in a circuitry complexity by reducting in connection of sustaining electrodes

by its logic function.

(3) Single dielectric, double electrodes structure. The upper electrode is covered by only a thin MgO protecting layer. This should allow easy use of low cost thick film processes.

In this paper, we have discussed the principle of the new panel which has a potential for use in low cost color AC-PDP.

## 5. ACKNOWLEDGEMENT

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## 6. REFERENCES

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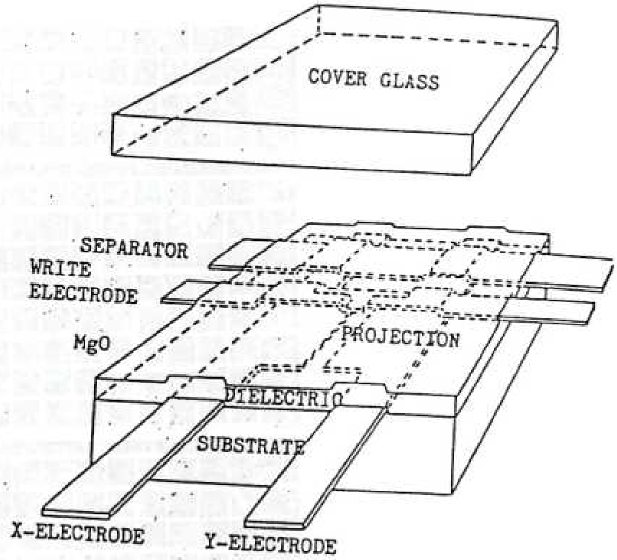
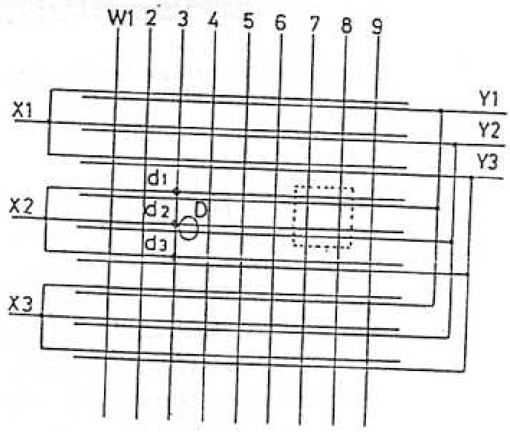
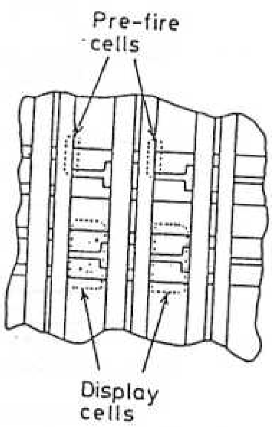



Fig. 1 Panel structure.




(a) electrode connection.




(b) Magnification of shaded area in (a).

Fig. 2 Electrode configuration.

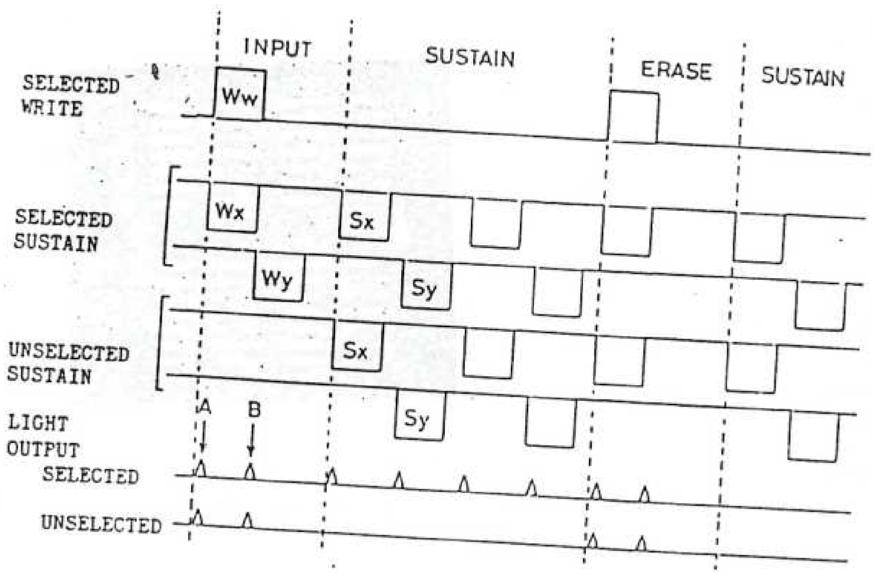
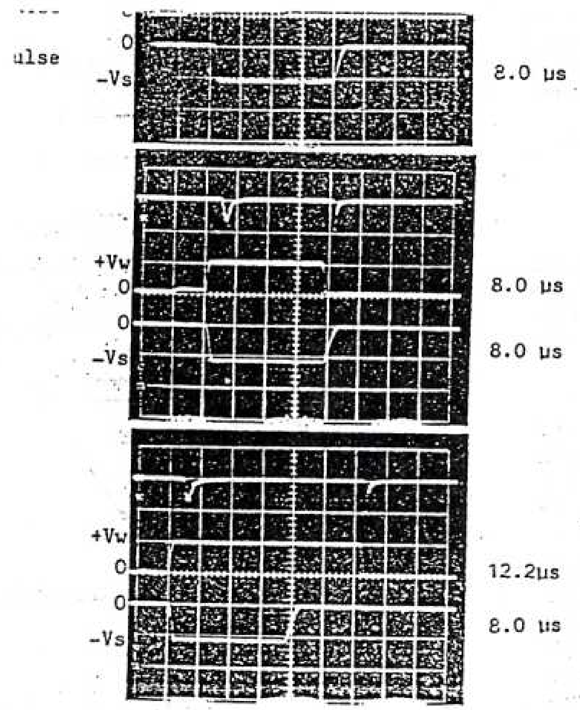
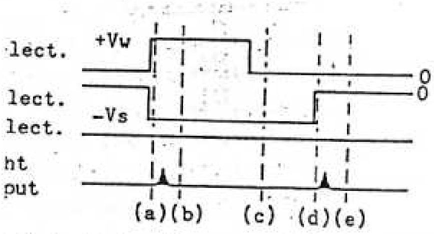


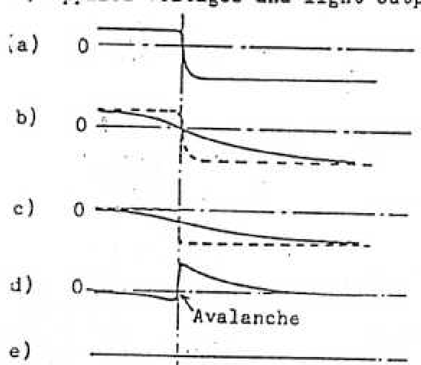

Fig. 3 Driving waveforms.



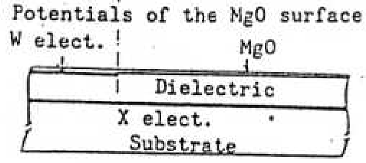

:. 4 Relationships between the light output and the width of Ww pulse.




A) Applied voltages and light outputs.

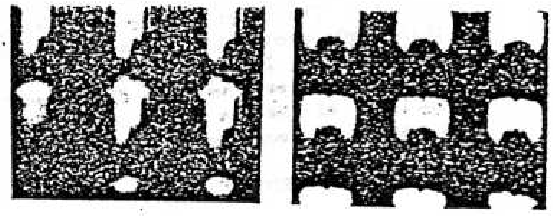



(B) Potentials of the MgO surface.




(C) Cross section

Fig. 5 Avalanche mechanism.



(a) Pre-fire spots (b) Display spots

Fig. 6 Discharge spot shapes


(a) With Wy (b) Without Wy

Fig. 7 Comparison between the light outputs of waveforms with and without Wy.

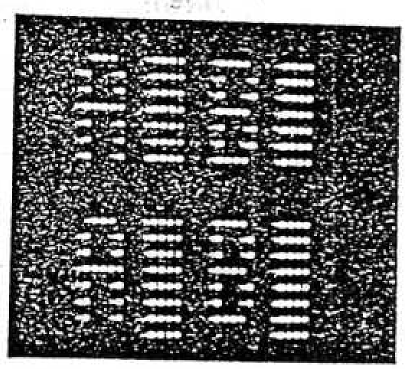


Fig. 8 Sample display.