15.3/3:00 P.M.: Characteristics of Surface-Discharge Color AC-Plasma Display Panels

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Introduction

The best way of creating a multicolor display with a gas panel is to use tricolor phosphor excitation with ultra-violet radiation in the gas discharge. But, for color AC-PDPs with opposed discharge,[1] in which phosphors were deposited on protecting layers, phosphor degradation by ion bombardment and contamination of the MgO surface in the phosphor deposition processes prevented the use of this method. The authors have reported a new type of color AC-PDP with surface discharge[2,3] which will remove the problems by separating phosphor sites from discharge sites and realize a long, stable operation. In this paper, we discuss basic characteristics of the new panel.

Panel structure and principle

Figure 1 shows the structure of the color AC-plasma display panel. The X and Y electrodes isolated by a dielectric layer are arranged orthogonally on a rear glass substrate. Suppression electrodes which are isolated from other electrodes are placed between the X electrodes. These electrodes are covered with a dielectric layer and a MgO protecting layer. The phosphors are deposited on a front glass plate. Zn_2SiO_4:Mn for green, (Y·Gd)BO_3:Eu for red, and $BaMgAl_{14}O_{23}$:Eu^{2} for blue. The gas is a ^{3}He + Xe(1%) mixture, and the pel pitch is 0.5 mm. The panel is operated by applying three kinds of pulses-sustain, write, and erase- between the X and Y electrodes, The gas discharges are ignited in the gas cavity at the cross point of the electrodes. Ultra-violet radiation emitted by discharges excites the phosphors deposited on the opposing glass plate.

Electrical characteristics

The two examples in photograph 1 illustrate the difference in discharge spot shapes between the panels with and without suppression electrodes. Discharges are ignited on horizontally and vertically alternate dots. In the case of a simple crossover electrode structure without suppression electrodes, discharges spread along the X and Y electrodes. This decreases firing voltage, which in turn decreases the operating margin, because of a large amount of charges being supplied to adjacent cells. There are two methods with floating electrodes, such as suppression electrodes, for widening the operating margin. One is "capacitive vias method",[4] the other is "suppression electrode method". The former uses the floating electrode to ignite the discharge effectively. On the other hand, the suppression electrodes suppress the discharge spread not only in the Y direction where suppression electrodes are placed, but also in the X direction as shown in photograph 1(a). Thus, as the suppression electrodes prevent charges from being supplied to adjacent cells, a wide operating margin is achieved in the new panel. Figure 2 shows the comparison of operating margins between the panels with (solid line) and without (dashed line) the suppression electrodes. The sustaining margin (Vs(max) - Vs(min)) and the writing margin (Vw (max) - Vw(min)) are greatly increased by the suppression electrodes.

Phosphor degradation

In the panel structure with surface discharge, when the cavity gap is sufficiently large, the bombardment of phosphors by high energy ions essentially does not occur. But, as the phosphor sites have been moved closer to the discharge sites on the opposing substrate to reduce optical crosstalk in our panel, there is the possibility that phosphors can be degraded by ion bombardment or UV radiation. Figure 3 shows the brightness changes in time with a 4o kHz square wave input. The values are normalized with the initial brightness levels. At 2000 hours operation, the loss in brightness levels of red, green, and blue cause less than 10%.

Optical characteristics

Because of the non-cell structure of the new panel, some of the UV from discharge spread out and excite phosphors at adjacent cell sites. We determined display quality by investigating the dependence of emission profile on the thickness and density of phosphor layers and the cavity gap as shown in figure 4. Crosstalk is evaluated with Bf/Bd, where Bf and Bd are defined as the brightness of lit cells and unlit cells, respectively, when the discharges are maintained on alternate cells as shown in photograph 1. The phosphor thickness and density are represented with transmittance of the phosphor layers. At the optimum value of 10 % transmittance, peak brightness is at maximum and the Bf/Bd is 16. And, with a cavity gap of 100 μm, the Bf/Bd is 11. The optimum cavity gap must be selected taking into account the influence on discharge voltage in addition to the brightness and Bf/Bd.

Photograph 2 is an example of the display of our experimental panel. The mean area brightnesses are 37 fL for green, 30 for red, and 11 for blue, and Bf/Bd is 11.

Conclusion

Basic characteristics of a "surface discharge color AC-PDP" were investigated and are summarized as follows.

(1) Changes in brightness level are less than 10% at 2000 hours operation for the tricolor phosphors used.

(2) Suppression electrodes decrease the charge coupling from adjacent ON cells and widen the operating margin.

(3) Emission distribution depends on thickness and density of phosphor layers, and the cavity gap. By selecting appropriate values, good display quality is realized

We have confirmed that the new panel has a potential to provide a multi-color AC-PDP with a stable and long operation.

Acknowledgments

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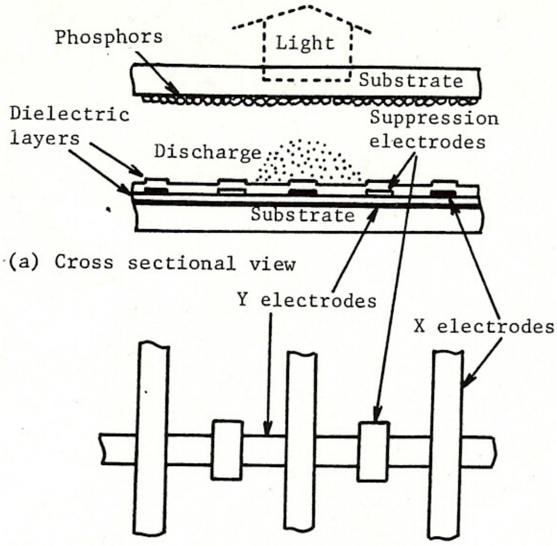


(b) Electrode structure (over view)

Figure 1 Panel structure.

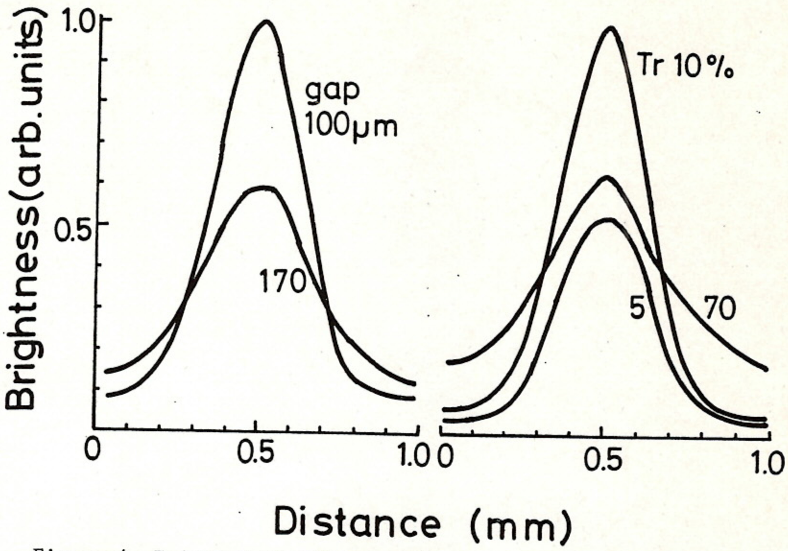


Figure 4 Emission profiles on the cavity gap and the transmittance (Tr) of phosphor layer.

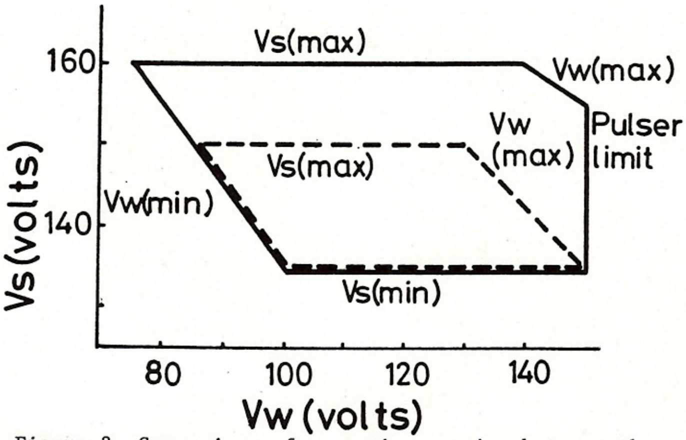
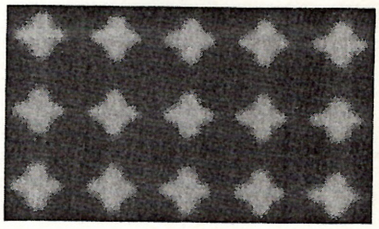
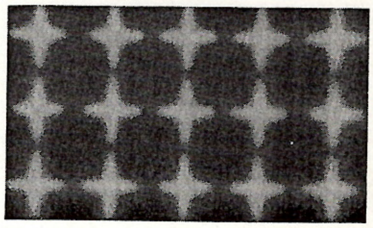


Figure 2 Comparison of operating margins between the panels with (solid line) and without (dashed line) the suppression electrodes.



(a) with suppression electrodes.



(b) without suppression electrodes.

Photograph 1 Discharge spots.

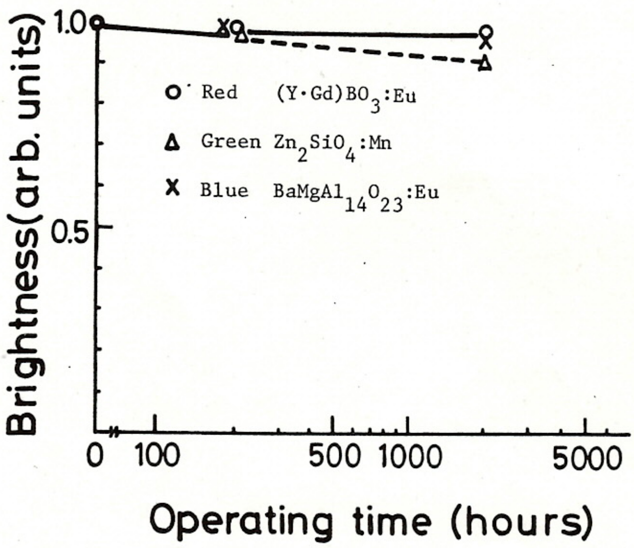
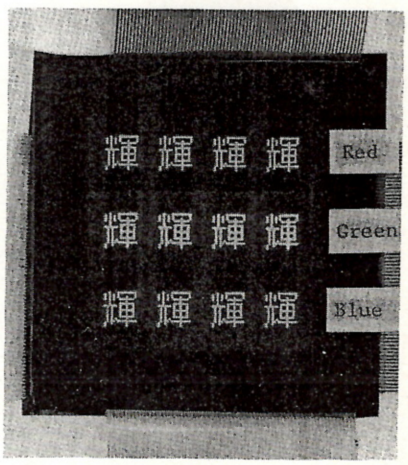


Figure 3 Brightness changes with operating time.



Photograph 2 Display example.