34.4: Improvement of Luminance and Luminous Efficiency of Surface-Discharge Color ac PDP

Tsutae Shinoda, Masayuki Wakitani, Toshiyuki Nanto, Teruo Kurai, Noriyuki Awaji, Masato Suzuki

Fujitsu Ltd., Akashi, Japan

INTRODUCTION

AC type plasma displays (PDPs) are self-luminescent so that it has various features such as high luminance, large viewing angle even in large display area, easy to make a large size because of simple structure and quick response. Fujitsu has developed and manufactured display devices utilized these features for 20 years. Up to now we have mass-produced various type and size of neon orange colored PDPs from small segment type to dot matrix type with large display capacity, i.e. 640x480 pixels and 1024x768 pixels for OA and FA use. Also we recently succeeded to develop dot matrix type with 1280x1024 pixels and have urgently worked for completing it as a product. Recently, however, various display colors in addition to neon orange are required so that many institutes and enterprises have promoted research and development on this problem.

As manufacturing color display device by LCDs are advanced it becomes clear that LCDs have a difficulty for making large size. While, because of easy making and display characteristics it is expected that PDP is a most probable device to realize a large direct viewed color flat display.

One of the authors showed the possibility of realizing the multi-colored PDP in 1980 by original surface discharge method (1) and has continued to improve its method since then. We offered surface discharge PDP with three electrodes in 1984 (2) and reported the 8-colored 15inch-diagonal PDP on a experimental basis applied this method in 1989(3). Investigation for a colored PDP using surface discharge method has developed by Bell Labs(4), Thomson CSF (5) and Hiroshima University (6) during these days and they successively reported sample displays with high luminance and high luminous efficiency . However, in order to realize the color PDP for practical use, the following problems were remained to be solved.

1) Realization of higher luminance and higher luminous efficiency, and
2) lengthening of life time.

Author et.al. improved the surface discharge panel which was reported in 1989 and solved two problems mentioned above and we have manufactured the 3-colored 20 inch-diagonal PDP for public use since fall in 1990.

PROBLEMS FOR PRACTICAL USE

The problems mentioned for realizing color PDPs for practical use were relevant to each other. High driving frequency was necessary to obtain practical high luminance because of low luminous efficiency of the previous surface discharge PDP. Applying high driving frequency causes large power consumption and increases in the deterioration of phosphor due to ion sputtering so that its life time becomes short. The further improvement of luminous efficiency is necessary to obtain practical high luminance with low driving frequency. Thus we introduced following two items.

1) Introducing new panel structure, and
2) development of new filling gas based on Ne+Xe gas.

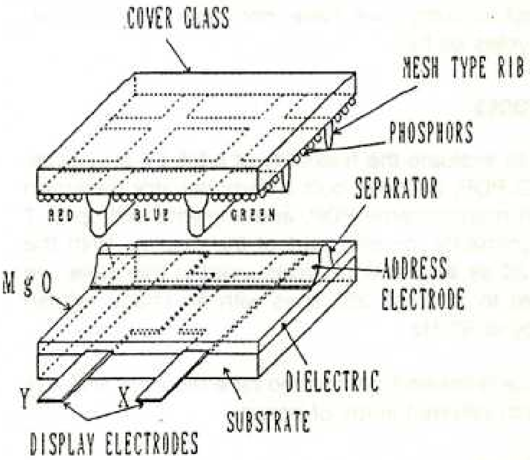

FIG.1 PREVIOS PANEL STRACTURE

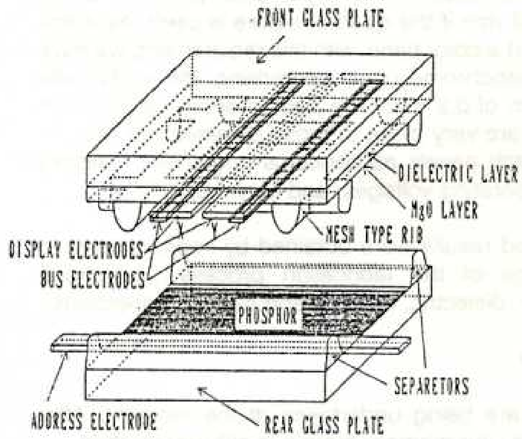

FIG.2 NEW PANEL STRACTURE

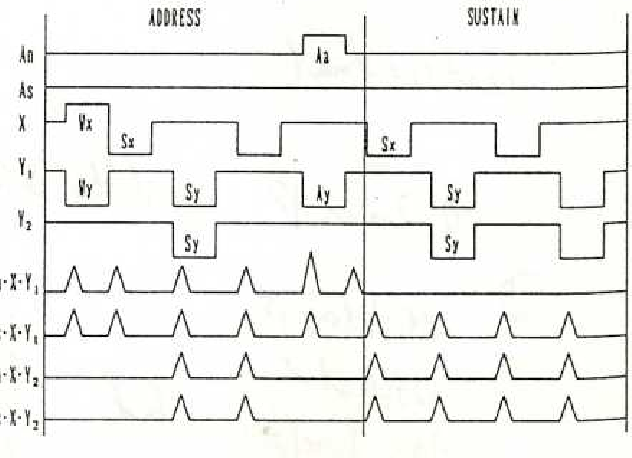

FIG.3 DRIVING WAVEFORM

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PANEL STRUCTURE AND DRIVING PRINCIPLE

Figure 1 shows the previous structure of surface discharge with three electrodes which was developed by us. The display electrodes and address electrode are formed on the same substrate. This panel is so called transparent type which one observes the light come through the phosphor. Following two problems were still remained in this type.

1) It is not able to utilize the luminance excited by ultra-violet ray sufficiently.
2) The capacitance between the address electrode and the display electrode is so large that it affects the driving waveform.

To solve these problems we introduced following two technical changes.

1) We adopt so called reflection type which one directly observes the light on the surface of the phosphor in order to realize the higher luminance. To realize this type, the display electrodes are composed of transparent electrode and auxiliary electrode.
2) To reduce the capacitance, the address electrode and the display electrode are formed on the different substrates.

Figure 2 shows the new panel structure. X and Y display electrodes composed of transparent material are formed on the substrate. In order to obtain sufficiently large dynamic margin, it is necessary to make active discharge in all cells to accumulate the sufficient wall charge even when all cells are lit simultaneously. To satisfy this condition, the voltage drop due to resistance of transparent electrode must be kept as small as possible. Thus an auxiliary electrode made of Cr-Cu-Cr multi-layer is formed on the transparent electrode. These electrodes are covered by a dielectric layer and mesh type ribs are formed on the dielectric layer. These ribs confine discharge in each cell and prevent from color cross-talk between adjacent cells. On the dielectric layer and ribs, MgO layer is formed as a protecting layer.

On the other substrate, address electrodes are formed. Address electrodes are exposed to gas space to prevent from accumulating electric charge on it. Separators are composed at the side of the each address electrode. These separators prevent the cells from the effect of erasing discharge in a non-selected adjacent cell. Phosphor is formed by the side of an electrode not to cover the address electrodes. Gap between two substrates are about 100um and Ne+Xe gas mixture is filled in this space.

We adopt the line at a time driving method for this panel. Figure 3 shows the driving waveform. Driving waveform is composed of address mode and sustaining mode. Address mode is composed of writing, sustainig and erasing pulses. Sustaining mode is composed of only sustaining pulse. As a first, the write pulses, composed of Wx and Wy pulses, which has higher voltage than firing voltage is applied between X and Y1 electrodes so that all the cells on the electrodes are lit simultaneously. After applying the sustaining pulses, the discharge in non-selected cells on this line are erased by applying the erase pulse between each address electrode and Y1 electrode. Erasing is done by self-erase mechanism as follows. The wall charge formed by discharge at the raising part of erasing pulse causes the discharge at its falling part. The space charge due to the second discharge neutralizes the wall charge formed on the dielectric layer on the X and Y1 electrodes. Thus non-selected cells are erased. Selected cells continue to lit due to successive sustaining mode pulse. As a next, the cells along the X and Y2 electrodes are addressed by the same method as mentioned above. This address method is applied to each line in order untill

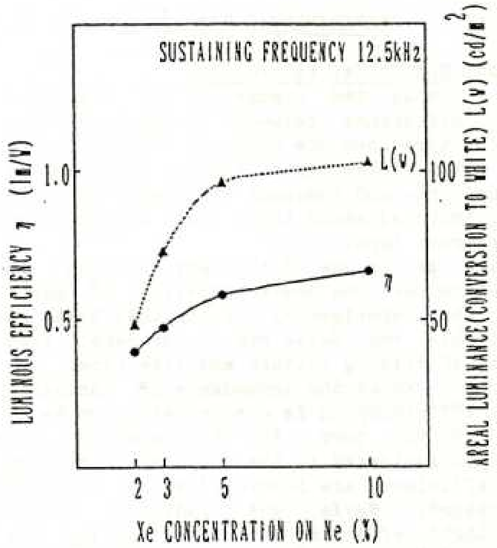

FIG.4 DEPENDENCE OF LUMINANCE AND LUMINOUS EFFICIENCY ON Xe CONCENTRATION

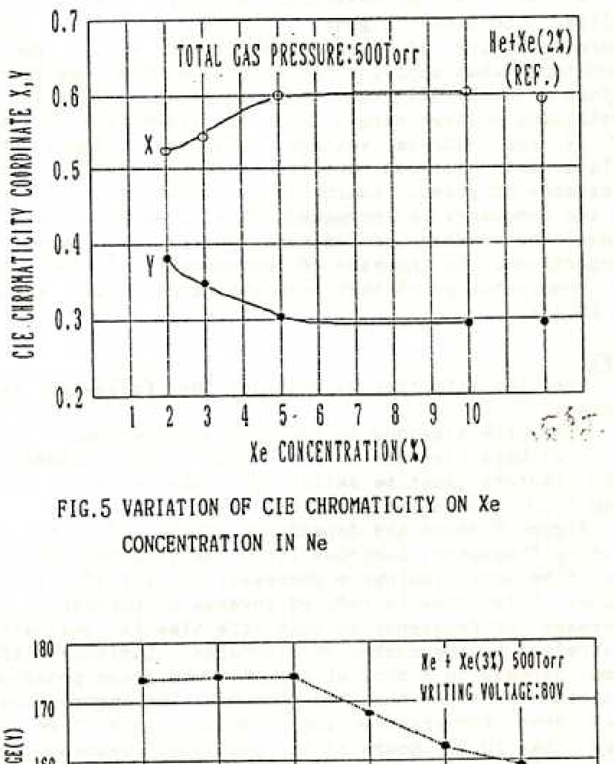

FIG.5 VARIATION OF CIE CHROMATICITY ON Xe CONCENTRATION IN Ne

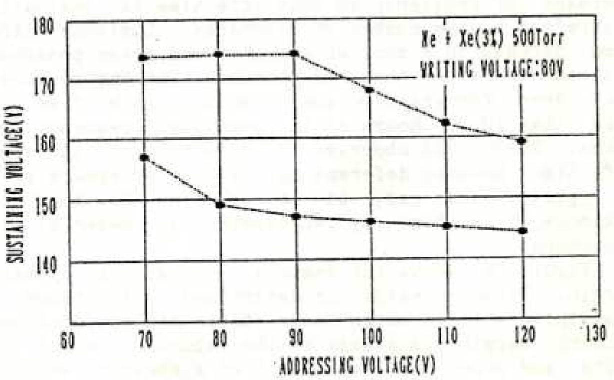

FIG.6 CHRACTERISTICS OF DYNAMIC MARGIN

the last line. Thus, one frame is completed.

EXPERIMENTAL RESULTS

OPTICAL AND ELECTRICAL PROPERTIES

Table 1 shows the comparison of luminance and luminous efficiency between transparent type and reflection type when one observes the excited light due to ultra-violet ray at the gas pressure of 500 torr. Luminance and luminous efficiency of reflection type are improved about twice times as large as that of transeparent type.

Filling gas is one of the very important factors which determines the characteristics of panel. We obtained the experimental results that Ne+Xe gas is more suitable than He+Xe gas to our panel from the view point of driving voltage and life time.

Figure 4 shows the dependence of luminance and luminous efficiency on Xe concentration on Ne at gas pressure of 500 torr. For the comparison data of He+Xe(2%) is indicated in the figure. Luminance and luminous efficiency are increased as Xe concentration is increased. Ne+Xe gas radiates neon-orange visible light affecting the color purity due to excitation of Ne atom. However, as the coordinate of chromaticity shown in Figure 5 indicates, the color purity is improved even on Ne+Xe gas mixture when Xe concentration is increased. In paticular, we observe the same color purity at the 10% of Xe concentration on Ne as that of He+Xe(2%) although the driving voltage becomes higher. Figure 6 shows the characteristics of dynamic margin of a new panel structure when applying the driving method mentioned before on Ne+Xe(3%) gas. We obtained about 20 V as a sustaining voltage margin under the range from 70 V to 120 V for address voltage. Figure 7 shows the relationship between driving frequency and the peak luminance of green. Luminance is linearily increased as the frequency is increased. This is expected result since the number of luminous pulses is increased proportional to increase of frequency for AC-PDP. It is remarkable point that peak luminance is 400 cd/m2 at 20 kHz.

LIFE

For the life time we consider the following two factors.

1) Life time due to luminous degradation.
2) Life time due to the change in the voltage.

Both factors must be satisfied by the value of more than 10,000 hours for practical use.

Figure 8 shows the dependence of the life time on driving frequency. Luminous life time is determined by the time until luminance decreases to half of initial value. Life time is reduced inverse proportional to increase of frequency so that life time is basically determined by the number of discharge. Luminous life time depends on a sort of phosphor and green phosphor deteriorate faster than red phosphor. The figure shows that even for green phosphor luminous life time is more than 10,000 hours at the practical frequency of 15kHz. Since one observes the deference of luminous life time between deferent material of phosphors such as green and red, it is possible to lengthen luminous life time by improvement of material of phosphors.

Figure 9 shows the temporal change of dynamic margin. Dynamic margin is determined by the range of sustaining voltage which keeps stable diplay. Obtained dynamic margin is stable at the value of about 20 volts and upper and lower limit of sustainig voltage are at about 165 V and 145 V, respectively.

We comfirmed the characteristics of long life which is one of the special features of surface discharge AC-PDP by figure 8 and figure 9.

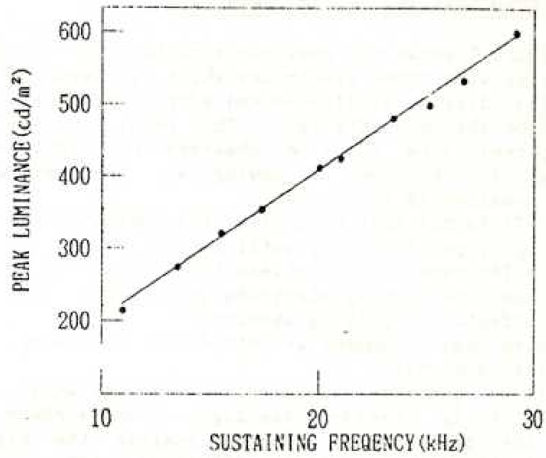

FIG.7 RELATIONSHIP BETWEEN DRIVING FREQENCY AND PEAK LUMINANCE

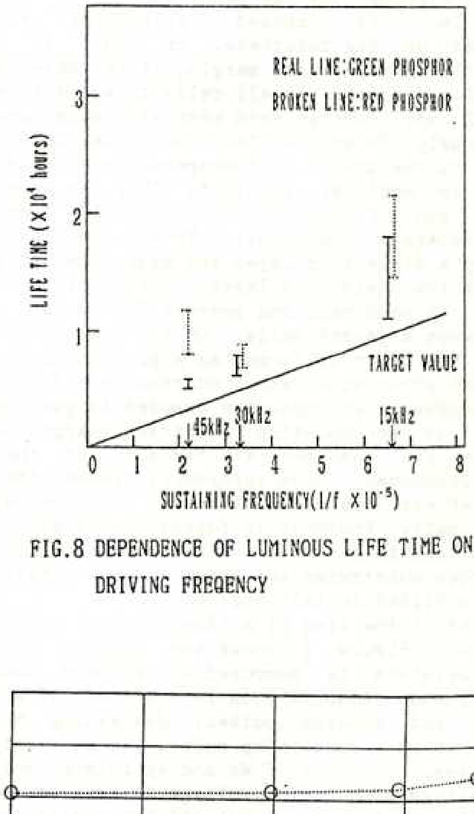

FIG.8 DEPENDENCE OF LUMINOUS LIFE TIME ON DRIVING FREQENCY

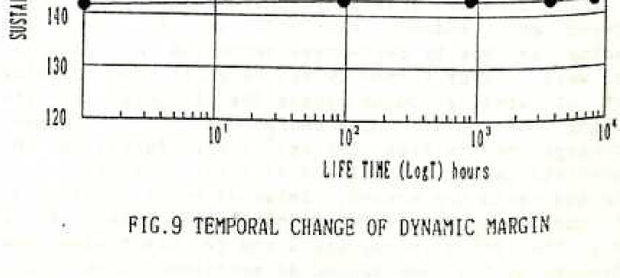

FIG.9 TEMPORAL CHANGE OF DYNAMIC MARGIN

Table 1. COMPARISON OF LUMINANCE AND LUMINOUS EFFICIENCY BETWEEN TRANSPARENT TYPE AND REFLECTION TYPE

Item	Trans. type	Reflec. typ
Luminance (white) (cd/m²)	39	73
Luminous efficiency (lm/w)	0.25	0.46

CHARACTERISTICS OF PUBLIC USE PANEL

Table 2 shows the characteristics of PDP for public use adopted the above mentioned reflection type panel structure. Figure 10 shows the composition of pixels used for this panel. One pixel is divided by 12 cells which are composed of 4 cells vertically and 3 cells horizontally. The horizontal 3 cells have a same color and red and green phosphors are arranged in two rows reciprocally. Pixel pich is 2.4 mm horizontally and 3.0 mm vertically. Cell pich is 0.8 mm horizontally and 0.75 mm vertically. The reason why one pixel is divided by small cells is that one can observe compound color of yellow more natural for large pixel and that one can hardly notice the movement of pixel when changing to the deferent color. Since horizontal 3 cells are addressed simultaniously, corresponding three address electrodes are binded on the panel. Figure 11 shows the sample display of our PDP for public use. One character is composed of 5x7 fonts.

CONCLUSION

We attempted the realization of higher luminance and higher luminous efficiency and lengthening of life time by adopting the reflection type structure. One erves the surface of illuminating phosphor directly the type.
As a result, we realized the panel which has the life time more than 10,000 hours under the driving condition which sustains the sufficient characteristics of luminance for public use. We have manufactureed the panel since fall in 1990. From now, we intend to make a large size of panel based on this results and also to investigate the driving method realizing a full color display.

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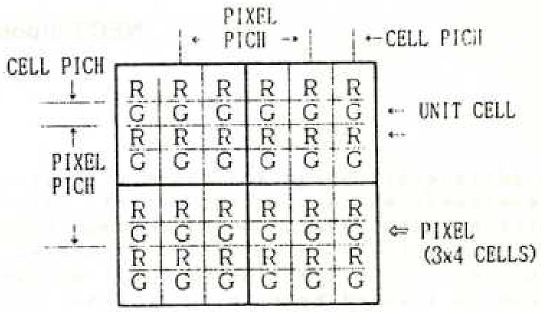

FIG.10 COMPOSITION OF PIXELS

Table 2. SPECIFICATION AND CHARACTERISTICS FOR PUBLIC USE

Item		Chracteristics
Display Area		20 inch diagonal
Display Character		18 charac. × 8 row (horizontal) (vertical) 5×7 font
Number of Pixels		90 (horizontal) × 56 (vertical)
Pixel pitch		3.0 × 2.4 (mm) (vertical) (horizontal)
Cell Size		0.75 × 0.8 (mm) (vertical) (horizontal)
Area Luminance (12.5kHz)	green	90 cd/m²
	red	57 cd/m²
Luminous Efficiency	green	0.59 lm/w
	red	0.37 lm/w
Driving Voltage (Typical)	sustain	160 V
	writing	80 V
	address	90 V
Power Consumption		85 W

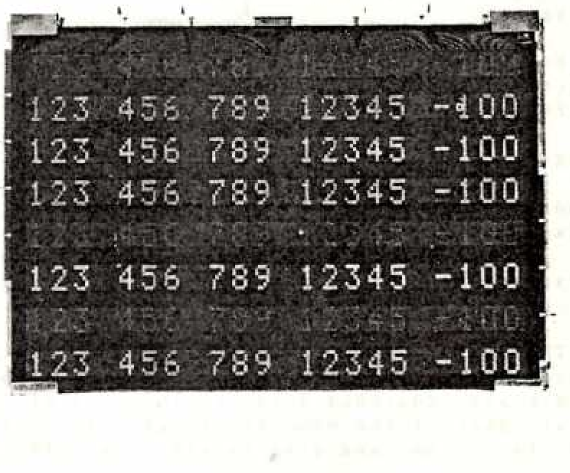

FIG.11 SAMPLE DISPLAY

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