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Optical Characteristics of Reflection-Type Surface-Discharge AC Plasma Display Panels

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Introduction

Recently flat display has been used in various fields such as OA and FA and the market has been steadily growing up. As the products i.e. Lap-top type computer, indicate the down sizing by flat display will influence greatly on the society in the future. Particularly, since AC color plasma display (PDP) which has been developed by several enterprise and institutions (1)(2)(3)(4) has several features such as high luminance, broad viewing angle and quick response, it is profitable to the display with large screen. Therefore AC color PDP is expected to commercialize at an early date in order to realize wall hanging TV etc.

While our company has supplied AC mono-color plasma display to market for many years, we have continued to research and develop a color plasma display(1)(5)(6). Then we succeeded in 20 inch multi color PDP commercialization for a public use in last year(7). This product has several features such as high luminance and long life time and it showed the possibility of commercializing a color PDP for high definition TV system.

In this paper we inform the results investigated dot size and gap between discharge electrodes in order to improve luminance and dynamic margin.

Panel structure

Our company's color PDP adopts so called reflection type surface discharge method which has the features of high luminance and long life time and it has the structure which is effective to use the light emission of phosphor. Fig.1 shows our panel structure. First of all pairs of X and Y display electrodes of transparent material are formed on the front glass substrate. In order to avoid the voltage drop due to resistance of transparent electrode, an auxiliary electrode made of Cr/Cu/Cr multi-layer is formed on the display electrodes by photolithography process. These electrodes are covered by dielectric layer and mesh type ribs are formed on the dielectric layer by the thick-film process. These ribs confine discharge in each cell and

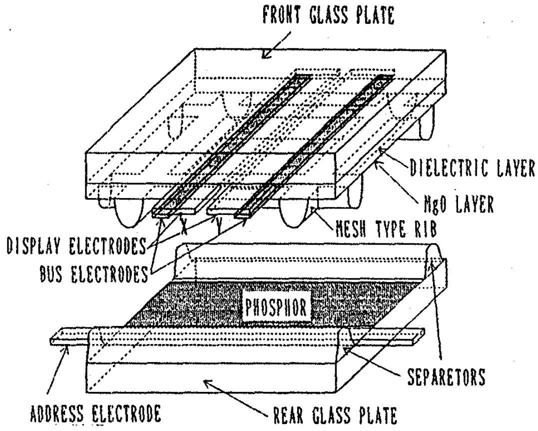

Fig. 1 NEW PANEL STRACTURE

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 of silver are formed. Address electrodes are exposed to the gas space to prevent from accumulating electric charge. Line ribs (Separator) are formed at the side of the each address electrode. These ribs prevent the cells from the effect of erasing discharge in a non-selected adjacent cell. Phosphor is formed by the side of the address electrode not to cover the address electrode. All of these are formed by thick-film process.

Gap between two substrates are about 100 um and Ne+Xe gas mixture is filled in this space. We chose Xe concentration about 3% at which practical target values of several features such as driving voltage, life time and color purity are satisfied.

Driving principle

We adopt the line at a time driving method for this panel. Fig.2 shows the driving waveform and light-output. Driving waveform is composed of addressing mode and sustaining mode. Addressing mode is composed of writing pulses, and erasing pulses. Sustaining mode is composed only sustaining pulses. Selection of the dot of every one line are carried out in the addressing mode and maintenance of selected state are carried out in the sustaining mode. As a first, Vx pulse and Vy pulse are applied simultaneously to X electrode and Y1 electrode respectively. Sum of Vx pulse and Vy pulse is higher than firing voltage so that all dots along Y1 electrode are lit simultaneously to accumulate the wall charge. After applying sustaining pulse Sx , Sy which cause discharge for stabilizing, Aa pulse and Ay pulse are applied to address electrode corresponding to non-selected cells and Y1 electrode respectively. The discharge due to Aa pulse and Ay pulse neutralizes wall charge in non selected dots. By successive sustaining pulse , selected dots continue to be lit in which the wall charge is still remained although non-selected dots aren't lit in which the wall charge is erased. As a next, the dot along Y2

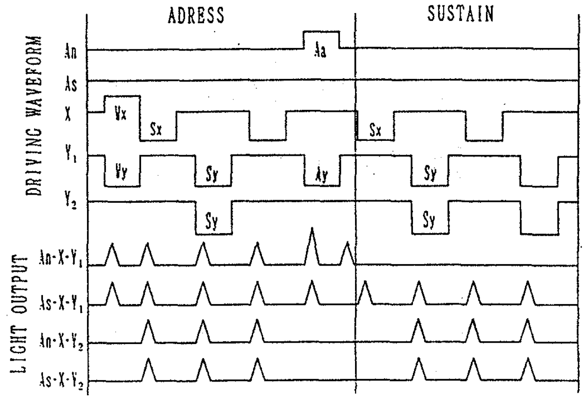

Fig. 2 DRIVING WAVEFORM

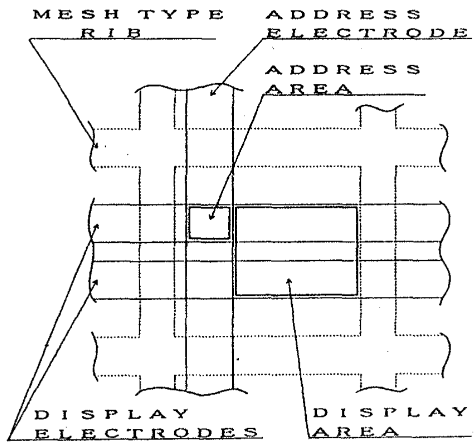

Fig. 3 DOT STRUCTURE

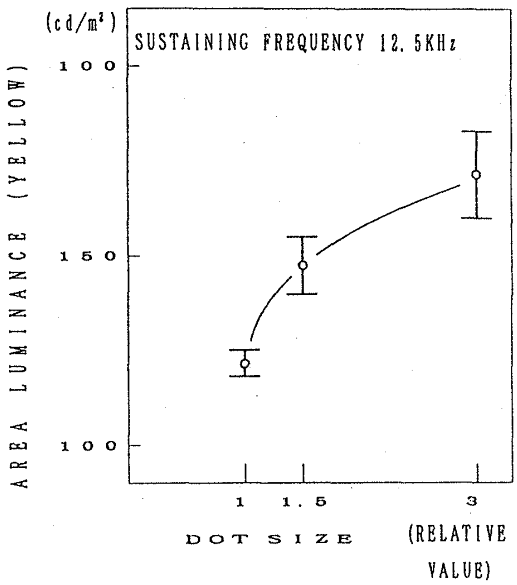

Fig. 4 DEPENDENCE OF AREA LUMINANCE ON DOT SIZE

electrode is selected by a similar method. At this time all cells along Y1 electrode maintain selected results since addressing mode are not applied to Y1 electrode. This address method is applied to each line in order until the last line. Then, one frame is completed.

The accumulation and the maintenance of the wall charge are done at the same time by the discharge between the display electrodes X and Y generated in the display area in the dot(Refer to Fig.3) on every one line or the entire screen. The erasing of the wall charge is done by the discharge between the address electrodes and the display electrodes Y generated in the address area in the dot(Refer to Fig.3). Since selection of each dot is done by erasing the wall charge, the stability of driving is dependent on erasing process of the wall charge.

Experimental results

Dot size

In the case of color PDP for public use, the size of the characters is large since it is observed from the distance of several meters or more so that dot size is also large. For instance its dot size is more than ten times larger than that of OA use. Therefore, it is necessary to achieve high luminance and stable driving at a large dot size.

Fig.4 shows the relation between the dot size and the area luminance. The area luminance is higher as the dot size is lager. This is caused by improvement of rate of open area as shown in Fig.5. This indicates that the area luminance is higher in proportion to rate of open area. One can obtain higher luminance by lager rate of open area by taking dot size as larger as possible.

The feature that the area luminance is proportion to rate of open area is one of the advantage of our panel. Because one can obtain high luminance in the case of comparatively large dot size. Fig.6 shows the luminous distribution in one dot of our panel. The peak luminance in one dot has very high uniformity so that the relation between rate of open area and the area luminance have the proportional relation. For the ordinal two substrates PDP, luminance is highest at the center of dot and gets lower as

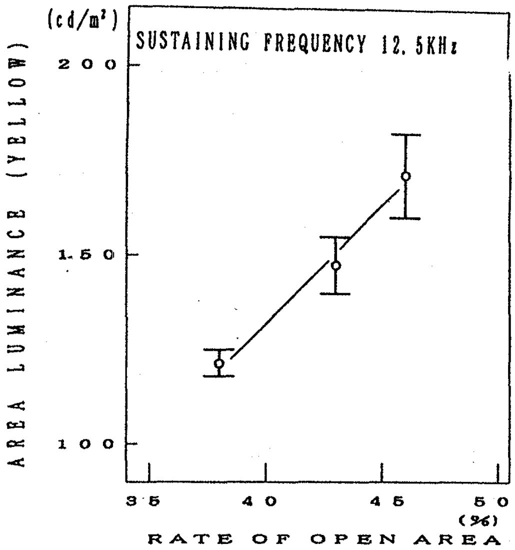

Fig.5 DEPENDENCE OF LUMINANCE ON RATE OF OPEN AREA

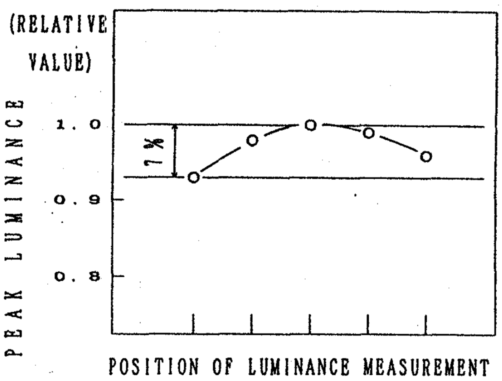

Fig.6 LUMINOUS DISTRIBUTION IN ONE DOT

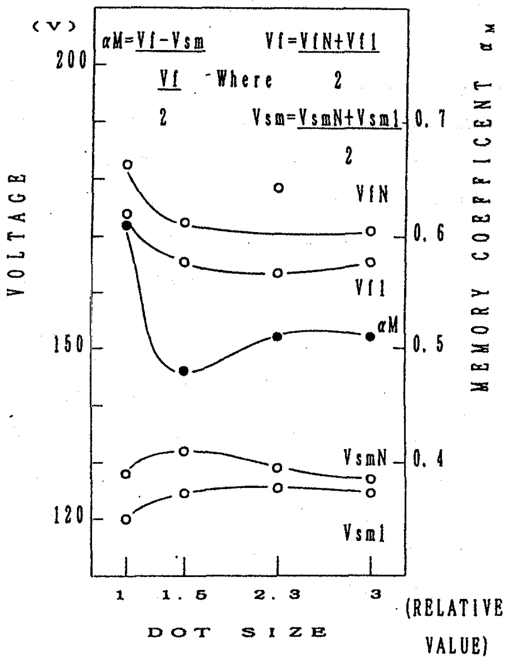

FIG.7 DEPENDENCE OF STATIC CHARACTERISTICS ON DOT SIZE

approaching to the surrounding. Therefore, a drastical improvement of area luminance cannot be expected by improving of rate of the open area.

The reason why the peak luminance in one dot has very high uniformity is come from panel structure which has following two features. First feature is the surface discharge method. The luminous distribution in one dot is proportional to the distribution of electric field. In the case of two substrates PDP, the electric field is the strongest at the intersection of electrodes and weakens for surrounding. While in the case of surface discharge PDP, the electric field is uniform in a parallel direction of display electrodes. Second feature is the reflection type structure. For the transmission type case, since one observes the light come through the phosphor, luminance lowers as phosphor is thicker so that luminous distribution is dependent on the thickness distribution of phosphor. While, for the reflection type case, the thickness of phosphor hardly effects luminance since one directly observes the light emission on the surface of phosphor. Therefore, the peak luminance in one dot has very high uniformity.

Fig.7 shows the relation between the dot size and the static characteristics. Horizontal axis represents the dot size and vertical axis represents static characteristics. A large memory coefficient is obtained for any dot size . Fig.8 shows the relation between the dot size and the dynamic margin. Horizontal axis represents the address voltage and vertical axis represents the sustaining voltage. As dot size is larger, the minimum value of address voltage is higher so that the dynamic margin tends to be decreased. This indicates that stronger address discharge is necessary to erase the wall charge when the dot size is larger.

In order to obtain larger dynamic margin as mentioned above, it is desirable that the dot size reduces. However, the area luminance decreases when the dot size reduces. Therefore, it is necessary to determine the best dot size under consideration of both the area luminance and the dynamic margin.

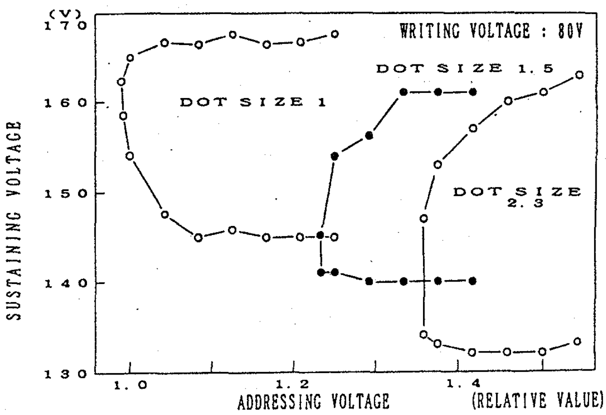

Fig. 8 DEPENDENCE OF DYNAMIC MARGIN ON DOT SIZE

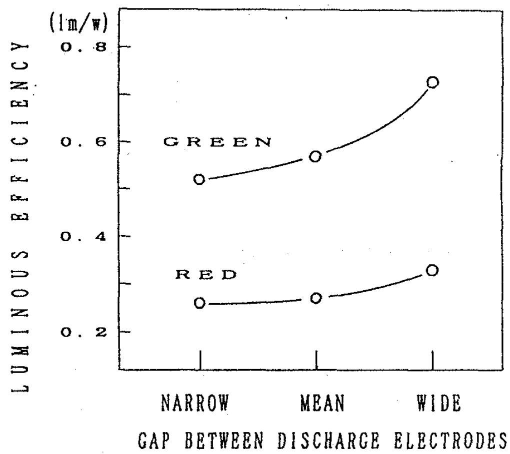

Fig. 9 DEPENDENCE OF LUMINOUS EFFICIENCY ON GAP BETWEEN DISCHARGE ELECTRODES

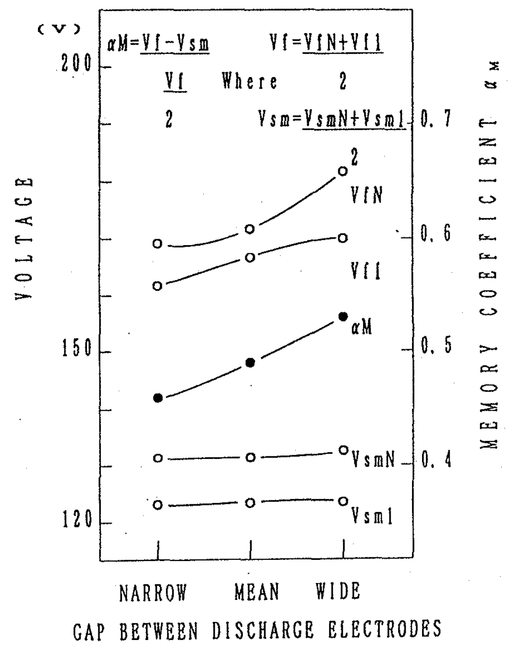

Fig. 10 DEPENDENCE OF STATIC CHARACTERISTICS ON GAP BETWEEN DISCHARGE ELECTRODES

<u>Gap between discharge electrodes</u>

Fig.9 shows the change of the luminous efficiency when gap between discharge electrodes (gap), which is a distance of display electrodes X and Y, is varied with three conditions. The luminous efficiency is higher as the gap is wider. In the case of the widest gap, luminous efficiency is about 1.4 times higher than that of the narrowest gap. The reason is that reduction of luminance is small although discharge current is considerably decreased as the gap is wider.

The relation between the gap and the static characteristics is shown in Fig.10. For any gap size our panel has a sufficiently large memory coefficient. The firing voltage is increased and the memory coefficient is also larger as the gap is wider. Fig.11 shows the relation between the gap and the dynamic margin. The dynamic margin is disappeared at the widest gap. Therefore it is necessary to take the narrower gap than some certain value in order to obtain stable driving.

As mentioned above, in order to obtain larger dynamic margin it is necessary to restrict the gap under some certain value, however, in order to improve luminance and luminous efficiency the wider gap is advantageous.

<u>Sample adopted our panel structure</u>

The commercialized multi color PDP for public use adopts composition of pixel as shown in Fig.12. One pixel is composed by 12 dots which are arranged 4 dots vertically and 3 dots horizontally. The dot size is determined by consideration of above results by which we obtain both large dynamic margin and sufficiently high luminance. Fig.13 shows sample display of this panel.

<u>Summary</u>

For displays for OA use , dot size is determined by their application. While, for displays for public use , it is possible to take optimum dot size since the range of allowance of the dot size is wide. For this reason, when developing 20 inch multi color PDP, we adopted the dot size at which we obtain sufficiently high

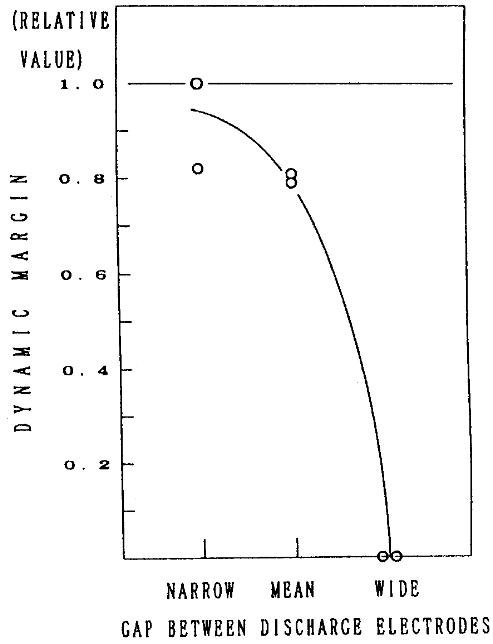

Fig. 11 DEPENDENCE OF DYNAMIC MARGIN ON GAP BETWEEM DISCHARGE ELECTRODES

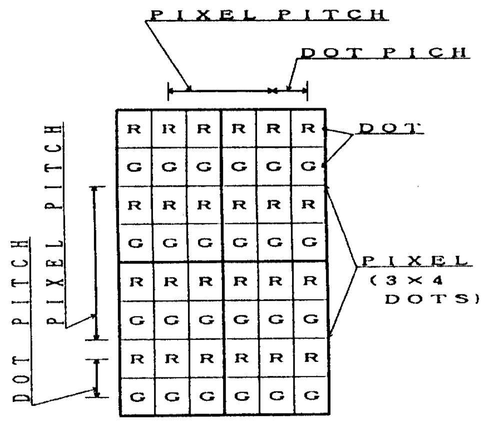

Fig. 12 COMPOSITION OF PIXEL

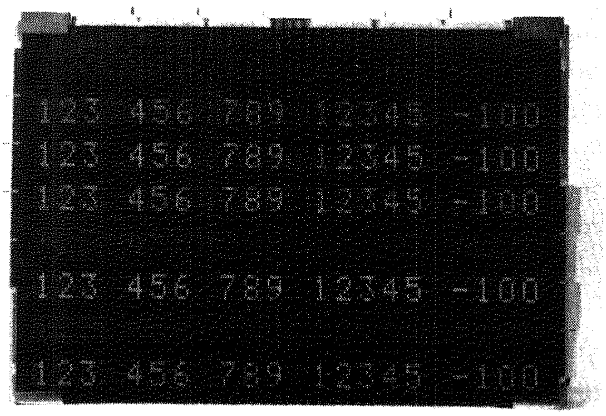

Fig. 13 SAMPLE DISPLAY

luminance and luminous efficiency and high stability of driving by the dependence of dot size as mentioned below. We also optimized the gap which affects discharge characteristics.

a. Luminance and luminous efficiency are improved by taking large dot size and wide gap .

b. Dynamic margin is improved by taking small dot size and narrow gap.

20 inch multi color PDP has several features such as high luminance and long life time and it showed the possibility of commercializing a color plasma display for high definition TV system. In future, it is necessary to improve luminance and luminous efficiency in smaller dot size in order to develop display product for high definition TV system. Also we will continue to investigate a high speed driving method and the display quality such as color purity etc.

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