

The Optimum Phosphor Thickness to Obtain the Highest Luminance and Luminous Efficiency in ac PDP

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Abstract

Plasma display panel(PDP) have gained great attention due to their potential application to large-area display including HDTV. The luminance and luminous efficiency of PDP, however, should be improved to realize this goal.

In this study, we examined experimentally the effects of phosphor thickness and discharge gap on the luminance and luminous efficiency of ac PDP. For the rib height of 110 ㎛, whereas the optimum phosphor thickness was about 30 ㎛. The optimum thickness of green phosphor was about 50 ㎛ for the rib height of 120～160 ㎛.

Keywords : Ac PDP, optimum phosphor thickness, luminance, luminous efficiency

1. Introduction

PDP is one of the most promising technologies for large area flat panel displays realizing 30 to 60inches diagonal and HDTV[1]. However, the low luminous efficiency is still one of the major problems of the present PDP.

The phosphor thickness may also affect the luminance and luminous efficiency. However, the optimum phosphor thickness to realize the highest luminance and luminous efficiency is not well known.

In this study, we examined the effect of thickness of phosphor layer as a parameter for Red, Green and Blue phosphors from the view point of luminance and luminous efficiency of ac PDP.

2. Experimental

Fig.1 shows a well-known discharge cell in a surface discharge type ac-PDP[2]. A model of specification PDP of 4-inch size used in this study is shown in Table.1. The rib height was varied in the range of 110～160 ㎛ as used in real PDP.

Actually, trio-primary color phosphors (Red, Green and Blue) are patterned in the corresponding grooves in the commercial PDP. But we have coated one phosphor per each panel eliminate the influence of other phosphors, as a parameter of the thickness of the phosphor. The phosphors tested in the study is shown in Table 2[3].

Fig. 2 shows the schematic diagram of experimental set-up. The experimental set-up consists of three parts, that is, circuits of driving ac pulses, signal controller and vacuum system. The circuits of driving ac pulses consist of sustain pulse circuits and erasing /writing pulse circuits. The signal controller generates the control signal to change frequency and pulse width.

The vacuum chamber is a cylindrical type with 12 cm in diameter and 17 cm in height. Both gas species and gas pressure can be varied. This vacuum chamber is exhausted up to 10^{-6} Torr using molecular pump to be affected by residual gas. And then, gases are filled to a given pressure 400 Torr. In this work, He+Ne(30 %)+Xe (2 %) mixture gas was used.

The electrical measurements include obtaining the minimum firing voltage V_f and maximum sustain voltage

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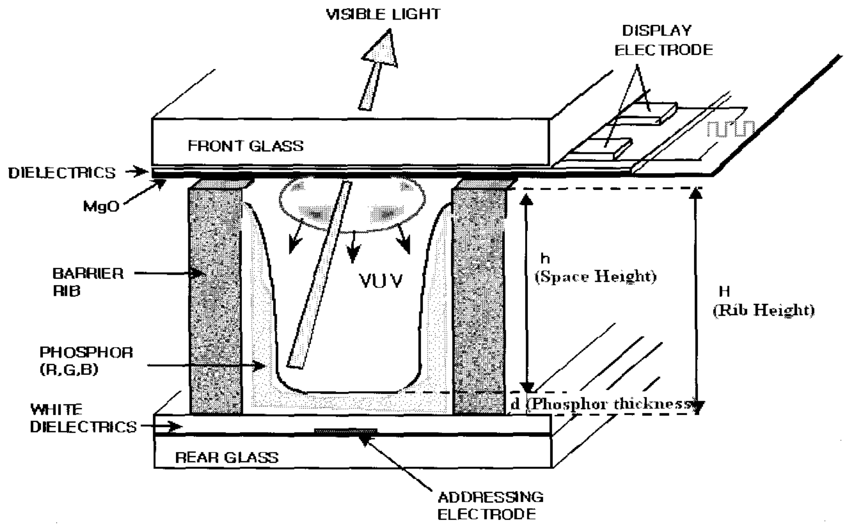


Fig. 1. The schematic diagram of a model ac PDP.

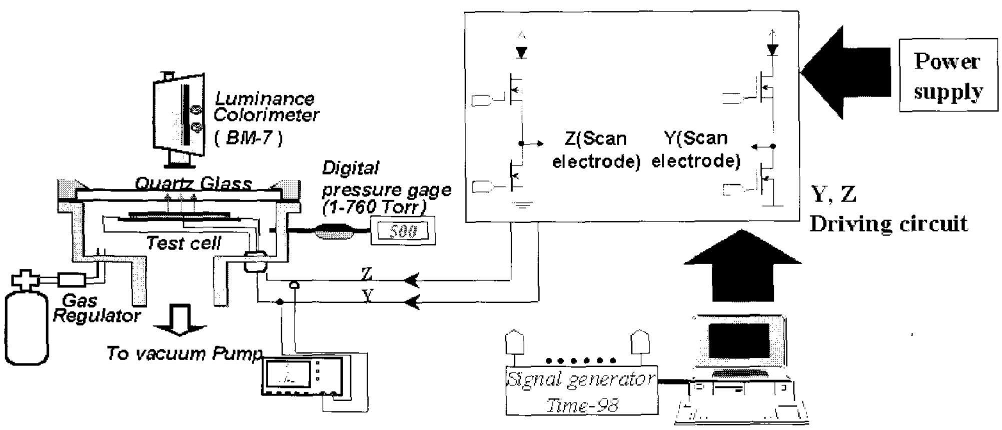


Fig. 2. The schematic diagram of test chamber for discharge.

TABLE 1. The conditions of applied voltage.

Front panel		Rear panel	
ITO width	310 ㎛	Whiteback thickness	20 ㎛
ITO gap	60 ㎛	Rib height	110~160 ㎛
Bus width	120 ㎛	Rib pitch	320 ㎛
Dielectric thickness	20 ㎛	Rib width	100 ㎛
MgO thickness	5000 Å	Gas pressure	400 Torr
Address electrode width	120 ㎛	Driving frequency	50 KHZ
		Driving voltage	185 V

TABLE 2. Phosphors for PDP.

RED	Composition
RED	$(Y.Gd.Eu)BO_3$
GREEN	$(Zn.Mn)SiO_4$
BLUE	$(Ba.Mg)Al_{14}O_{23}$

V_s for panels with a square wave voltage drive.

The minimum firing voltage V_f was measured by progressively increasing applied voltage to initiate the discharge, and then the maximum sustaining voltage V_s was measured by reducing their applied voltage to the point at which the on cells begin to extinguish.

After ascertaining the V_f and V_s, the luminance was measured in the range between the V_f and V_s. The luminance was measured by calorimeter(Topcon, BM-7). The average luminance was measured the area of 10 mm diameter and the peak luminance was decided the brightest point of one cell among the values measured the area of 0.2 mm diameter using attachment lens(Topcon, AL-6).

The luminous efficiency of ac PDP is defined as the ratio of the luminous flux to the power consumption. Suppose the radiation surface is a lambertian surface. The luminous flux which are radiated through 2π steradian is

$$L = \int I(\theta)d\Omega = \int_0^{2\pi}\int_0^{\frac{\pi}{2}} I_0 \sin\theta\cos\theta d\theta dp$$
$$= I_0\int_0^{2\pi} dp \int_0^{\frac{\pi}{2}} I_0 \sin\theta\cos\theta d\theta = \pi I_0 = \pi BS$$

According to the definition of luminous efficiency,

$$Luminous\ efficiency\ (lm/W) = \frac{luminous\ flux\ (L)}{power\ consumption\ (W)}$$
$$= \frac{\pi B\ (cd/m^2)\ S\ (cm^2)}{power\ consumption\ (W)}$$

3. Results and Discussions

Figs. 3~5 show the effect of green phosphor thickness on the luminance and luminous efficiency as a parameter of barrier rib height.

For the rib height of 110 ㎛, the maximum luminance and luminous efficiency are obtained at a phosphor thickness of 30 ㎛. However, for the rib height of 130 ㎛ and 150 ㎛, the maximum value are obtained at the thickness of 50 ㎛.

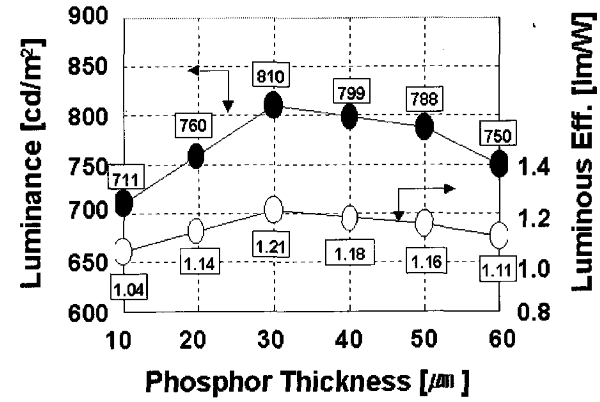


Fig. 3. Effect of the thickness of green phosphor on the luminance and luminous efficiency at the rib height 110 ㎛.

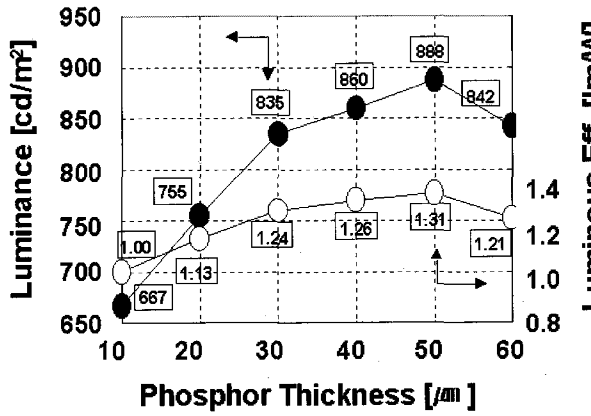


Fig. 4. Effect of the thickness of green phosphor on the luminance and luminous efficiency at the rib height 130 ㎛.

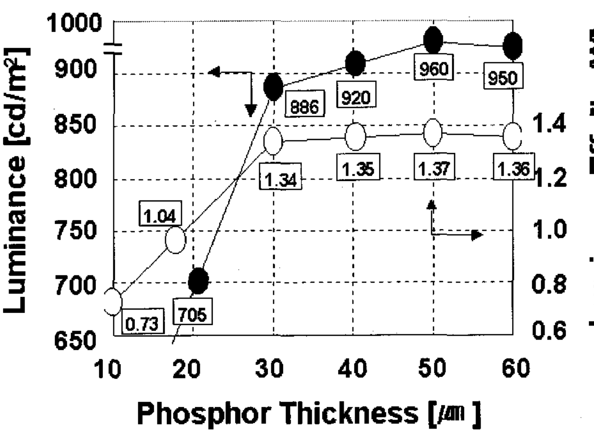


Fig. 5. Effect of the thickness of green phosphor on the luminance and luminous efficiency at the rib height 150 ㎛.

The maximum luminance and for the height 110, 130 and 150 ㎛ were 810, 888 and 960 cd/㎡, respectively. The maximum luminous efficiency were 1.18, 1.31 and 1.37 lm/W, respectively.

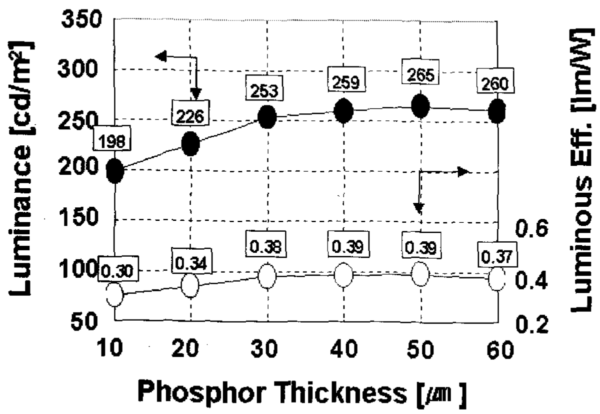


Fig. 6. Effect of the thickness of blue phosphor on the luminance and luminous efficiency at the rib height 130 ㎛.

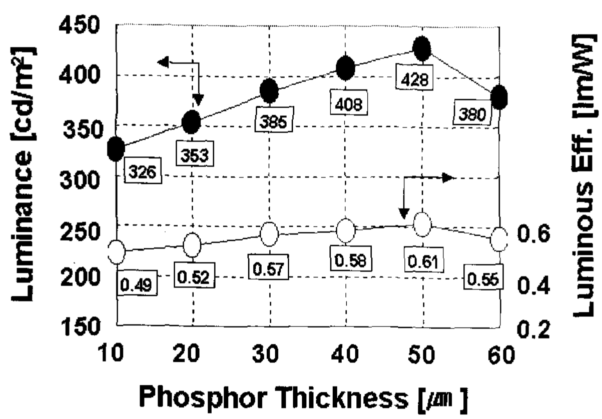


Fig. 7. Effect of the thickness of red phosphor on the luminance and luminous efficiency at the rib height 130 ㎛.

Figs. 6 and 7 show a typical effect of blue and red phosphor thickness on the luminance and luminous efficiency under the condition of constant rib height of 130 ㎛.

It can observed from Figs. 3 ~ 7 that the maximum luminance and luminous efficiency are obtained at the phosphor thickness of 50 ㎛, regardless of the kind of R, G, B phosphors at the rib height of 130 ㎛.

Figs. 8~10 show the typical results for the effect of phosphor thickness on the luminance and luminous efficiency under the condition of constant space gap of 100 ㎛.

It is found out that the maximum luminance and luminous efficiency is also obtained at the phosphor thickness of 50 ㎛ in the range of space gap of 80 ~ 110 ㎛, regardless of the kinds of phosphors.

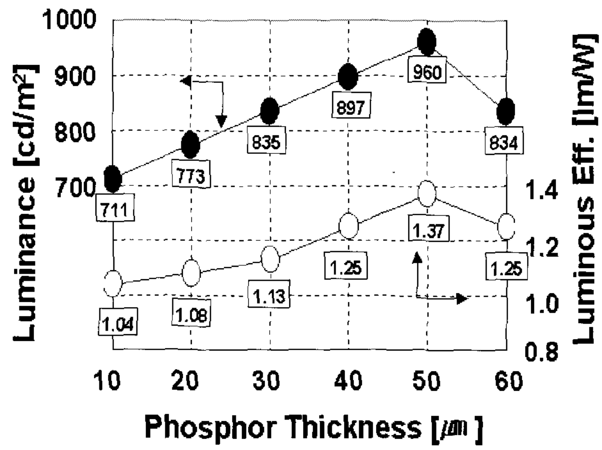


Fig. 8. Effect of the thickness of green phosphor on the luminance and luminous efficiency under the conditions of constant space gap (100 ㎛)

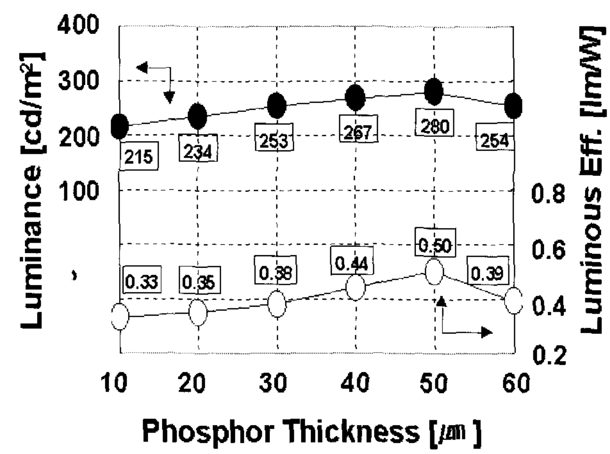


Fig. 9. Effect of the thickness of blue phosphor on the luminance and luminous efficiency under the conditions of constant space gap (100 ㎛).

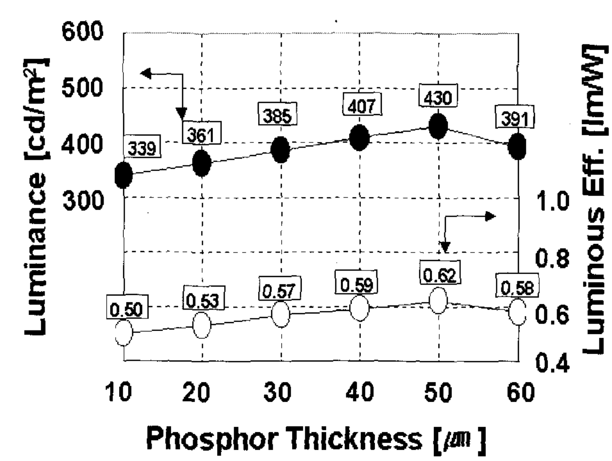
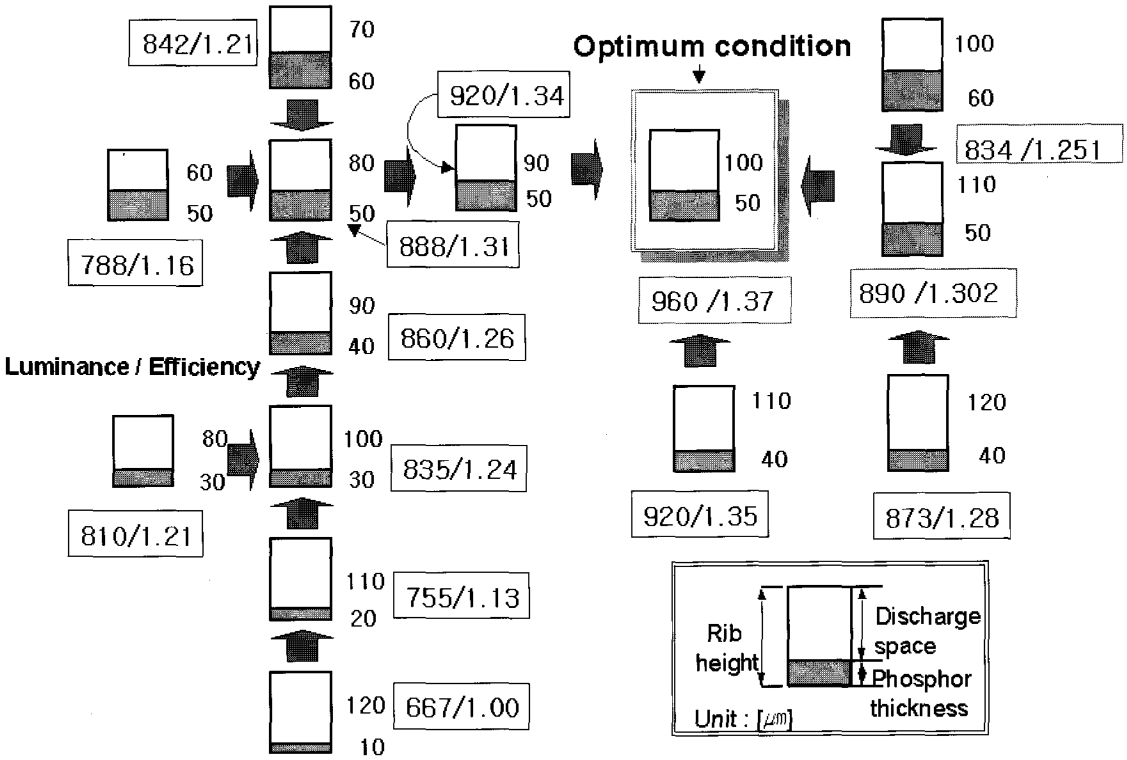


Fig. 10. Effect of the thickness of red phosphor on the luminance and luminous efficiency under the conditions of constant space gap (100 ㎛).



The arrow shows the directions of high luminance and luminous efficiency for Green phosphor.

Fig. 11. The effect of rib height and thickness of phosphor on the luminance and luminous efficiency.

In order to find out the optimum rib height and phosphor thickness, the optimum discharge space gap (shown in Fig 11) and the optimum phosphor thickness should be obtained separately. Especially the optimum discharge space gap should be determined by conditions of the minimum diffusion loss of generated discharge plasma, minimum excitation collapse of Xe gas and maximum visible light emission[4]. Furthermore, the optimum phosphor thickness should determined to have maximum visible light emission and maximum VUV trapping by the vacuum ultraviolet ray from the discharge.

However, it is very difficult to meet all the above-mentioned all conditions completely, even in theory. Therefore, in this paper the optimum phosphor thickness is investigated experimentally with real model ac PDP for VGA size as a parameter of rib height and phosphor thickness.

Fig. 11 shows the summarized experimental results of luminance and luminous efficiency as a parameter of rib height and phosphor thickness for green phosphor.

From this figure, it can be noticed that for the VGA size the maximum luminance and luminous efficiency can be obtained for the rib height of 150 μm and the phosphor thickness of 50 μm. In this case, the discharge space gap is 100 μm.

However, for the rib height of 110 μm, the optimum phosphor thickness are about 30 μm. The results may be due to the following reasons. Although the optimm phosphor thickness is 50 μm, in this case, the optimum luminance and luminous efficiency are not obtained under the optimum length of discharge space gap. Because in the panel the optimum phosphor thickness is function of rib height. If the discharge space gap is smaller than the optimum value of 100 μm, the diffusion loss of the generated discharge plasma is increased. As a result, weak discharge plasma is formed in the discharge space, which leads to low VUV-ray and low luminous efficiency. Therefore, the phosphor thickness should be decreased in order for longer discharge space gap, in this case. The optimum discharge space gap, and phosphor thickness were 80 μm and 30 μm, respectively.

For the rib height of 130 μm, the maximum luminance and luminous efficiency are obtained for the phosphor thickness of 50 ㎛. However, the discharge space gap of 80 ㎛ is shorter than the optimum gap of 100 ㎛,

For the rib height 160 ㎛, the maximum luminance and luminous efficiency is also obtained for the phosphor thickness of 50 ㎛. In this case, the discharge gap is 110 ㎛ which is longer than the optimum gap of 100 ㎛. If the discharge space gap is longer than the optimum value, the more visible light may be absorbed to the wall side. Therefore, the luminance and luminous efficiency for the rib height of 160 ㎛ is lower than that of 150 ㎛.

For the red and blue phosphors, the same tendency is found for the rib height of 130 ㎛, more precise experimental study will be continue for the red and blue phosphor.

4. Conclusions

In this paper, the optimum phosphor thickness to obtain high luminance and luminous efficiency in ac PDP in the range of 110～160 ㎛ is investigated experimentally. For the rib height of 110 ㎛, the optimum phosphor thickness was 30 ㎛. However, for the rib height of 120～160 ㎛ the optimum thickness was 50 ㎛ for the green phosphor. These results were not affected by the variation of in the range of the space gap of 80 ～110 ㎛.

For the red and blue phosphors, the same tendency were found for the rib height of 130 ㎛. More precise experimental study will be done for the red and blue phosphor.

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