# The improvement of discharge characteristics and lifetime of PDP by MgO deposition on the phosphor


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## Abstract

*An alternate application of MgO film for the improvement of discharge characteristics and life time in an ac plasma display panel (PDP) is suggested. In this research, we deposited MgO on the phosphor to get the same address characteristics irrespective of each phosphor. To avoid the luminance and efficiency degradation by MgO deposition on the phosphor, we optimized the MgO thickness through experiments. The results showed that PDP with MgO coated phosphor has a uniform formative delay in address discharge and improved degradation characteristics.*


## 1.Introduction.

The PDP is one of the flat panel devices being regarded as a good candidate for the large-sized, wall hanging multimedia display. But there are many problems to improve the performance of the PDP such as luminance, efficacy, lifetime, etc. For the realization of HDTV[1], many pixels are needed with decreased pixel size, which consequently results in difficulties in obtaining a fair sized common driving voltage margin. Moreover, high speed addressing is needed for the realization of the full HDTV.

To solve the problem of the different addressing characteristics of each phosphor, we adopted MgO coating on the phosphor to get a uniform addressing characteristics and extension of lifetime which is related to phosphor degradation.

## 2. Experiments and Results.

### *2.1 Optimization of MgO thickness.*

MgO is usually used as a protection layer of dielectric. In that case, MgO is deposited in the range of 5000 ~ 8000Å by Sputtering, Ion plating, or E-beam evaporation method. In addition to the role of protection layer, MgO has a good secondary electron emission characteristics.

Even though MgO is transparent in the visible range,

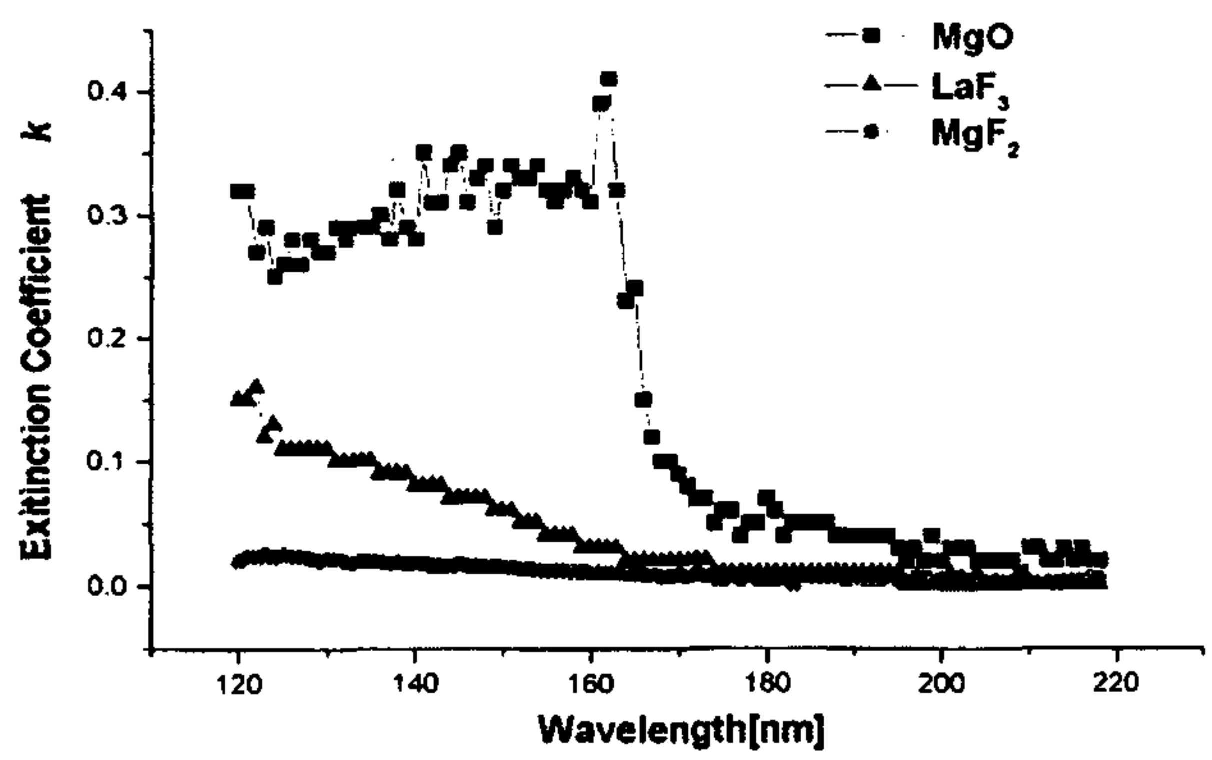



**Figure 1. Extinction coefficient of MgO, $LaF_3$, $MgF_2$ [2],[3]**

the extinction coefficient of MgO is high for vacuum ultra violet (VUV)[2],[3].

Thus determining the optimal MgO thickness is very important in our work.

In general, the equation of light propagation in the absorption medium is,

$$I(z) = I(0)\exp(-\alpha z) \quad (1)$$

$$\alpha = \frac{4\pi}{\lambda}k \quad (2)$$

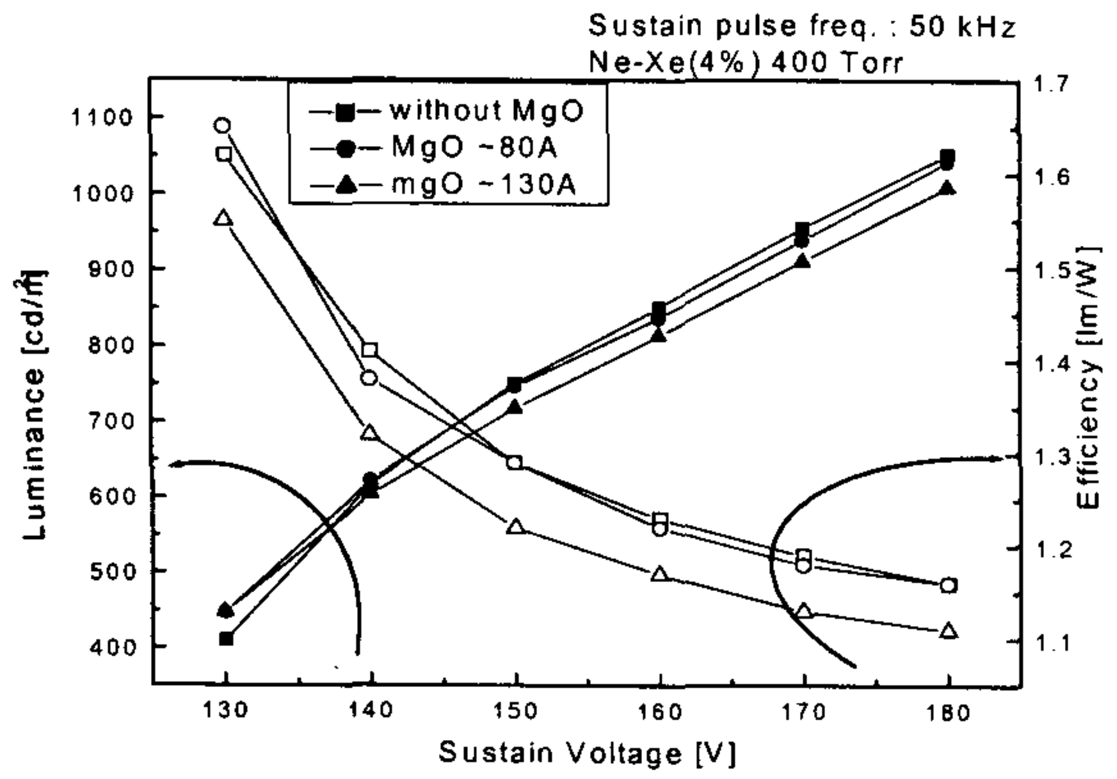
where, α is the absorption coefficient,

The extinction coefficient is,

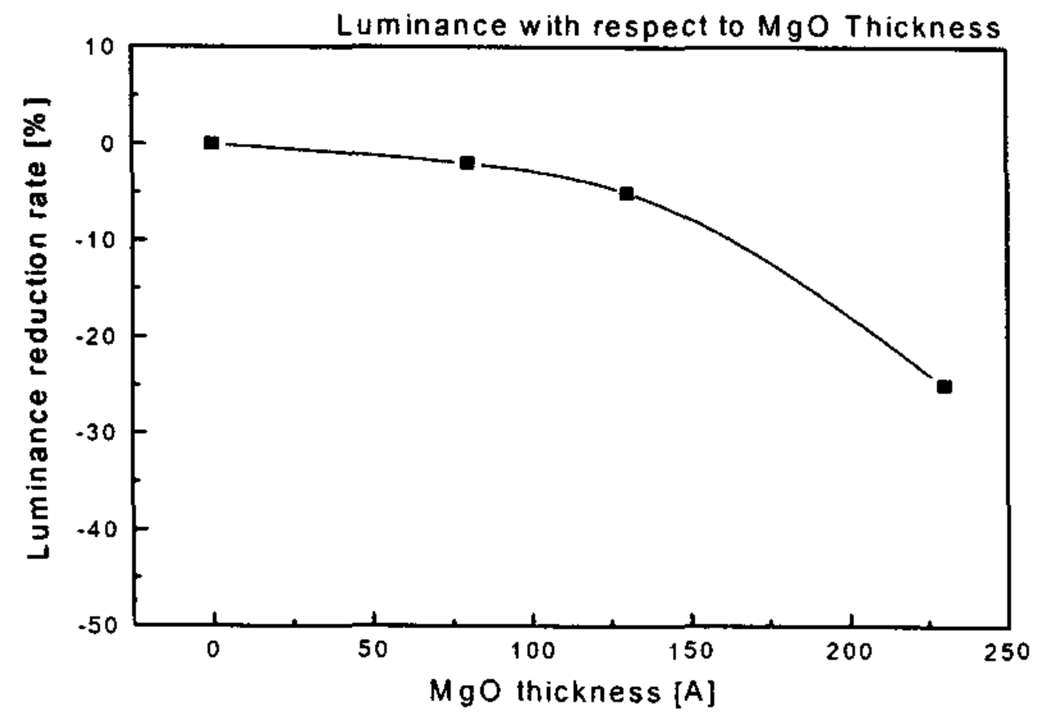
$$k = -\frac{\lambda}{4\pi z}\ln\left[\frac{I(z)}{I(0)}\right] \quad (3)$$

The thickness of MgO whose transmittance at 147nm is ~ 80 %, is turned out to be z =~87 Å.

On the base of above theoretical results, we carried out luminance and luminous efficacy experiments by changing the MgO thickness to decide the proper thickness in which luminance and efficiency degradation is within 5%. The panel used in this research was a coplanar type 4-in diagonal ac PDP with a 1080-$\mu m$ cell pitch, of which electrode widths were 340-$\mu m$ with 80-$\mu m$ separation from each other. The barrier ribs were 150-$\mu m$ high. The panel was




(a)




(b)

**Figure 2. Luminance and efficiency of green phosphor test panel with respect to MgO thickness (a) Luminance and efficiency as a function of sustain voltage (b) Luminance degradation as a function of MgO thickness.**

filled with Ne-Xe(4%) mixture gas to a pressure of 400 torr, and divided in 3 part where upper part is without MgO, mid is MgO deposited ~80 Å, and lower is ~130 Å MgO.

Figure 2. shows the results of luminance and efficiency by changing MgO thickness on the phosphor. In this result, luminance degradation by depositing MgO on the phosphor is just ~ 5% in 80 Å MgO thickness. The difference of calculated and experimental results is guessed by two factors. One is an excessive difference between the size of phosphor particle(~10$\mu$m) and deposited MgO thickness(~100 Å), and the other is thinner deposition MgO on the side wall.

### *2.2 Improvement of discharge characteristics.*

From the above results, MgO thickness was determined to ~90 Å, and full color(Red, Green, Blue) test panel which is divided in 2 part (with MgO, without MgO) was used. We employed the ramp reset type driving scheme as shown in Fig. 3

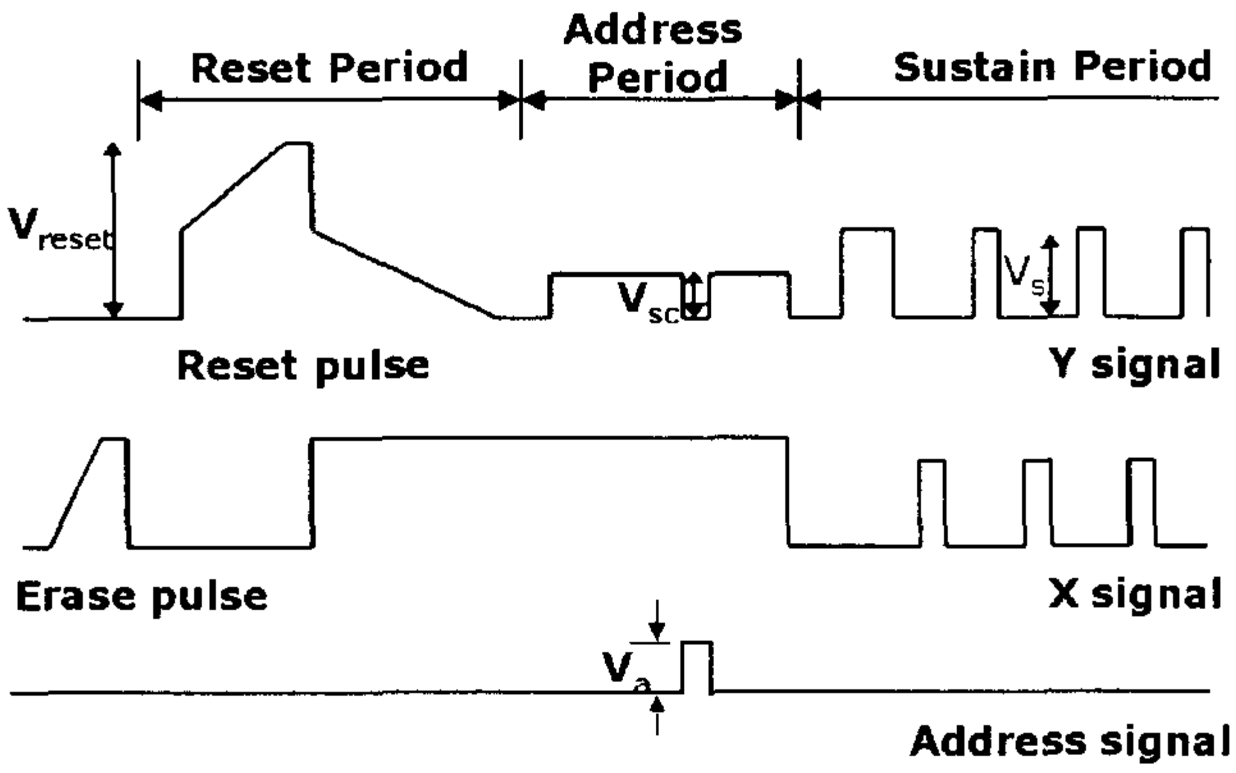



**Figure 3. Ramp reset type driving scheme used in experiments.**

and turned the cells on every 6 line in this experiment. For the proper driving of the test panel, reset voltage ($V_{reset}$) and scan voltage ($V_{sc}$) were set to the 310V and 45V respectively. According to sustain voltage, minimum and maximum values of addressing voltage were plotted in Fig. 4. The results show that the discharge characteristics is improved by depositing MgO on the phosphor. Minimum address voltage distribution of each phosphor was made to be uniform ($\Delta$Va_min:3~4V$\Rightarrow$1~1.5V), and address and sustain voltages are also lowered by depositing MgO on the phosphor. (Sustain voltage reduction : ~10V , Address voltage reduction : ~12V). From the results of Fig. 4, it was supposed that the MgO on the phosphor plays a role of high secondary electron emission cathode material during reset period. It enables more wall charge accumulation on the scan and address electrodes and results in lower address voltage.

Fig. 5 shows the measurement of IR emission from the each cell by the photo diode detector which works in the infra red range. From the IR emission of each cell, addressing current shape can be estimated. In the Fig. 5, we can see that MgO deposition on the phosphor enables uniform and high speed addressing irrespective of each phosphor. That means the MgO coated phosphor can provide much improved secondary electron emission characteristics during reset period, and enough wall charge for addressing discharge. Table 1. shows the experimental conditions and averaged (256 times) delay time $\Delta$t of each part.

Fig. 6 shows the cumulative distribution of peak time of addressing current by counting 200 times for each cell. The peak time distribution of IR emission became uniform for each part by depositing MgO on the phosphor.

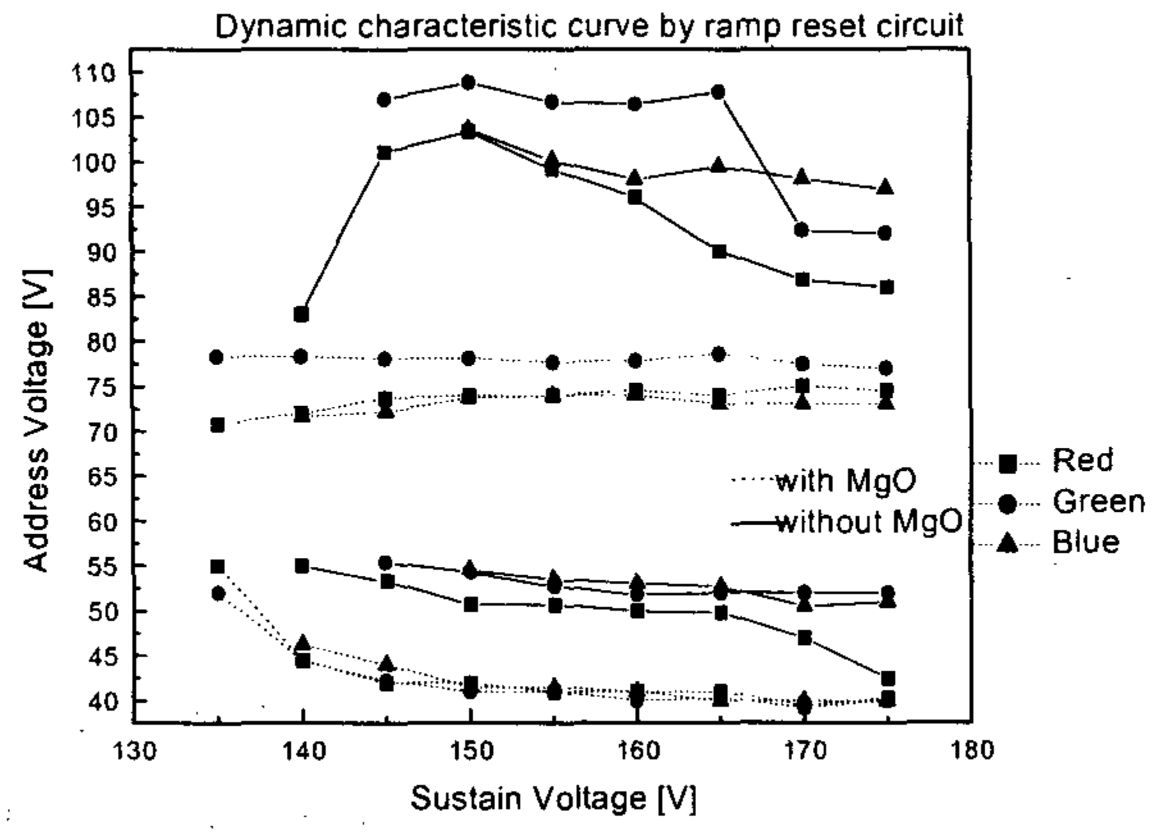



**Figure 4. Dynamic characteristic curve of each phosphor**

## *2.3 Improvement of lifetime.*

It is known that the erosion of transparent dielectric protection layer and degradation of phosphor performance are the main factors which affect the PDP lifetime. Up to now, for the protection layer of transparent dielectrics in the ac PDP, MgO is widely used as the predominant materials.

In the ac PDP, phosphor is exposed to the plasma directly and cohesive force of phosphor is very weak. Therefore, we adopted MgO as the phosphor protective layer against plasma [4].

Fig 7 shows the white luminance of test panel which is divided in 2 part (MgO deposited type, conventional type) as a function of time.

The test panel has been driven by ramp reset type driving method for 200 hours. At the beginning of aging experiment, the luminance of conventional type was 6.1% higher than those of the MgO deposited type as we expected. But after 16 hour aging, absolute luminance value of two type were exchanged, and after 200 hours, MgO deposited type showed 7% higher luminance than that of the conventional type.

**Table 1. Measurement conditions of IR emission & delay time of addressing current on MgO thin film. ($\Delta t$ : delay time, $\Delta_{max}$ : maximum deviation of delay time in each phosphor)**

| Experiment condition | $\Delta t$ | | | |
|---|---|---|---|---|
| | With MgO | | Without MgO | |
| $V_{reset}$: 330V<br>$V_s$ :160V<br>$V_a$ : 45V<br>$V_{sc}$ : 40V | Red | 1.32μs | Red | 1.78μs |
| | Green | 1.38μs | Green | 2.3μs |
| | Blue | 1.36μs | Blue | 1.88μs |
| | $\Delta_{max}$ | 0.06μs | $\Delta_{max}$ | 0.52μs |

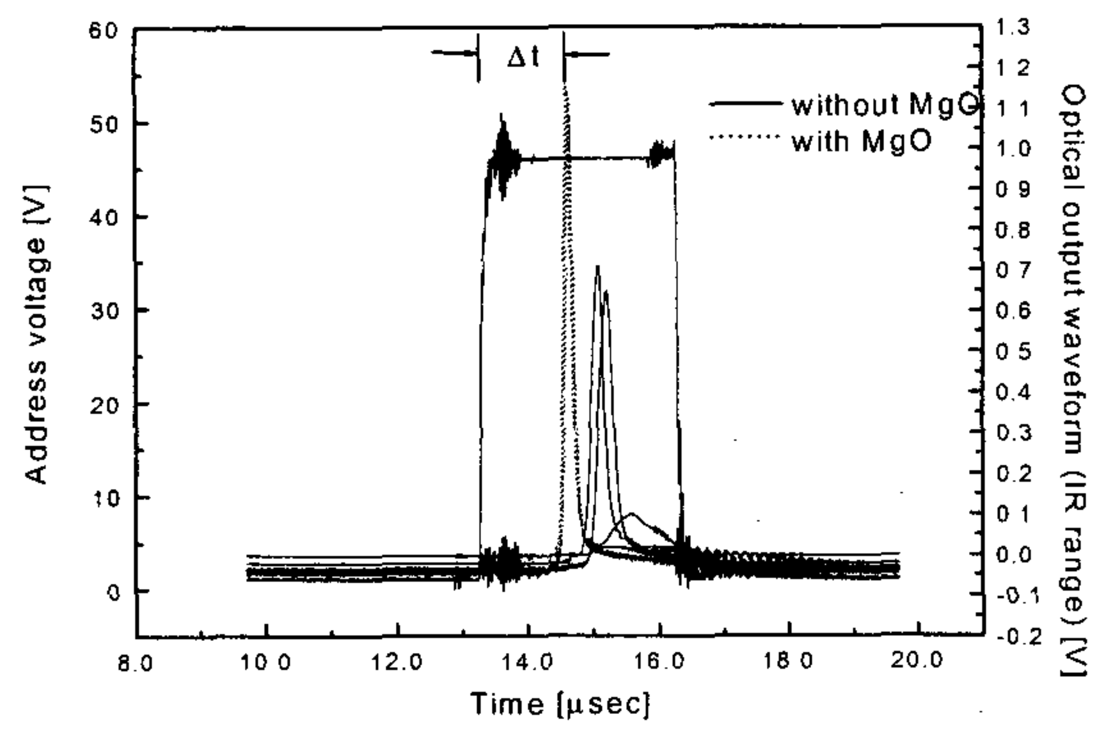



**Figure 5. IR emission of each phosphor at the time of addressing**

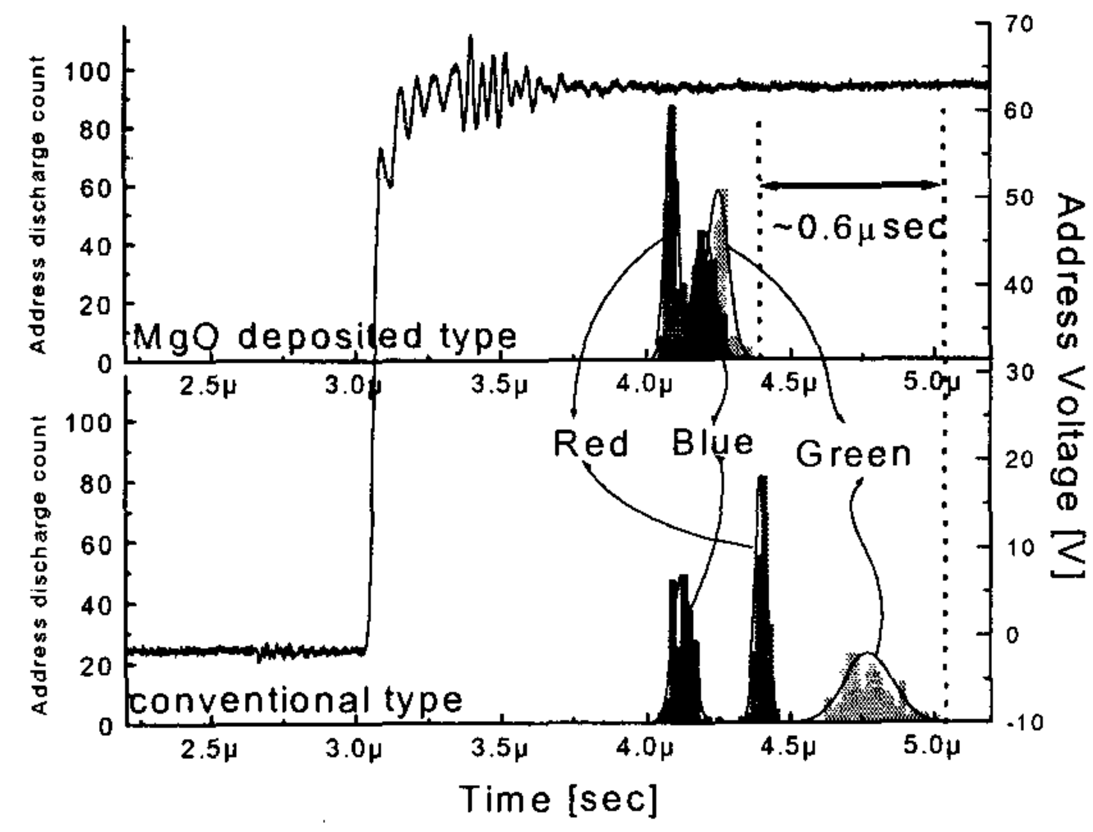



**Figure 6. Cumulative distributions of peak time of IR emission**

## 3. Conclusion.

We adopted the MgO thin film as a phosphor protective layer, which resulted in improved address discharge characteristics and lifetime in ac PDP.

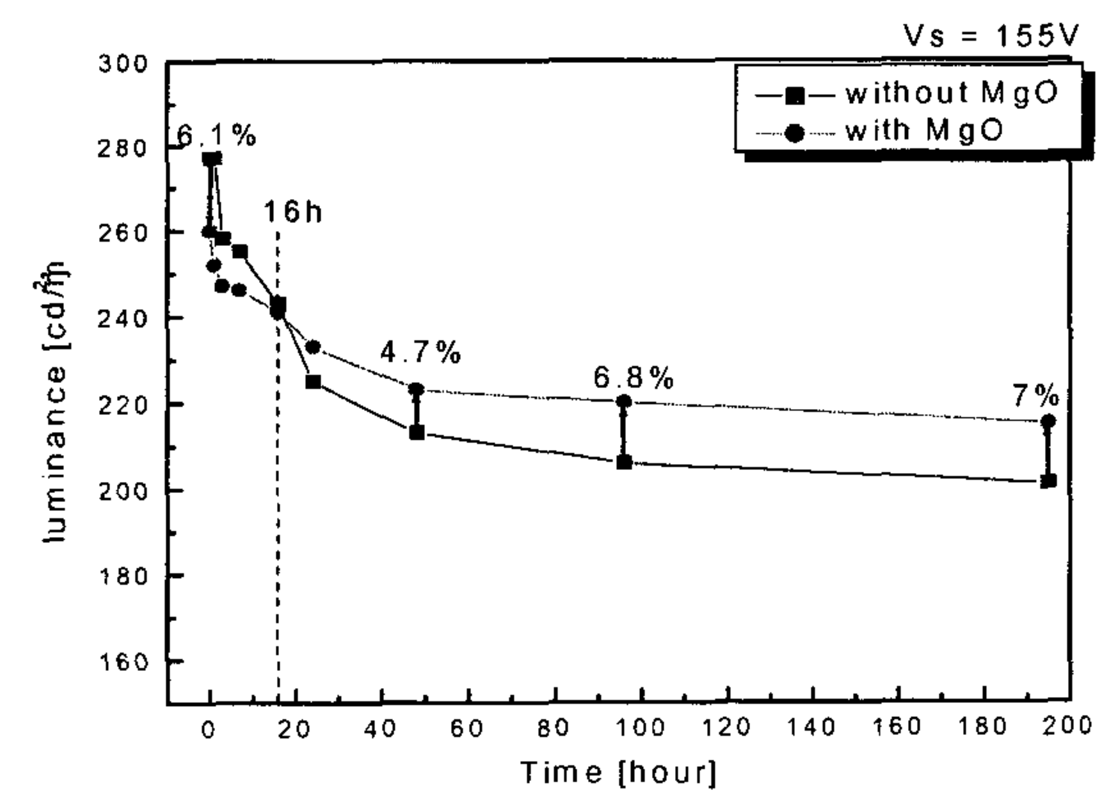



**Figure 7. Luminance curve of full color test panel by long-term aging experiment**

We optimized MgO thickness (~90Å) in which the initial luminance degradation is within 5%, and tested the dynamic characteristics of full color test panel driven by ramp reset scheme.
By depositing MgO on the phosphor, address discharge characteristics of each phosphor was made to be uniform and address and sustain voltages lowered and addressing speed became faster(~0.6 $\mu$s) than conventional type test panel.
The long term aging test showed that the luminance of MgO deposited type became 7% higher than conventional type after 200 hour aging in ac PDP.

## 4. References


[1]Y. Sano, T. Nakamura, K. Numomura, T. Konishi, M. Usui, A. Tanaka, T. Yoshida, H. Yamada, O. Oida, R. Fujimura 19.1 SID 98 DIGEST

[2] B. M. Song, J. K. Kim, M. S. Hwang, J. H. Yang, and K. W. Whang J. Vac. Sci. Technol. B 19(4), Jul/Aug 2001

[3] Byung Moo Song, Thesis of Master degree, (1999)

[4] M. Ushiroawa. 16.4 SID 00 DIGEST