A Study on the Accelerated Life-time Test method Of MgO thin film in the AC PDP

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Abstract
In this paper, an accelerated lifetime test method of MgO thin film is suggested. The most important test factors are surface temperature of the PDP, gas pressure, the applied voltage and frequency. The standard test conditions are 50 ℃, 400Torr, 20% over voltage and 300㎑ ,respectively. The accelerated lifetime of MgO is significantly varied with the MgO preparing conditions.

1. Introduction
The lifetime of ac PDP is correlated with the many factors as shown in Table1.

Generally speaking, the weakest point determines the lifetime of ac PDP. In order to improve the lifetime of ac PDP, the weak point should be strengthened. However, it is difficult to find out or improve the weak points, as the lifetime is too long to test experimentally.

In this paper an accelerated life-time test method of MgO thin film is suggested and the lifetime of MgO thin film by this method is tested as a parameter of deposition rate and the thickness of the MgO. The results are discussed, because the MgO thin film is generally known as the weakest point in ac PDP.

2. Accelerated lifetime test conditions.
The deterioration of MgO thin film comes from the sputtering phenomena by ion bombardment in discharge space. The sputtering rate R can be expressed as follows from the experimental results.

$$R = k\left(\frac{JT}{P}\right)^{\alpha} \bullet f \qquad (1)$$

Where, k: const
J: discharge current density
T: surface or ambient temperature
P: gas pressure
f: applied voltage frequency.

2.1 Surface temperature of the panel
As the surface temperature of ac PDP increases, the space charge particle and wall charge are activated and make self-erasing phenomena in the main discharge process as shown in Figure1.

Therefore, the rise of surface temperature must be suppressed not to make the self-erasing.

In lifetime test, the number of discharge cells are controlled in order not to increase the panel surface temperature above 50℃, which is ordinary panel temperature in real PDP.

2.2 The working gas pressure
The bombarding ion energy W is correlated with gas pressure as follows.

$$W = k\frac{qE}{P} \qquad (2)$$

Where, k: const q: ion charge
E: electric field P: gas pressure

From equation (2), bombarding ion energy increases with decrease in the pressure. In this test, the gas pressure is maintained at 400Torr in order to make almost the same glow plasma conditions with real panel.

2.3 The applied voltage and frequency
Figure 2 shows the discharge voltage as a parameter of panel temperature. At the pulse frequency of 50KHz, the discharge voltage is maintained almost constant values.

Figure 3 shows the relationships between the self-erasing voltage and panel temperature when the sustain frequency is 300KHz.

To accelerate the degradation of the panel, the voltage 20% higher than the firing voltage of the panel was applied during the test period.

The accelerating test point is shown in Fig3. The test point is 20V lower than the self-erasing region.

The accelerating frequency is determined by the limit of surface temperature on the panel.

3.Experimental

Table 2 shows the specification of the 4-inch model test panel.

The test panel is annealed at 300℃ for 2 hour before sealing process. The firing/sustain voltage of the panel is about 180V/140V.

The lifetime test is ended when the sustain voltage of the sample increases about 10%(According to our experimental results, the 10% increased point of sustain voltage agrees well with the point which the luminance of the panel decreases to the half of the original level).

Although the acceleration tests are done with acceleration test conditions, such as 210V with 300㎑ at 50℃ panel temperature, the luminance and sustain voltage are tested at normal condition, that is 160V with 50㎑ at room temperature.

4. Experimental Result and Discussion

Figure 4 and 5 show the change of firing and sustain voltage during the test period. The thickness of the MgO layer is 2000Å and 8000Å respectively.

In case of the panel having 2000 Å MgO layer, the mean voltage of V_f and V_s reached 174 V after 25 hours sustain discharge. The luminance at this point was 377 cd/m^2. This value corresponds to the 50% of the luminance of the fresh panel. If we define the lifetime of the panel as the time when the luminance decreases to half of the original value, it can be said that the lifetime of this sample is 25 hours under the condition of accelerated lifetime test.

In case of the sample having 8000Å MgO layer, it takes 92hours to lose 50% of its original luminance.

Figure 6 and 7 show degradation characteristics for of the panels, which have the same MgO thickness of 5000Å but different deposition rate. The deposition rate is 625 Å/min (sample A) and 208 Å/min (sample B) respectively.

The measured lifetimes of sample A and B are 67 and 85 hours under the condition of accelerated lifetime test respectively.

The reason why discharge voltage rises during lifetime test is the MgO degradation by sputtering that takes place with bombardment of positive ions in discharge plasma and the effect of impurities that appear by discharge in the panel.

Impurities are generated by the residual contamination in cells during exhaust process, the very small amount of impurity in working-gas, the impurities from rib and frit glass and heated phosphor or MgO thin film.

Especially, a small amount of impurity can be incorporated in MgO film during the deposition process.

These impurities can be released in the form of H_2, CO or CO_2. For example, CO is electro-negative. These gases capture an electron during the discharge process. Thus, the discharge voltage increases. It is well known that the aging process emits the impurity gas on MgO surface. It has a remarkable effect from surface to 100Å of MgO. But, small quantity of impurity still remains in deeper part than 100Å of MgO. These impurities are exposed the discharge space by MgO erosion, and that is why discharge voltage rises.

It is speculated that crystalline quality of the MgO film becomes better as they grow up and the property of sputter-resistance may be improved. Therefore, the decrease of luminance is likely to reduce. So high luminance can be sustained for a long time.

If deposition rate of MgO is increased by E-beam power, a lot of evaporated MgO particle are accumulated in a short time. Then, MgO film has a sparse combination and an adhesive power of MgO film gets worse. So, it doesn't get hard. On the contrary, when deposition rate of MgO is decreased, MgO film will be in dense combination, an adhesive power of the film will get better and an occurrence rate of MgO cluster will decrease. Therefore, the lifetime of MgO will be improved.

5. Conclusion

In this study, an accelerated lifetime test method of MgO thin film is suggested. The standard test conditions are 50℃, 400Torr, 20% over voltage and 300㎑. The relationships between e-beam MgO manufacturing conditions and the ac PDP lifetime are also investigated. The results may be summarized as follows.

The lifetime of MgO 2000Å and 8000Å was 25hour and 92hours under the condition of accelerated lifetime test respectively.

The lifetime of MgO about deposition rate of 5000Å/8min(sample A) and 5000Å/24min(sample B)

was 67hours and 85hours under the condition of accelerated lifetime test respectively.

6. References

[1] Chung-Hoo Park, Young-Kee Kim, Sung-Hyun Lee, Woo-Geun Lee, Youl-Moon Sung, " Surface-discharge characteristics of MgO-thin films prepared by reactive RF unbalanced magnetron sputtering", Thin Solid Films, vol.366, pp.88-94, March. 2000.

[2] Chung-Hoo Park et al, "Effect of MgO annealing process in a vacuum on the Discharge Characteristics of AC PDP", *Material Science & Technology*, Vol, B60, pp149-155 1999.2

[3] Chung-Hoo Park, Young-Kee Kim, Sung-Hyun Lee, Woo-Geun Lee, Youl-Moon Sung, " Surface-discharge characteristics of MgO-thin films prepared by reactive RF unbalanced magnetron sputtering", Thin Solid Films, vol.366, pp.88-94, March. 2000.

[4] Chung-Hoo Park et al, "Effect of MgO annealing process in a vacuum on the Discharge Characteristics of AC PDP", *Material Science & Technology*, Vol, B60, pp149-155 1999.2

[5] T. Urade, et al, " A Protecting Layer for the Dielectric in AC Plasma Panels", IEEE Transactions on Electron Devices, March, 1976

[6] Chung-Hoo Park et al, "A Study on the New Type Sustaining Electrode Showing High Luminous Efficiency in AC PDPs" *IEEE Transactions on Electron Devices*, vol. 48, no.10, pp2255-2259, 2001

[7] Chung-Hoo Park, Sung-Hyun Lee, Dong-Hyun Kim, Woo-Geun Lee and Jeong-Eun Heo "Improvement of Addressing Time and its Dispersion in AC Plasma Display Panel", IEEE Transactions on Electron Devices, vol.48, no.10, 2001

[8] Chung-Hoo Park, Dong-Hyun Kim, Sung-Hyun Lee, Jae-Hwa Ryu, Jung-Soo Cho, "A New Method to Reduce Addressing Time in a large AC Plasma Display Panel", IEEE Transactions on Electron Devices, vol.48, no.6, pp.1082-1086, 2001

[9] Aboelfotoh and Sahni, "Aging Characteristics of AC Plasma Panels", Proceedings of the SID, vol.22, pp.219-227, April, 1981

[10] S. Choi, et al, "Application of optical method for quantitative investigation of MgO erosion in a.c. plasma display panels", Thin Solid Films, vol.384, pp.115-119, 2001

Table1. Factors of the lifetime

Factor	Parameter
MgO	1) deposition process (E-Beam, Sputtering, Ion Plating)
	2) the optimum thickness
	3) surface morphology, density, orientation
	4) development of substitute material
	5) anti-sputtering
Working-gas	1) gas species
	2) gas pressure
	3) impurity gas in the manufaturing and discharge process
Dielectric	1) breakdown of void
	2) scattering of impurity gas
Phosphor	1) deterioration by heating process and discharge plasma
	2) deterioration by plasma sputtering
	3) deterioration by MgO scattering
	4) paste development of phosohor scattering prevention
Rib height	1) deterioration of phosphor by plasma
	2) deterioration by badness of discharge formation

Table 2. Specification of test panel

Working-gas: He+Ne (30%)+Xe (4%) 400 Torr			
Front glass		Back glass	
Thickness of dielectric layer	30㎛	Width of address electrode	100㎛
Width of electrode	310㎛	Thickness of white back	20㎛
Electrode gap	60㎛	Height of rib	130㎛
		Pitch of rib	360㎛
		Width of rib	60㎛

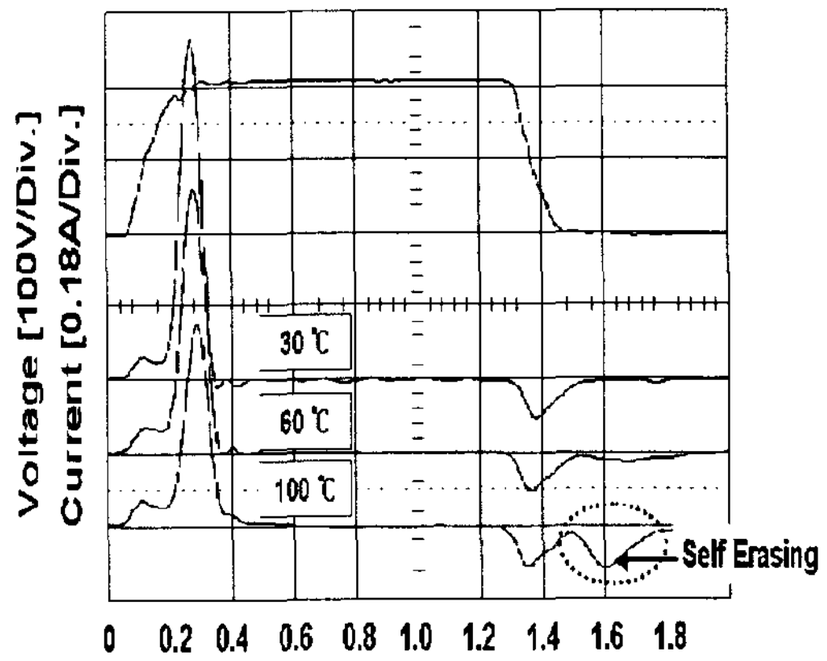

Fig.1 The current waveform as a parameter of each ambient temperature.

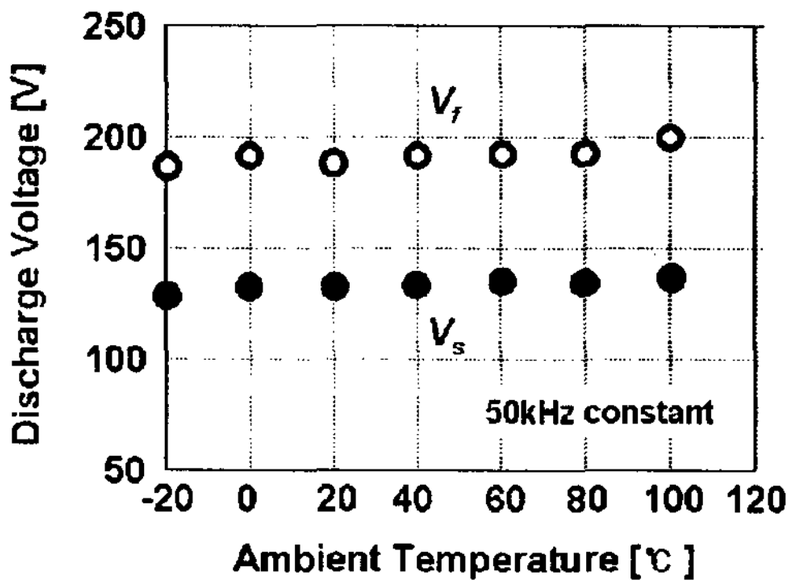

Fig.2 The characteristic of discharge voltage as a parameter of an ambient temperature at 50kHz.

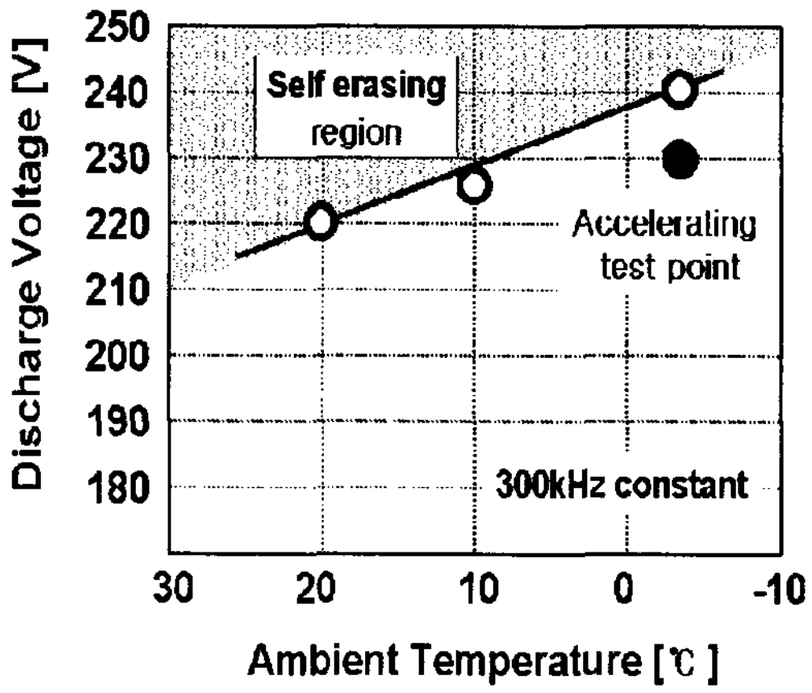

Fig.3 The self-erasing region at 300kHz and the operating temperature (V_f ; 235V Vs ; 165V at 50kHz, working-gas ; He+Ne(30%)+Xe(4%), VGA class)

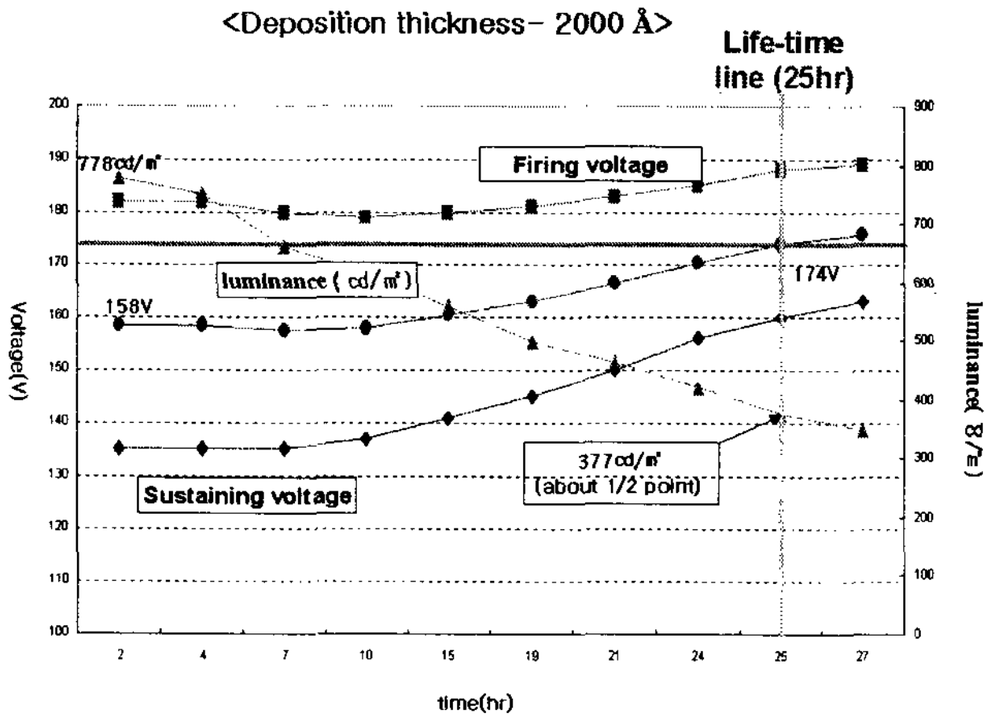

Fig.4 Discharge voltage characteristics and luminance after accelerated life test for MgO thickness of 2000Å.

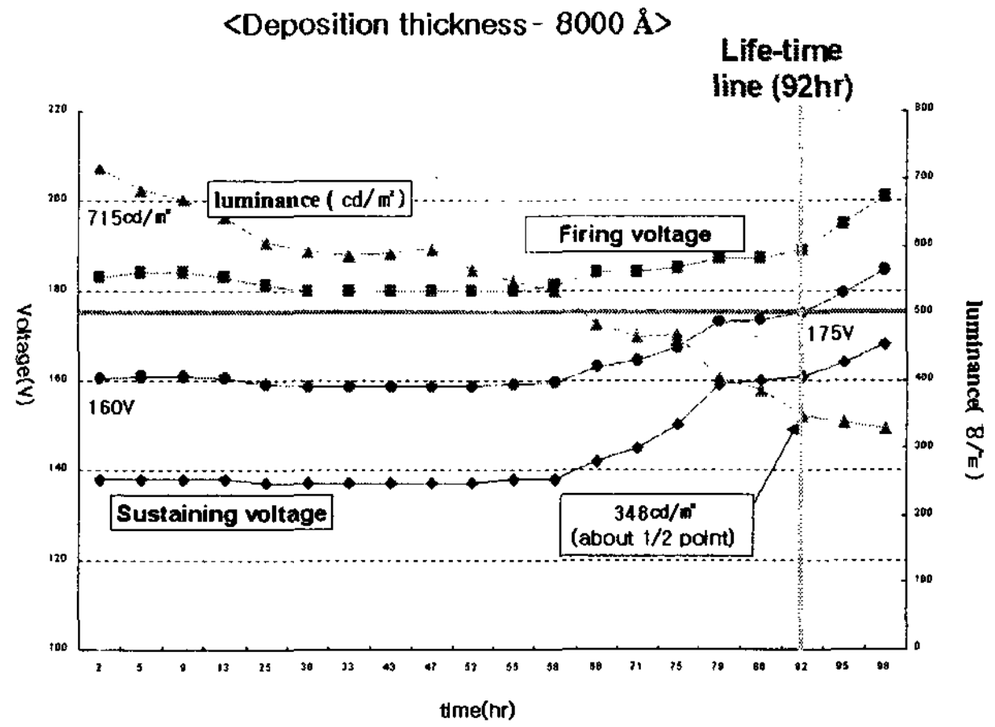

Fig.5 Discharge voltage characteristics and luminance after accelerated life test for MgO thickness of 8000Å.

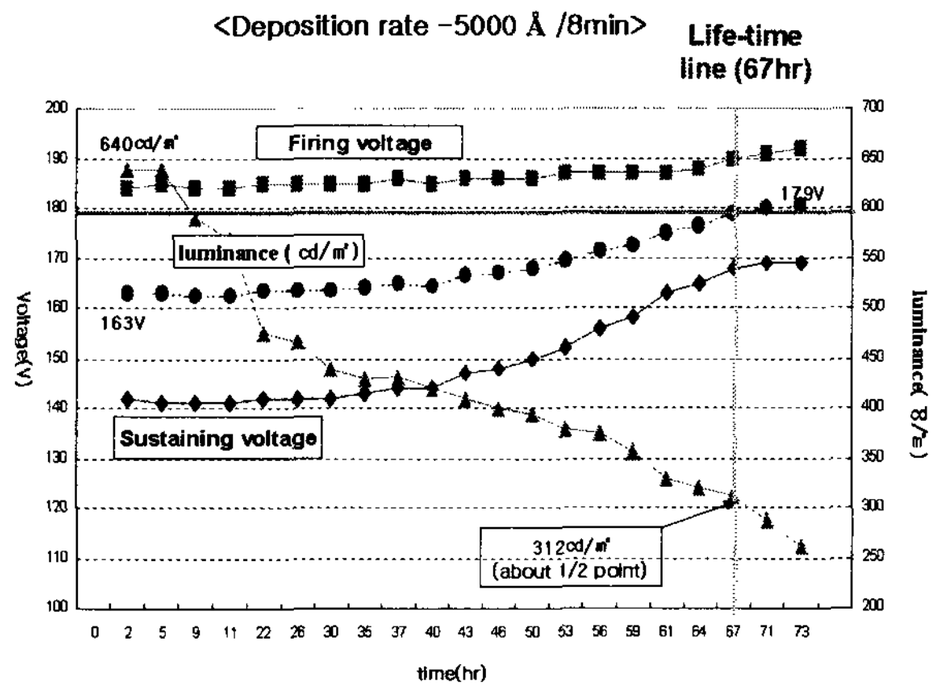

Fig.6 Discharge voltage characteristics and luminance after accelerated life test for the deposition rate of MgO 5000Å/8min.

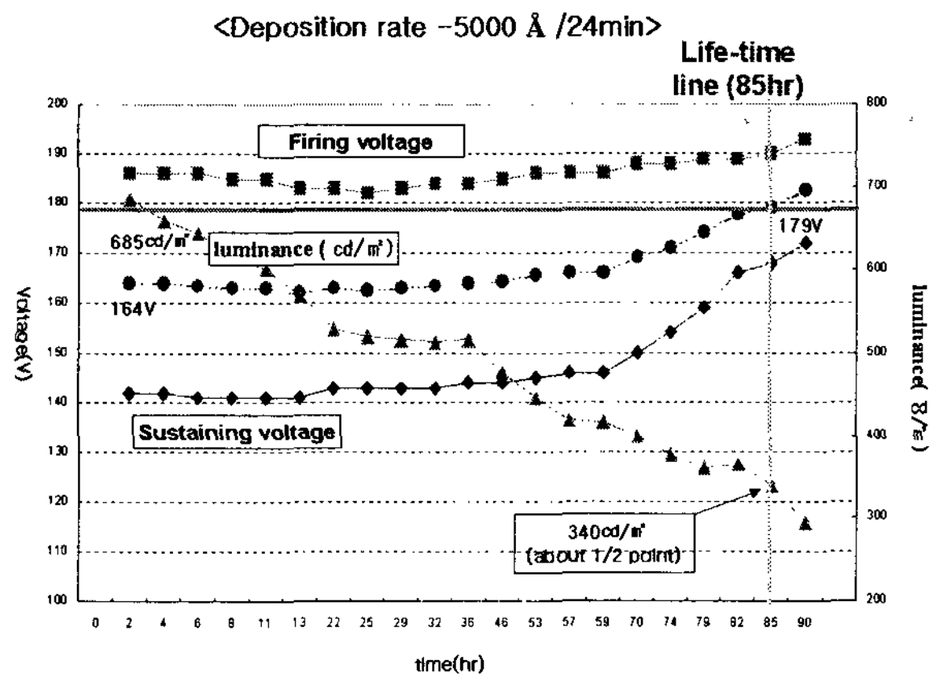

Fig.7 Discharge voltage characteristics and luminance after accelerated life test for the deposition rate of MgO 5000Å/24min.