# The Aging-time change by the plasma-treatment of MgO film in AC-Plasma Display Panels

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## Abstract

*We applied the Atmospheric Pressure Plasma (AP-plasma ) to the MgO film to try to control the Aging-time on the PDP production-line. The MgO film surface and the discharge characteristics of AC-PDPs were investigated, using the plasma-treated MgO film. The Aging-time change can be achieved by treating the MgO film with plasma. This method can be adapted to the mass production-line.*

## 1. Introduction

In AC Plasma Display Panel (PDP) manufacturing, the aging process is necessary to obtain a stable discharge characteristics and it is one of the most time-consuming processes.

It is a well-known phenomenon that as the aging process continues, the roughness of the MgO film surface gets smoother. The roughness change is accompanied by a variation in the work function of the MgO film surface. This means that the roughness of MgO film is related to the secondary electron emission coefficient ( γ -coefficient )[1]. The larger the γ -coefficient , the lower the firing voltage in AC-PDP.

Several papers have reported on the annealing effects of the MgO film in a vacuum chamber[2,3,4]. However, it is not practical for the PDP production-line, because the annealing process is done in a vacuum chamber. Moreover, for performing the annealing process, thermal expansion coefficient of the MgO film and the Dielectric layer on the Front panel should be considered.

In this paper, we report an efficient method of controlling the Aging-time. We applied the AP-plasma to the MgO film for surface modification. The AP-plasma can be adaped to the mass production due to its simple in-line installation.

## 2. Experiments

The front and rear panels were manufactured by a conventional PDP manufacturing process. The front panel glass plate had a length of 199mm, a width of 119mm, and a thickness of 2.8mm. Electrodes were made by a photo-lithography method. Dielectric layers were formed by Lamination. A MgO film was deposited on the dielectric layer by E-beam evaporation. The thickness of that film was about 8000Å. After that , the MgO film was treated with the AP-plasma.

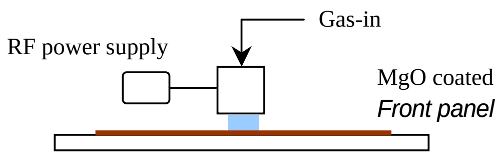



Fig.1 Schematic diagram of AP-plasma treatment

The surface roughness and the chemical state of the plasma-treated MgO film were investigated by AFM, SEM and XPS, respectively.

The discharge inception voltage( $V_{first\_on}$ , $V_{last\_on}$ ) and discharge sustain voltage( $V_{first\_off}$ , $V_{last\_off}$ ) were measured as a parameter of the roughness of the MgO film surface.

$V_{first\_on}$ defined the voltage when the first discharge cell turned ON. The applied voltage increased further until all cells were ON, was called $V_{last\_on}$. At this point, the applied voltage decreased until the first cell turned OFF. This was the $V_{first\_off}$ of the panel. The voltage when all cells turned OFF, was denoted as $V_{last\_off}$ .

## 3. Results and discussion

### 3.1. MgO film surface variation and the firing voltage change during the aging process

The change of MgO film surface after the aging process is shown in Fig.2. Table 1 shows the differences of discharge voltages with respect to the Aging-time. The difference between firing voltages ( $V_{last\_on}$ ) were getting larger as the Aging-time increased to 12 hrs.

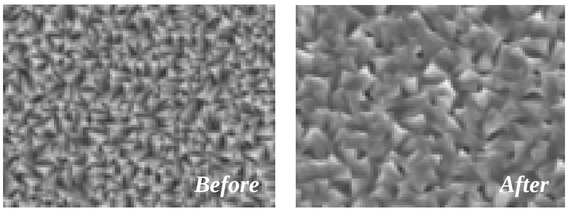



Fig.2 The roughness change of MgO film surface before / After the aging process (SEM image)

Fig.2 shows that the aging process made the MgO film surface smoother, and this roughness variation of the MgO film surface had an effect on changing the firing voltage of AC-PDP.

Table 1. The discharge voltage change with respect to the Aging time

| Aging time | 4 hrs | 8 hrs | 12 hrs |
|---|---|---|---|
| $\Delta V_{last\_on}$ | 12V | 21V | 25V |

The electrical properties of the reference and test panels gave us a possible relationship between the Aging-time variation and the roughness of the MgO film surface.

It may be noted inversely that, if we control the roughness of MgO film surface, it may be possible to change the Aging-time as well as the firing voltage.

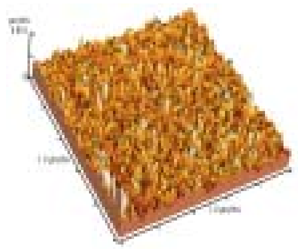
### 3.2. The roughness change of MgO film surface by Plasma treatment

In order to change the roughness of the MgO film surface, the AP-plasma treatment was conducted on that surface. The variables for plasma treatment are summarized in Table 2. The power, gas, and substrate temperature were fixed. The heating time and the plasma treatment time were set as two variables. Fig.3 shows the modified MgO film surface according to these two variables.

Table 2. Variables and conditions of AP-plasma treatment

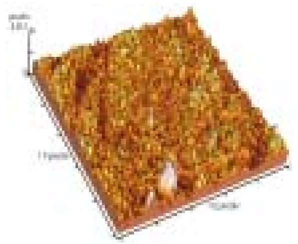
| Variables | Condition |
|---|---|
| Power | 300W |
| Gas | He (15 ℓ) + $O_2$ (15cc) |
| *Substrate temperature* | *170   180 ℃* |
| *Heating time (Ht)* | *0 , 10min , 60min , 80min* |
| *Plasma treatment time (Pt)* | *0 , 10min* |

The longer the heating and the plasma treatment time were, the smoother the roughness of the MgO film surface became.



(a) Rp-v = 32.36 , Rq=2.967 at Ht=0 min , Pt=0 min

(b) Rp-v = 31.68 , Rq=2.346 at Ht=10 min , Pt=10 min



(c) Rp-v = 24.22 , Rq=1.748 at Ht=60 min , Pt=10 min

(d) Rp-v = 11.42 , Rq=1.131 at Ht=80 min , Pt=10 min

Fig.3 AFM images of the MgO film surface as a function of the heating time and the plasma treatment time

We investigated the impurity gases - mainly $H_2O$ - on the MgO film surface by XPS. Many papers have reported that the impurity gases inside the AC-PDP made the firing voltage increase[5,6,7] .

The adsorption ratio variation of impurity gas between intact and the plasma-treated MgO film surface is shown in Fig 4.

The 20% larger portion of the impurity gas at 0 hr was detected on the intact MgO film surface, compare with the plasma-treated one. It increased to 30% after 24 hr-exposure to the atmosphere. This result indicated that the plasma treated MgO film turned less hydrophilic, so we can expect a lowered firing voltage.

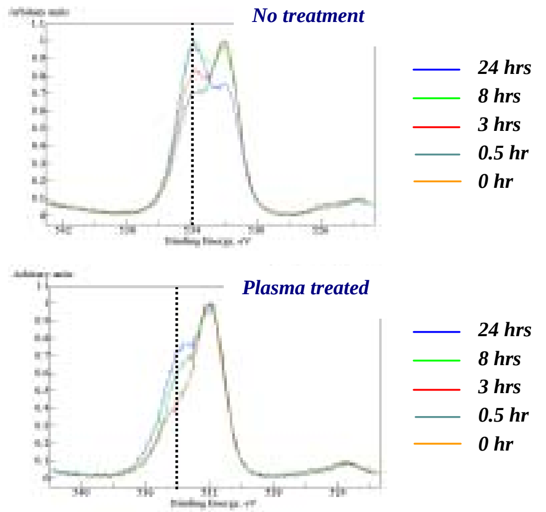



Fig.4 XPS spectra of $OH^-$

The adsorption ratio change of the MgO film surface with and without plasma treatment

### 3.3 Electrical characteristics of the plasma treated Front panel

To confirm the effect of the MgO roughness change to the firing voltage, we made 7.5-inch MgO coated Front panel and treated with AP-plasma, then assembled the Front and Rear panel.

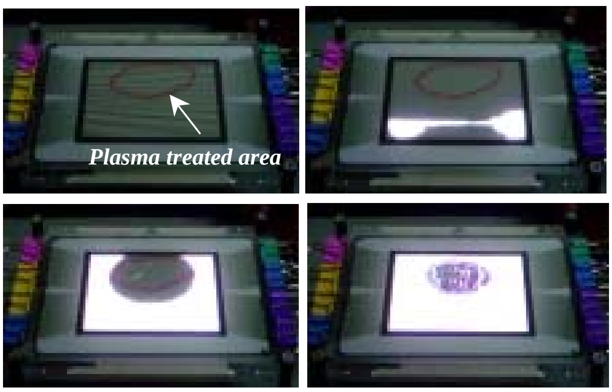



Fig.5 Firing voltage difference between plasma treated area and intact area

We checked the discharge characteristics of this panel while increasing the sustain voltage. The difference of firing voltage ( $\Delta V_{last\_on}$ ) was 50V between the plasma-treated and untreated area. This experiment depicted that the firing voltage is largely dependent on the roughness of the MgO film surface.

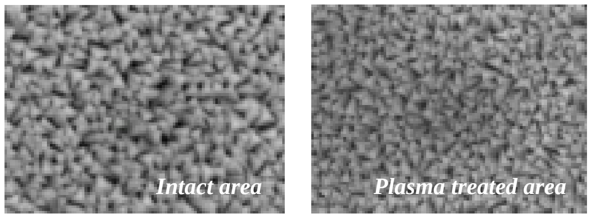



Fig.6 Comparison intact MgO film surface with the plasma treated area ( SEM image )

## 4. Conclusion

As the aging process continues, the roughness of the MgO film surface gets smoother. That increases the secondary electron coefficient, which results in lowering the firing voltage.

In this paper, we confirmed the roughness of the MgO film surface had a great influence upon the electrical properties in AC-PDP. Moreover, we obtained positive results of removing impurity gas adsorbed on the MgO film surface as well as changing the MgO film surface property to less hydrophilic.

These results imply that controlling the roughness of MgO film surface controls not only the Aging-time but also the firing voltage in AC-PDP.

The AP-plasma is a good method to control the Aging-time. The removal of the impurity gas on the MgO film surface is a positive side effect, it can be useful to decrease the firing voltage of AC-PDP.

## 5. Acknowledgement

The author would like to thank the PSM staff for contributions to this work.

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