

In-situ Characterization of MgO Surface with Discharge Aging at Elevated Temperatures of AC-Plasma Display Panels

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The effect of aging temperature on discharge characteristics of the MgO film of alternating current-plasma display panels (AC-PDPs) has been investigated from the point of view of surface contamination on the MgO protective layer. AC-PDP front panel samples were tested with Ne-Xe (4%) gas discharge after aging at elevated substrate temperatures. Real time analysis of the plasma composition near the MgO surface was performed by optical emission spectroscopy (OES) in the aging chamber. In-situ characterization of X-ray photoelectron spectroscopy (XPS) and discharge characteristics revealed that aging temperature at 100 °C gave the best result for discharge condition which can be achieved by controlling the MgO surface with less content of C and H for the reduction of the sustain voltage V_s and less residue of Xe for the reduction of the firing voltage V_f .

1. Introduction

Plasma display panel (PDP) is one of the leading and promising flat panel displays in the information display industry. The main advantage of the PDP over other display devices is that it can provide high information contents and full color images at large sizes that are no thicker than 4 inches. However, power consumption and cost must be reduced in order to survive in the market.

In alternating current plasma display panels (AC-PDPs), magnesium oxide (MgO) film is widely used as a transparent protective layer [1,2]. A schematic diagram of the front panel of an AC-PDP is shown in Fig. 1. The MgO protective layer plays an important role in preventing the dielectric layer from sputtering by ions. Moreover, MgO film has a high secondary electron emission yield γ which reduces the firing voltage V_f for discharge [3-5]. Another important factor to improve the discharge characteristics of AC-PDP is the ability to accumulate the wall charge at the MgO surface. High electric resistance of the MgO film reduces the sustain voltage V_s which is the minimum voltage to maintain the discharge. Therefore, the discharge characteristics of the

AC-PDP are critically dependent on the physical and chemical properties of MgO surface such as surface orientation, morphology, defects, and impurities [6-8]. The hydroxyl groups or surface impurities adsorbed on MgO surface may deteriorate the surface discharge characteristics, which result in surface discharge instability.

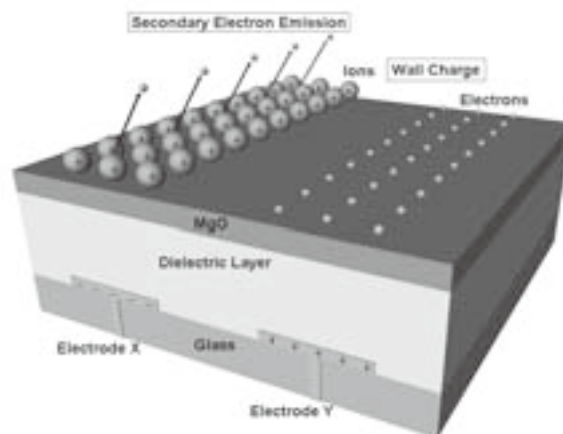


Figure 1. Schematic diagram of the front panel of an AC-PDP showing secondary electron emission and wall charge accumulation at the MgO surface during discharge.

In order to obtain uniform discharge and ensure stable operation of AC-PDP, process like discharge aging is usually performed. In this work the effect of aging temperature on discharge characteristics has been investigated in conjunction with surface contamination characterized in-situ by X-ray photoelectron spectroscopy (XPS)

2. Experiment

Silver electrodes were formed on the glass of the front panel using film technology and photolithography. Then, electric condenser was coated in printing type. After forming sealing material, 500 nm thick MgO film with (111) orientation was deposited by electron-beam evaporation technique on the dielectric layer. The prepared samples were subjected to thermal annealing in an aging chamber for 30 min at a temperature of 350 °C in order to activate the MgO surface. A photograph of the in-situ characterization apparatus with the aging chamber is shown in Fig. 2. The base pressure of the aging chamber was 5×10^{-7} Torr.

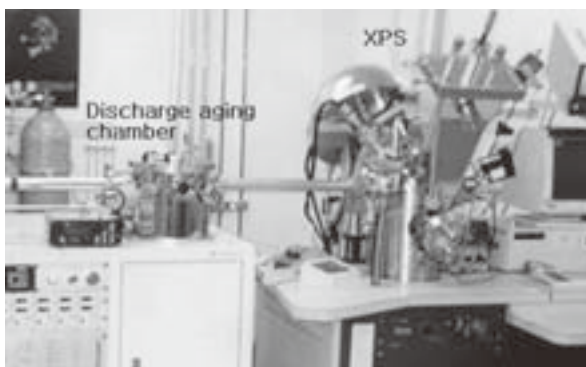


Figure 2. Photograph of the in-situ characterization apparatus with XPS and discharge aging chamber.

After annealing the main process of discharge aging for 6 hours was performed at the temperatures of 25 °C, 100 °C, and 150 °C. The aging chamber was filled with Ne-Xe (4%) gas at a pressure of 400 Torr. The discharge voltage of the gas mixture was maintained at 210 V. The composition of the plasma near the MgO surface was monitored by optical emission spectroscopy (OES) during discharge. Fig. 3 shows OES scan spectra at room temperature for Ne, C, CO, and H during discharge for 6 hours which is 21600 seconds. Ne sharply increases in intensity at the beginning and decreases slowly to a steady state value with some fluctuations. The intensity

of C, CO, and H, however, increases to a great extent at the beginning but slows down to increase after 30 minutes. It means that the surface of MgO protective layer is steadily exposed to impurities like C, CO, and H during discharge aging. After aging the discharge characteristics of each samples were studied by measuring the firing voltage V_f and the sustain voltage V_s .

In order to investigate the elemental composition on the MgO surface immediately after discharge aging, XPS experiments were carried out in an ultra high vacuum chamber which was connected to the aging chamber as shown in Fig. 2. The sample was transferred directly into XPS analysis chamber using a magnetic load-lock system in order to prevent the incorporation of atmospheric impurities.

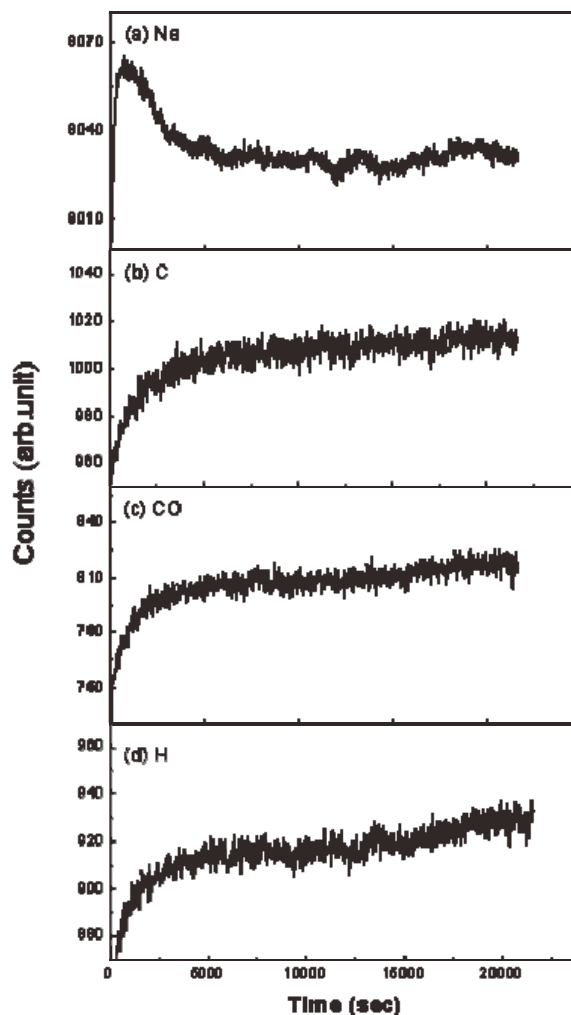


Figure 3. OES scan spectra during discharge aging at the temperature of 25 °C: (a) Ne (585.16 nm), (b) C (723.58 nm), (c) CO (560.76 nm), and (d) H (655.70 nm).

3. Results and Discussion

The measured firing voltages V_f and the sustain voltages V_s at the aging temperature of 25 °C, 100 °C, and 150 °C are plotted in Fig. 4 with the calculated value of memory coefficient (MC). The value of MC is determined by using the following equation [9]:

$$MC = 2 \times (V_f - V_s) / V_f \quad (1)$$

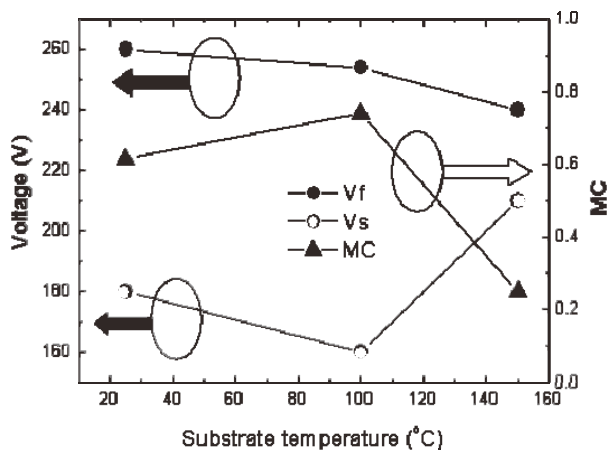


Figure 4. V_f , V_s , and MC of MgO films as a function of aging temperatures of the substrate.

The firing voltage V_f at room temperature is 260 V whereas the sustain voltage V_s is 180 V which results to the memory coefficient value of 0.62. These are typical values for discharge characteristics with 4% Xe content. After discharge aging at 100 °C both values of V_f and V_s are reduced compared to the values at room temperature. The value of MC, however, is increased which indicates that the amount of reduction of V_s is bigger than that of V_f . Greater value of MC means higher probability of stable operation of PDP. Thus, discharge aging at 100 °C substrate temperature gives better results of discharge characteristics than that at room temperature. The value of MC, however, drops sharply down at 150 °C substrate temperature. This poor memory margin comes from the sharp increase in sustain voltage V_s and a certain decrease in firing voltage V_f . The results of the discharge characteristics reveal that aging temperature of 100 °C is preferable over other aging temperatures of 25 °C and 150 °C.

In order to understand the tendency of discharge characteristics at various aging temperatures the variation of

the compositional elements at the MgO surface must be studied. The XPS wide scan spectra with increasing substrate temperatures of 25 °C, 100 °C, and 150 °C are shown in Fig. 5. Expected elements like Mg, O, and C can be seen in all three spectra. Xe 3d peaks around 675 eV are observed at the spectrum of 25 °C aging temperature while no visible Xe 3d peaks are observed at 100 °C and 150 °C. There is no evidence for Ne even in the spectrum of 25 °C aging temperature which was the major component of the gas mixture for discharge.

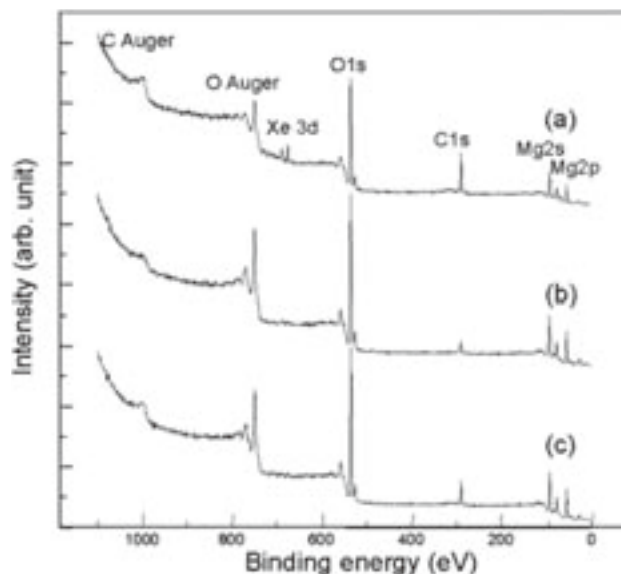


Figure 5. XPS wide scan spectra of MgO films at three different aging temperatures: (a) 25 °C, (b) 100 °C, and (c) 150 °C.

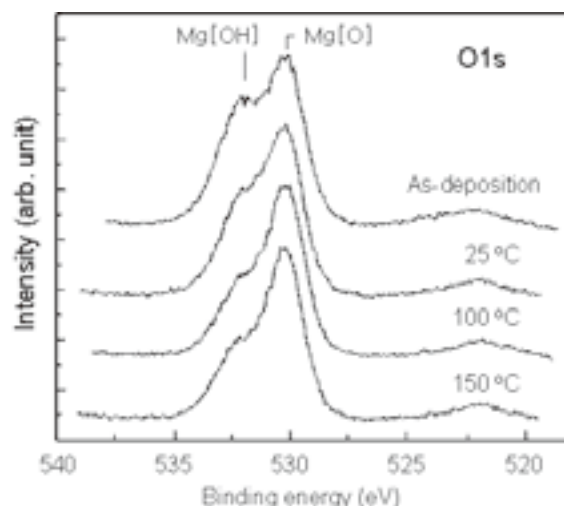


Figure 6. XPS O1s narrow scan spectra of MgO films at three different aging temperatures of 25 °C, 100 °C, and 150 °C compared with the pre-aging sample (as-deposition).

The peak intensity of C 1s is reduced when the aging temperature of the sample is increased from 25 °C to 100 °C. At 150 °C aging temperature, however, the peak intensity of C 1s is increased to some extent. This kind of tendency is similar to that of the measured value of the sustain voltage V_s in Fig. 4.

Figure 6 shows XPS O 1s narrow scan spectra with increasing substrate temperatures of 25 °C, 100 °C, and 150 °C compared with the pre-aging sample (as-deposition). The intensity of the hydroxyl groups marked as Mg[OH] in Fig. 6 decreases significantly at 25 °C compared with the pre-aging sample and reaches the minimum value at 100 °C. At 150 °C, however, the intensity of the hydroxyl groups seems to increase again. This kind of intensity variation is similar to that of C 1s peak intensity in Fig. 5. In Fig. 4 we observed that the sustain voltage V_s has the smallest value at 100 °C aging temperature. The peak intensities of C 1s and Mg[OH] also showed minimum values at 100 °C aging temperature. We can infer from the above observation that surface impurities like C and H can affect the surface conductivity of the MgO film. More C and H on the surface will enhance the conductivity of the surface and hence reduce the ability of charge accumulation that means less wall charge with the consequence of higher sustain voltage V_s . For lower sustain voltage V_s we need to control the MgO surface in the other direction, namely less C and H.

The process of secondary electron emission at the MgO surface can be explained by the theory of Auger neutralization [10,11]. Ne ion with greater ionization energy than Xe ion has greater value of the secondary electron emission yield γ . The γ value increases with the presence of defect states in the band gap of MgO film [12,13]. More defect states can increase the yield of secondary electron emission and therefore can reduce the firing voltage V_f for discharge. So, we can explain the reduction of V_f from 100 °C aging temperature to 150 °C with the incorporation of C and H on the MgO surface as defects. The reason for the increase of V_f at 25 °C compared with that at 100 °C may be the existence of Xe atoms on the MgO surface as an embedded residue which can influence the Auger neutralization process.

4. Conclusion

We have investigated the effect of aging temperature

on discharge characteristics of AC-PDP from the point of view of the surface contamination on the MgO protective layer. In-situ characterization of XPS has been performed after each aging process at elevated substrate temperature. Aging temperature at 100 °C revealed the best result for discharge characteristics. In order to get the optimum operation of PDP and the condition for discharge aging we need to control the MgO surface with less content of C and H for the reduction of the sustain voltage V_s and less residue of Xe for the reduction of the firing voltage V_f .

5. Acknowledgement

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6. References

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