Analysis on the Aging Process of ac-Plasma Display Panel

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Abstract

AC-plasma display panels were examined before and after the aging process to analyze the effect of the aging process. The gas analysis was done to detect the impurity gases out of the MgO film and phosphor by a residual gas analyzer. There were no differences found in the components. The MgO film was analyzed to find out the effect of an ion bombardment due to discharge. The surface roughness of the MgO film was different from regional groups due to the different degree of ion bombardments. XPS analysis showed that the 8 hour aging process was not sufficient to remove $Mg(OH)_2$ and $MgCO_3$ existed on the MgO surface. Photoluminescence measurement showed the small deterioration of blue and green phosphor.

1. Introduction

The aging process in the AC-plasma display panel (PDP) fabrication is considered to be important because the panel properties are greatly improved.

The aging process is generally carried out for 10 hours by applying voltages between the sustain electrodes of a front plate. By applying the aging process, non-uniformities of luminance or color coordinates are reduced and the firing voltage decreases greatly. There have been many studies to show the effect of the aging process on the panel operations. They discuss about the importance of the surface roughness [1], carbon and water contaminations [2], and cathodoluminescence spectra of the MgO film [3].

Although the aging process is important in the PDP fabrication process, the effect on the panel properties is little known to the public. If we can find out more about the aging process, the panel properties and the aging process can be improved further.

In this study, the aging process was examined with an 42 inch PDP fabricated in the mass production line. The study was carried out for the gas, the MgO film, and phosphors with various methods because they were directly exposed to the discharge.

2. Experiments

AC-plasma display panels of 42 inch size fabricated in the mass production line were used. The panels received the aging process of 0, 2, 4, and 8 hours, respectively. The experiment was made on the gas, the MgO film, and phosphors of the panels.

The gas analysis was first done to detect the impurity gases out of the MgO film and/or phosphors. Gases such as H_2, H_2O, O_2, CO, and CO_2 were mainly analyzed by a residual gas analyzer because they are easily adsorbed to the MgO film and/or phosphors, and deteriorate the properties of the MgO film and/or phosphors. Before analyzing the gas components, the panels of 2, 4, and 8 hour aging were discharged for 30 minutes to activate the adsorbed gases to the MgO and/or phosphors.

The panels were separated into front and rear plates to analyze the MgO film and phosphors. After the separation, front plates were immediately packed with a vacuum seal because the MgO film easily deteriorates when exposed to air. The analyses of the MgO film were carried out to investigate the effect of the ion bombardment due to discharge by an optical microscopy (OM), a field emission scanning electron microscopy (FESEM), an atomic force microscopy (AFM), and an x-ray photoelectron spectroscopy (XPS).

Photoluminescence (PL) of phosphors was measured by irradiating 147 nm vacuum UV which is mainly generated during discharge. PL intensity of blue, green, and red phosphors was simultaneously measured because the beam diameter of UV light was large enough to cover many pixels.

3. Results

Figure 1 shows the gas concentration of the panels of 0 and 8 hour aging. Concentration of each component was not different between the two panels

even though we discharged the panel of 8 hour aging just before the analysis. Oxygen and carbon were thought to increase due to the out-gassing from the MgO surface and/or phosphor. However, there was no difference. It is important to mention that the unit of H_2O is not concentration, but measured value by the gas analyzer because H_2O can not be quantified.

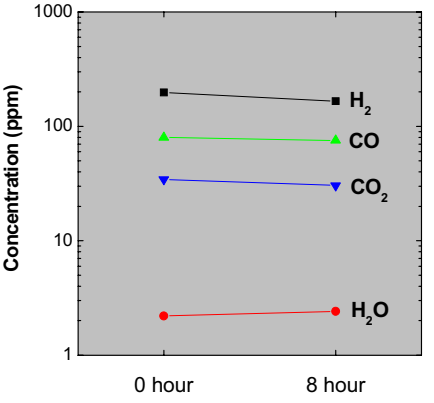

Figure 1. Gas concentrations of 0 and 8 hour aging panels.

The MgO surface was examined by OM and SEM. The schematics of electrode structure and OM images of the front plate are drawn in Fig. 2. Two fogged regions of an asymmetrical dumbbell shape were formed at each side of electrodes due to the ion bombardments during the aging discharge.

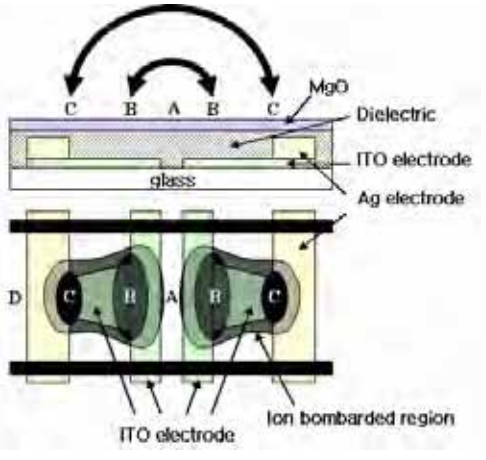

Figure 2. Schematics of the electrode structure and the ion bombarded regions.

While 'A' region of ITO gap suffered little ion bombardments, 'B' and 'C' regions on the electrodes suffered intense ion bombardments. 'C' region was specially smoother than 'B' region. This can be easily seen by the SEM inspection shown in Fig. 3.

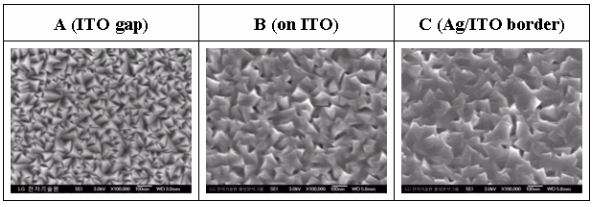

Figure 3. SEM images of the MgO surface at a point of A, B, and C. The magnification was x100,000.

To quantify the degree of ion bombardments, the RMS roughness was measured by AFM. The RMS roughness of 'A', 'B' and 'C' regions were 16.6, 12.6, and 9.3 nm, respectively. It should be noted that more ion bombardments does not seem to represent more intense discharge at that point because the light intensity measured by infrared charge coupled camera shows the highest peak at the ITO gap. The relationship between the surface morphology and the light intensity should be further investigated.

Figure 4 shows the XPS analysis of carbon and oxygen spectra of MgO films of 0 and 8 hour aging panels. The results are summarized in Table 1. $Mg(OH)_2$ and $MgCO_3$ were detected in the surface, but the quantities of $Mg(OH)_2$ and $MgCO_3$ were not different between panels. During the experiments, the MgO film had three chances to be exposed to air ; when the front panel came out from the deposition chamber, for about 10 minutes from the panel separation to vacuum sealing, and for about 10 minutes before the insertion of an MgO sample into the XPS chamber.

Because the separation of the 42 inch panel was very difficult in N_2 or vacuum chamber, we separated the panel in air, and therefore the MgO surface was exposed to air for about 20 minutes.

To confirm the origin of $Mg(OH)_2$ and $MgCO_3$, the XPS spectra were measured sputtering the MgO surface with Ar ion. Figure 5 shows the XPS spectra of the MgO surface of 0 hour aging panel for carbon (upper) and oxygen (lower). The sputter time was 0, 0.5, 2, and 20 min. Carbon peaks decreased due to the removal of carbon, but the oxygen peaks increased due to the removal of hydroxyl group with sputter time. After 20 min sputtering, $Mg(OH)_2$ and $MgCO_3$

were greatly reduced. This means that the $Mg(OH)_2$ and $MgCO_3$ were not formed during the MgO deposition, but at exposure to air.

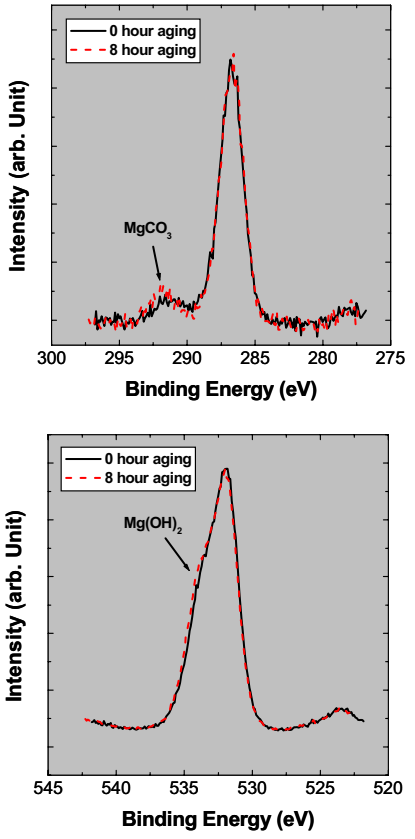

Figure 4. The XPS analysis of carbon (upper) and oxygen (lower) spectra of MgO films of 0 and 8 hour aging panels.

Table 1. Chemical composition of the MgO surface of 0 and 8 hour aging panels. The values of $-CO_3$ and -OH are a percentage in the carbon and oxygen spectra, respectively.

(at. %)

	C	O	Mg	-CO3	-OH
0 hour aging	15.0	51.0	34.0	14	42
8 hour aging	15.2	50.2	34.6	13	43

From the gas analysis, we found out that there was no detectable change in the concentration of H_2, H_2O, O_2, CO, and CO_2, meaning that there was no out-gassing from the MgO surface and/or phosphor after 8 hour aging. This coincides with the XPS result which did not show any difference in the concentration of $Mg(OH)_2$ and $MgCO_3$. We also reported that $Mg(OH)_2$ was not changed for 30 minute exposure to air [4]. $Mg(OH)_2$ and $MgCO_3$ may be formed at the first exposure to air after the deposition. Therefore, they may be detected in the XPS analysis because the 8 hour aging process carried out generally was not effective to remove $Mg(OH)_2$ and $MgCO_3$.

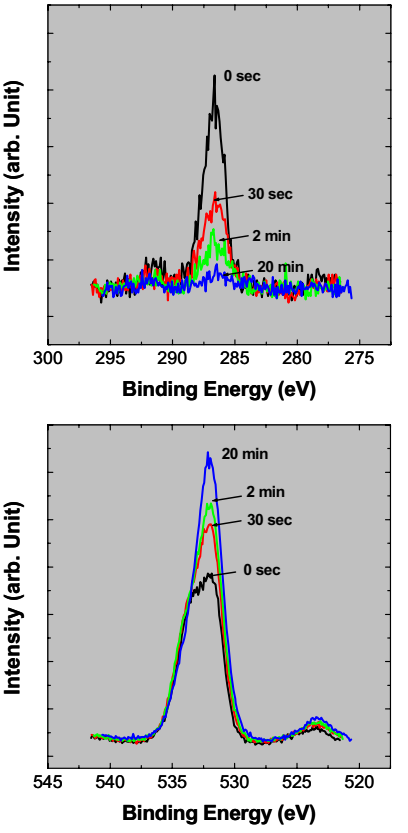

Figure 5. XPS spectra of the MgO surface of 0 hour aging panel for carbon (upper) and oxygen (lower). The MgO surface was sputtered with Ar ion for 0, 0.5, 2, 20 min.

Soh et al. reported that the aging process results in the decrease of $MgCO_3$ and $Mg(OH)_2$ and the contaminants can not be seen finally after the 12 hour aging process, but they aged the panel with 50 kHz, which was a severe aging process [2].

Phosphors are generally characterized by the photoluminescence (PL). PL intensity of PDP phosphors was measured by irradiating 147 nm vacuum UV light which is mainly generated during

Ne-Xe gas discharge. PL intensity of blue, green, and red phosphors were simultaneously measured because the beam diameter of UV light was large enough to cover many pixels. PL intensity of blue and green phosphor decreased by 10 % and 5 % after 8 hour aging, respectively, but that of red phosphor did not decrease.

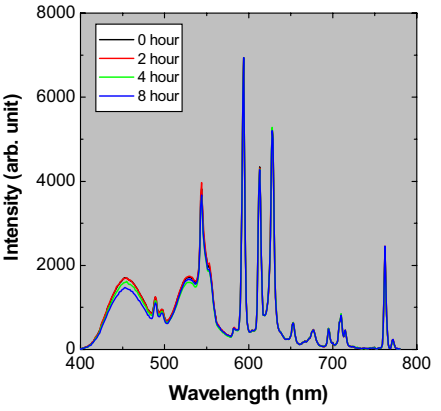

Figure 6. Photoluminescence spectra of blue, green and red phosphors as the aging time increases.

It is generally said that phosphors deteriorates because they are exposed to ion, electron, and UV light during discharge, but there are still many arguments on the origin of degradation of each phosphor. An investigation is underway to find out the degradation mechanism of phosphors by applying surface treatments like plasma cleaning, ion sputtering, UV irradiation, and electron bombardment to the phosphors.

4. Conclusion

AC-plasma display panels before and after the aging process were analyzed to find out the effect of the aging process. Gas concentration such as H_2, H_2O, O_2, CO, and CO_2 was not different before and after the aging process.

The surface roughness of the MgO film decreased with increasing the aging time, and was different from regional groups due to the different degree of ion bombardments.

The XPS analysis showed that $Mg(OH)_2$ and $MgCO_3$ were formed by the exposure to air, not during the MgO deposition. From the gas and XPS analyses, we could say that $Mg(OH)_2$ and $MgCO_3$ were detected in the XPS analysis because the 8 hour aging process carried out generally was not effective to remove $Mg(OH)_2$ and $MgCO_3$.

PL intensity of blue and green phosphor decreased by 10 % and 5 % after 8 hour aging, respectively, but that of red phosphor did not decrease.

Although there are some differences, the above physical and chemical analyses are insufficient to fully figure out the effect of aging process. Therefore, other methods such as cathodoluminescence or secondary electron emission measurement are needed for further understandings [3,5-6].

5. Acknowledgements

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6. References

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