Contaminations of MgO Thin Films by Phosphors for the Surface and Vertical Discharge Type AC-PDP

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Abstract

The panels were fabricated to characterize the contamination of Magnesium Oxide (MgO) thin films by phosphors and ion bombardments in AC-PDPs. Forty-six inch WVGA panels of the surface and vertical discharge type were manufactured. The experiment was designed to investigate the relationship between the MgO thin films and phosphor contamination caused by ion bombardments in a plasma environment to produce a life time test. The contamination of MgO thin films by phosphors was investigated by way of X-ray photoelectron spectroscopy (XPS).

1. Introduction

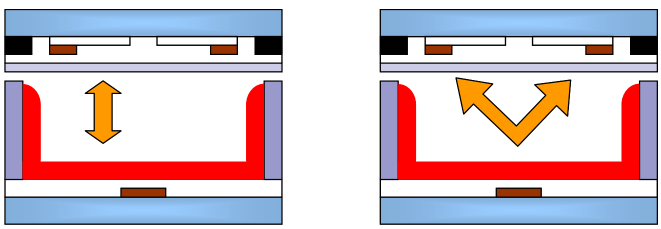
Plasma display panels (PDPs) are one of the most promising technologies for large size flat panel displays. Even though there are a lot of efforts to improve panel performances, a further study of luminance efficiency, power consumption, lifetime and image sticking is still needed [1,2].

The degradation of the Magnesium Oxide (MgO) protective layer and the phosphorous layer plays a very important role for the PDP performance because both layers are exposed to plasma in the cell. According to recent research, the transparency of MgO protective layer is degraded over long time exposure to ion bombardments [3]. The luminance efficiency of PDP is reduced due to the decreasing transparency of MgO thin films because of contaminants. The degradation of phosphorous layer also leads to decreased luminance and the worse color performances in PDPs [4]. Even though the degradation of MgO thin films and phosphorous layers has significant effect on panels, there is currently no report of the degradation of MgO thin films between the phosphorous layer in AC-PDP as a whole. Therefore, we propose to figure out which properties of MgO thin films has the largest influence on the panel properties [5,6]. Then, the critical factors for the degradation of the panels will be characterized during the fabrication and operation of PDPs.

2. Experiment

There were two full sized 46-inch panels made for this experiment. One of the experimental panels is shown in figure 1. The MgO films were deposited on the PDP's front panel by electron beam evaporation. Also, the conventional phosphorous layers of PDPs were printed on the rear panels: the main component of red, green and blue phosphorous layers are (Y, Gd, Eu) BO_4, $(Zn, Mn)_2SiO_4$ and (Ba, Eu) $MgAl_{10}O_{17}$, respectively. The difference between the two panels is the operation mode. To speed up the degradation of MgO protective layer, the PDP No.1 panel was modified as facing sustained mode, which generates plasma vertically between the sustained electrode on the front panel and address electrode on the rear panel, instead of conventional surface type plasma discharge between two sustained electrodes. We have assumed that this setup would make stronger ion bombardment between MgO layer and phosphorous layers, and possibly result in more contamination in the MgO layer caused by phosphors. However, the No.2 panel was operated as a conventional surface discharge type PDP to compare with the No.1 panel. In this paper, an accelerated relative-lifetime-test for MgO thin films is proposed by using higher operating voltage and sustained frequency than those of normal conditions. After operating for a period of time, panels were investigated to identify the surface morphology and contaminations of MgO thin films using Atomic Force Microscopy (AFM) and X-ray Photoelectron Spectroscopy (XPS).

Fig. 1 The photograph of the 46-inch PDP panel



(a) Vertical discharge (b) Surface discharge

Fig. 2 Schematic diagram of the surface sustain discharge and vertical sustain discharge

3. Results and Discussion

In this work, the 700-hour operation for vertical discharge panel and 16000-hour operation of the surface discharge type panel was performed to degrade the MgO thin film. It is reported that the surface morphology of MgO layer and its degradation is dependent on different areas in a single micro-cell [2]. This makes the surface of the MgO layer non-uniform. Figure 2 shows the surface morphology of the MgO thin film after the accelerated lifetime test by atomic force microscope (AFM). The AFM pictures clearly show evidence of the erosion of the MgO layer. The erosion of the MgO layer in the glow discharge in an ac PDP occurred by ion bombardment on the MgO thin film. After long time sustained discharge, significant grain growth occurred as shown in figure 3 (a) and 3 (b). Especially, the surface profile of the 16000-hour operated sample clearly exhibited that the erosion of the MgO layer was much more severe than the 700-hour one. The RMS roughness of the sample with 16000-hour surface discharge is over 10 times larger than that of the sample with 700-hour vertical discharge. We think that this is because of the much longer time ion bombardment for the surface discharge one. For the same accelerated test time, it is expected that the vertical discharge type panel leads to stronger ion bombardment and changes the surface morphology and thickness of the MgO layer in some specific part.

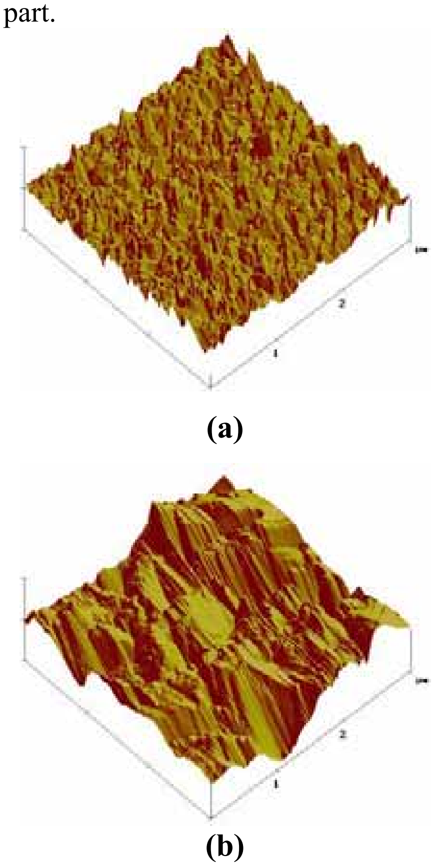
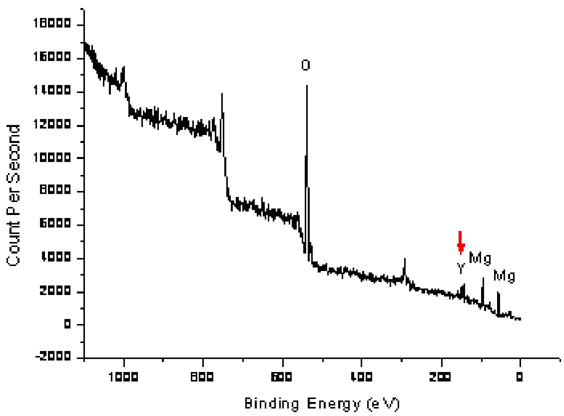


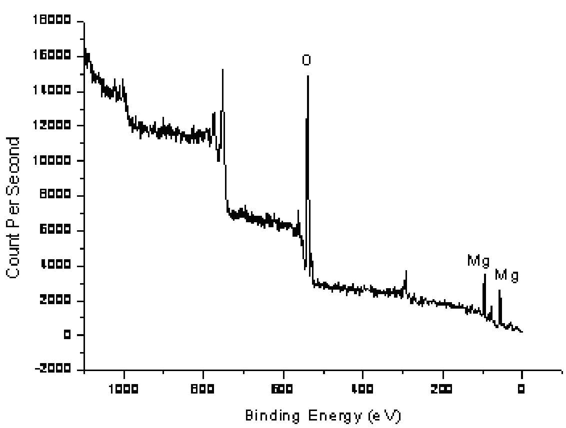
Fig. 3 (a) AFM images of MgO thin films vertical discharge type panel after 700-hour accelerated test time. (b) AFM images of surface discharge type panel after 16000-hour accelerated test time.

The XPS analyses are shown in figure 4 (a) and 4 (b) for the vertical discharge type panel and the surface discharge type panel. The figures represent the element in the surface of MgO layer. The peaks for Mg (89 eV) and O (536 eV) can clearly be observed. In figure 4 (a) we also notice the smaller peaks around 150 eV, which can be considered as yttrium from the red phosphor (Y, Gd, Eu) BO_4. However, in figure 4 (b) the yttrium doesn't appear at 150 eV. The elements Fe, Si, Al, and Mn may come from the MgO source material before deposition. However, there is a high possibility that the Yttrium elements come from the phosphors. The difference between the two panels possibly resulted from the stronger ion bombardments between the MgO layers and the phosphorous layers. The contaminations and ion bombardment may change the surface morphology of MgO thin film.

This would affect transparency and the secondary electron emission coefficient related to the luminance and sustained voltage. However, there are no other phosphor elements detected. It may result from different dielectric and surface properties of each phosphor. The green phosphor $(Zn, Mn)_2SiO_4$ has negative surface discharge while those of red and blue phosphors are positively charged [7], which results in smaller wall charges stored by the reset discharge in the green cell than in the red or blue cells. This phenomenon would make weaker vertical discharge between the MgO layer and the green cell, which results in little contamination in the MgO thin films.



(a)



(b)

Fig. 4 (a) XPS surface analysis of the vertical discharge type panel after 700-hour accelerated test time. (b) XPS surface analysis of the surface discharge type panel after 16000-hour accelerated test time

We think it is difficult to detect the difference for the trace amounts of the impurity and another method needs to be tried.

4. Conclusion

In this paper, a short-term relative lifetime test was proposed for MgO thin films in an ac-PDP. The surface morphology and contaminations in the MgO thin films were investigated. By means of XPS, we confirmed that a part of contamination results from ion bombardment to the phosphors. Even though the surface discharge type has stronger erosion on the MgO thin film because of long time discharge, the contaminations for the vertical discharge type were severe. We demonstrated that the degradation of the MgO thin films in AC-PDP was partially caused by contaminations from phosphor. The effect of discharge characteristic changes in the MgO thin films can be an important property which needs to be studied.

5. Acknowledgements

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6. References

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