Reconstruction Characteristics of MgO (111) Textured Protective Layer by Over-Frequency Accelerated Discharge in AC Plasma Display Pannel

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Abstract

The reconstruction characteristics of MgO (111) textured protective layer by over-frequency accelerated discharge in AC-PDP were investigated and correlated to the variations of electronic structures. The reconstruction process and exaggerated grain growth (EGG) were explained by defect-assisted 2-D nucleation and growth mechanism combined with charged cluster model.

1. Introduction

Plasma display panels (PDP) have been remarkably developed for large size, high-brightness flat panel display and high-definition television (HDTV). In spite of previous many researches, the further improvements are required to enhance image quality and lifetime, and reduce production cost and power consumption. The protective layer plays a very important role for the protection of dielectric and electrode layer as well as the promotion of discharge efficiency in AC plasma display panels (AC-PDP) 1. Magnesium oxide (MgO) film, which generally has (111) textured structures, is widely used for the protecting layer due to its high anti-sputtering characteristic and secondary electron emitting ability 2-4. On these reasons, MgO protective layer is the key material and necessarily required to be developed because it dominates the discharge characteristics and lifetime in AC-PDP.

Recently, the degradation of MgO protective layer has been one of the most important problems that should be solved for the advance in PDP technology 5-7. Many researches have been accomplished until now but the mechanism is still unclear. Therefore, the variations of MgO protective layer by discharge in AC-PDP are of great importance to be studied for the advance of high efficiency AC-PDP. On these backgrounds, the reconstruction characteristics of MgO (111) textured protective layer by over-frequency accelerated discharge in AC-PDP were investigated.

2. Experimental

AC plasma display panels were prepared using undoped MgO protective layer with textured structure grown to <111> preferred orientation. Prepared panels were discharged by a extremely severe condition of over-frequency accelerated discharge for sufficiently long time to investigate the reconstruction characteristics of MgO (111) textured protective layer during discharge in AC-PDP. After discharge, the panels were separated into front and rear plates and MgO (111) textured protective layer in the front panel was analyzed to investigate the effect of over-frequency accelerated discharge in AC-PDP. Structural variations of the MgO layer were analyzed by X-ray diffraction (XRD) and grazing incidence X-ray diffraction (GIXD), and the changes in electronic states of bulk and surface were investigated by X-ray absorption spectroscopy (XAS) using synchrotron radiation at Pohang light source (PLS) in Korea. The variation in the morphology of the MgO layer was observed by field emission scanning electron microscope (FE-SEM) to clarify the reconstruction process and grain growth behavior of MgO (111) textured protective layer by over-frequency accelerated discharge in AC-PDP.

3. Results and discussion

Figure 1 shows the typical morphology of as-grown MgO (111) textured protective layer in AC-PDP. Triangular pyramid shape of MgO layer was clearly observed and this is attributed to {100} facets due to the reconstruction of MgO (111) surface to minimize the surface energy related with Madelung potential.

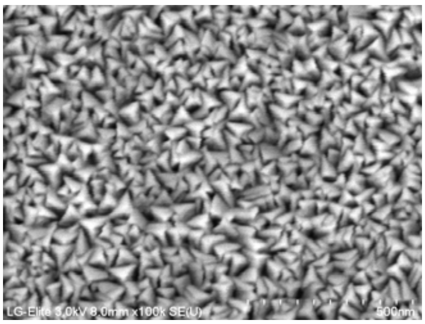

Fig. 1. SEM image of as-grown MgO (111) textured protective layer in AC-PDP.

The schematics of the front panel and electrode structure are drawn in Fig. 2. The regions of (a) and (b) display the area of sustain electrode where over-frequency accelerated discharge process occurred by sustain operation in AC-PDP. Actually, the columns of two dark regions were observed at the surface of MgO protective layer and these were formed at each side of ITO electrode by sustain process during discharge in AC-PDP.

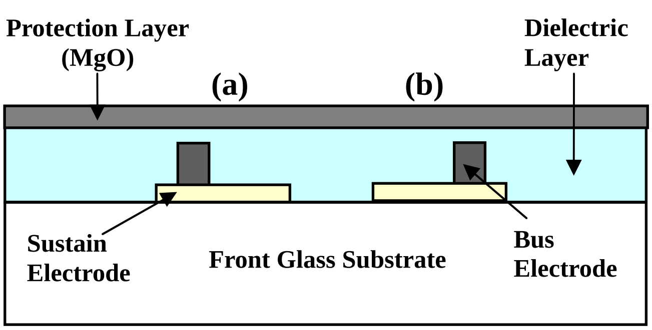

Fig. 2. Schematics of the electrode structure and over-frequency accelerated discharge regions by sustain process in AC-PDP.

Figure 3 reveals the variation in the morphology of MgO surface by over-frequency accelerated discharge at the point of (a) and (b), as shown in Fig. 2. The reconstruction of MgO (111) textured protective layer and grain growth occurred at the surface by over-frequency accelerated discharge consuming triangular pyramid shape of the MgO layer, as revealed in Fig. 1. However, the directions at the point of (a) and (b) were completely opposite and this result indicates evidently that material transfer of MgO is strongly influenced by electric field during over-frequency accelerated discharge in AC-PDP.

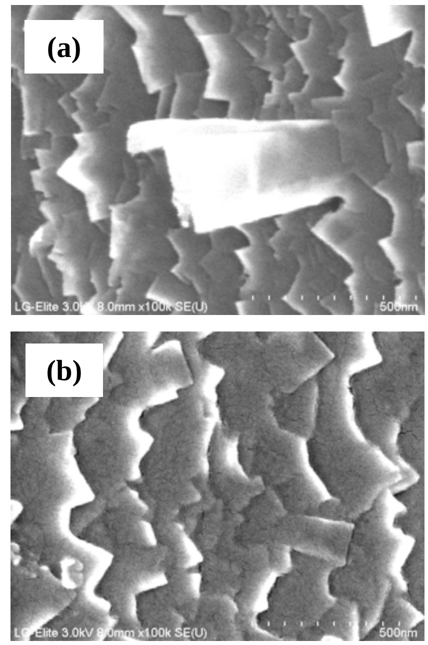

Fig. 3. SEM images of the morphology of MgO surface by over-frequency accelerated discharge at the point of (a) and (b) in AC-PDP shown in Fig. 2.

Also, a very large grain was partially identified in the matrix revealed in Fig. 3 (a) and a limited number of grains, which grew much larger than the matrix grain with faster growing rate, were observed sporadically at the surface of the MgO layer by over-frequency accelerated discharge as shown in Fig. 4. Usually, this phenomenon is often referred to as exaggerated or abnormal grain growth (EGG or AGG).

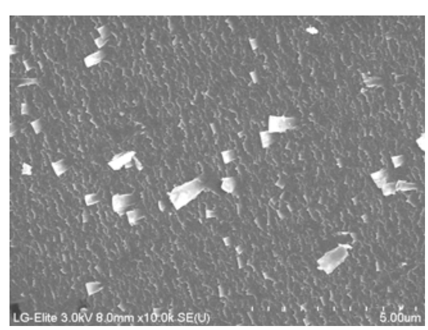

Fig. 4. SEM images of exaggerated grain growth occurred sporadically at MgO surface by over-frequency accelerated discharge in AC-PDP.

Figure 5 shows XRD profiles for out-of-plane and in-plane of MgO (111) textured protective layer before and after over-frequency accelerated discharge in AC-PDP. The intensity of (111) plane, which is surface normal direction, was nearly similar but slightly broadened by discharge revealed in Fig. 5 (a). In case of in-plane diffraction, XRD profiles for *h*-scan of (220) plane showed nearly similar results like the case of (111) plane shown in Fig. 5 (b) suggesting that the bulk structure was influenced slightly by discharge. However, the tendency of (200) plane was quite different. Fig. 5 (c) reveals that the intensity for *h*-scan of (200) plane was drastically increased and this indicates that the reconstruction process proceeds to <200> preferred orientation by discharge.

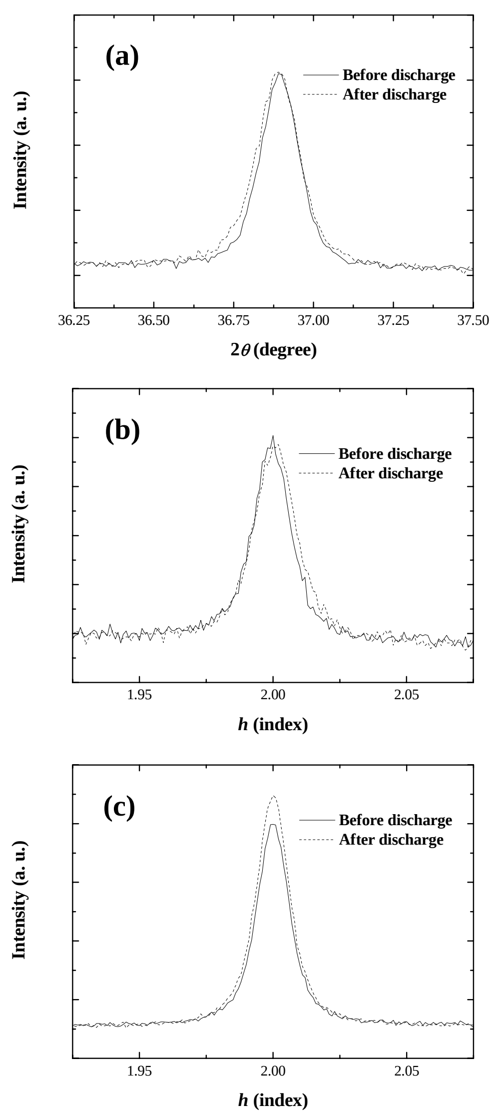

Fig. 5. XRD profiles of (a) (111), (b) (220) and (c) (200) planes of MgO layer before and after over-frequency accelerated discharge in AC-PDP.

Grazing incidence X-ray diffraction (GIXD) was accomplished by 0.2° incident angle to investigate the structural variation at the surface of the MgO layer. GIXD profiles revealed that the crystallinity of MgO surface was slightly decreased and (200) peak, which was not detected in the initial stage, appeared and this peak increased significantly after over-frequency accelerated discharge as shown in Fig. 6. These results are in good accordance with those of XRD profiles revealed in Fig. 5 and this indicates evidently that the crystallinity of the MgO layer was slightly decreased and the surface reconstruction and grain growth including EGG happens to the preferred orientation related with {200} faces by discharge under electric field in AC-PDP.

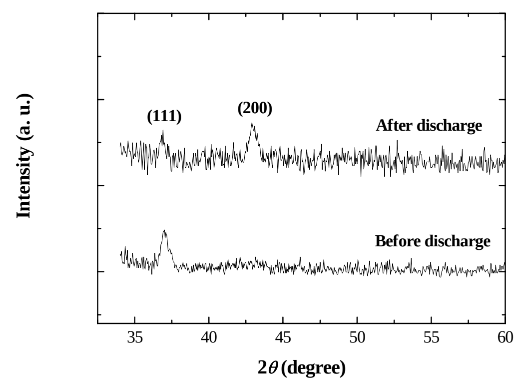

Fig. 6. GIXD profiles of MgO layer by 0.2° incident angle before and after over-frequency accelerated discharge in AC-PDP.

Fundamentally, grain growth is affect significantly by the surface structure. The kinetics of atom attachment to a growing interface during grain growth depends on the density of kinks on that interface. Interface-controlled growth occurs at the atomically smooth interface, which is characterized by the limited number of kinks, through kink-generating sources such as screw dislocation or two-dimensional nuclei. On the other hand, an atomically rough interface, which characterized by infinite number of kinks, tends to have diffusion-controlled growth. EGG is known to occur at angular grains with interface atomically smooth by a limited number of grains, which have enough driving force to overcome nucleation barrier for growth, through defect-assisted 2-D nucleation and growth process. In AC-PDP, material transfer of MgO protective layer is believed to proceed mainly through evaporation of atom, molecule or cluster by cyclic damages at the surface under ion flux distribution with low energy during plasma discharge process. In most CVD and some PVD processes, important parameters of thin film growth are the cluster size and charging behavior of cluster, which are affected by process conditions. Charged clusters are known to be easily formed in the plasma process and thus, the growth behavior of the MgO protective layer mainly through evaporation and condensation process is strongly influenced by electric field during discharge in AC-PDP. Therefore, these reconstruction characteristics and EGG can be explained by defect-assisted 2-D nucleation and growth mechanism combined with charged cluster model occurred on {100} facets of MgO (111) textured protective layer at the surface, which is closely correlated with <200> preferred orientation, mainly through evaporation and condensation of MgO under ion flux distribution with low energy during discharge process in AC-PDP.

Figure 7 reveals the O *K*-edge XAS spectra of the MgO layer before and after over-frequency accelerated discharge measured by electron yield and fluorescence yield representing the electronic states of surface and bulk with different proving depths, respectively. The results revealed that the electronic states in the bulk, fluorescence yield, were similar regardless of discharge but those at the surface, electron yield, showed quite different states and this is attributed to the reconstruction process, change in crystallinity and defect formation at the surface of the MgO layer by discharge in AC-PDP.

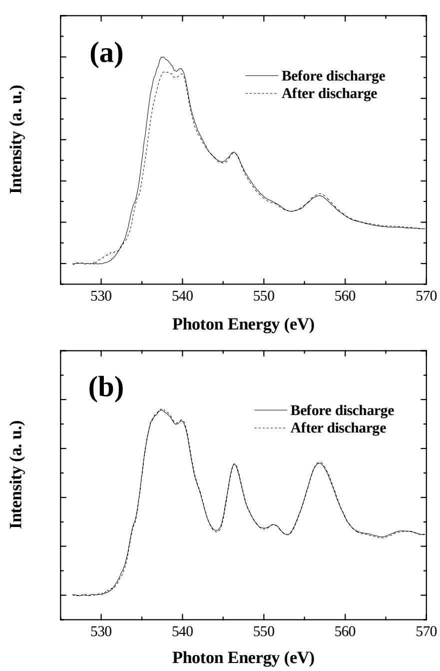

Fig. 7. O *K*-edge XAS spectra of MgO layer before and after over-frequency accelerated discharge measured by (a) electron and (b) fluorescence yield.

Until now, the mechanism for the reconstruction process and EGG of MgO (111) textured protective layer by discharge in AC-PDP has been unclear. These results suggest evidently that the reconstruction characteristics and EGG occurs by defect-assisted 2-D nucleation and growth mechanism combined with charged cluster model on {100} facets of MgO (111) textured protective layer and closely correlated with the electronic states at the surface of MgO protective layer. This is expected to be one of the most important parameters to affect discharge characteristic in AC-PDP and further study is needed. Nevertheless, the mechanism proposed by this study is believed to give an important clue for the advance in MgO protective layer and PDP technology.

4. Summary

The reconstruction characteristics and EGG of MgO (111) textured protective layer through over-frequency accelerated discharge in AC-PDP were investigated by FE-SEM and synchrotron radiation and correlated with the electronic states of the MgO protective layer. The reconstruction process and EGG were explained by defect-assisted 2-D nucleation and growth combined with charged cluster model occurred on {100} facets of MgO (111) textured protective layer at the surface mainly through evaporation and condensation strongly affecting the electronic states of MgO surface under ion flux distribution with low energy during discharge process in AC-PDP.

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