

Discharge characteristics of MgO layer prepared via aqueous solution process

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Abstract

In this study, an attempt was made to form magnesium oxide layer via aqueous solution route of salt precipitation process. A layer with flake morphology was formed from the process and various dopants were added during the forming process. The films formed were characterized using SEM, XRD, and cathodoluminescence measurement. In addition, the discharge characteristics were evaluated using panel tests. The results indicate that MgO film can be formed via the aqueous solution process successfully, of which characteristics are comparable to those of MgO film formed by e-beam evaporation process.

1. Introduction

Magnesium oxide thin film is currently being used in plasma Display Panel (PDP) as electron emission layer for glow discharge. The firing voltage and discharge delay of PDPs are largely dependent on electron emission characteristics of MgO thin film [1]. The secondary electron emission from MgO has been noted to be affected mainly by type and concentration of intrinsic and extrinsic defects such as stoichiometry, vacancy, interstitials, electrons and holes within the film [2,3]. The formation of such defects during the formation of MgO via e-beam evaporation process is very difficult to control because of following several limiting factors. Firstly, the e-beam evaporation of MgO is highly non-equilibrium process and the control of such defects is kinetically limited. Secondly, evaporation rate of doping elements is different from that of MgO during the e-beam evaporation process. Therefore, the concentration of doping elements in the film is quite different from that in the source. Thirdly, the solubility of doping elements in MgO layer at processing temperature of 300°C is very low and the control of doping concentration to a certain level is very difficult.

In this study, therefore, we attempted to vary the defect type and concentration in MgO by preparing the thin layer via aqueous solution process. The defects were created by adding Li^+ and Al^{3+} ions

during the film forming process [4]. After the aqueous process, the film formed was crystallized by heating to elevated temperatures. Microstructure of MgO film prepared by the aqueous process was observed to have platelet type morphology which has not been reported previously. The firing voltage of MgO films were measured using test panels and showed a possibility of enhanced discharge characteristics of PDPs. In order to investigate causes of such improvements, XRD, SEM, cathodoluminescence analyses were conducted on the film.

2. Experimental Procedure

After a thin seed MgO layer is deposited on glass substrate by e-beam evaporation process, MgO film was grown by aqueous solution process. Various aqueous solutions including nitrate, acetate and chloride solutions were used for the process. The temperature of the coating process was varied from 30°C to 60°C. For the doping experiments, Li^+ and Al^{3+} ions were selected as they create oxygen and magnesium vacancies in MgO, respectively. The doping was conducted by adding Li- and Al-salts to the aqueous solution.

The thin MgO layer grown on the glass substrate was heated to convert the magnesium hydroxide to oxide. Thickness of the film was $\sim 7000 \text{ \AA}$. The cathodoluminescence of the films was measured using a SEM equipped with double monochromator. In addition, the orientation and microstructure were analyzed using XRD, and FE-SEM

The firing voltage and yield of secondary electron emission were measured for MgO layers formed via aqueous solution process and compared with MgO formed via e-beam evaporation process. The measuring procedures of this set-up can be found in more detail elsewhere [5].

3. Results

3-1. Formation of MgO film by aqueous solution process

Morphology of MgO layer formed at various processing temperatures is shown in Fig. 1. For this process, nitrate solution was used. As noted from the figure, morphology of the film is flake-like shape, which is quite different from the e-beam evaporated sample. As the processing temperature is increased, the size of the flake was increased.

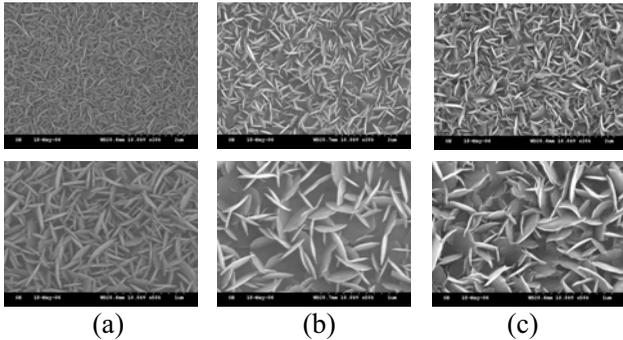


Fig.1. Surface morphology of MgO thin film grown at (a) 30°C , (b) 45°C and (c) 60°C.

XRD analysis of the film formed via the aqueous solution process indicated that the flake type sample is Mg(OH)₂ compound (Fig. 2). Heat treatment of the sample at 150°C for 3 hours did not affect the diffraction pattern. The heat treatment at 550°C for 3 hours, however, converted the compound to MgO completely as shown in the figure. For comparison, the diffraction pattern of MgO film prepared via e-beam process is shown in the figure. The XRD pattern obtained via the heat treatment was almost identical to that of MgO film obtained via e-beam evaporation

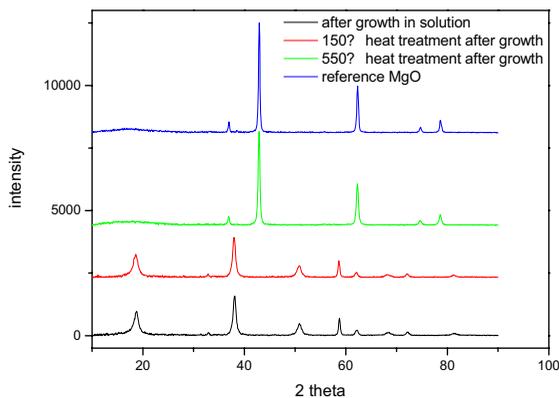


Fig.2. XRD pattern of MgO film prepared by aqueous solution process

process. FE-SEM observation of the layer indicated that the morphology of the flake-like MgO layer was not affected by the heat treatment at 550°C.

The effect of doping on morphology of MgO layer formed is shown in Fig. 3. The typical flake type morphology was not affected by the doping. The density and preferred orientation of the films, however, were affected by the addition of doping elements. With Al³⁺ doping, the size of the flake was increased and density of the layer decreased. Doping with Li⁺ ion, on the other hand, decreased the size and increased the density as noted from the figure.

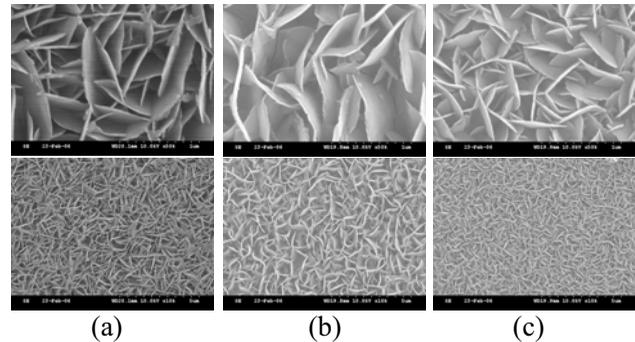


Fig.3. Morphology of MgO layer: (a) without doping, (b) Al³⁺ doping and (c) Li⁺ doping.

XRD diffraction patterns of the layers after heat treatment at 550°C for 3 hours are shown in Fig. 4. (220) peak was highest with Li⁺ doping and (200) orientation peak with Al³⁺ doping. The doping did changed the preferred orientation of the layer formed.

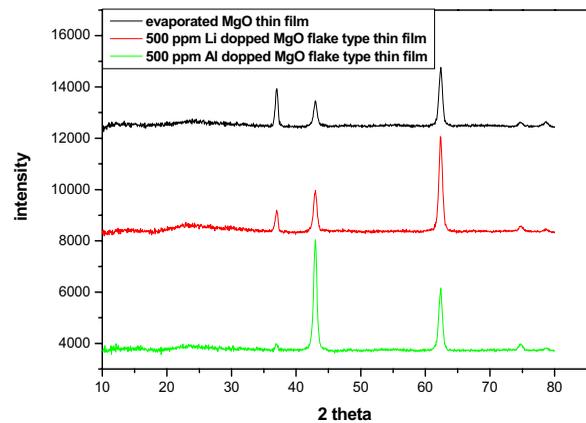


Fig.4. XRD patterns of doped MgO film

3-2. Discharge characteristics of flake type MgO thin film

Paschen curves of the MgO film prepared by the aqueous nitrate solution process were measured. Fig.5 shows the effect of processing temperature on the firing voltage. The voltage was found to decrease as the processing temperature is decreased. When the processing temperature was 45°C, the Paschen curve was similar to that of MgO film prepared by e-beam process. As the processing temperature is decreased to 30°C, firing voltage of the film was lower than that of the thin film. This indicates a possibility of reducing firing voltage by using MgO film grown by aqueous process.

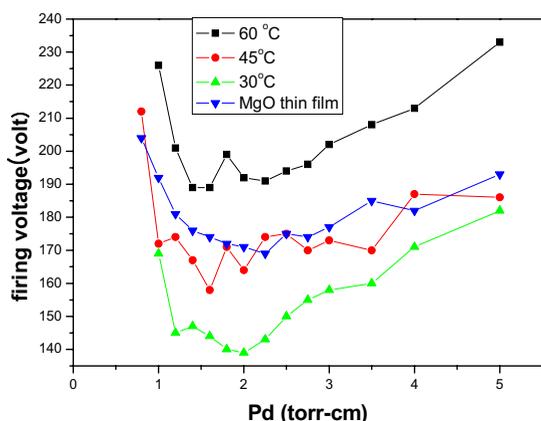


Fig.5. Effect of processing temperature on Paschen curves of MgO film.

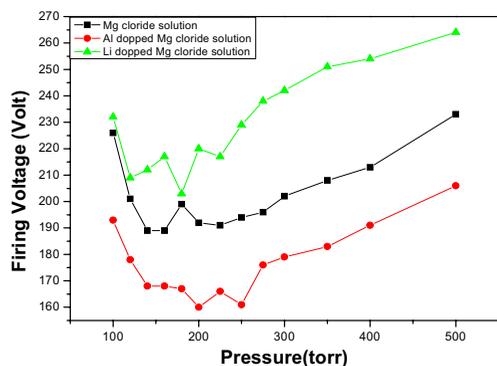


Fig. 6. Paschen curves of MgO film prepared by aqueous solution process with doping elements.

Effect of doping element on Paschen curve is shown in Fig. 6. As noted from the figure, Al doping reduced

the firing voltages compared with that without dopant. The sample with Li doping, however, showed higher firing voltages.

Fig. 7 shows the cathode luminescence spectra from MgO layers formed via the aqueous solution process. As shown in the figure, CL spectra mainly due to F and F⁺ centers which are similar to that observed with e-beam evaporated MgO thin film was obtained. This indicates that the defect structure within MgO layer formed via aqueous solution process is similar to that formed by the e-beam process. Preliminary results on CL measurement on MgO layer indicated that the peak intensity of CL spectra is increased by one order of magnitude, suggesting that the defect density in MgO layer formed via the aqueous process is higher than that in e-beam evaporated layer.

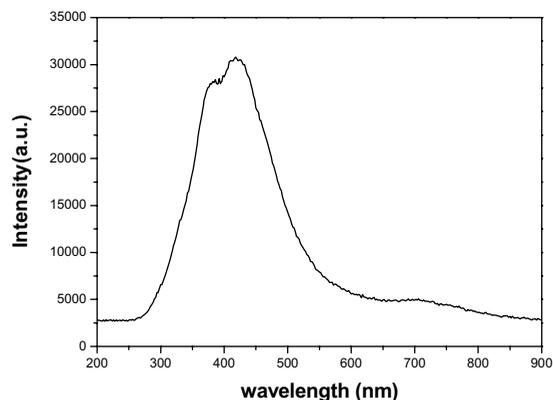


Fig.7. Cathode luminescence spectra from MgO layers formed via the aqueous solution process.

4. Conclusion

MgO layer formed via aqueous solution process was found to have flake-like morphology. The heat treatment and doping did not change the morphology of the layer. The firing voltage was reduced by decreasing processing temperature and doping with Al³⁺ ion. The characteristics of the MgO layer formed via the aqueous process were comparable with those of the layer formed via e-beam evaporation process.

5. Acknowledgements

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6. References

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