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The Analysis of Memory Margin of an Alternative Current-Plasma Display Panel with K-Ion-Doped MgO

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An ac-type plasma display panel (ac-PDP) with K ion-doped MgO film formed via a sol-gel precursor was analyzed and compared to an ac-type PDP with MgO formed by e-beam evaporation. As the dopant content was increased, memory margins of test panels were linearly reduced and the surface charging caused by the secondary electron emission (SEE) was decreased. From these results we suggested the amounts of surface charging has a close relation to the wall potential of ac-PDP.

Keywords: ac-PDP; doped MgO; memory margin; secondary electron; surface charging

INTRODUCTION

The initial discharging voltage or operational voltage of a Plasma display panel (PDP) is influenced by a secondary electron coefficient of MgO related to the crystalline structure, as well as defect sites of the MgO. Many reports have shown that the secondary electron coefficient can be increased by the impurities in MgO materials owing to the creation of defects energy level. However, what with the difficulty in the preparation of doped MgO and the difficulty in characterization of doped MgO, especially in the study on secondary electron emission (SEE), the study of doped MgO has been limited.

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The MgO layer, as an insulator, has charged surface after primary or secondary electron emissions giving a serious influence on the next emissions [1–6]. These charging phenomena in SEE studies of MgO have been noted in many literatures, however, few reports have mentioned on the relation between memory effect in an ac-PDP and charging phenomenon on the MgO surface after the SEE or during the SEE measurement.

In this study, we introduce an MgO film and various contents of K ion doped MgO films with a nano-sized pore structure and then examined the relation between the surface charging after the SEE and operational memory margin. In addition the influence of pores of MgO film on discharging properties of ac-PDP was discussed.

EXPERIMENTAL

Synthesis

MgO precursors were prepared from a stabilized magnesium hydroxide sol that was derived from a starting material of magnesium methoxide. Firstly, a distilled acetylated carbitol solution was mixed with a stabilizer of naphthalene at 373 K for 10 min and then cooled down. At room temperature, the prepared solution was reacted with magnesium methoxide solution, and then hydrolyzed with methanol solution containing distilled water. Finally, the solution was refluxed to remove methanol at 373 K for 10 min. The prepared sol was highly stable owing to the addition of naphthalene, even with a strong base such as potassium *tert*-butoxide, which is a source of K^+ ions. The prepared precursor sol was reacted with K^+ ion source of potassium *tert*-butoxide butoxide in mole ratios of 1000 to 3, 6, and 12, respectively. And then, finally it was dispersed into a screening solution consisting of ethyl cellulose, acetylated carbitol, and terpineol [7].

Fabrication of Ac-PDP

To ensure reproducible results, we designed the structure of the test panel of ac-PDP to have saw-type electrodes, as shown in Figure 1. Furthermore, to minimize fluctuations in the thicknesses of the dielectric layer and electrodes, the ac-type PDP cell was made of thin film ITO electrodes without the assistance electrodes, which are normally used in real ac-type PDP structures and a 2-μm-thick layer of SiO_2 was used as the dielectric layer formed by e-beam evaporation.

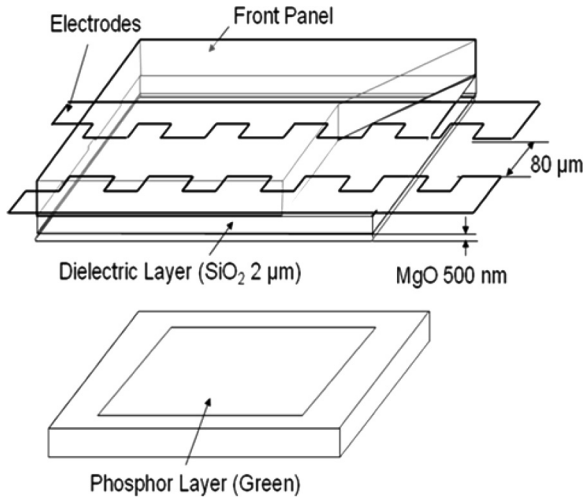

FIGURE 1 A structure of ac-PDP used in this experiment (The test panel has 48 cells and 100 μm gap between a front and rear panel.).

Measurements

The experimental apparatus for measuring the secondary electrons consisted of an ion gun (SPECE-German), a measuring component, and a vacuum system [8]. The ion source was of the electron-bombardment ionization type, where the electrons emitted from a filament are accelerated in the discharge chamber. For the activation of samples, we attached a heater to the rear of the target; the temperature of the heater could be varied from room temperature to 673 K. The samples were activated under a high vacuum at 633 K for 6 h. We then injected Ne + Xe (4%) gas mixture into the ion-gun chamber and maintained the pressure of vacuum chamber at 3×10^{-5} Torr. The acceleration voltage of the ion beam was fixed at 500 V, and the measuring temperature was fixed at 583 K, where we observed stable SEE from the MgO film formed by e-beam evaporation.

RESULTS AND DISCUSSION

Every doped MgO film has a similar morphology to pure printed MgO irrespective of the dopant concentration. On the surface of the MgO

there existed many small pores, of several nanometers in size, developed probably by the large contents of organics in the pastes. The XRD spectra of MgO films with various levels of potassium content in Figure 2 show typical MgO peaks of predominant (200) peak and the weak (111) peak. The thickness of the MgO film was uniformly controlled in a range 2000 Å to 2300 Å.

Figure 3 shows the firing voltages of test panels in which the MgO films have various concentrations of K ions. All the doped samples have a lower firing voltage than that of printed pure MgO film owing to the creation of a defective band that enables the emission of secondary electrons from the Xe gas ions. The operational memory margin of the doped panels in Figure 4 indicates a linear relation between the dopant concentration and the operational memory margin regardless of aging time in this experimental range. This result seems to be related to the surface conductivity of MgO films which can effect on the amount of charged particles on the surface of doped MgO films.

The CL spectra in Figure 5 confirming the creation of defects energy levels in the band gap of MgO show that the F^+ center is the main defect in doped MgO films. According to the reports, the F and F^+ centers in MgO are located at the 3.0 eV and 2.96 eV above the top of the valence band, respectively. The luminescence from F^+ centers has theoretically the wavelength of 390 nm caused by the

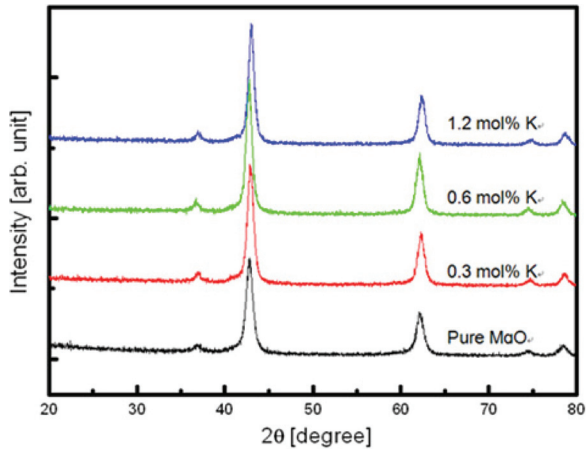

FIGURE 2 XRD spectra of MgO films deposited with various potassium dopant contents.

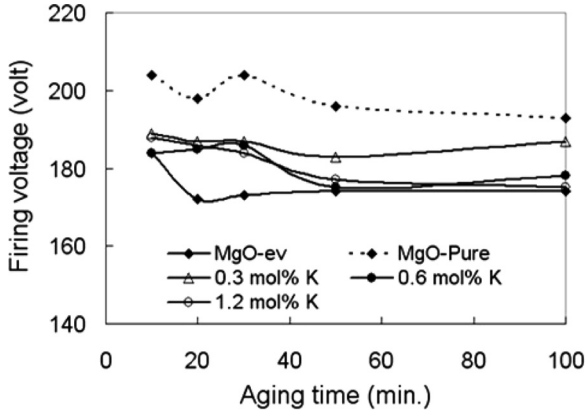

FIGURE 3 Initial firing voltages of test panels with various MgO films versus aging time (every panel was activated at 833 K for 5 h under high vacuum.).

transition from O defect states to Mg defect states in the energy band of MgO [9,10].

The SEE from the printed dopant-free MgO film is highly unstable owing to the surface charging. Considering the measurement temperature of SEE, 583 K thought to be a sufficiently high temperature to release surface charging for MgO films formed by vacuum techniques, the surface charging in this experiment seems to be caused by the porous structure of the printed MgO films. In contrast, we observed more and more stable SEE from doped MgO

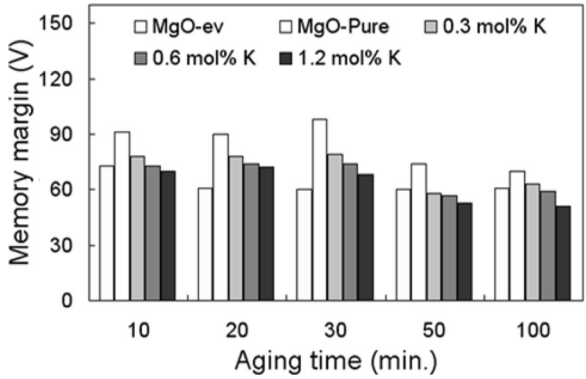

FIGURE 4 Operational memory margin of ac-PDP with various MgO films (E-B means MgO film formed by e-beam).

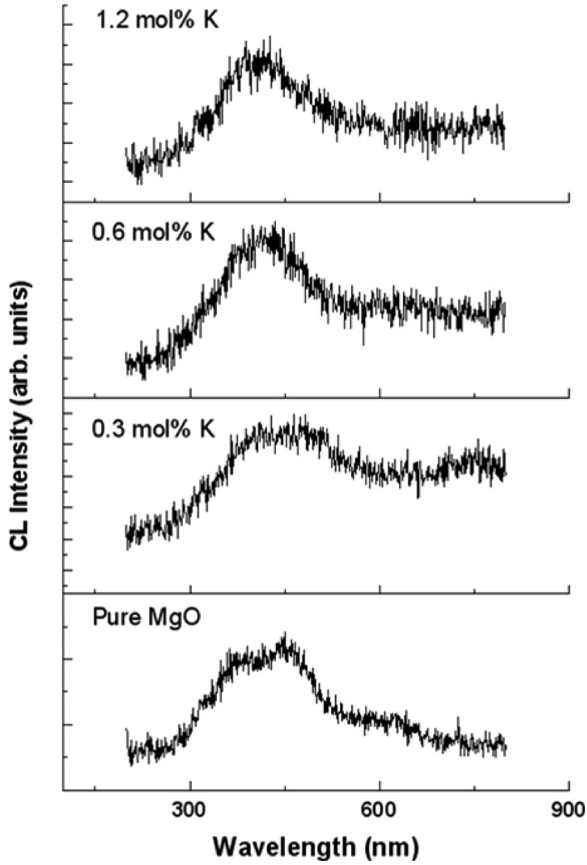

FIGURE 5 CL spectra of potassium ion doped MgO films with different dopant contents.

as the potassium content increasing. According to reports on SEE study from MgO layers, the growth of strong electric fields throughout the pores produces higher SEE yields than those of bulk MgO materials [3–6]. That kind of the field emission or the abnormal emission near the pores makes us hardly compare the SEE yields directly between samples having different pore structures. However, the trend of the saturation of SEE dependent on collector voltages in Figure 6, which is related to the amount of surface charging, shows clearly a proportional relationship to the dopant concentration and also, implies a proportional relationship between the amount of surface charging and the operational memory margin of an ac-PDP.

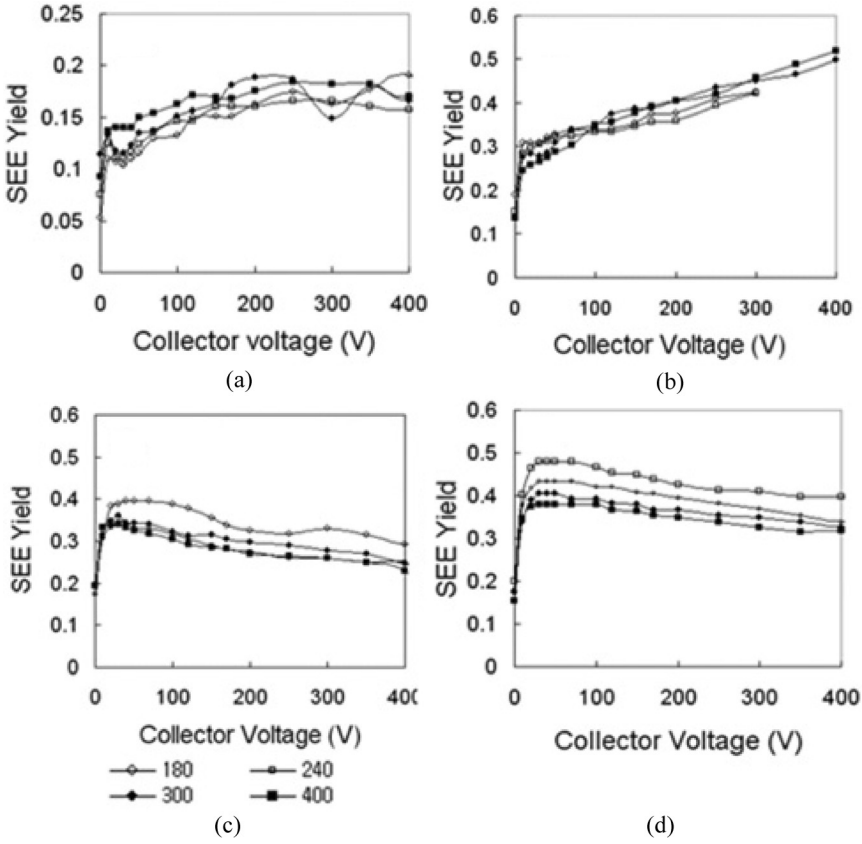

FIGURE 6 The surface charging trend dependent on measuring time of SEE; (a) printed pure MgO, (b) MgO with 0.3 mol% K^+, (c) MgO with 0.6 mol% K^+, and (d) MgO with 1.2 mol% K^+.

CONCLUSIONS

K ion-doped MgO films with a nano-sized pore structure were introduced and characterized in ac-PDP structure. The doped MgO clearly reduces the initial firing voltage of test panels of ac-PDP; it also reduces the operational memory margin of ac-PDP probably due to the increased conductivity of the MgO film. In addition the SEE results and discharge properties of test panels showed a linear relation between the amounts of surface charging occurred during the SEE measurement and the wall potential of an ac-PDP.

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