Discharging Characteristics of the AC-PDP with MgO Protective Layer Evaporated using Oxygen IBAD Method

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Abstract: *We found that the oxygen ion beam assisted during the MgO deposition by e-beam evaporation plays a significant role in the structural of the MgO layer and the resultant discharging characteristics of the PDP. The firing inception voltage, the brightness and the luminous efficiency were measured depending on the oxygen ion beam energy. Crystallization of MgO was also measured by XRD and AFM.*

Keywords: AC-PDP; MgO Protective Layer; Ion Beam Assisted Deposition

Introduction

Plasma Display Panel (PDP) is currently obtaining strong attention because of its potential application to a large-sized high definition television sets with high brightness, fast response and wide view angle performances. For further expansion in share of the large-sized display market, it is of great importance to reduce the manufacturing costs and improve a luminous efficiency [1, 2].

In ac-PDPs, MgO has been widely used as a surface protective layer for dielectric materials because of its low sputtering yield, very large band gap and large secondary electron emission coefficient (SEEC) γ.

The MgO is currently prepared by electron beam (e-beam) evaporation method [3]. But some problems are shown in the MgO deposited with the e-beam evaporation. It's said that the ion beam assisted method was appropriate to deposit MgO for a protective layer for ac-PDPs [4-8]. In the paper, we have studied the structural and discharge characteristics of the MgO prepared by oxygen ion beam assisted deposition (IBAD) to improve the discharge characteristics of ac-PDPs .

Experimentals and Results

The MgO thin films were deposited by the IBAD method. Figure 1 shows the schematics of the IBAD system. The e-beam is used to evaporate MgO (99.99%). The base pressure was 3×10^{-6} torr and the working pressure was 1.6×10^{-4} torr during the deposition with oxygen ion beam assistance. The oxygen (99.99%) flow rate was 10 sccm. The oxygen ion was produced by the RF ion source and carried out by the ion gun. The power of the RF ion source for generation of the oxygen ions was 200 W. The substrate temperature was fixed at 300 ºC during deposition. The energy of the assisting oxygen ion beam was varied from 100 eV to 500 eV by controlling the acceleration voltage of the grid electrode consisting of the ion source. The deposition rate was controlled by 5Å/sec, and the deposition thickness was about 5,000Å.

Figure 2 shows the XRD spectra of the annealed MgO film. The MgO deposited by e-beam evaporation without assisting oxygen ion beam has (111), (200) and (220) preferred orientation. The MgO prepared with IBAD have weak peak (111). The (200) peak was disappeared at the energies between 100 eV and 300 eV, and it began to appear at the energies above 400 eV. On the other hand, the (220) peak height was manifest between 100 and 300 eV and again decreases with the ion beam energy increasing above 400 eV. It may be the preferred orientation transition from (220) to (200) in order to produce a stable orientation as a result of increase of kinetic energy of the oxygen ion. Figure 3 shows AFM images of the MgO film. The fine needle-shaped grain growth occurs on the surface of the substrate, which was prepared with assisting ion beam energy of 300 eV, as shown in Fig. 3(d). However, with the increase of assisting ion beam energy, the mountain-shaped crystallite structure comes out as shown in the Fig. 3(e), (f) as a result of aggregation of gains.

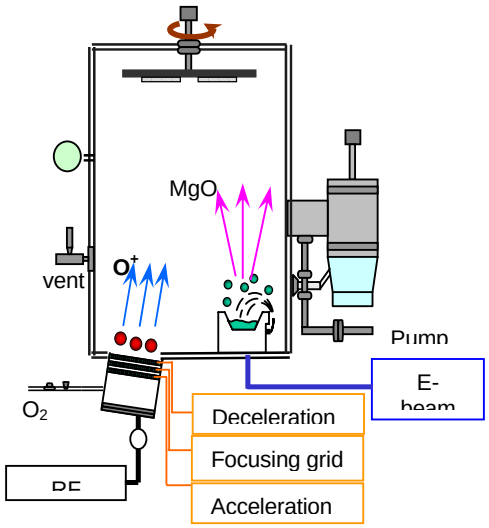

Figure 1. Set up for the ion beam assisted deposition (IBAD) of MgO film.

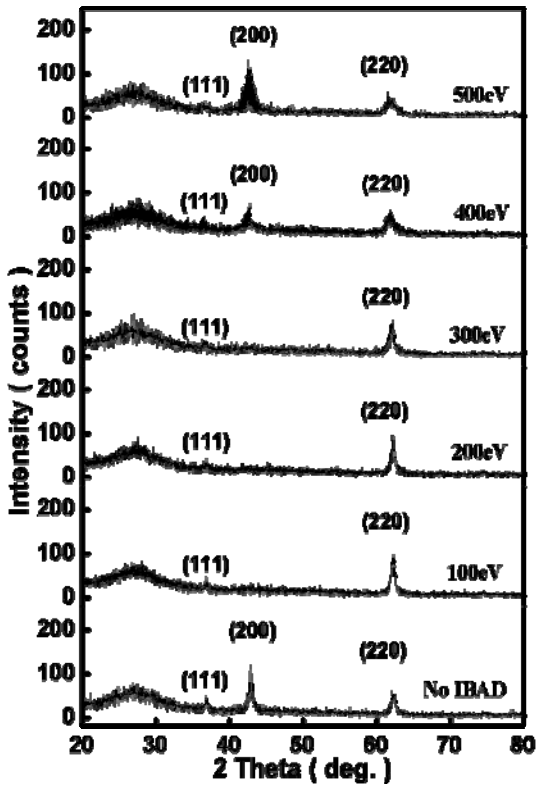

Figure 2. XRD spectra of MgO versus acceleration voltages.

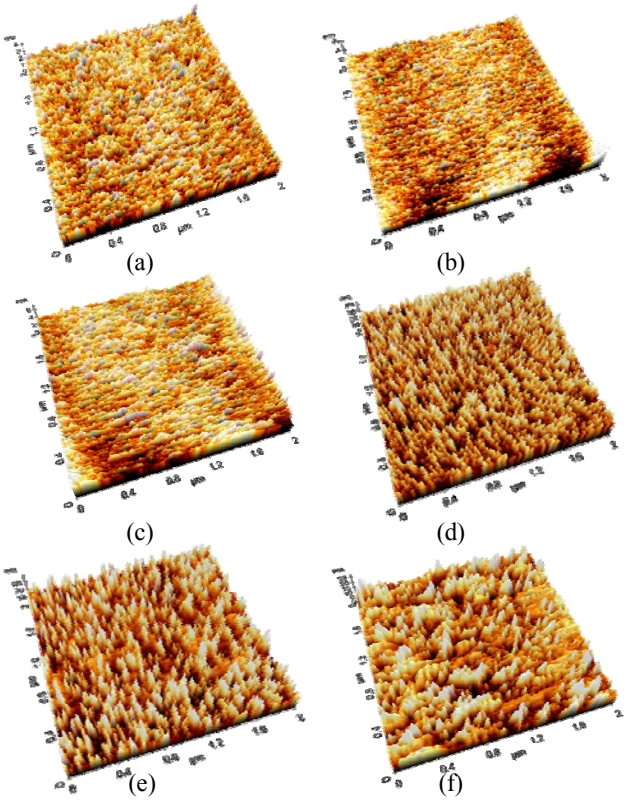

Figure 3. AFM images of MgO versus acceleration voltages (a) No IBAD, (b) 100eV, (c) 200eV, (d) 300eV, (e) 400eV, (f) 500eV**.**

In order to investigate the electrical and optical characteristics of ac-PDP depending on the assisting energies of the oxygen ions, operational PDPs were fabricated. The PDP panel in our study is composed of two glass substrates. The glass plate has a size of 6 cm × 9 cm and a thickness of 2.8 mm. The size of effective luminescent area is 3.5 cm × 3.5 cm. All the processes were done using a photo aligner, a screen printer, a furnace, and an in-vacuum sealing and characterization system, etc. installed in a clean room. For the front panel, bus electrodes were printed on the ITO-patterned glass using screen printing method, and then dielectric layer was printed over the bus electrodes with a thickness of about 24 μm, and then MgO layer was deposited using an e-beam evaporator on the dielectric layer with a thickness of 5,000Å. The deposition rate was fixed at 5Å /sec with a substrate temperature of 300 °C. For the rear panel, address electrodes were first printed on the glass substrate, and the dielectric layer, of which thickness is about 24 μm, was printed over the address electrodes, then the barrier ribs with a height of 120 μm were printed on the dielectric layer using screen printing method, and finally the phosphor layer was printed between the barrier ribs.

For measuring the PDP characteristics, the front glass plate and the rear glass plate were placed into a vacuum chamber, facing each other with a gap distance given by the barrier ribs. The chamber was evacuated to 1×10^{-6} torr using a turbomolecular pump. The Ar gas was filled up to 250 torr and the panel was annealed at 300 °C for 1 hour. After annealing, the chamber was again evacuated to the base vacuum level of about 1×10^{-6} torr at room temperature. After evacuation, the gate valve of the turbomolecular pump was closed and the gas mixture of Ne with 4% Xe was introduced into the chamber until the gas pressure indicated by a pressure gauge was reached to 400 torr. Driving pulse voltages were supplied to sustain (X) and Scan & Sustain (Y) electrodes of the front glass plate. Address (Z) electrodes of the rear glass plate were maintained at ground level. The frequency of the rectangular pulses was 50 kHz and the width of the pulse was 3.0 μs. The discharge current including displacement current was measured using a current probe (TCP-A312) and luminous efficiency was measured using a chroma-meter (CS-100A).

The firing inception voltage (V_f) and the sustaining voltage (V_s) are shown in the Fig. 4. The firing voltage V_f) is defined as the applied voltage between the electrodes X and Y when the first cell turns ON. The sustain voltage(V_s) is defined as the voltage when the first cell turns OFF. The minimum V_f is obtained when assisting ion beam energy is 300 eV and then increases with the assisting ion beam energy increasing. The brightness of the samples deposited with assisting ion energy of 300 eV was higher than others.

We also measured the discharging current with the current probe and calculated the luminous efficiency with the following equation:

$$\eta = \frac{\pi \times B \times S}{\int_0^T v(t) \times i(t) dt \times F} \quad (1)$$

where, π is 3.14, B is the brightness, S is the discharge area of the panel, *v(t)* is the discharging voltage, and *i(t)* is the discharging current, F is the frequency of the discharging voltage.

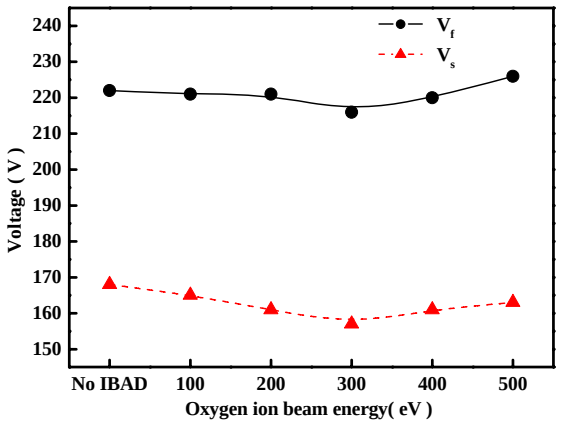

Figure 4. Discharging voltage characteristics of the MgO thin films as a function of assisting ion beam energy.

The luminous efficiency is shown in the Fig. 5 as the function of the assisting ion beam energy. The highest luminous efficiency was obtained when the assisting ion beam energy is 300 eV. The luminous efficiency increases with increase of the assisting ion beam energy from 100 eV to 300 eV, which is more than the No IBAD. However, the luminous efficiency is lower than the No IBAD when the assisting ion beam energy is over 400 eV.

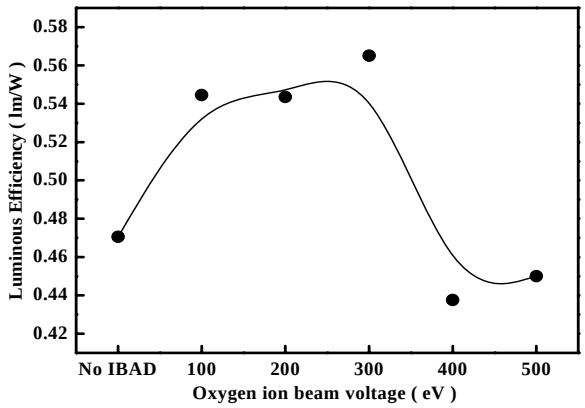

Figure 5. Luminous efficiency of each sample deposited by the IBAD method with different assisting ion beam energy.

MgO layer has an important properties in lowering the firing voltage due to a high secondary electron emission coefficient. The secondary emission of a dielectric surface exposed to a discharging gases may be analyzed by the ion-induced emission process modeled by Auger neutralization. As an ion with ionization energy E_i approaches the insulator surface, it undergoes a neutralization process whereby one electron in the valance band of the insulator is captured by the ion. The energy gained by this neutralization process is simultaneously used to excite a second electron to a higher energy level. If it exceeds the surface barrier energy ε_o, the excited electron can escape from the surface and becomes a secondary electron.

In the respect of our results, the (200) or (220) preferred orientation of the MgO insulator, and the smoother surface can be contributed to the higher secondary electron emission by modifying the work function and the surface states According to research by by Y. Motoyama [9], secondary electron emission by low-velocity Xe^+ ions occurs principally by the Auger transitions for the F and F^+ centers of the MgO films. Moreover, M. S. Park et al [10] have reported that the smoother surface of the MgO film increases the intensity of F^+ centers. Therefore, we can conclude that the smoother surface and/or the preferred orientation of the MgO film can induce in the higher secondary electron emission.

Conclusion

In this paper, the MgO thin films were deposited with the oxygen ion beam assisted deposition method. The experimental results suggest that the assisting oxygen ion beam energy has direct effects on the structural and the discharging characteristics of MgO thin films. And the lowest firing inception voltage, the highest brightness, and the highest luminous efficiency were obtained when the assisting ion beam energy was 300 eV. Comparing with the No IBAD, it is considered that the ion beam assisted deposition method is suitable to the MgO thin films deposition with a proper assisting ion beam energy.

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