The Characteristics Depending on the Annealing Conditions in the PDP Vacuum In-line Sealing

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Abstract

This paper deals with the various sealing conditions in a vacuum and the discharge characteristics. The MgO thin film is prepared by e-beam evaporation method. Sealing process was performed in a vacuum at panel temperature of 430 ℃. We find the cracks on the MgO film surface, which results in higher discharge voltage and lower luminous efficiency. The vacuum in-line sealing technology does not require additional annealing process but induces the MgO cracks because of the high temperature sealing cycle in a vacuum. Therefore we modify the vacuum in-line sealing cycle which the MgO cracks are not found and the good characteristics of plasma displays are found in higher sealing pressure at sealing temperature of 430 ℃.

1. Introduction

One of very successful technologies for large-format displays is the plasma display panel (PDP). However, for its further progress in the large-sized display market, it is of great importance to reduce the cost and improve the efficiency. Among the issues for reducing PDP fabrication cost, sealing process has a lot of room for improvement. A PDP composed of two glass plates are generally filled with a mixture gas such as Ne and Xe, and driven in a row-column passive-matrix method. Typically, in AC plasma display panels, the electrodes of front panel are coated with glass dielectric layer and then MgO thin films are deposited on the dielectric layer. In the conventional sealing method, first two plates are sealed together by using frit sealing under the atmospheric environment. Then, the panel is evacuated by a diffusion pump through a glass tube sealed to a corner of rear glass plate, of which dimension has typically a few tenths cm in length and a diameter of around 2 mm. After evacuating under baking for a long time, a plasma mixture gas is introduced into the panel and a final tip-off process is done. The total time consumed for the sealing is longer than 15 hours and the obtainable base vacuum level is limited by the pumping conductance mainly attributed from the rectangular nozzle-shaped structure given by the barrier ribs and the closely spaced glass plates. In the PDP panel of 40inch diagonal size with dimensions of 150μm gap between two glass plates and 320μm width between adjacent barrier ribs, it was estimated that the base vacuum level at the panel center was less than 1×10^{-3}torr. The most probable method for obtaining the initial high vacuum level with a minimum sealing process time is the vacuum in-line sealing technology which consists of the sealing of two glass plates within a high vacuum chamber, a filling with a plasma mixture gas, and finally tip-less hole-off. In the previous works[1-3], we have proved the feasibility of the vacuum in-line sealing technology by showing an operational PDP fabricated by the vacuum in-line sealing technology.

In this study, the dependence of the operation voltage and luminance efficiency on the sealing temperature in a vacuum obtained before gas filling was investigated for Ne-Xe gas pressure of 400 torr in a commonly used cell structure. The panel was introduced into a vacuum chamber and driven by a driver circuit interfaced to the chamber via an electrical feed-through. Luminance was observed by using the in-situ measurement from the chroma-meter equipped on the top-side view port. The setup of the vacuum in-line sealing equipments is shown in Fig. 1.

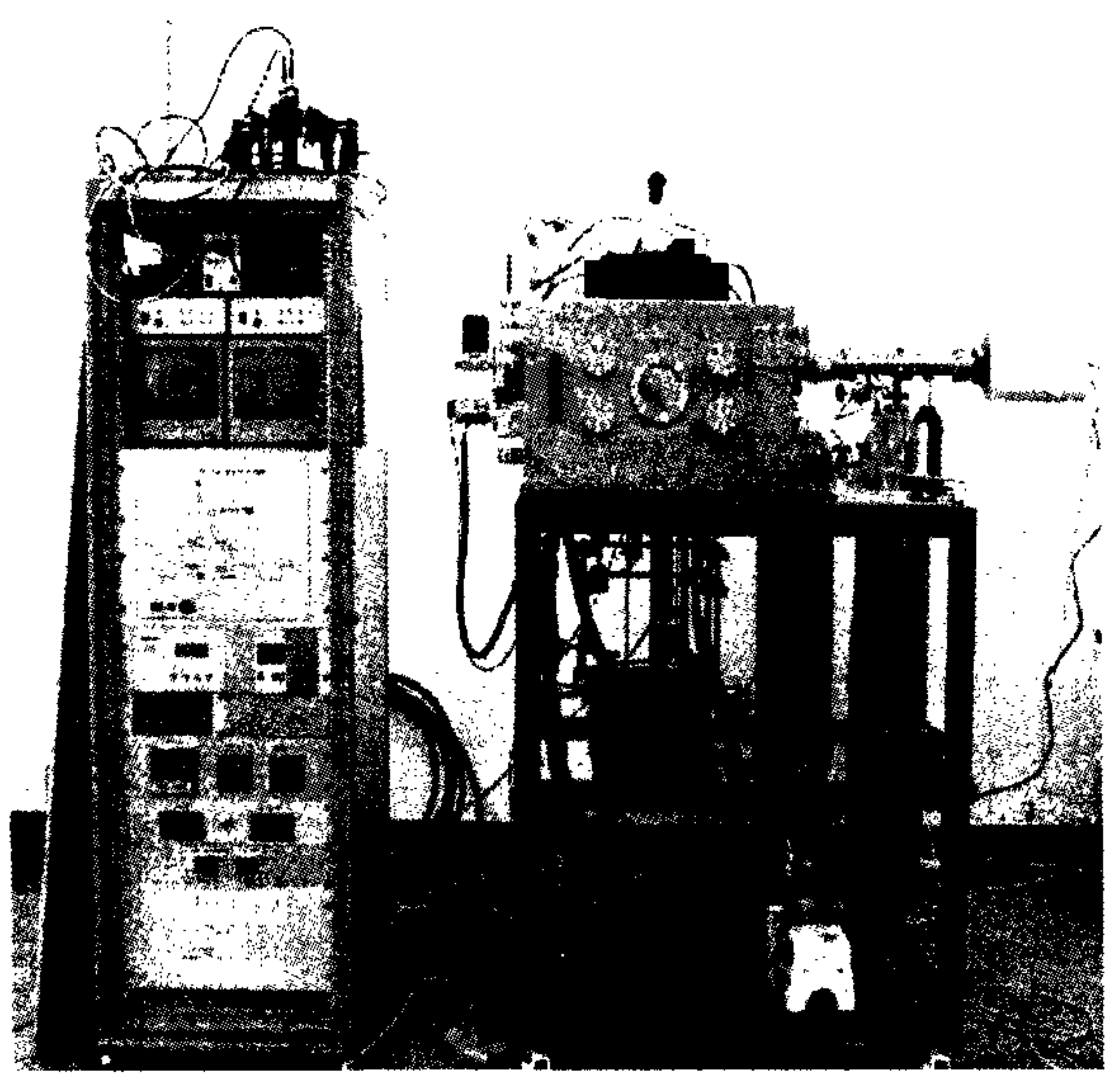


Fig. 1. The setup of the vacuum in-line sealing equipments.

Discharging current and sustain voltage were measured by using oscilloscope and current probe. Fig. 2 shows the biasing system for plasma discharge and measurement for discharging current and sustain voltage.

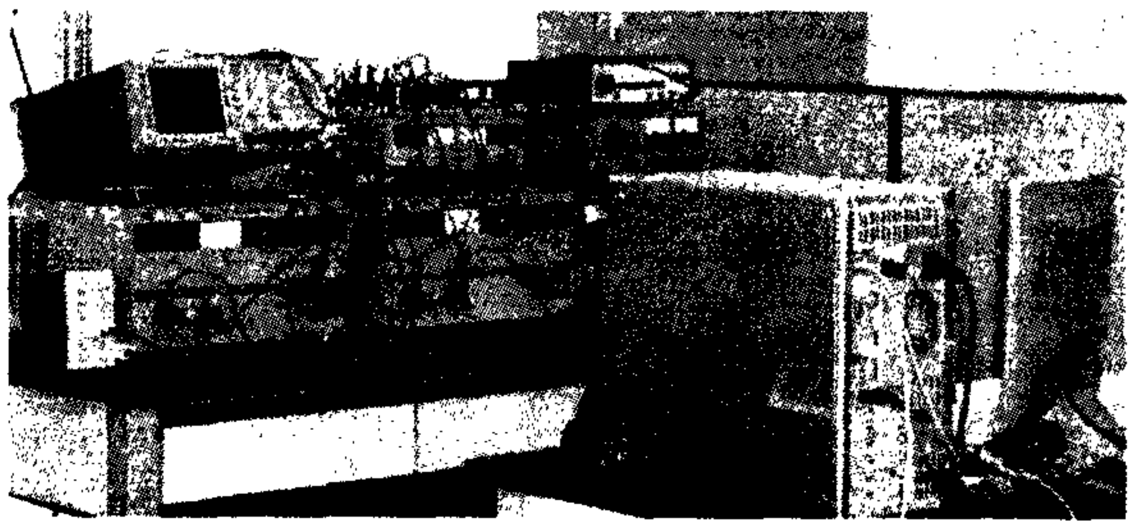


Fig. 2. Biasing and measurement system for plasma discharge.

2. Experimental Procedures

A test panel in our study is composed of two plates of ASAHI glass. The glass plate has a size of 6cm×9cm and a thickness of 2.8mm. The size of active area was 3.5cm×3.5cm.

At the front panel, the bus electrodes was printed on the ITO patterned glass by screen printing method, and the dielectric layer (which the thickness was approximately 24μm) was printed on the bus electrodes, and the last, MgO layer (which the thickness was 5,000Å) was deposited on the dielectric layer.

At the rear panel, the address electrodes was printed on the normal ASAHI glass, and the dielectric layer (which the thickness was approximately 24μm) was printed on the address electrodes, the barrier ribs (which the height was approximately 120μm) were printed on the dielectric layer, and the last, the phosphor was printed on the barrier ribs.

For the panel discharging, the front panel and rear panel were loaded into a vacuum chamber, facing each other with a gap of 200μm. A high vacuum level was obtained by using a turbomolecular pump, the base vacuum level before plasma gas filling was 6×10^{-7}torr, and the discharge gas was mixed with Ne and Xe(4vol%) to 400torr.

The experiments were performed for the difference between the annealing process and the non-annealing process, and the sealing process was measured for the finding the difference of the annealing process.

In the annealing process, the process was performed at the panel temperature of 320℃ for about 2hrs. After the panel cooling, the sustain voltage, discharge current, and the brightness was measured.

In the sealing process, the process was performed at the panel temperature of 430℃ for the panel sealing for about 1hr, and then the hole-off process was performed at the panel temperature of 320℃ for about 40mins. After the panel cooling, the sustain voltage, discharge current, and the brightness was measured.

In the measurement process, AC driving pulses were supplied to the bus electrodes of the front panel through the electrical feed-through, and address electrodes of the rear panel were maintained the ground level. Frequency of the driving pulse was 50kHz and sustain voltage amplitude was variable. Finally, the brightness and discharge current in case of each sustain voltages was measured by TDS-540C the oscilloscope and CS-100A the colorimeter for calculating the luminance efficiency.

As the first experiment, the annealing process was not performed and the plasma gas was introduced into the panel when the base vacuum level of the chamber arrived at 6×10^{-7}torr. We applied an AC pulse voltage with frequency of 50kHz between the front electrodes. The firing voltage (full cells were turned on) and sustain voltage (first cell was turned off) were measured, then the brightness and discharge current were measured from the sustain voltage upto the firing voltage with a step of 10V.

The second experiment was performed at a base vacuum level of 6×10^{-7}torr, the panel was annealed at panel temperature of 320℃ for about 2hrs, and then the plasma gas was introduced into the panel. The characteristics are measured at same conditions as the first experiment. Then we performed the sealing process at a base vacuum level of 6×10^{-7}torr and the panel temperature of 430℃ for about 1hr, and hole-off process at 320℃ after discharge gas filling process.

The measurements for finding the difference between the first experiment and the second experiment was performed by measuring the discharge current and the brightness in every differential sustain voltage, and then the luminance efficiency was calculated using the discharge current and the brightness.

3. Results and Discussion

For the first time, we wanted to know the luminance efficiency difference between the annealed panel and the non-annealed panel, however, in the sealing process the MgO cracks were found, and due to the cracks, the luminance efficiency was more decreased.

Fig. 3 and Fig.4 show the MgO cracks measured by SEM (Scanning Electron Microscope) and optical microscope.

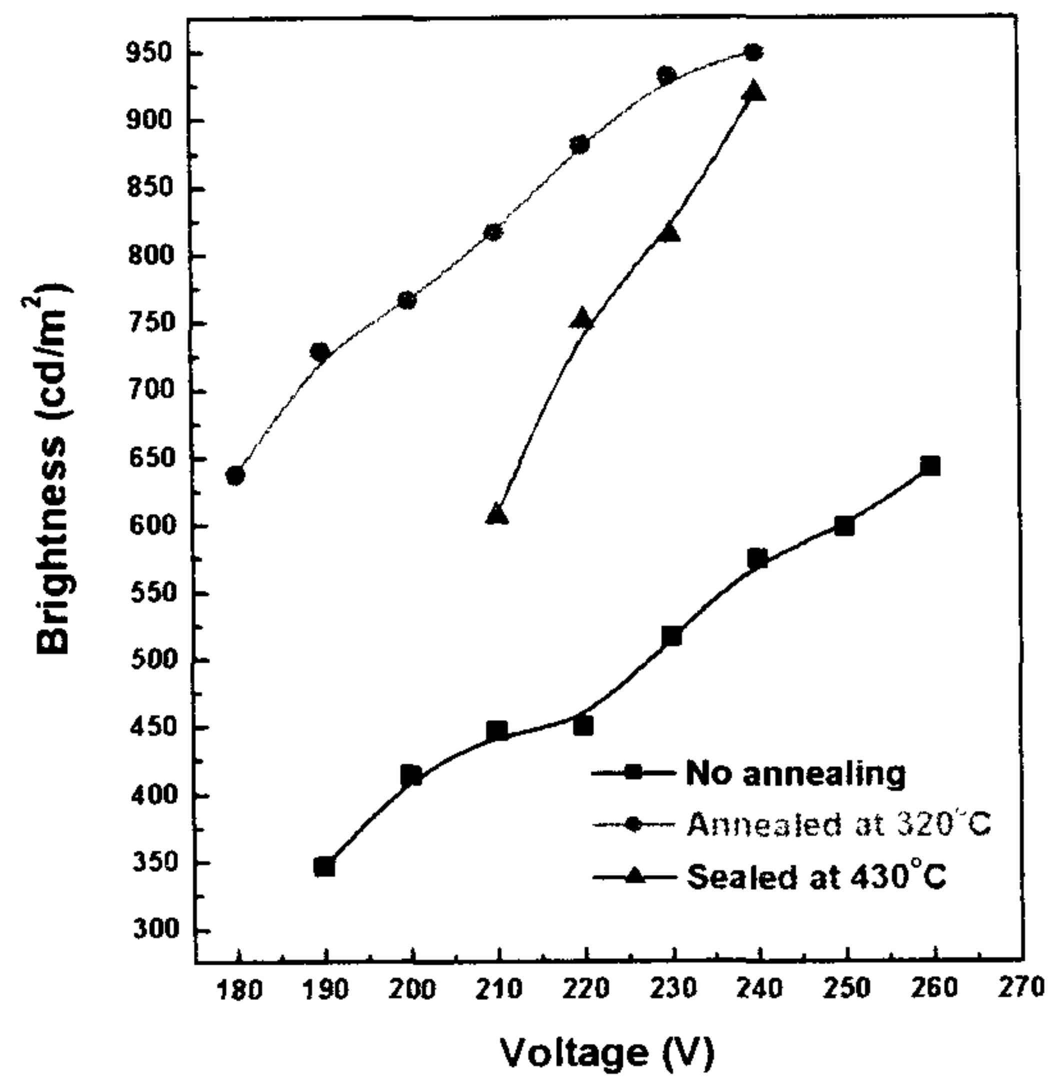
Fig. 4. The photo of the MgO cracks at the panel temperature of 430℃.(optical microscope. ×50)

Fig. 3. The photo of the MgO cracks occurred by dielectric softening at sealing temperature of 430℃. (SEM view)

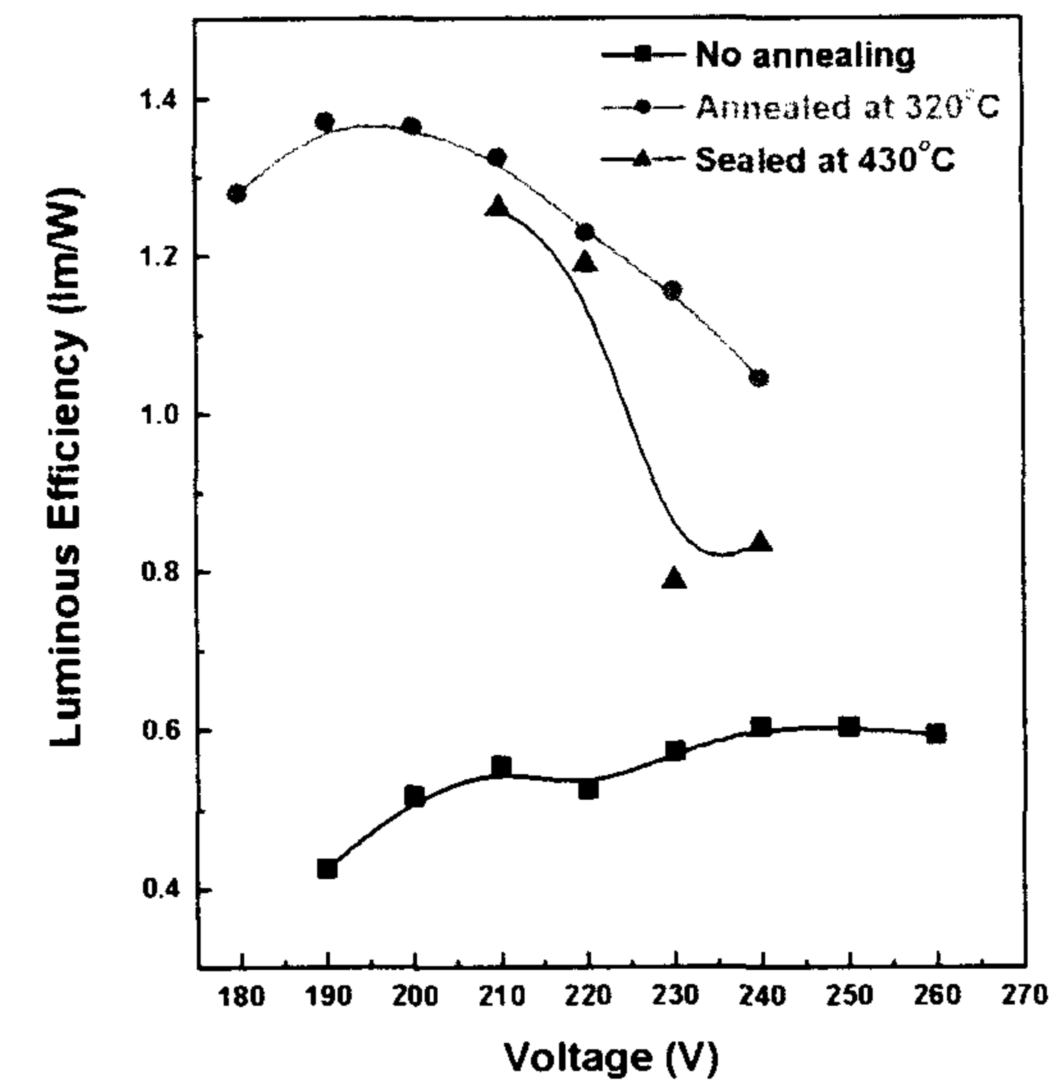
In this experiment, we found that MgO cracks were occurred during annealing at 430℃ under a vacuum environment, which could reduce the efficiency [4]. Fig. 4 shows that the MgO cracks occurred by a dielectric softening.

At the annealed panel, the luminance efficiency was more increased than the non-annealed panel, however, at the panel that performed the sealing process, the luminance efficiency was more decreased than the annealed panel. The comparisons of the characteristics between each panel are shown in Fig.5.

As shown in the figures, the panel performed the annealing process was the better characteristic than the panel performed the sealing process. We think that the characteristic difference may be caused by the MgO cracks in the vacuum in-line sealing process.



(a)



(b)

Fig. 5. The characteristics depending on the annealing conditions in a vacuum chamber.

(a) brightness, and (b) luminous efficiency

We have found that the vacuum in-line sealing cycle have to be modified for good characteristics. For better characteristic sealing, we may use the lower temperature sealing process by using auxiliary heating line technology.

4. Conclusions

We have found the MgO affect to electrical characteristics of plasma displays, and the major critical problems for the vacuum in-line sealing by the MgO cracks, and we guess MgO was cracked by high sealing temperature in a vacuum. So, applying an auxiliary heating line technology to seal the plasma displays will be able to avoid MgO cracks.

5. References

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