Electrical and Optical Characterization of the Vacuum In-Line Sealed PDP Panel

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Abstract

By using vacuum in-line driving and photoluminescence measuring method, we have observed the electrical and optical characteristics of the vacuum in-line sealing technology and analyzed the effect of the base vacuum level before filling the plasma gas. In the case of base vacuum level of 1×10^{-3}*torr, the firing voltage of a 2-inch diagonal PDP panel was ranged from 310 to 345V depending on the plasma gas pressure of 200 to 300torr and luminous efficiency was ranged from 0.0227 to 0.0367 lm/W depending on the input voltage level of 330 to 225V. While, in the case of* 1×10^{-6}*torr, the characteristics were significantly improved. As a results, the firing voltage was ranged from 295 to 318V and luminous efficiency was from 0.0278 to 0.0451 lm/W.*

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 Xe and Ne, and driven in a row-column passive-matrix method. Typically, the front glass plate contains the components such as ITO electrodes, bus electrodes, an insulation layer, and a MgO layer. The rear glass plate contains the components such as address electrodes, reflecting layer, barrier ribs, and phosphor layers. In the conventional sealing method, first two plates are sealed together by using frit sealing under the atmospheric environment. Then, the panel is pumped 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 pumping 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 40 inch 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[5, 6], 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 on the base vacuum level obtained before gas filling was investigated for several Xe-Ne gas pressures 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 luminance colorimeter equipped on the top-side view port.

2. Experimental Apparatus

An test panel in our first study is composed of two plates of asai glass. The glass plate has a size of 6cmx9cm and a thickness of 2.8 mm. The size of active area was 3.3cm×3.3cm.

First of all, the front glass plate and rear glass plate are loaded into a vacuum chamber, facing each other with a gap distance of 200μm. A high vacuum level was obtained by using a turbomolecular pump. The base vacuum level before plasma gas filling was controlled by pumping and/or an intentional leaking through a leak valve.

First, we have tried to observe the electrical and optical characteristics at a base vacuum level of 1×10^{-3}torr. Once this vacuum level was arrived, a gate valve of turbomolecular pump was closed and the mixture gas of Ne with 4% Xe was introduced into the chamber until the gas pressure indicated by a pressure gauge was arrived at a given pressure. In this experiment, the gas pressure was varied from 200 to 400torr with every 50torr increase. In order to obtain the equilibrium gas pressure between two glass plates consisting of the PDP panel, a waiting time was given for 10min at this pressure.

Driving pulses were supplied to the X and Y electrodes of the front glass plate and address electrodes of the rear glass plate were maintained the ground level circuit through electrical feed-through. Frequency of X and Y pulses was 11kHz and positive width of the pulse was 7.3μsec. and the amplitude was varied depending on the conditions.

Second, we have repeated the same procedures for a base vacuum level of 1×10^{-6}torr and compared with those of 1×10^{-3}torr.

Figure 1 shows the system set-up for the vacuum in-line sealing and in-line characterization. The heating of two glass plates is done by using an infrared light source consisting of tubular heating arrays. After arriving at the critical temperature, the two panels put into contact by using positional controls, that is, the lower glass plate is moved up via a x-y-z manipulator until it touches the upper glass plate. The manipulator gives a large enough press to seal two plates. Alignment system with two CCD camera views was equipped. The PDP panel loaded on the stages inside the vacuum chamber is shown in Fig. 2.

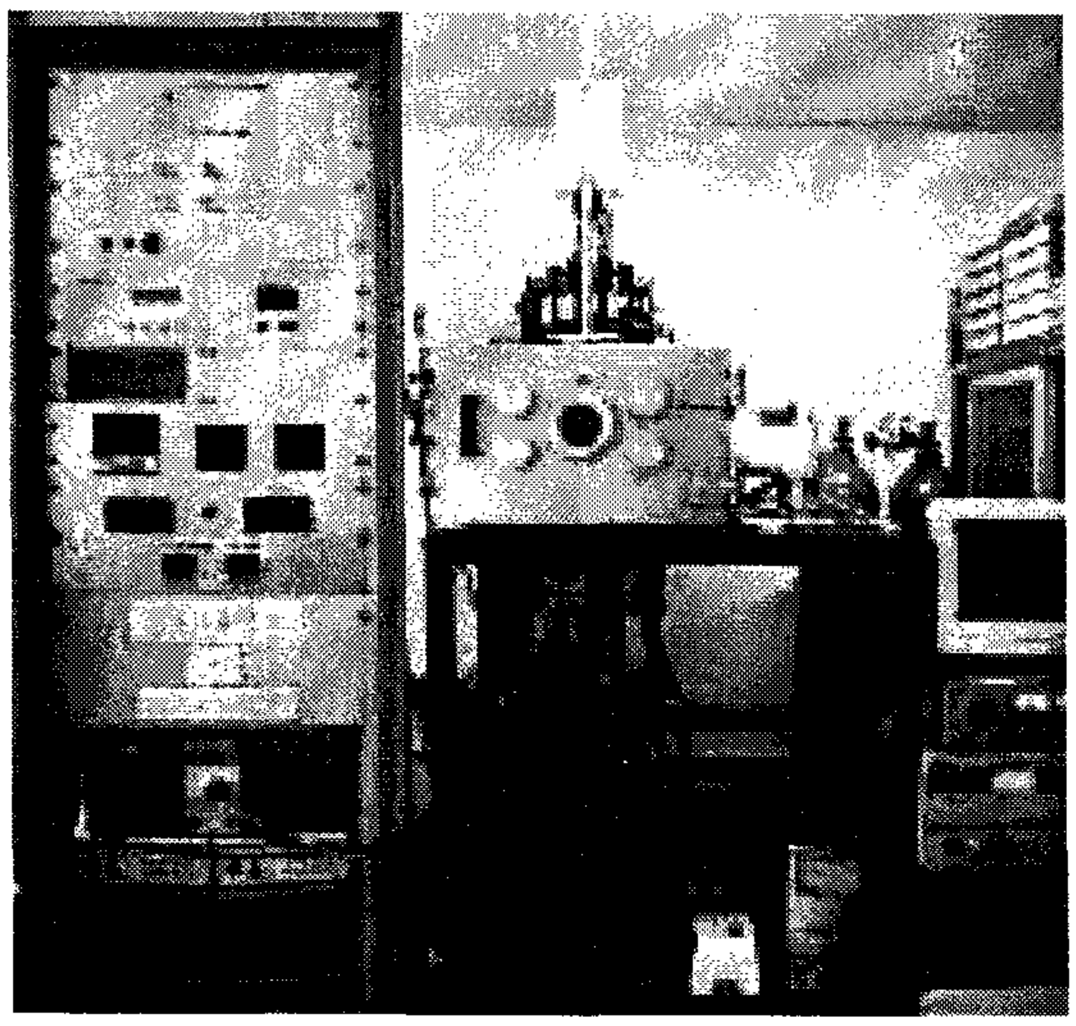


Fig. 1. System for the vacuum-in line sealing and the in-line characterization of PDP.

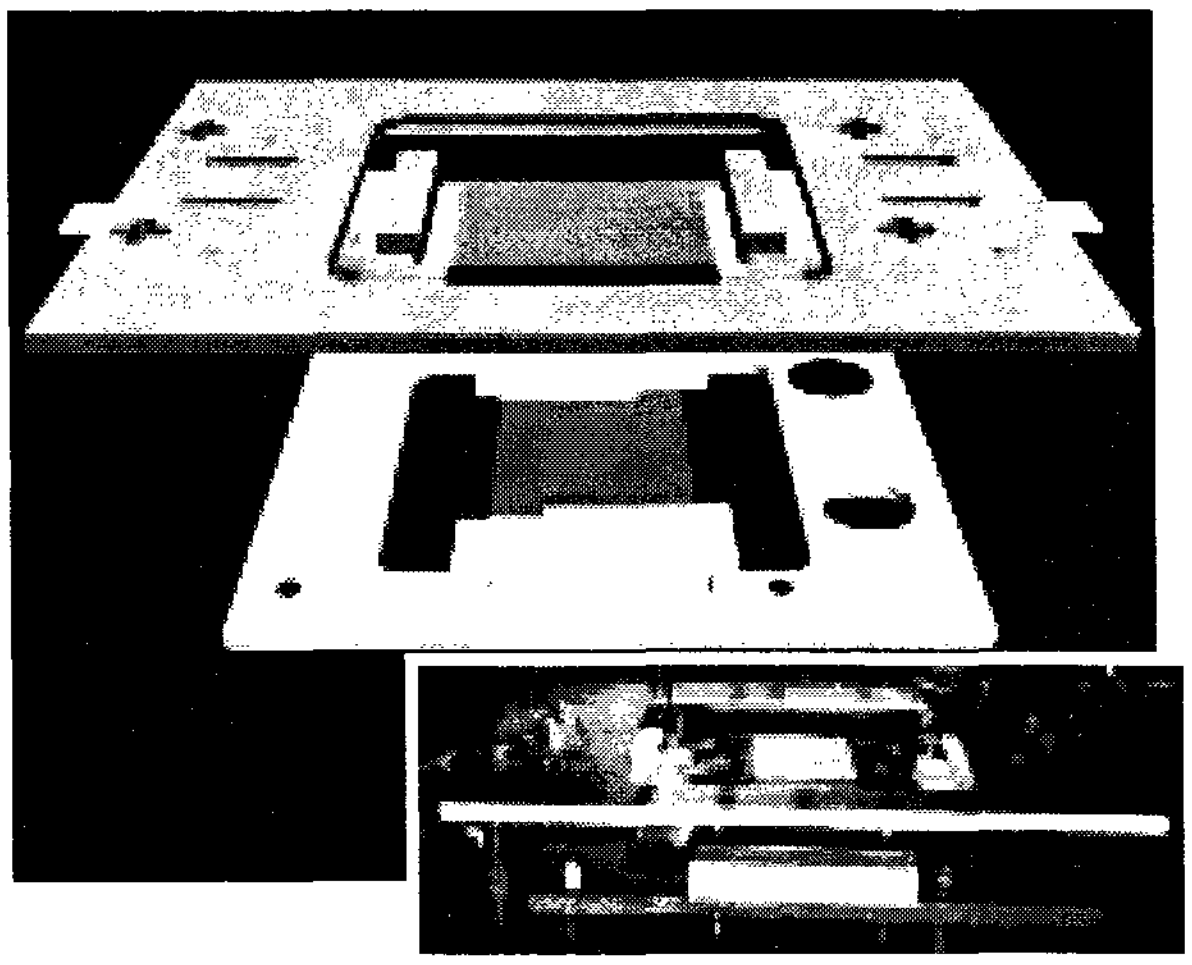
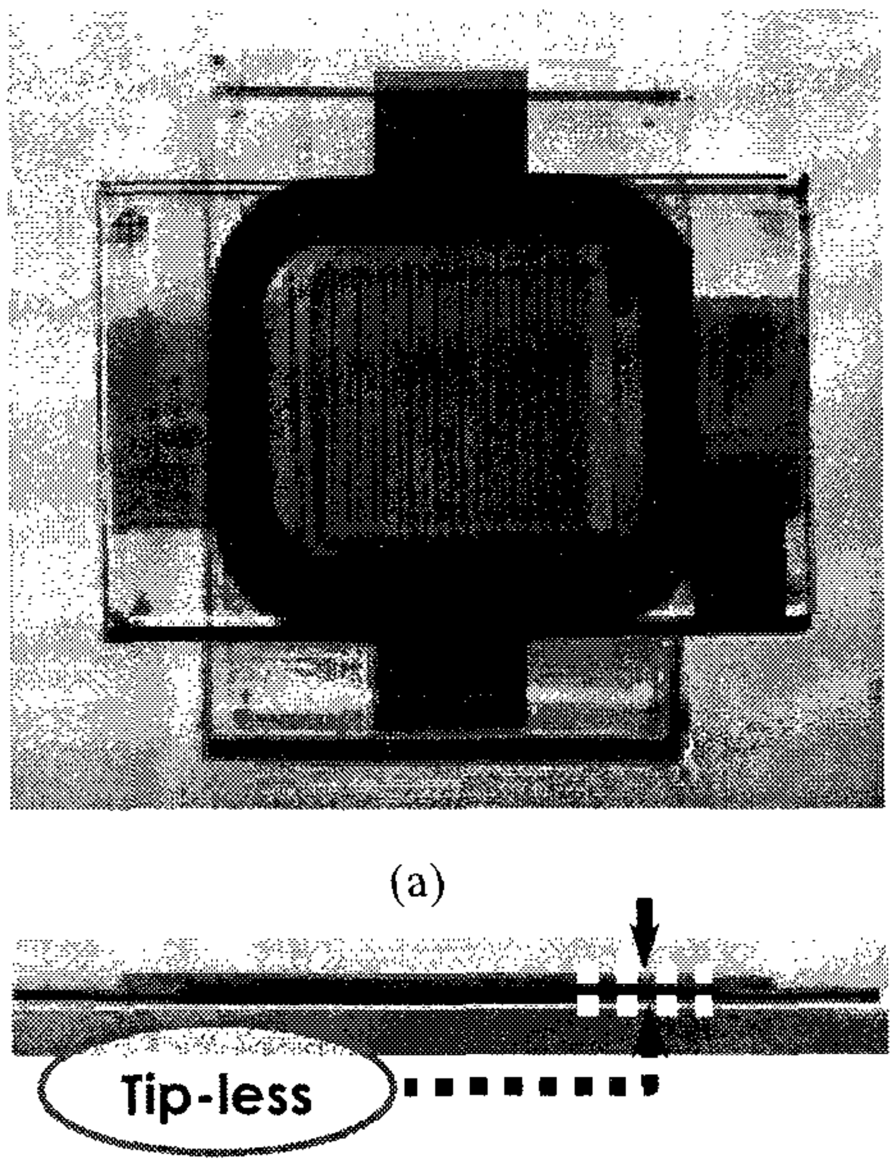


Fig. 2. PDP panel loaded into the vacuum in-line sealing and characterization chamber.

The tubeless-type PDP panel fabricated by using this vacuum in-line sealing technology is shown in Fig. 3. A comparison in the sealing process cycles between a conventional and the newly developed vacuum in-line method is shown in Fig. 4. The figure notes that the total sealing time and temperature cycles could be prominently reduced in the case of the vacuum in-line sealing method.



(a)

(b)

Fig. 3. An operational tubeless-type PDP panel sealed by using the vacuum in-line sealing technology : (a) front-view and (b) side-view.

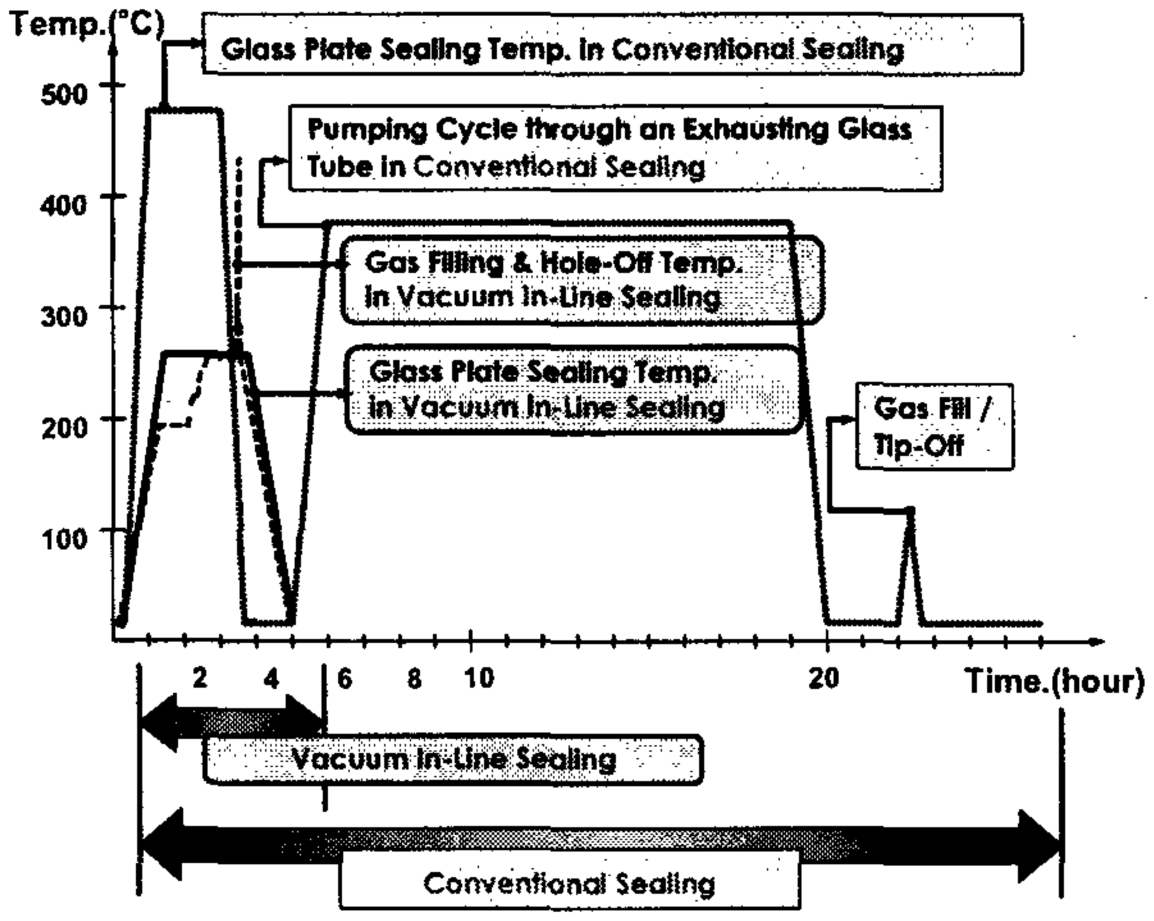


Fig. 4. Comparison of the sealing temperature cycles between a conventional and the newly developed vacuum in-line method.

3. Results and Discussion

As a first experiment, the plasma gas was introduced into the panel when the base vacuum level of the chamber arrives at 1×10^{-6}torr. The firing and minimum sustaining voltages for plasma ignition were measured depending on the plasma gas pressure which is shown in Fig. 5.

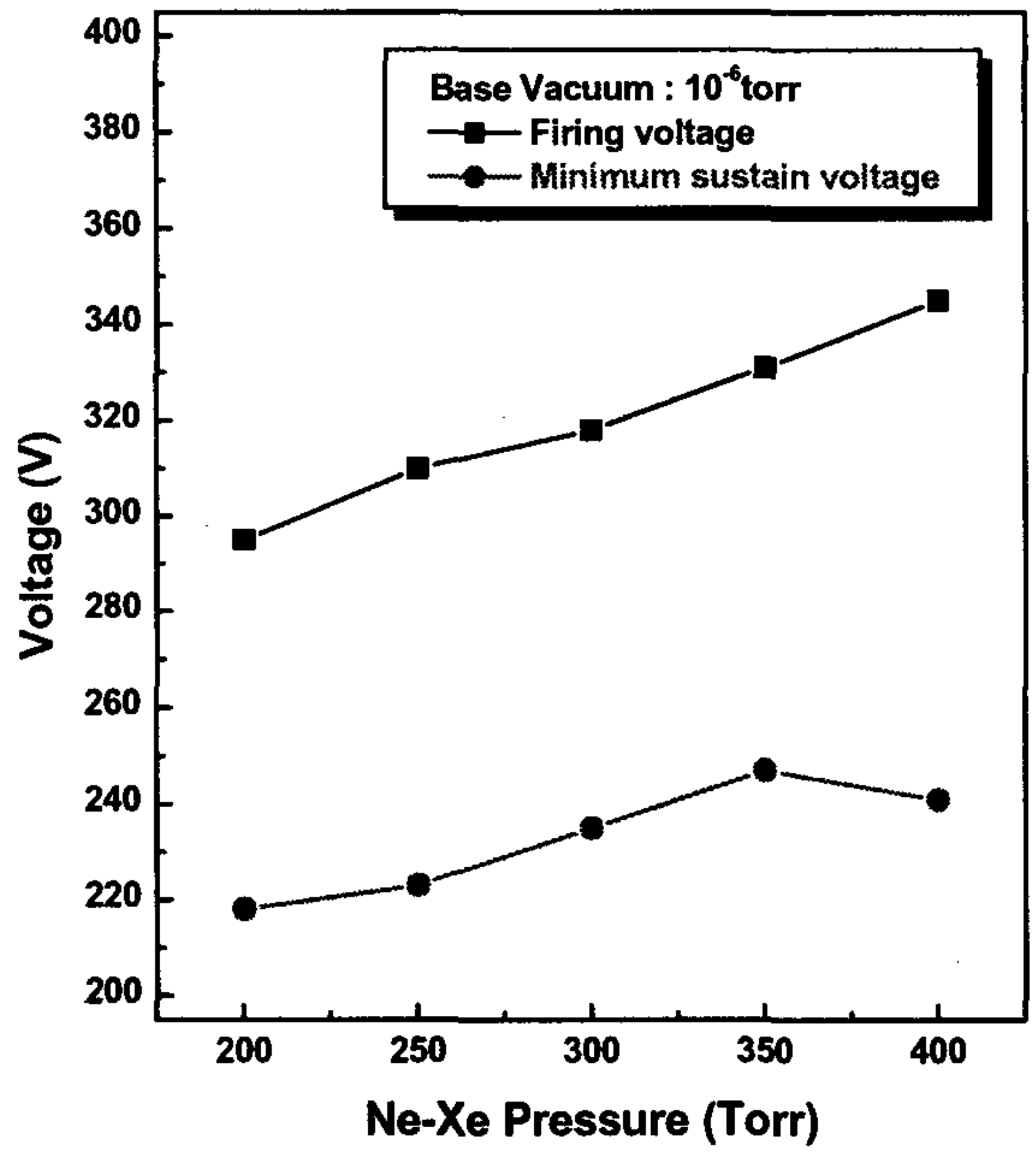


Fig. 5. Firing and minimum sustaining voltages depending on the plasma gas pressure when the base vacuum level was 1×10^{-6}torr.

As shown in the figure, the firing voltage increased from 295 to 345V and the sustaining voltage from 218 to 241V as the pressure increased from 200 to 400torr with every increase of 50torr. For the second experiment at a base vacuum level of 1×10^{-3}torr, the plasma gas was evacuated and the chamber was vented. Again, the chamber was pumped until the vacuum level arrived at 1×10^{-3}torr. Subsequently, plasma was introduced and the driving pulses were supplied after a proper holding time of 10min at the given pressure. The measured firing and sustaining voltages were shown in Fig. 6. Compared to the results at 1×10^{-6}torr, both voltages were increased. As shown, the firing and sustaining voltages ranged from 310 to 345V and from 212 to 240V respectively, as the gas pressure increases from 200 to 300torr.

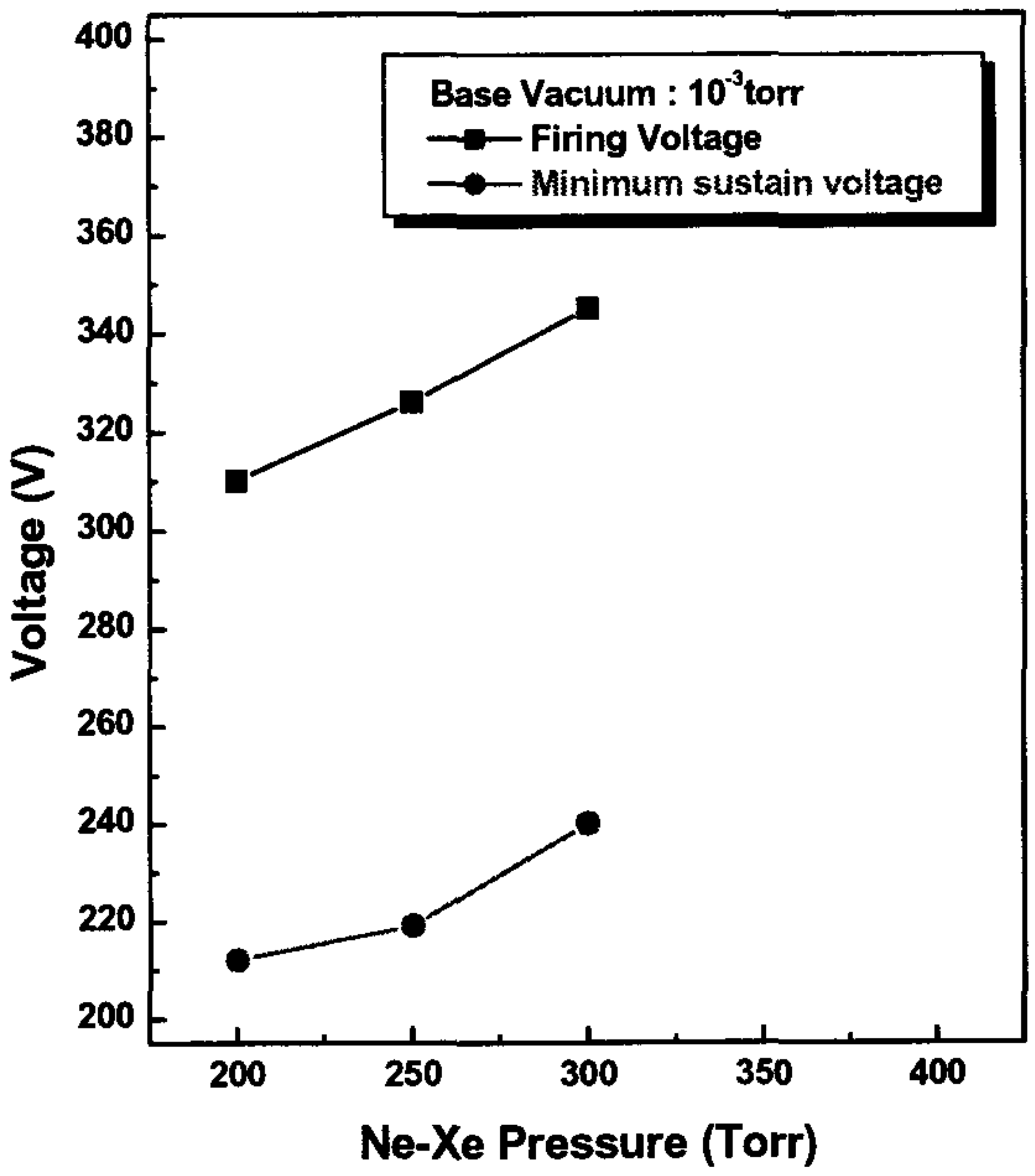


Fig. 6. Firing and minimum sustaining voltages depending on the plasma gas pressure when the base vacuum level was 1×10^{-3}torr.

During the plasma ignition at 255, 285, 330V pulses, luminance was measured by the in-line equipped colorimeter for all the conditions implemented as before. Fig. 7 shows the variation of the firing voltage and the measured luminous efficiency depending on the four different base vacuum levels. We can see that, also in view of the optical effect on the base vacuum level, the better base vacuum level can improve the luminous efficiency slightly as well as reduce the firing voltage significantly.

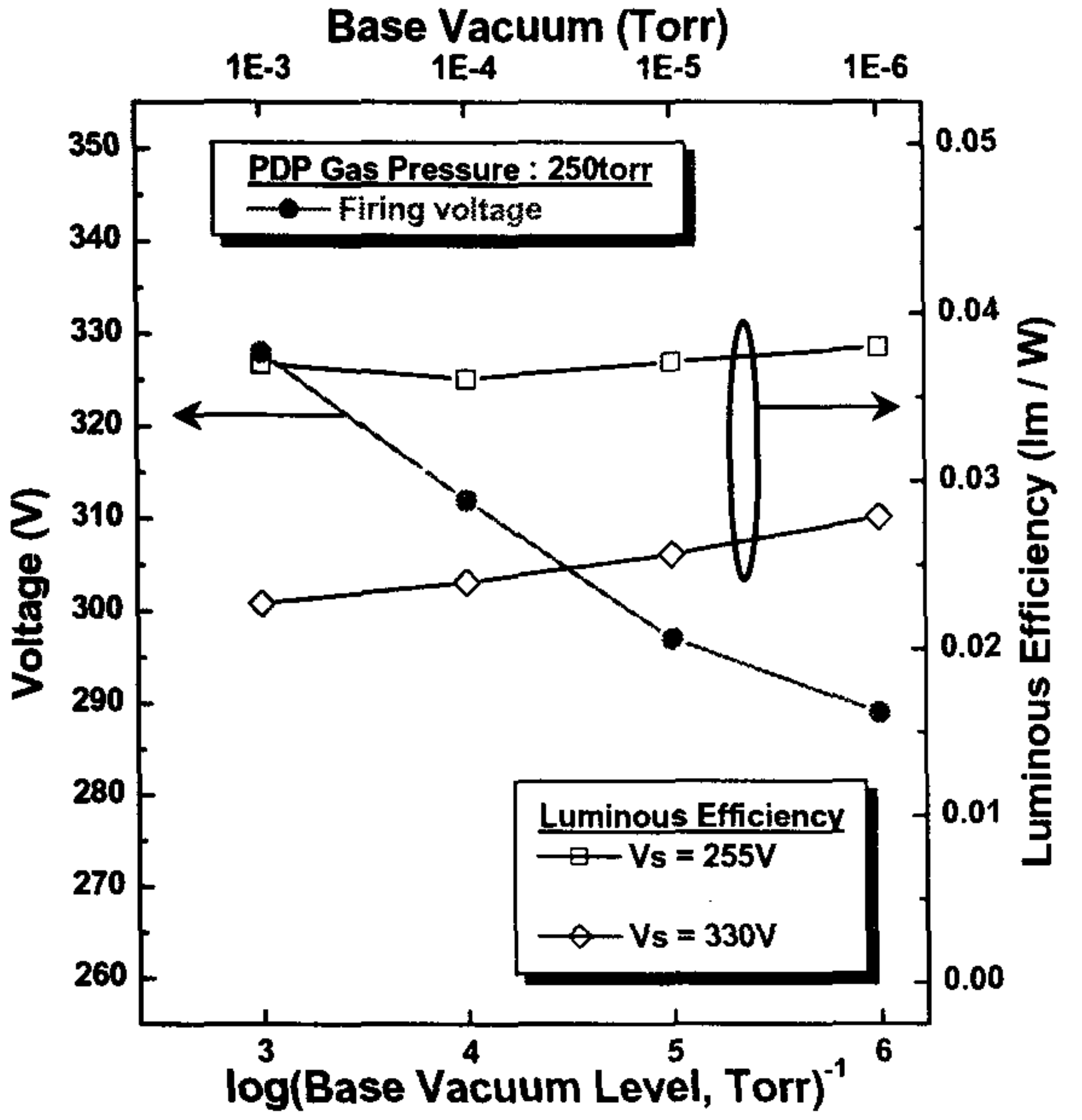


Fig. 7. Luminous efficiency and firing voltage effect on the base vacuum level. The operating pulses were 255, 285, and 330V with a frequency of 11.1kHz.

4. Conclusions

We have observed the effects on the electrical and optical characteristics of the PDP panel depending on the base vacuum level able to be obtained by the pump evacuation before the plasma gas filling. Operating voltages including the firing and the minimum sustaining voltage were significantly reduced as the base vacuum level increased from 1×10^{-3} to 1×10^{-6}torr. In addition, the luminous efficiency was affected by the base vacuum level, that is, although that is small, the better base vacuum level produced the improved luminous efficiency. Those results indicate that, instead of the conventional tabulation furnace sealing, the vacuum in-line sealing technology could ultimately provide the fundamental solution for enhancing the efficiency of the PDP panel due to a pure gas environment as well as the cost reduction effect due to a short sealing time.

5. References

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