The Journal of Korea Vacuum Science & Technology
Vol. 3, No. 1, April 1999, pp. 95~97

High vacuum packaging and vacuum evaluation for field emission display

S. J. Jung, K. J. Woo*, N. Y. Lee, S. Ahn, G. J. Moon*, K. S. Kim* and M. S. Kim*

Flat Panel Research Center Ajou University, 5, Wonchun-dong, Paldal-ku, Suwon 442-749, Korea. Institute for Advanced Engineering,
**Orion Electric Co. Ltd*
(Received February 22, 1999)

Abstract – A 3.12" FED panel was packaged successfully using the anode plate on which phosphors and black matrix were coated and cathode plate containing emitter arrays. The vacuum level of the panel was investigated during panel evacuation, tip-off and getter activation process. The packaged panel exhibited vacuum level below 2×10^{-6}Torr. Similar experiments were carried out for 10" panel made of bare plates. In addition, the vacuum level of two panels was compared continuously after tip off process; one with the getter and the other without it.

Keywords: FED, Vacuum Packaging, Vacuum Evaluation, Spinning Rotor Gauge (SRG)

I. Introduction

FED packaging process has many key technologies, i.e., spacer, face and base plate alignment, sealing, high vacuum evacuation and getter process, and the reliability of FED panel depends on these technologies ultimately [1].

The most important thing for the lifetime of the panel is the vacuum level. If the panel pressure is not good enough, the accelerated electrons from the cathode to the anode ionize the gas in the panel. Therefore, the ionized gas may cause sputtering and chemical reaction with the materials in the panel and arcing in the worst case.

In spite of the importance of the pressure of panel as mentioned above, it was difficult to improve the package process to get good pressure of panel because there is no easy way to measure the panel pressure [2].

In this paper, Spinning Rotor Gauge (SRG) is introduced to measure the pressure of FED panel and the change of panel pressure is successfully measured during package process [3, 4].

II. Results and Discussion

Fig. 1 shows the schematic diagram of the pressure evaluation system with the SRG used in our laboratory. The pressure data of the panel measured by SRG is transmitted to the computer via RS 232 port of the SRG with the pressure data of the chamber. Also, we developed the data acquisition program for this system and could easily get the useful graphic data from it.

Fig. 2 shows the schematics of experimental panel. The SRG sensor used in this experiment was made by our own method in laboratory. The position of SRG sensor is opposite corner against an exhaust hole to measure the worst vacuum data in the panel during the evacuation process.

Fig. 3 shows the pressure change of 3.12" and 10" panels during a room temperature evacuation with the change of the chamber pressure. The 3.12" panel contains spacers, phosphors, black matrix and emitter arrays, but 10" panel contains only spacers. The spacers were printed with the height of 200 μm.

As we can see in the figure 3, the pressures of 3.12" and 10" panels didn't drop below 10^{-5}Torr even though they were evacuated during over 1400 seconds, and were saturated in that pressure. It means that the small amount of gas is continuously degassed from the materials in the panel during the room temperature evacuation. It shows the importance of the high temperature evacuation. In Fig. 3, we can also see that the evacuation speed of 3.12" is lower than that of 10". This implies that the quite

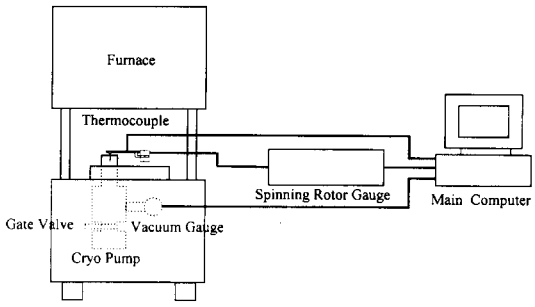

Fig. 1. Schematic diagram of vacuum evaluation system during an evacuation process.

large amount of gas comes out from the FED materials. In Fig. 3, the variation of the chamber pressure of each case is almost same during the exhausting process.

The SRG used in this experiment is mainly used as a standard gauge for the calibration of other high vacuum gauges and can accurately measure the pressure in the range of 10^{-6}~10^{-3} Torr. But the offset value should be considered.

We compared the SRG with the hot cathode ion gauge on the UHV chamber and the result is shown in figure 4. In Fig. 4, (a) shows a difference between the SRG and ion gauge in the range below 10^{-5}Torr. And (b) is an offset calibrated data and it is almost the same with the ion gauge data. From (a), we can find that the offset value is 4×10^{-6} Torr. Offset calibrated data means the data after subtracting offset value from the SRG data.

Fig. 5 shows the change of the pressure of 3.12"

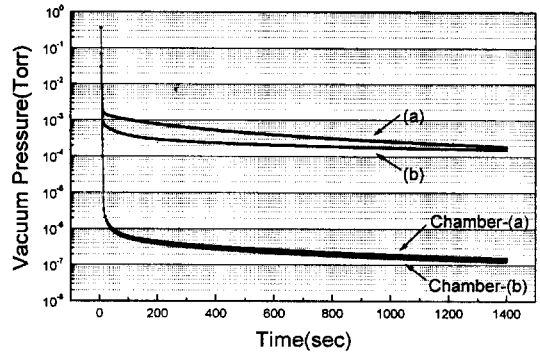

Fig. 3. The change of panel pressure during room temperature evacuation. (a) 3.12" panel(phosphor, black matrix, printed spacer and emitter array), (b) 10" panel(bare glass and printed spacer).

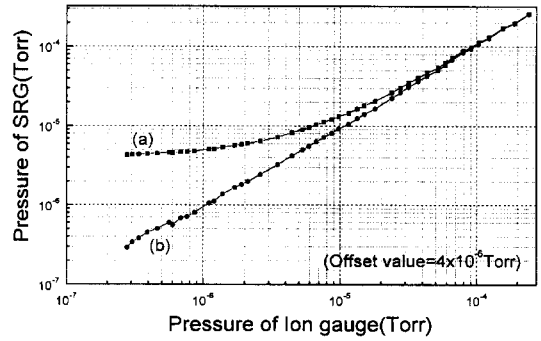

Fig. 4. Comparison of measured values of SRG with the hot cathode ion gauge installed on the UHV chamber. (a) Comparison of measured values of SRG with the ion gauge, (b) Comparison of offset-calibrated value of SRG with the measured of ion gauge.

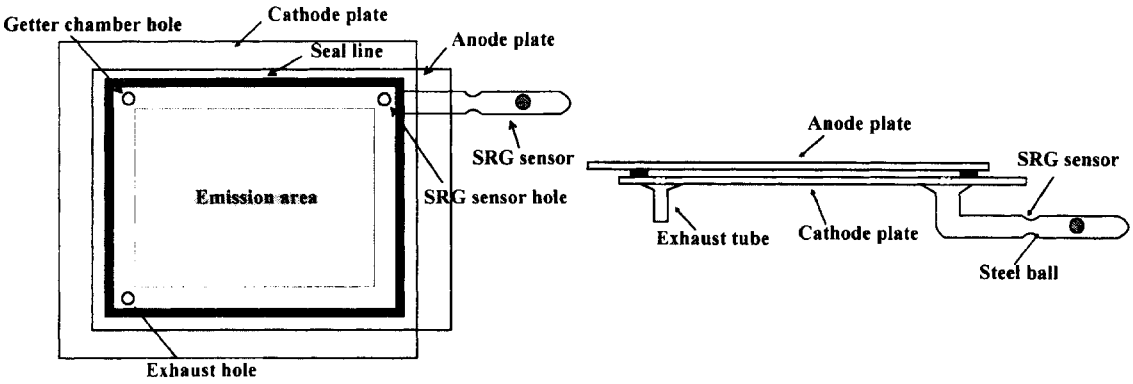

Fig. 2. The schematics of an experimental panel.

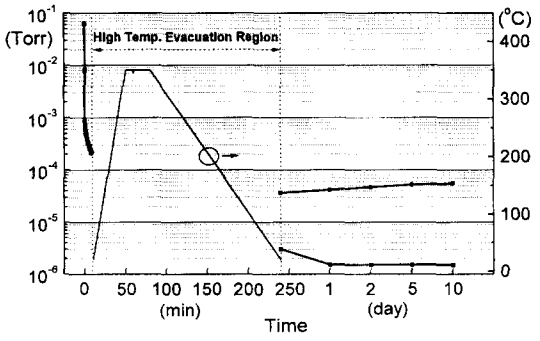

Fig. 5. The change of pressure after high temperature evacuation and tip-off process of the 3.12" FED panel (● : without the getter, ■ : with the getter)

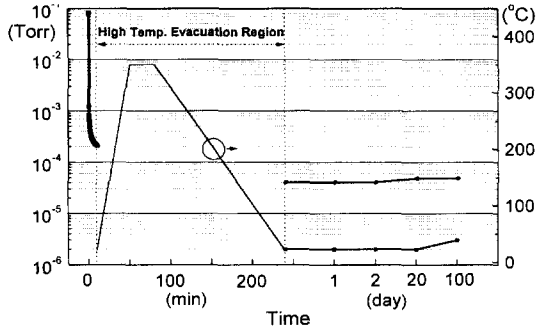

Fig. 6. The change of pressure after high temperature evacuation and tip-off process of the 10" panel with bare glass and only printed spacer used (● : without the getter, ■ : with the getter).

panel during the high temperature evacuation and after the tip-off. In Fig. 5, the upper graph (●) is a case of panel without the getter and the bottom graph (■) is a case of panel with the getter. The face plate consists of the R, G and B phosphors, the black matrix and the spacers with the height of 200 μm. The Mo emitter arrays are formed on the base plate.

The getters used in each experiment are the HPTF (High Porous Thick Film) getter with the size of 0.15 mm(T)×2 mm(W)×50 mm(L). Each panel contains a piece of getter and it is activated for ten minutes at 550°C by current heating process. Panels are evacuated at 350°C, during 30 minutes. And the continuous measurement of the panel pressure is carried out after the tip-off and the getter process.

In the case of without getter, the pressure of 3.5×10^{-5} Torr was measured after tip-off, it goes up to the pressure of 5.5×10^{-5} Torr after 10 days. This shows how much gas comes out from the materials in the panel. In the case of with getter, right after tip-off and getter activation, the pressure was 3.0×10^{-6} Torr. After one day the pressure was changed to 1.5×10^{-6}Torr. And this pressure, 1.5×10^{-6} Torr, is continuously maintained for 9 days because of the effect of the getter mounted in the panel..

Fig. 6 is the result of 10" panel of which the experiment condition is the same as the 3.12" panel. The upper graph (●) is without getter and the bottom graph (■) is with getter. Only the spacers with the height of 200 μm are formed on the face plate and nothing on the base plate. In the case of without getter, the pressure measured after tip-off is 3.7×10^{-5} Torr, and it goes up to 5.5×10^{-5} Torr after a hundred days. In the case of with getter, the pressure after getter activation is 2.0×10^{-6} Torr and the pressure is a little changed to 2.5×10^{-6} Torr after a hundred days.

Conclusion

A 3.12" FED panel having 1.5×10^{-6} Torr was fabricated and the packaging process for the 10" panel was also developed, and the change of the panel pressure was measured using the SRG during the packaging processes.

In the case of room temperature evacuation, the evacuation speed of a 3.12" panel containing phosphor, black matrix and emitter arrays is lower than that of 10" panel fabricated with only bare glass and spacers.

After high temperature evacuation of 30 minutes at 350 and tip-off process, it was found that the pressure of the panels were maintained at 10^{-5}Torr in the case of without getter, and 10^{-6}Torr with getter in 3.12" FED panel and 10" panel made by bare glass.

References

[1] L. Branst and F. Pothoven, *Semiconductor International* (1996).

[2] B. Gnade and J. Levine, *SID Seminar Lecture Notes* (1995).

[3] J. K. Fremerey, *J. Vac. Sci. Technol.* **A3**, May/June 1985. p. 1715

[4] B.E. Lindenau and J. K. Fremercy *J. Vac. Sci Technol.* **A9**, Sep/Oct 1991. p. 2737.