Vacuum In-Line Sealing by a Halogen Lamp Heating of Frit-Glass Seals for Flat Panel Display

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Abstract

Sealing of two glass plates composing of FED panel was done in a vacuum chamber. Several factors related with a heating process of a frit glass were investigated, including comparisons with a conventional method.

I. Introduction

One of the most important technologies for fabricating the microelectronic display devices such as FED, PDP, and VFD is to obtain a high vacuum level inside the panel[1-3]. In addition, sustaining the initial high vacuum level permanently is also very important[4]. A problem in the high vacuum glass sealing of FED is how to obtain such a high vacuum level in the miniature space given by about 200μm distance between a rough cathode emitting surface and an anode screen. Furthermore, the reduction of a sealing process time is very important in respect of commercial product. The most probable method for obtaining the initial high vacuum level inside the space with such a miniature and complex geometry is a vacuum in-line sealing which seals two glass plates within a high vacuum chamber.

II. Experimental Results and Discussion

First, a sealing material of so-called frit is preformed along edge of a front glass panel in atmosphere. Then, front and rear glass panels are loaded into a vacuum chamber, faced with each other having. In order to seal two panels, they should be heated up to about 400°C corresponding to a firing temperature of the preformed frit. After that, two panels come into contact by positional controls.

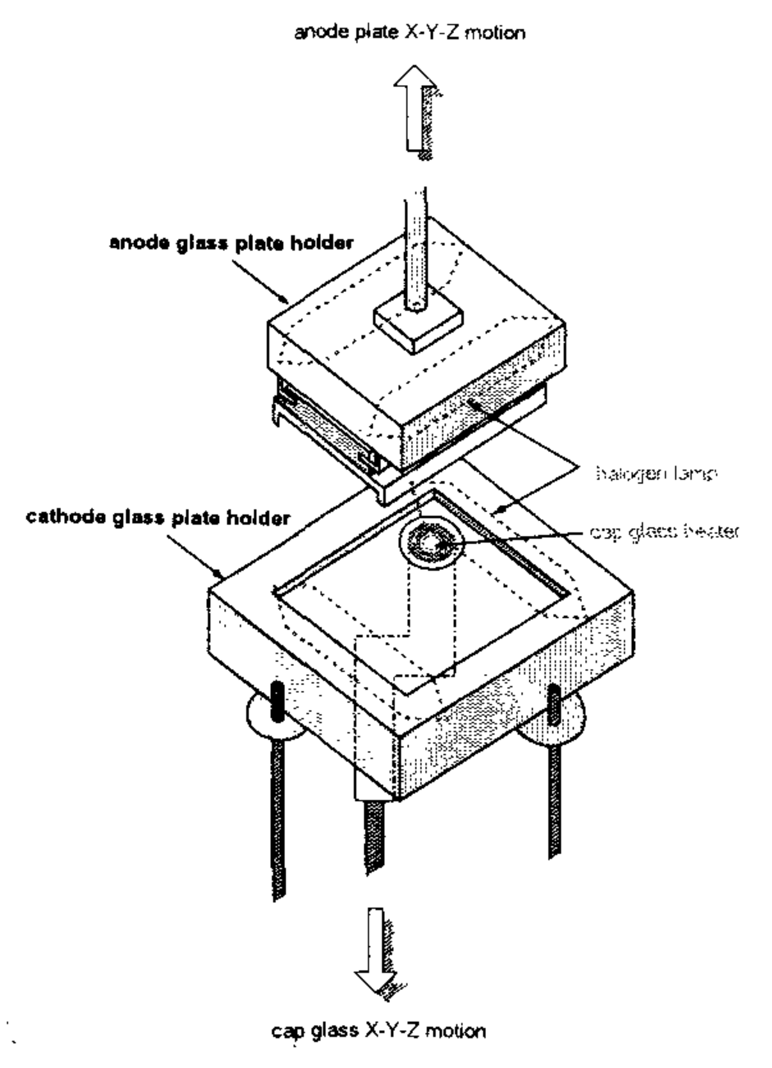

Fig. 1. Schematic diagram showing the heating and holding stages of the vacuum in-line sealing system.

However, it is not so easy to treat the frit glass in a vacuum environment because outgassing or vaporization phenomena occurs severely during heating resulting in bubbles inside the frit which becomes leak channels. In this study, we have tried to package a cathode glass plate with Mo-tip FEA based on Si substrate[5] and an anode glass plate with a ZnO:Zn phosphor screen within a vacuum chamber which is called a vacuum in-line sealing. In order to minimize above problems, heat up cycle should be precisely controlled. Fig. 1 shows the heating stages of our system for the vacuum in-line sealing. Heating two glass plates is done by halogen lamp array heaters with a buffer substrate holder. After arriving a critical temperature, upper glass plate is moved down until touching lower glass plate via a x-y-z manipulator. A little press is given by the manipulator enough to seal two plates. After cool down step, the panel is unloaded to complete the sealing process. As mentioned before, due to a high vapor pressure of some components contained in the frit glass in the vacuum environment, bubbles occurs during heating cycle in the vacuum chamber. Fig. 2 shows the camera views of the frit surface, in which much bubbles are appeared. In order to minimize the bubbles, the heat up rate should be precisely controlled.

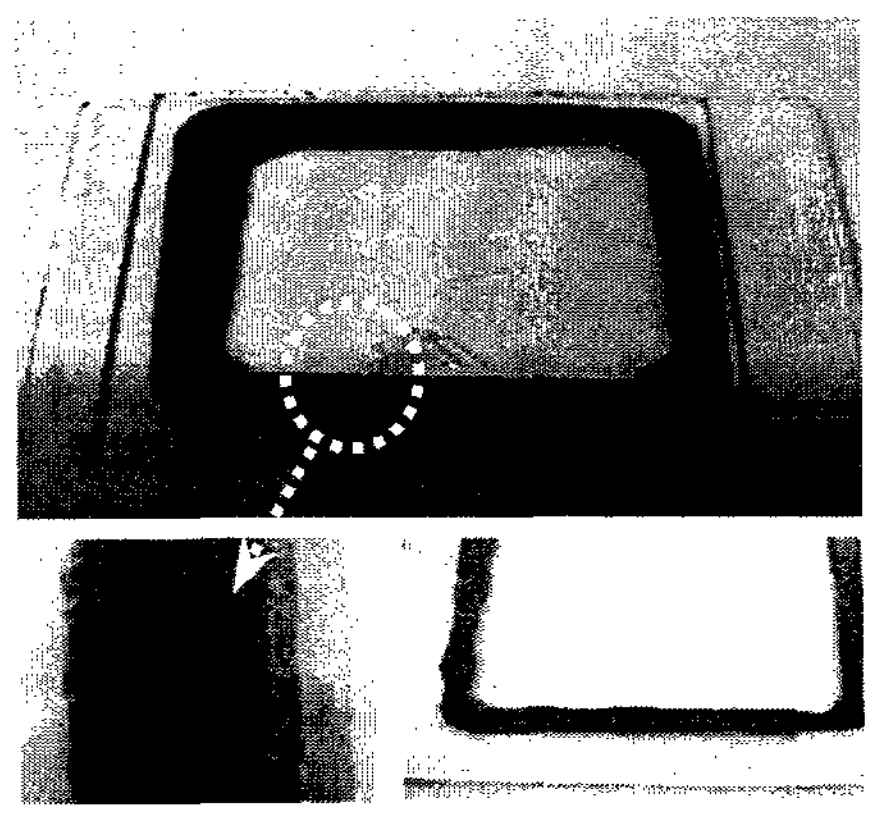

Fig. 2. Pictures showing the bubbles contained in the frit glass treated thermally in a vacuum chamber.

We have tested a leak rate for two cases as shown in Fig.3. Leak test is done by pumping through an exhausting glass tube connected previously to one side of the panel by a frit sealing in air environment. As shown in the figure, the pump down rate in the case of the panel sealed in vacuum chamber was slower than that of the case sealed in air environment, which verifies that some leak points are remained in the frit glass treated in the vacuum chamber. Emission current was measured for one pixel which consists of 625 tips. From Fig. 4, we can see that emission is fluctuated severely in the case of the vacuum in-line sealing. And also, the emission current level is lower and a gate leakage is much higher than that of the conventional sealing.

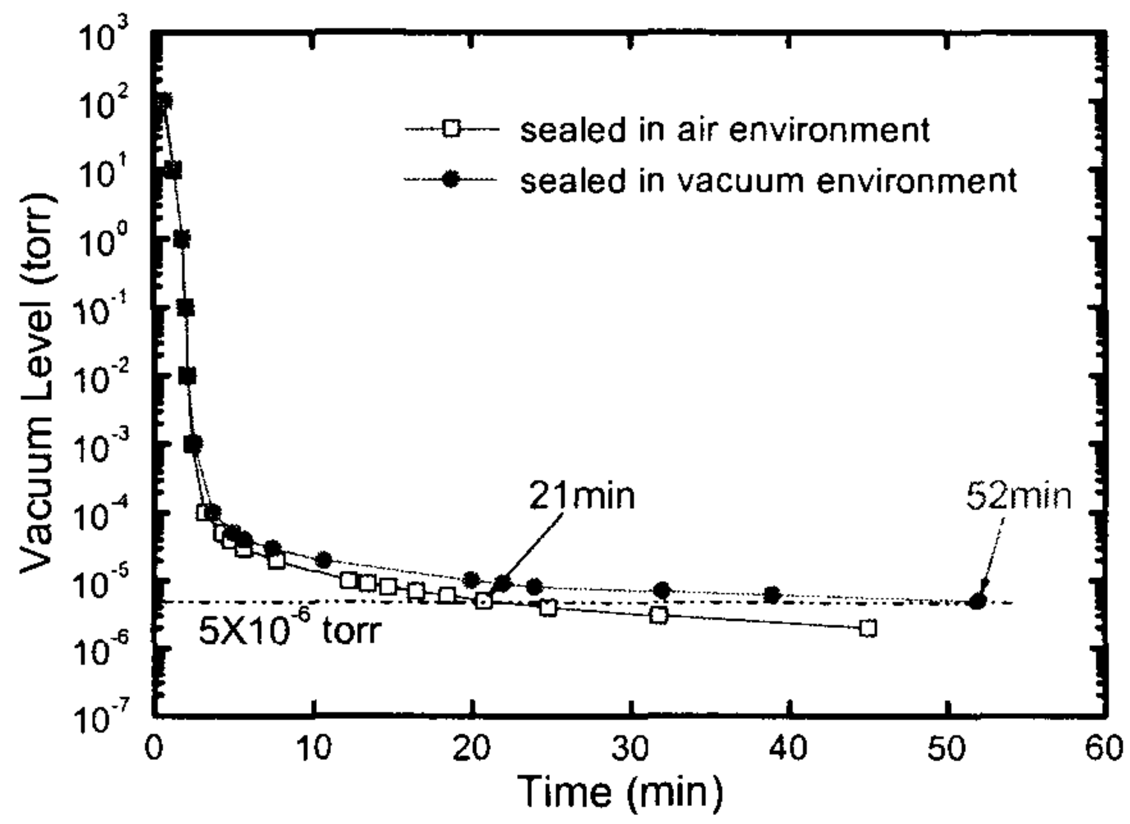

Fig. 3. Pump down rates for the panels sealed in (a) air environment and (b) vacuum environment.

However, turn on voltage is not changed so much. These results may come from a poor vacuum level by leaking and a contamination due to outgassing or vaporization in the case of vacuum in-line sealing. In a conventional sealing of Fig.4(a) , plot #1 is a field emission characteristics before seal-off by a melted plugging of exhausting glass tube, plot #2 is the one right after the seal-off, and plot #3 is the characteristic after a getter activation which is done at 500°C for 20minutes.

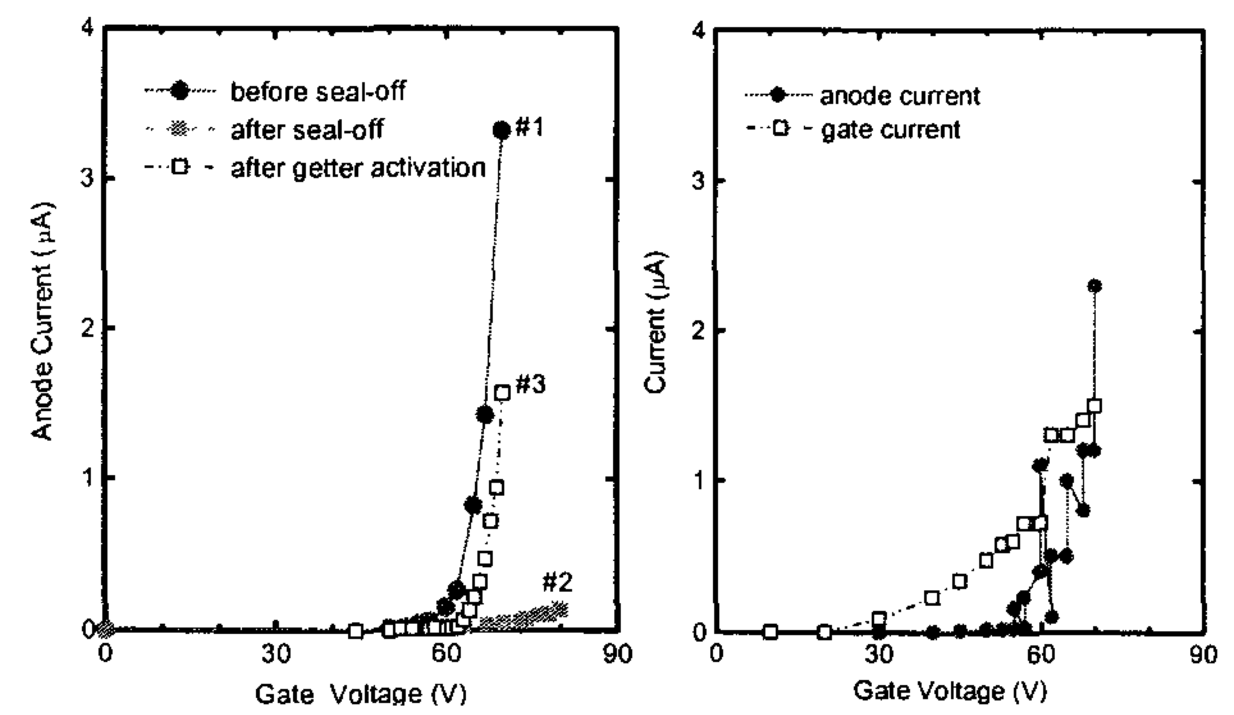

Fig. 4. Field emission characteristics from a pixel in the panel sealed using (a) a conventional, and (b) a vacuum in-line method.

As shown, the emission current level decreases by about 40 times compared with the value before seal-off, which may come from the pressure increase inside the panel due to the vaporization of some components contained in the soda-lime glass tube during melting. However, the current level was recovered by about 1 order after activation of the getter. It tells that the getter plays as a good role of in-situ mini pump by the activation at reasonably low temperature[6]. However, some particles stuck to the emitters or protruding morphology of the tips will be still remained. Two results of Fig. 4(a) and (b) say a coincidence in the respect of an emission dependence on the vacuum level and the contaminant due to outgassing or leak.

For both cases, light emission was observed from a ZnO:Zn phosphor screen and the resultant patterns are shown in Fig. 5(a) and (b). Emission from one line of the conventionally packaged panel was more stable than that from one pixel of the vacuum in-line sealed panel. In the latter case, life time was too short.

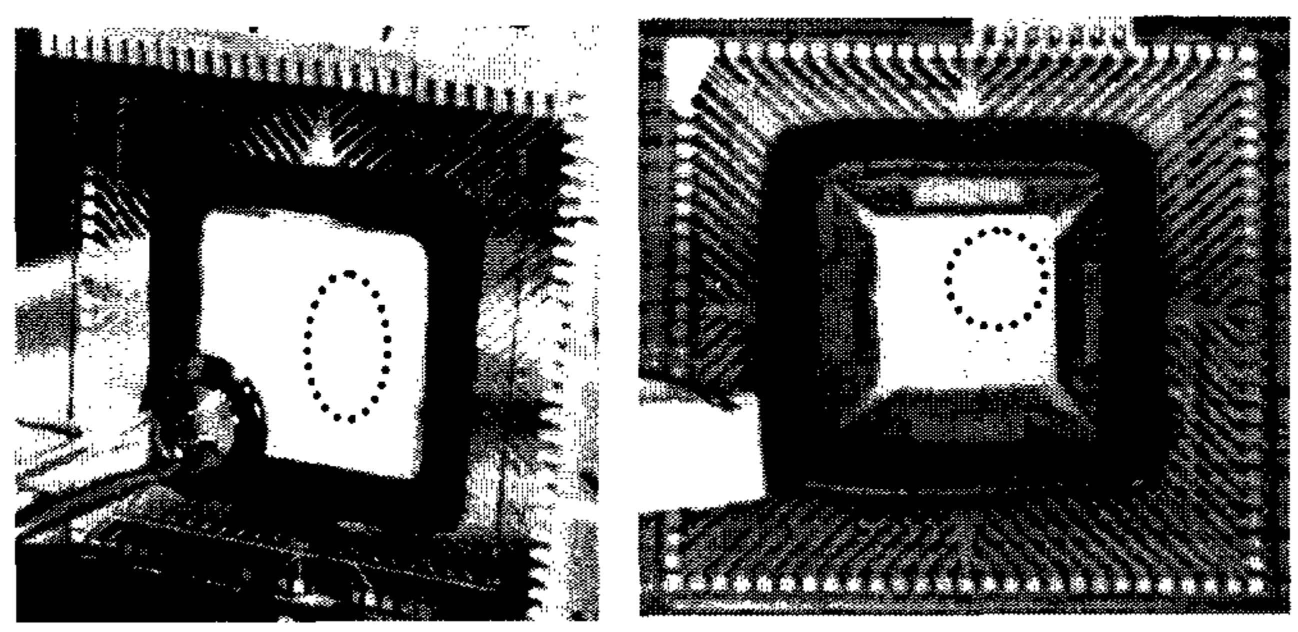

Fig. 5. Light emission patterns of (a) a conventionally, and (b) a vacuum in-line sealed panels.

III. Conclusions

In conclusion, we have tried to package a FED panel in the vacuum chamber by using vacuum in-line heating through a halogen lamp array. In this case, vaporization or outgassing from the frit glass result in severe problems such as a leak path due to bubbles and a tip contamination due to outgassing. In order to minimize these problem, a heat up cycle in the vacuum chamber and a heating source should be selected deliberately.

Acknowledgments

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