

The Reliability Test of Sealing Glass Frit in AC PDP

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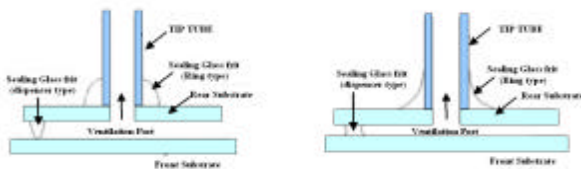
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Abstract

For reliability evaluation of AC-PDP, one of the most important factor is sealing property. In this paper, the reliability evaluation test method of the commercialized sealing glass frit in AC-PDP was studied. 6 inch AC-PDP panels were tested for evaluation of sealing glass frit by vibration shock test, thermal shock test, non-destructive X-ray inspection, residual stress inspection and residual gas detection. These test methods are proposed as a standard for testing the reliability of sealing glass frit. The main failure mode of sealing glass frit in AC-PDP seems to be the crack propagation from thermal cycling rather than mechanical factor.

1. Introduction

In the manufacturing of plasma display panel (PDP), sealing process of back end is very important factor for product yield. The required properties of sealing glass frit in PDP panel are the thermal expansion coefficient, hermetic property, wetting property and chemical property. Especially, matching of thermal expansion coefficient with glass substrate is the most important factor. Nowadays, thermal expansion coefficient of commercialized sealing glass frit is 71~78 ($\times 10^{-7}/^{\circ}\text{C}$) with the filler addition. The sealing glass frit was used as a paste in dispenser method. [1,2,3,5,6]



(a)Before Sealing Process (b)After Sealing Process

Figure 1. Panel image before and after sealing process

Generally it is not easy to relate the material property itself with its effect on the device. We proposed the method how to evaluate sealing glass frit when it was sealed in PDP panel.

Table 1. Items and conditions of reliability test

	Test Item	Test Condition & Method	Evaluation Standard	
Total Performance Test	General Performance Test	Size Distribution	ASTM C-1070 Product Spec	
		Softening point	ASTM C-338 Product Spec	
		Transition Point	ASTM C-1356 Product Spec	
		Thermal Expansion Coefficient	ASTM C-824 Product Spec	
		Mismatch	ASTM E-218 Product Spec	
		Flow Button	ASTM C-374 Product Spec	
		Crystallization Time	ASTM E-794 Product Spec	
	Environmental Test	High Temperature & Humidity	40°C, 95%, 240hrs	Leak rate : Below 5×10^{-8} atm·cc/sec
		Vibration Shock Test	20~2000Hz, 0.5g, 3axis	Leak rate : Below 5×10^{-8} atm·cc/sec
	Life Cycle Test	Thermal Shock Test	1 Cycle : 40°C ? 120°C ? -40°C	Leak rate : Below 5×10^{-8} atm·cc/sec

2. Experimental

For the reliability evaluation of sealing glass frit, we selected one of the commercialized ones and 6 inch AC-PDP panels were made with it. Table 1 shows the items and conditions of reliability evaluation test prescribed in reliability standard of sealing glass frit. [4] Among these, we performed vibration shock test and thermal shock test with these panels with the vibrator (LDS V790, England) and thermal cycling tester (ACS CST-157, Italy). For evaluating the reliability of hermetic sealing characteristics, leak test was followed by these tests. Figure 2 shows the process and equipments of leak test. In addition to this sealing area was inspected with non-destructive X-ray analyzer (X-Tek VTX xi, England) and residual stress

of sealed area was performed by automatic stress analyzer (I-sensor Korea IS-PASM-P200, Korea). Finally TG-MS analysis (Netsch STA-MS, Germany) was performed to check the components from the glass frit during the thermal treatment.

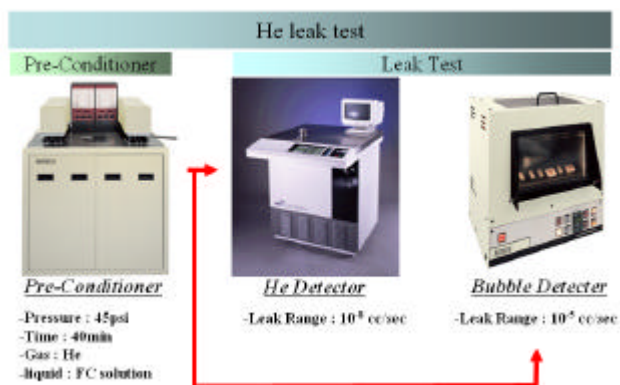


Figure 2. Process of leak test

3. Results and discussion

Vibration test and thermal cycling test were performed to predict the life cycle of sealing of 6 inch PDP panel and several new methods were proposed to evaluate the characteristics of sealing properties of PDP panel. Non-destructive X-ray inspection method was performed to check the sealing conditions such as size of pores and number of pore in sealed areas and TG-MS analysis was performed to check the possibility of out-gassing of sealing glass frit. Residual stress was measured to check the thermal mismatch between the sealing glass frit and glass substrates. From above results, we can establish the reliability testing method of sealing glass frit.

3.1 Vibration shock test

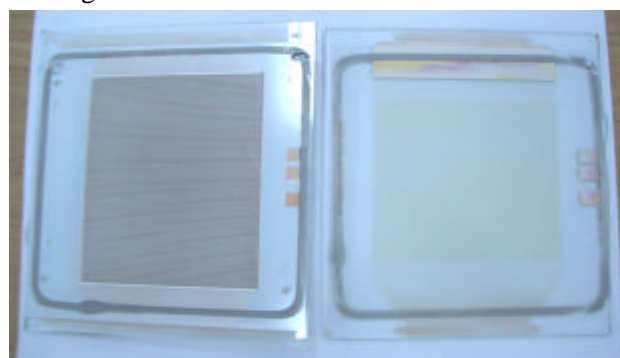
As an environmental test, vibration shock test was performed. 6 inch AC-PDP panels were vibrated under the conditions of x, y, z axis per 30min, 0~2000 Hz at 1 cycle. Table 2 shows the various conditions of vibration test. He detector and bubble detector also used after the vibration test to checked the hermetic property of sealing glass frit. Tested panels showed no leakage after the test. It means that sealing glass frit showed good resistance for mechanical fatigue from the vibration test.

Table 2. The result of vibration shock test

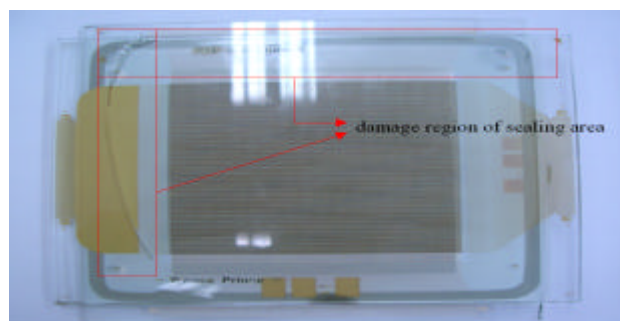
	Unit	1	2	3
Maximum acceleration (g)	9.8m /sec ²	0.5	10	20
Force	Kgf (N)	0.18 (1.75)	3.55 (34.79)	7.1 (69.58)
Axis	-	X, Y, Z	X, Y, Z	X, Y, Z
Time	Min	30/Axis	30/Axis	30/Axis
Fine Leak (He Detector)	atm.cc/sec	0.0 x 10 ⁻¹¹	0.0 x 10 ⁻¹¹	0.0 x 10 ⁻¹¹
Gross Leak (Bubble detector)	Number of Bubble	Nothing	Nothing	Nothing

3.2 Thermal shock test

The thermal shock test was performed with 6 inch AC-PDP panel to guarantee the life cycle of the sealing glass frit. PDP panels were tested 100 cycles of thermal shock (-40°C, 30min & 120°C 30min at 1 cycle). After the thermal shock test, failure of sealing glass frit was checked by leak detector, He detector & Bubble detector. One of the panel was opened and the other showed crack propagation on the glass substrate after the vibration test. The main failure mode of sealed PDP panel seems to be the crack initiation originated from the thermal mismatch between glass frit & glass substrates.



(a) Thermal shock tested sample A



b) Thermal shock tested sample B

Figure 3. Thermal shock tested PDP panel

3.3 Non-destructive X-ray inspection

Figure 4 shows the results of Non-Destructive X-ray irradiation analyzed with sealed area of 6 inch PDP panel. With this instrument, we could check the conditions of forbidden sealed area. Every PDP panel samples showed more pore at corner area than the liner sealing area. It showed that the corner area might act as a source of crack initiation rather than the liner area of sealed region.

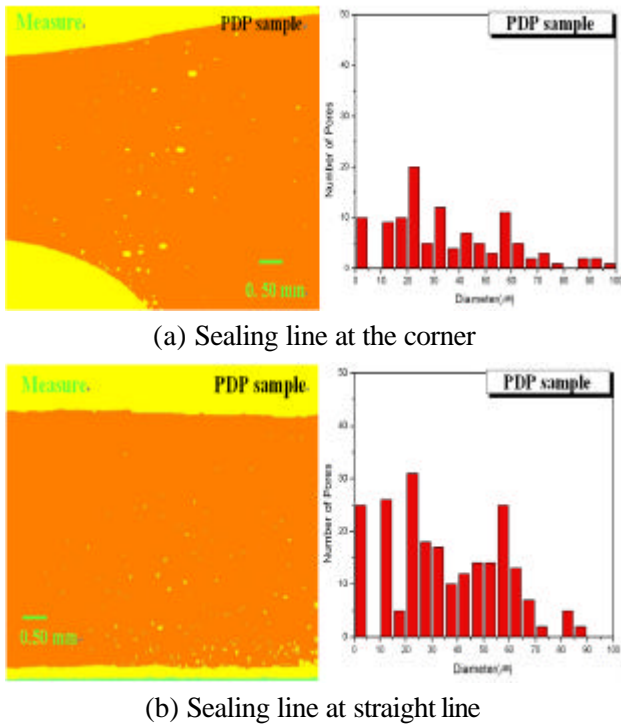
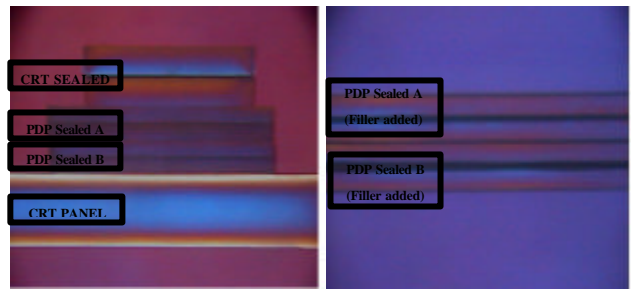


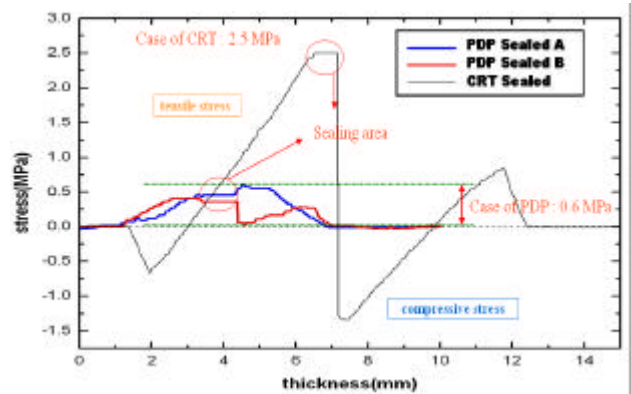
Figure 4. Non-destructive X-ray image of sealed area and pore distributions

3.4 Residual stress inspection

Figure 5 shows the residual stresses of glass substrates sealed with sealing glass frit measured by automatic stress meter. Measured residual stress of PDP glasses was about 1 MPa while the stress of sealed CRT glass was a tensile stress of 2.5 MPa. The reason why the sealed CRT glasses showed high value is the differences of thermal expansion coefficient between the panel & funnel glass. In case of PDP, residual stress of sealed glass substrates was small, because the front & rear panel substrates are the same in PDP. The stress of each glass substrate was weak compressive one in PDP. [4]



(a) Strain viewer images of sealed areas



(b) Residual stress

Figure 5. Residual stress of sealed glasses

3.5 Out-gassing inspection (TG-MS)

In most display device, out-gassing problem is one of the main problem which decrease the properties of display. In case of sealing glass, the possibility of out-gassing should be checked above reason. Figure 6 shows the result of TG-MS of glass frit followed by the thermal schedule of sealing and evacuation process of PDP. The maximum temperature was 900°C. Detected components were H₂O, O₂, CO, CO₂, but the level of detection was so low that we can conclude that the possibility of causing out-gassing problem of tested sealing glass frits is low.

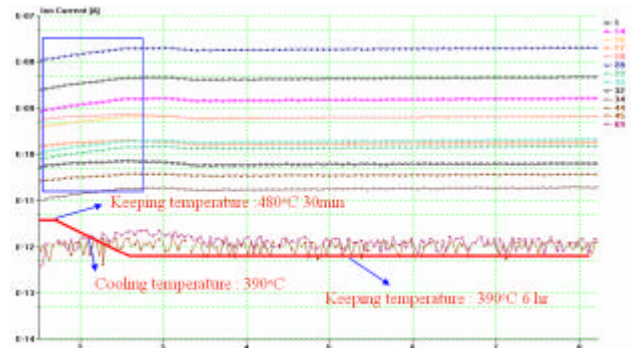


Figure 6. The result of TG-MS out-gassing inspection

4. Conclusion

Recently, various flat panel display devices, such as PDP, LCD, FED, VFD are commercialized very rapidly. But, proper reliability assessment standards for these are not established yet, especially in sealing material. We introduced many new analytical methods to evaluate sealing conditions and life cycle of hermetic sealing with the 6" AC-PDP Panels. Finally we established the reliability evaluation test process of the sealing glass frit in PDP.

5. References

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