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Characterization of Residual Stress and Pore Distribution in Sealed Area of Large PDP Panel

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Residual stress of front and rear glass substrates and remained pore in sealed areas of AC-PDP panel were measured to see the trend of the characteristics of sealed area as the panel size of PDP increased. For this, we compared these characteristics of 6", 42" and 80" panels, between the corner side & straight line, the vertical & horizontal sides, and the around area of ventilation port & area far from that each. Residual stress was measured by the automatic stress meter and the remained pore was analyzed by non destructive X-ray detector and optical microscope. As a result, we showed the trend of sealed area characteristics according to the magnification of PDP panel.

Keywords: plasma display panel; pore distribution; residual stress; sealed areas; sealing glass frit

INTRODUCTION

Figure 1 shows the configuration of general PDP panel. Low temperature melting glass frits is used for the sealing of PDP panels as a form

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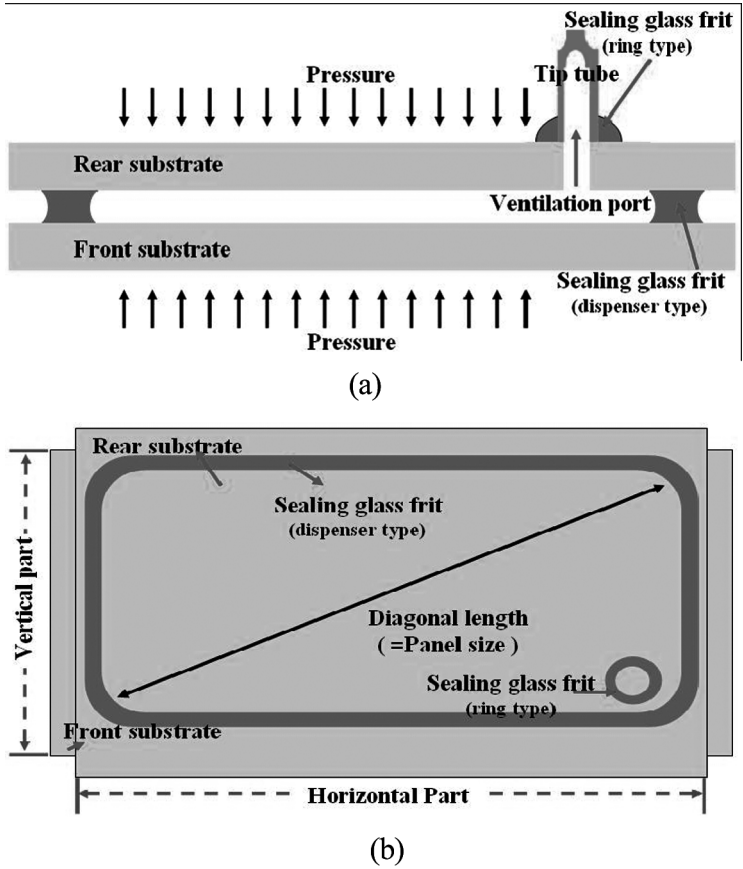


FIGURE 1 Configuration of plasma display panel; (a) side view (b) front view.

of glass paste, which is the mixture of glass frit, vehicle and polymer binder for high productivity. The sealing glass paste is spread on the glass substrate by the method of dispenser and finally thermal sealed at $450\sim 480^{\circ}\text{C}$ [1–3]. Required properties for the sealing glass frit are as follows 1) high strength of sealing, 2) hermetic sealing, 3) low out-gassing, 4) low thermal expansion mismatch. As a representative of large size flat information display, PDP has a little bit larger aspect ratio of 16:9 compared to normal 4:3 ratio of regular CRT TV. Internal pressure of PDP panel is still kept at low pressure after the exhaustion process and inflow of inert gas, like Xe, Ne, He [4,5]. So the substrate glass is supported with vertical direction of surface. Resultant stress may cause bending the substrate glass and the crack of glass and

stress of glass frit and finally panel will be broken. In addition to this, thermal mismatch caused by the difference of thermal expansion coefficient between the glass substrate & sealing glass frit also can be one of the reasons of destruction [5,6]. Also remained pore in sealing glass frit after sealing process may have a bad effect on the bonding strength, hermetic sealing and the crack generating [7,8]. In this study, we examined the trend of remained thermal stress and remained pore of sealing area between the corner & straight area, vertical & horizontal area and the around area of ventilation port & area far from that each.

EXPERIMENTAL

To study the characteristics of sealing of PDP, we measured residual stress of front and rear glass substrates and the remained pore in sealed areas of 6'', 42'' and 80'' PDP panels and compared these results between the corner side & straight line, vertical & horizontal side and the around area of ventilation port & area far from that. Residual stress was measured by the automatic stress meter (I-sensor Korea, IS-PASM-P200, Korea) and the remained pore was analyzed by non destructive X-ray detector (X-Tek, VTX xi, England). The cross section of sealed area was analyzed by optical microscope (Olympus, BX51, Japan).

RESULTS AND DISCUSSION

Table 1 shows the residual stress of sealed area of 6'', 42'', 80'' PDP panel. Residual stress of each panel lies between $-2.2 \sim +1.6$ MPa. Residual stress of 80'' PDP panel which has large display area was bigger than that of 42'' and 6'' panel. The reason seems to be not only the large size of glass substrate but also large width of sealing line of 80'' panel. The line width of 80'' was almost double in some area. In addition to this, the residual stress of corner area was bigger than that

TABLE 1 Comparison of Residual Stresses of Sealed Area in 6'', 42'', 80'' PDP Panel

PDP sample	Residual stress (MPa)		
	Around the ventilation	The corner	The straight line
80 inch	$-2.2 \sim +1.6$	$-1.8 \sim +1.4$	$-1.3 \sim +1.3$
42 inch	$-1.2 \sim +1.4$	$-1.0 \sim +1.3$	$-0.8 \sim +1.2$
6 inch	$-0.8 \sim +1.2$	$-0.6 \sim +1.1$	$-0.4 \sim +0.9$

of area of straight line regardless of panel size. One of the particular thing was that the residual stress in the near area of ventilation port was bigger than in the sealed area of far from that.

Figure 2 shows the residual stress of horizontal side and vertical side of 42'' and 80'' PDP panel measured by automatic stress meter. Figure 2(a) shows that residual stress of vertical side of 80'' PDP glass was bigger than that of horizontal side and also in Figure 2(b) of 42'' panel.

Figure 3 shows the strain viewer images of horizontal side and vertical side of 6'', 42'', 80'' PDP panel measured by automatic stress meter. Residual stress of front & rear glass substrate of 80'' PDP panel showed both tensile & compressive residual stress were distributed continuously in vertical part, but in horizontal part, rear glass substrate showed only tensile stress while the residual stress of front substrate glass showed both tensile & compressive stress. In addition

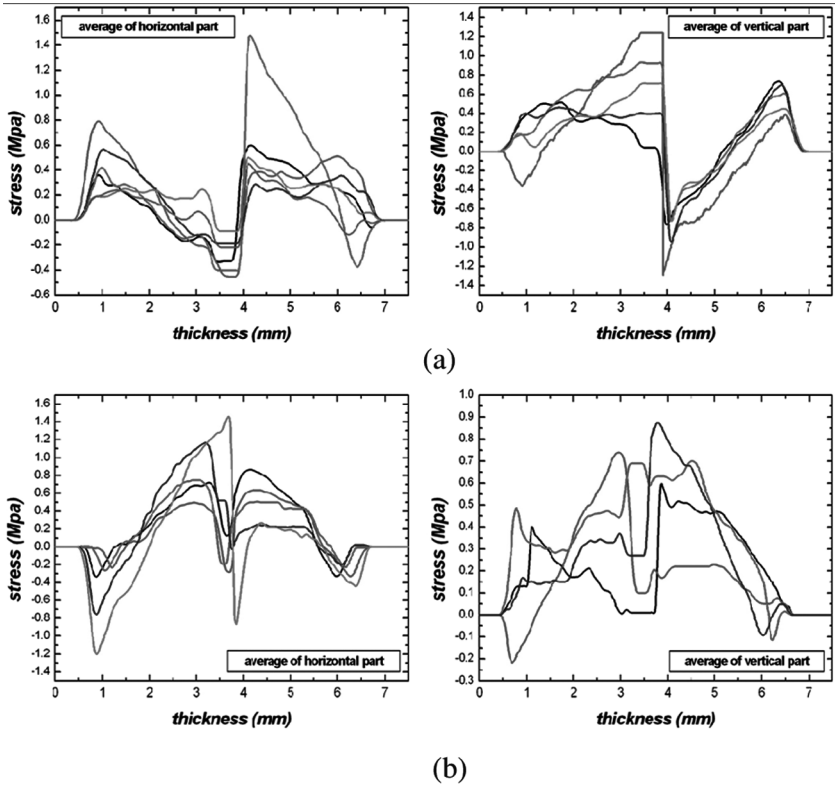
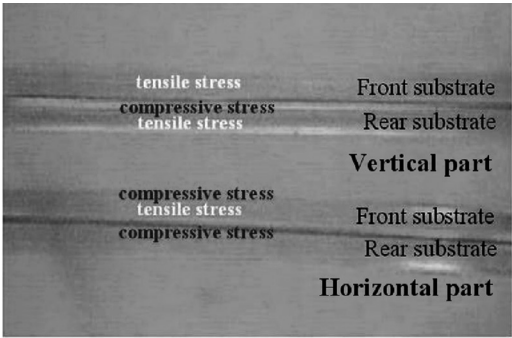
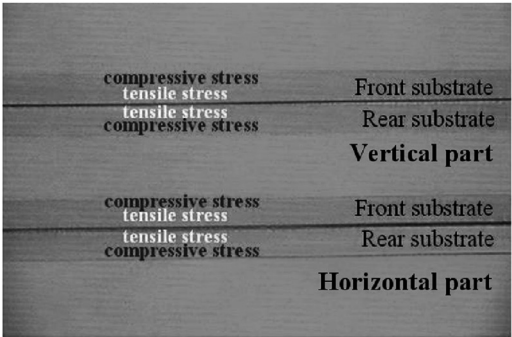


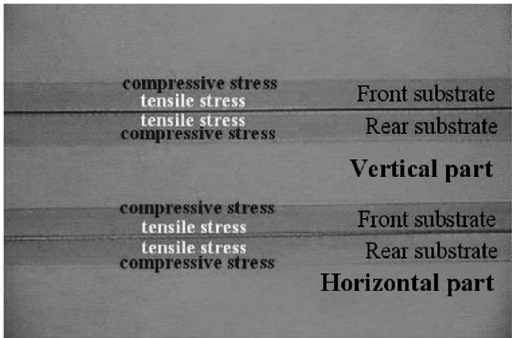
FIGURE 2 Residual stresses of sealed areas; (a) 80'' PDP sample (b) 42'' PDP sample. (See COLOR PLATE XVII)



(a)



(b)



(c)

FIGURE 3 Strain viewer images of sealed areas; (a) 80" PDP sample, (b) 42" PDP sample, (c) 6" PDP sample.

to this, we can see that sealed part of vertical part and horizontal part in 80'' PDP panel was got bent. Owe to the different aspect ratio in PDP panel, horizontal side got bent a little, which is longer than the vertical side. As we can see, the rear glass substrate was bent for there is only tensile stress where there is no compressive stress which compensate the tensile stress [7,9]. But the residual stress of front and rear glass substrate of 6'' and 42'' showed that both tensile and compressive stress were distributed continuously. So the degree of getting bent was increased by the panel size accordingly.

Figure 4 show the total residual stress distribution of sealed area of 80'' PDP panel. Most desirable residual stress distribution of front and rear glass substrates has been gotten with bilateral symmetry of sealing glass frit. But measured residual stress of front and rear glass substrate were different [3,6]. Residual stress of front glass substrate was $-1.6 \sim 1.3$ MPa and that of rear glass substrate was $-2.5 \sim 1.5$ MPa. This difference of residual stress between the front and rear glass substrate was caused by the sealing process. Sealing glass paste is dispensed on the rear glass substrate firstly and it is pre-sintered before sealed with front glass substrate overlapped [2,3]. So the width of seal line of rear glass substrate becomes wider than that of front glass substrate. Such a difference of residual stress

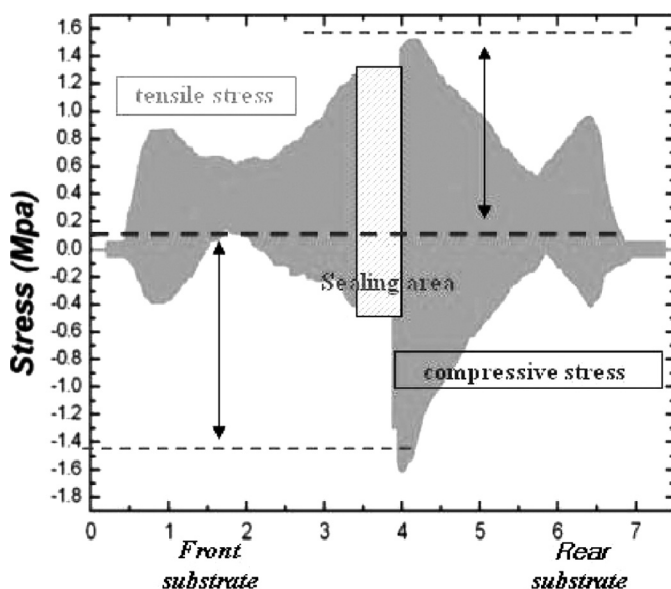
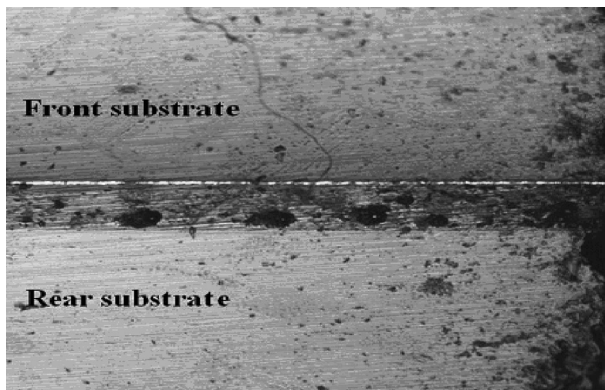


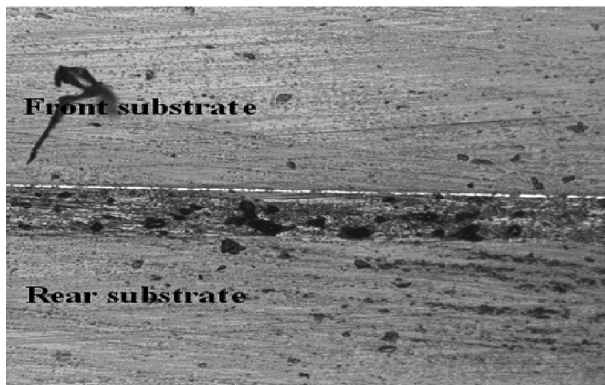
FIGURE 4 Total residual stress distribution of 80'' PDP sample.

between the front and rear glass substrate may cause the crack in PDP panel, so the panel may broken or the lifetime of PDP panel also may be shorten, especially in large size of PDP panel [10,11].

Figure 5 shows the cross section of sealed area analyzed by optical microscope. The remained pores were located near the rear glass substrate. It was caused by the raising of pores in the glass frit during the sealing process. In sealing process, glass frit had the flow-ability and the rear glass was located on the top of front glass substrate. Such a difference of pore distribution between the front & rear glass substrate also may be the reason for the unbalance of residual stress distribution as shown in Figure 4.



(a)



(b)

FIGURE 5 Optical microscope images of cross section of sealed area; (a) 80'' PDP sample A, (b) 80'' PDP sample B.

Figure 6 shows the remained pore distribution analyzed by non-destructive X-ray. In case of 80'' panel, the number of pores in the area of inside of PDP panel was larger than that of outside of panel. But in case of 6'' and 42'' was vice versa. This means that the remained pore in inside of panel of 80'' PDP panel was hard to removed during the exhaustion process for its large size of panel. In addition to this, the number of pores in the near area of ventilation port was smaller than in the sealed area of far from that regardless of panel size. The reason is why the pore can be exhausted more easily in the near area of ventilation port sealed area and more pores would remain in the sealed area of far from that. Such a difference of remained pore distributions

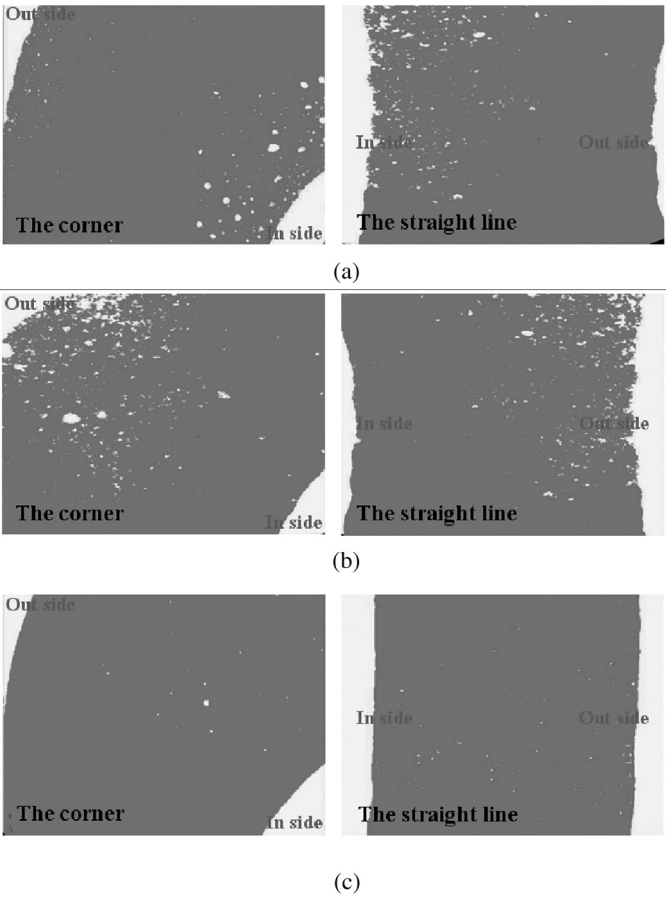


FIGURE 6 Non-destructive X-ray images of sealed areas; (a) 80'' PDP sample, (b) 42'' PDP sample, (c) 6'' PDP sample.

were increased with the PDP panel size getting larger and the width of seal line getting wider.

CONCLUSIONS

The characteristic of sealing was examined with various PDP panel. Residual stress of glass substrate and pore distributions of sealed area of glass frit showed different behaviors with the site of sampling and size of PDP panel. Residual stress of corner area was bigger than that of area of straight line and that of near area of ventilation port was bigger than in the sealed area of far from that. Measured residual stress of front and rear glass substrates was also different. Owe to the different aspect ratio in large size of PDP panel, horizontal side got bent a little, which is longer than the vertical side. The degree of getting bent was increased by the panel size accordingly. The number of pores in the near area of ventilation port was smaller than in the sealed area of far from that regardless of panel size but the residual stress showed opposite phenomenon. From this, we could find close relationship between the number of pore and degree of residual stress.

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