New Barrier Rib Forming Method for PDP Fabrication

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Abstract

In this paper, a new barrier rib forming method of embossed barrier rib (EBR) formation process for the PDP rear panel was introduced. The process is mainly composed of green sheet fabrication, lamination of the green sheet on the rear glass panel having data electrodes, and roll embossing followed by firing. The EBR process has two advantages over the conventional barrier rib forming methods. One is the process requires less equipment investment than the conventional methods by about 20% of the current rear panel fabrication equipment investment owing to the simplified fabrication process. The other advantage is its reduced rear panel manufacturing cost by eliminating the time consuming and complicated processes and waste of materials in the conventional methods. In this study, general procedure of EBR fabrication process is described and the characteristics of prototype PDP using EBR panel are discussed.

1. Introduction

In these days many new technologies are developed and applied so drastically in the information display industry and new devices such as flexible LCD, electronic paper, micro display and so on enter into the display market. Furthermore the flat panel display market expands more rapidly than before and in large-sized flat panel display market, it is expected that in 2005, the demand from the consumer market for wall hanging TV at home will exceed that from the industry for information displays at public places. In this market trend, the manufacturing cost becomes more important issue for several types of flat panel displays to penetrate into the consumer market deeply. Compared with liquid crystal display, PDP has faster response time and wider view angles and the fabrication process for PDPs is still more cost-effective than that for LCDs. However, although there have been many successful efforts to reduce the PDP manufacturing costs, the high manufacturing cost of the panel is still one of the major obstacles for widespread use of PDP TV. Among the various parts of the panel, the barrier rib was of special interest since it can determine the panel resolution and the manufacturing cost for the barriers consists a significant portion in the panel cost. As one of efforts to reduce the PDP manufacturing cost, various barrier forming methods such as screen printing, sandblasting, etching, pressing, and so on [1-6] have been tried and some of them are employed in the mass-production. However, to realize further fine pitched and cost effective panels, still more advanced barrier forming process should be developed and in this paper, new barrier forming process of embossed barrier rib formation is introduced.

2. Embossed Barrier Rib Panel (EBR Panel)

Embossed barrier ribs are defined by firing the roll-embossed green sheet which is laminated on the data electrode defined rear glass panel.

Figure 1 and Figure 2 show the flow charts for the conventional and EBR rear panel manufacturing procedures, respectively. As shown in these figures, several processing steps are eliminated in EBR process, especially the processes related to the formation of dielectric layer and barrier ribs and the number of processes could be decreased from 27 to 20 in EBR process. (If each repeated printing processes is considered as a separate process step, the number of processes for the conventional

method becomes 40)

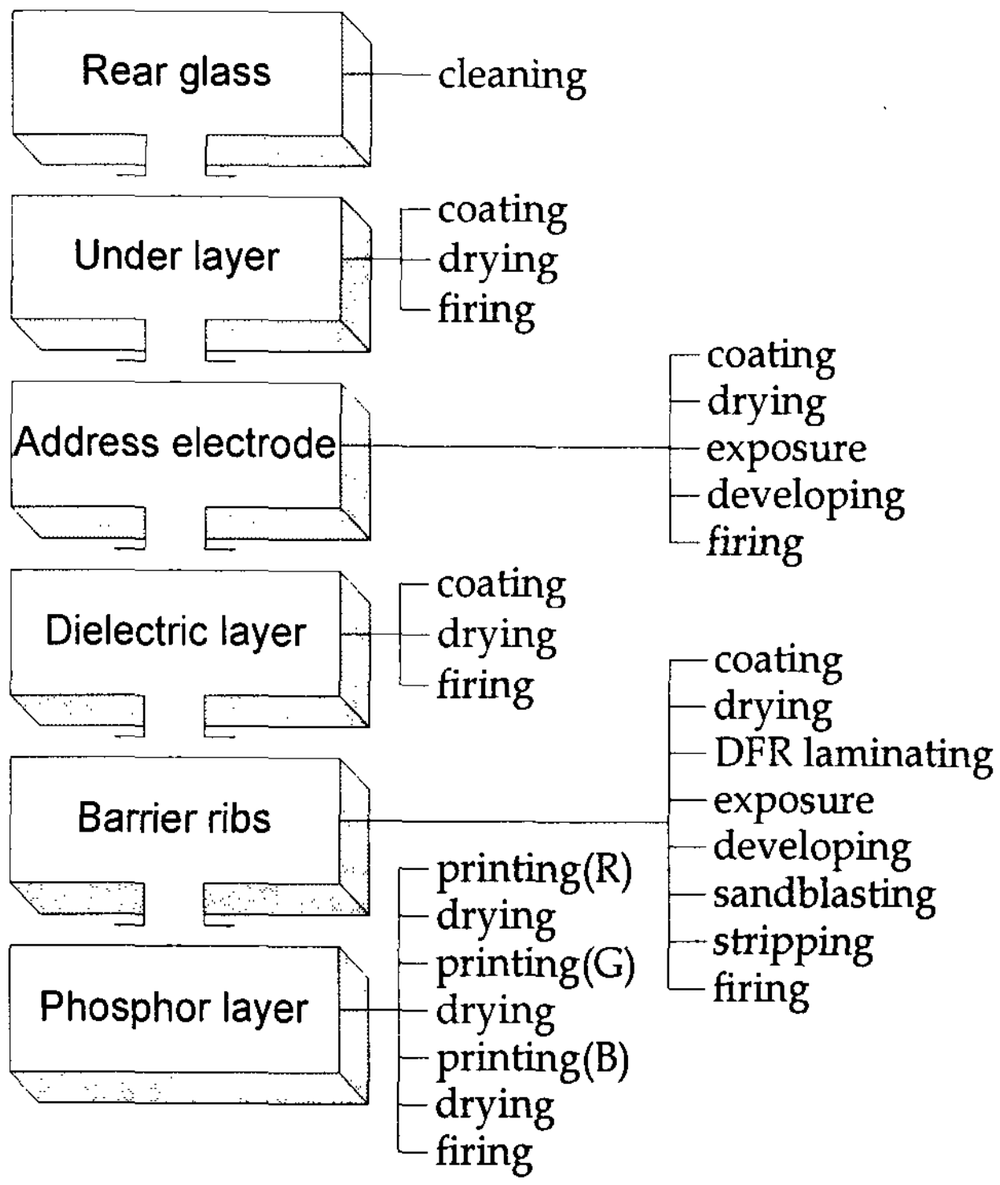

Figure 1. Flow chart of the conventional process (rear panel).

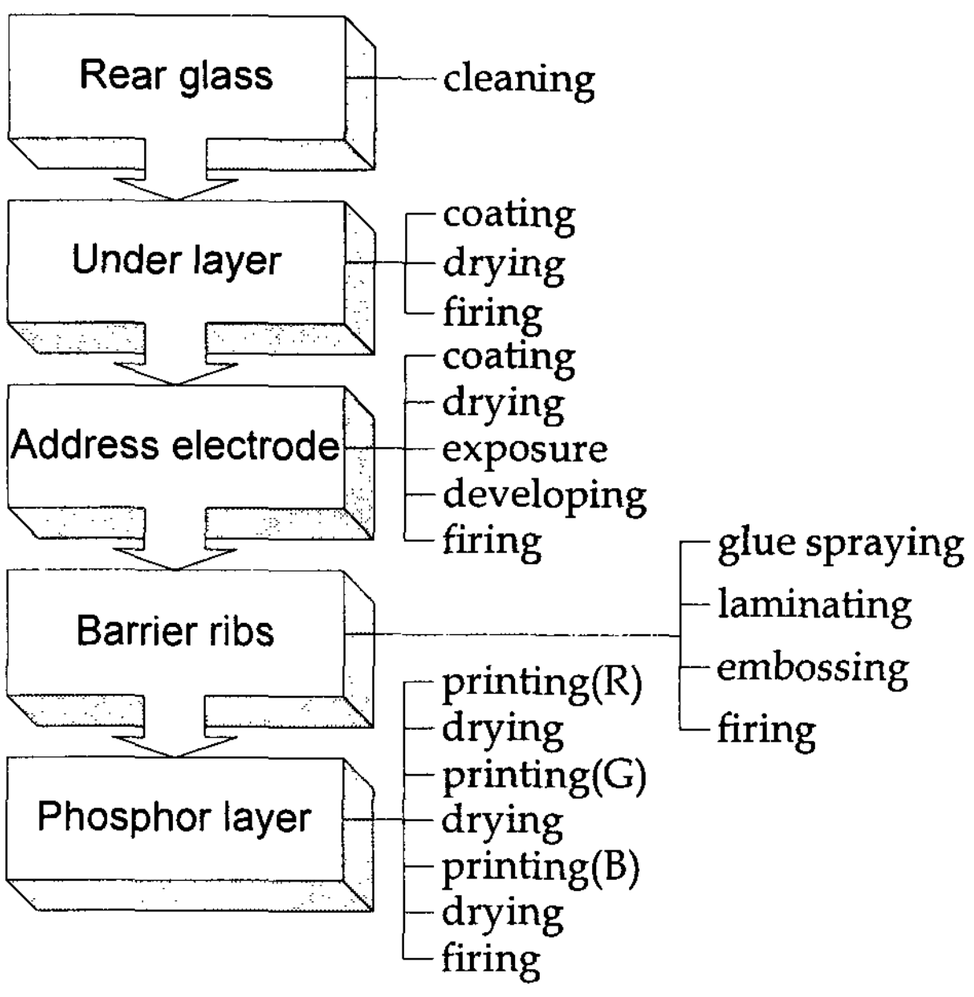

Figure 2. Process flow chart for the fabrication of EBR panel.

Compared with the conventional barrier forming methods, eliminating the firing process for dielectric layer gives little distortion to a glass substrate and furthermore firing of dielectric layer and barrier ribs together, shape of which are defined in green state during roll embossing process provides little delamination from each other. As a result, the drastic decrease in the processing steps can save the investment cost for rear panel manufacturing by 20% of the current rear panel fabrication equipment investment and improve the throughput yield remarkably.

3. Embossing Process - Rolling

In EBR process, the barrier shapes are mainly determined by roll embossing process. From the point of manufacturing capability, roll embossing process has several superior characteristics compared to the conventional barrier forming methods. Firstly, as mentioned in the previous session, the number of process steps could be decreased drastically. For example, as the dielectric layer and barrier ribs are formed simultaneously in the EBR process, there is no need for firing dielectric layer separately as in the conventional barrier forming processes. Secondly, embossing process requires smaller amount of rib materials than the sandblasting method. As the sandblasting process is a subtractive process, a coating thickness should be over 200㎛ and two thirds of coating material is removed with sand powders during the process. Therefore, the amount of the rib materials for embossing could be reduced to nearly 40% of that for sandblasting, which results in making the material expenditure for barrier ribs decrease remarkably. From this material cost savings, it can be estimated that for manufacturing 30,000 panels per month, 1.3 million dollars would be curtailed. Apart from the material savings, the by-products of waste material in the sandblasting method require the high disposal cost and may cause environmental problems. These kinds of problems are also issued in the etching process. Thirdly, embossing makes it possible to realize desired barrier rib shapes with high aspect ratios. As the barrier ribs with high aspect ratio lead to large open volume for discharging, the luminance of panel can increase.

Figure 3 shows the schematic diagram of embossing

equipment. In addition to a main roll die, the back-up roll had to be used in order to achieve the uniformity in the embossing pressure. And several sub-rolls were applied to control the applying pressure precisely. Roll die was heated by resistance heating method to prevent sticking of green sheet to the die (detaching from the glass substrate). As the flatness and level of the working table is very important for the embossing process, the granite table was employed and the supports were placed under the four corners of the table to keep the level.

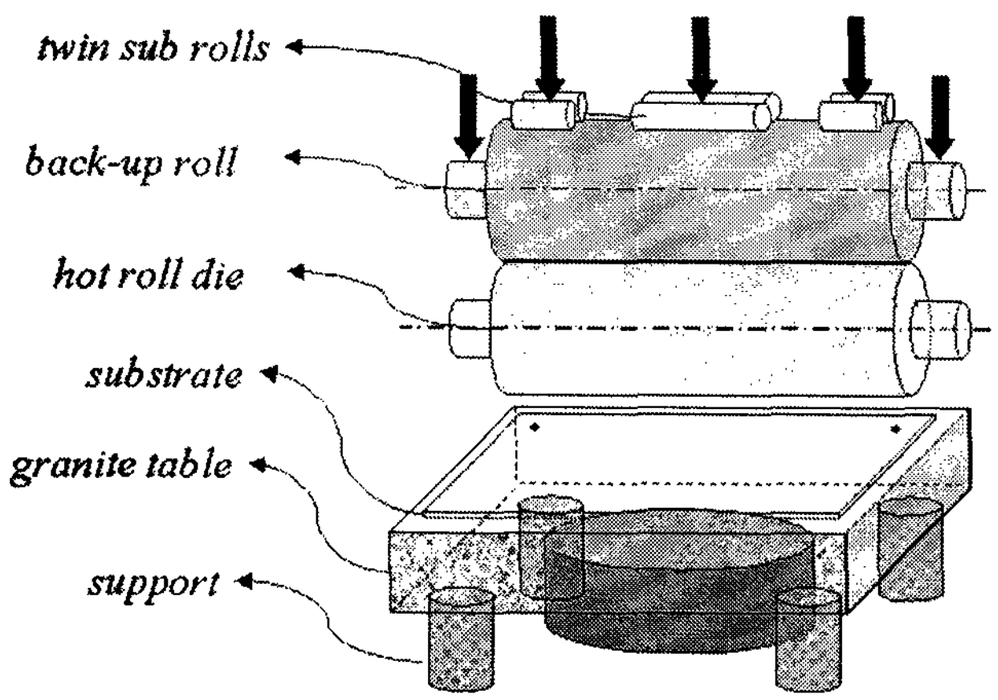

Figure 3. Schematic diagram of roll embossing equipment.

4. Green Sheet Fabrication

Green sheet has many advantages over the thick film paste employed in the sandblasting or screen printing methods. Firstly the use of green sheet makes a PDP barrier forming process very simple. Even the repeated printing process for forming barrier ribs in the sandblasting barrier forming process could be substituted with the process of laminating a green sheet on a glass. In addition, laminating green sheet doesn't require a drying process as does in printing or coating process in other methods. Secondly, the thickness of green sheet is relatively uniform than that of the printed paste. In the conventional barrier forming methods, as the thickness uniformity of the thick film during the repeated printing or coating is rather poor, it causes the undulation of barrier ribs. Therefore the adoption of a pre-formed green sheet of uniform thickness improve the thickness uniformity of the barrier ribs over the large area, which implies that the plasma display apparatus can be made larger and finer, and mass production throughput will be enhanced. Finally, there is no different thermal history inside the barrier ribs because the barrier ribs are formed in the green sheet by roll embossing without any need to the repeated paste printing and drying process like in the conventional barrier forming methods. In the sandblasting method, the repeated paste printing and drying process to define the proper height of the barriers before sandblasting causes barrier ribs to have the different thermal history and results in a layered structure, which in turn induce the difficulty in controlling the etching rate uniformly.

In EBR panel fabrication process, green sheet is the most important material to control. The green sheet is composed of glass-ceramic powder, resin, solvent, and a small amount of additives and the composition of the green sheet is determined in such a way to enhance flowability under applied pressure, not to stick to the die groove during rolling, and to maintain its embossed shape after firing. The required properties and characteristics of green sheets for embossing process are described in other paper.[6] Regarding the green sheet composition, solid powders and organic binder ratio should be higher than those of the green sheets for normal LTCC or MLCC modules. Particle size of the powders could have great effects on the embossing behavior of the green sheet such that small particles can flow better than large particles in organic binder medium under pressure. In addition, selection of the plasticizer and the amount of additives can cause a significant difference in the mechanical properties of the green sheet and embossing behavior.

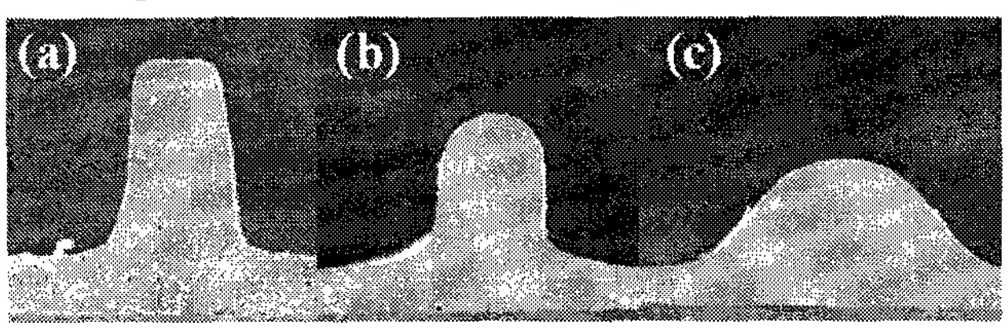

Figure 4. SEM images of barrier ribs for various filler to glass ratios. : (a) 30wt%, (b) 15wt%, and (c) 0wt%.

With different solid content and the filler ratio to glass powder, the height of the barrier ribs can be controlled as shown in Figure 4. In determining the filler ratio, proper filler ratio should be considered not to weaken the strength of the barrier ribs, although some kind of fillers can enhance the strength of the barrier rib materials after firing.

Microstructure of the fired barrier rib has a great effect on the mechanical strength. Usually, barrier ribs with porous microstructure have lower strength and can break easily under tiny impact and vibration on the panel. Figure 5 shows the cross sectional view of barrier ribs observed in SEM. As shown in the figure, barrier ribs have a uniform dielectric thickness and no layered structure is observed.

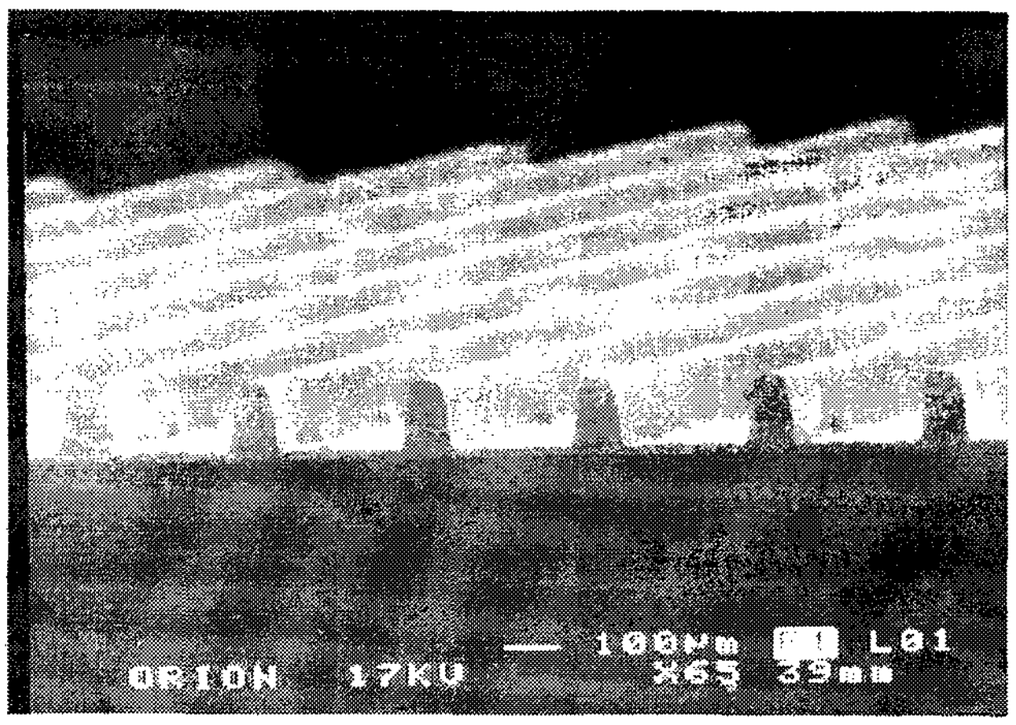

Figure 5. The cross sectional images of barrier ribs formed by embossing.

5. Characteristics of EBR panel

The light-up image of the prototype 42-inch EBR PDP is shown in Figure 6 and the characteristics of EBR panel are summarized in Table 1.

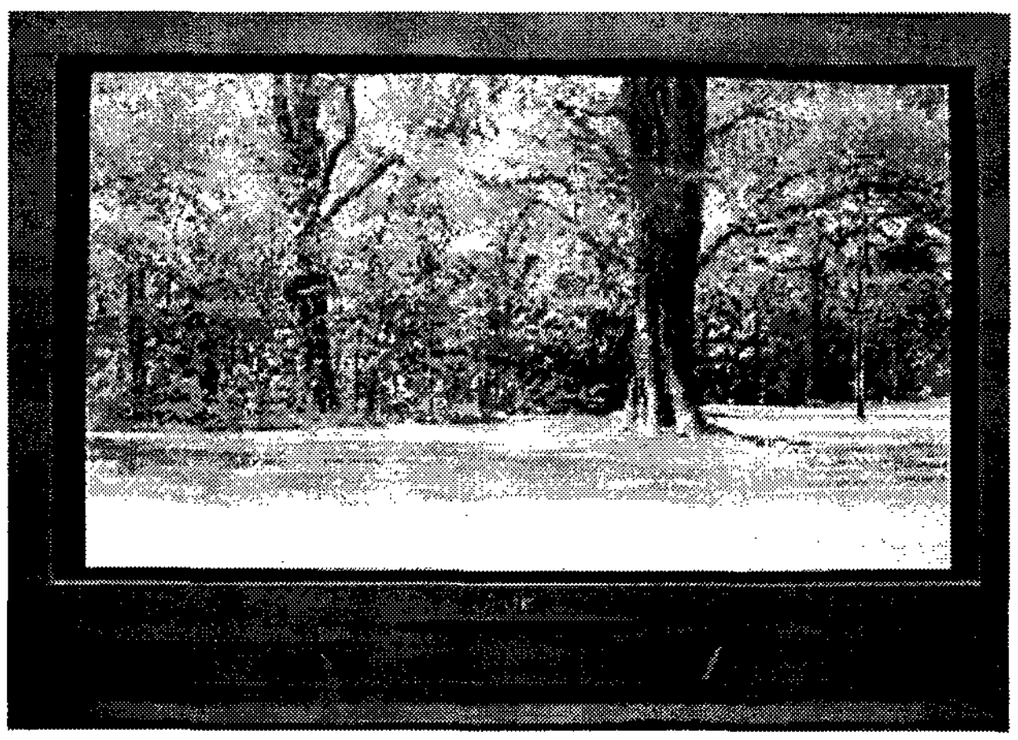

Figure 6. Light-up image of prototype 42-inch EBR panel.

The peak brightness of EBR panel with an optical glass filter was measured to be better than that of the current conventionally fabricated panel by nearly 50% and dark room contrast was also enhanced to 2000:1. Although further investigation of the main contribution to the improvement is needed, the improved brightness was thought to be caused by the combination of the effects from the larger open areas, the removal of black rib layer, and the smoothness of barrier ribs sides.

Table 1. The characteristics of EBR panel.

Item	Specification
Screen ratio	16:9
Number of pixels	853 X 480
Pixel pitch	1.08mm(0.36X3)
Active area	921.24mm X 524.88mm
Brightness (peak)	321 cd/m^2
Color temperature	8200K
Contrast (dark room)	2000:1

6. Conclusion

In this paper, a new barrier rib forming method of embossed barrier rib (EBR) formation process for the PDP rear panel was introduced. As the EBR process is mainly composed of green sheet fabrication and roll embossing, it has two outstanding advantages over the conventional barrier rib forming methods. One is less equipment investment by about 20% of the current rear panel fabrication equipment investment. The other is its reduced rear panel manufacturing cost by eliminating the material expenditure and the environmental expenses.

Regarding the characteristics of prototype PDP using EBR panel, the brightness of panel increased greatly than the panel fabricated by the conventional method and the dark room contrast ratio improved to 2000:1 probably due to the larger open areas, the

removal of black rib layer, and the smoothness of barrier ribs sides.
It is expected when it is further developed to the mass production level, it can contribute to the saving of panel fabrication cost too greatly and could be one of main barrier forming methods.

7. Acknowledgements

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8. References

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