Development of UV-curable paste for micro mold transfer process of barrier ribs of PDPs

Yoo-Seong Kim, Tae-geum Koh, Yong-Seog Kim
Dept. of Information Display Engineering, Hongik University, 72-1, Seoul, Korea
Phone: +82-2-322-0644 , E-mail: xguessx1@naver.com hone

Abstract

In an attempt to reduce processing cost and to improve resolution of PDPs, micro mold transfer processing route for barrier ribs of plasma display panel was developed. In this study, the parameters that may cause defects during the process were identified, which include the shrinkage during UV curing process, stress due to evaporation of organic components, and sintering shrinkage. Considering such parameters, UV curable paste was developed and barrier ribs of PDPs were successfully processed via the process. In addition, the process was successfully applied for the processing of barrier ribs with embedded counter electrodes.

1. Introduction

In recent years, performances of PDPs such as image quality, luminance, power consumption, contrast ratio, and resolution, have been improved significantly enough for general use in digital TV applications. In addition, continuous reduction in selling price of PDPs, ~ 20% annually, led to a rapid expansion of PDP TV market. In order to sustain such growth of PDP market, manufacturing costs must be reduced further and the resolution, bright room contrast ratio, and power consumption need to be improved significantly.

Processing technology of PDP barrier ribs has significant impacts on such issues. The technology determines resolution of pixel and manufacturing cost of the panel. The shape of the barrier ribs, which is affected by the processing technology, has a significant influence on luminance efficiency and power consumption of the panel. Barrier ribs have been manufactured via powder blasting route by most PDP manufacturers. The barrier ribs produced by this process, however, are poor in rib morphology and resolution. Therefore, the ribs produced by the process have been limited mainly to SD and HD resolutions. For barrier ribs of HD or Full HD resolutions, new processing routes such as chemical etching of sintered barrier rib layer [1] and UV lithography process of photosensitive glass frit paste [2] have been developed.

Recently, micro mold transfer method has been developed to reduce processing steps further and increase resolution of barrier ribs [3-6]. This process consists of preparation steps of master mold, replication of the mold by working mold, and filling UV curable paste into the cavities of working mold. The UV curable paste consisted of glass frit, UV curable vehicle, and dispersants. After the working mold filled with paste are cured by UV radiation and fired to densify the glass frit.

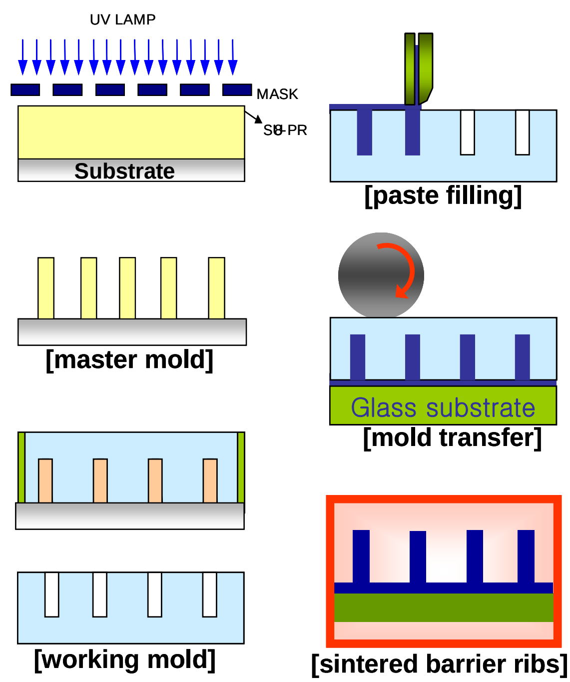


Fig. 1. A schematic illustration of processing steps of barrier ribs via micro mold transfer process.

For the successful application of the process, distortion and cracking of the barrier ribs during sintering process must be minimized. Parameters that may cause such defects are shrinkage during UV curing process, stress occurring upon evaporation of organic components, and shrinkage due to densification upon sintering. Thus, in this study, effects of such parameters on distortion and cracking of barrier ribs were investigated. Based on such study, a UV curable paste was developed and barrier ribs of PDPs were successfully processed via micro molding process.

2. Results

2.1. Effect of paste compositions on defect formed at barrier ribs

Table 1 shows a typical chemical composition of paste formulated based on conventional UV paste composition. A mixture of oligomer and monomer was selected to develop the pseudoplastic behavior of the paste.

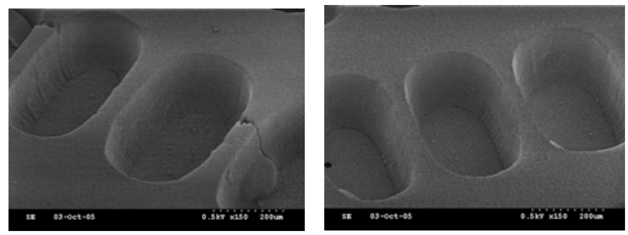
Table 1. Chemical compositions of UV paste used in this study

(wt.%)

acrylate oligomer	acrylate monomer	Photo initiator	solvent	defoamer	dispersant	Glass frit
5.7	5.7	0.1	5.7	0.1	0.6	82.2

Using the paste, barrier ribs were transfer molded on glass substrate and heated to 260°C and 400°C, respectively and observed their microstructure. These temperatures were selected in order to determine the effect of shrinkage stress developed during evaporation of organic constituents on defect formation in barrier ribs. As noted from Fig. 2(a), the sample heated to 260°C developed numerous cracks in the barrier ribs. This indicates that the evaporation of solvent during heating process develop stress large enough to fracture the barrier ribs in green state. On the other hand, the sample which was not fractured during the evaporation of solvents did not develop any crack after evaporation of oligomers and cross-linked monomer by heating to 400°C (Fig. 2(b)). These results suggest that the paste should be designed without using solvent for the micro mold transfer process.

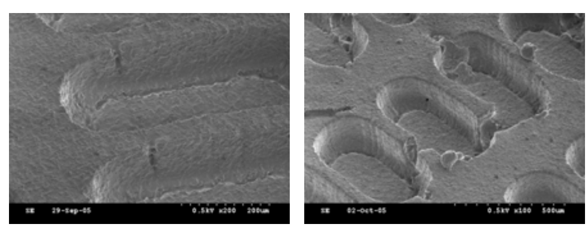
Thus, a paste consisted of monomers, photo initiator and dispersant was designed in this study. Solvents and oligomers used in conventional paste were replaced with monomers that can be cross-linked via UV curing process. Monomers with different functional groups were used for the paste.



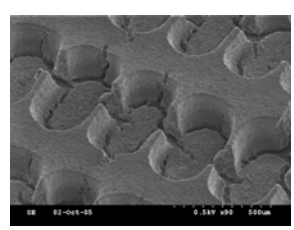
(a) (b)

Fig. 2. SEM micrographs of barrier ribs after heating to (a)260°C and (b) 400°C.

Fig. 4 shows the effect functional groups on the sintering defects of barrier ribs. The barrier ribs transferred were heated to 570°C at a heating rate of 5°C/min. As the functional group of monomers is increased from 1 to 3, the degree of crack development in the barrier ribs increased notably. In general, the shrinkage of the paste during UV curing stage increases with the increase in functional group [7]. The stress developed during UV cross-linking reaction of monomers might have played an important role in the developments of cracks in the barrier ribs.



(a) (b)



(c)

Fig.3. Effects of monomer functional group on sintering defects: (a) 1 functional group (b) 2 functional group, and (c) 3 functional group.

Thus, the paste consisted of 1 functional groups was designed for this study. Using such paste, various types of barrier ribs were manufactured successfully without any defect formed as shown in Fig. 4.

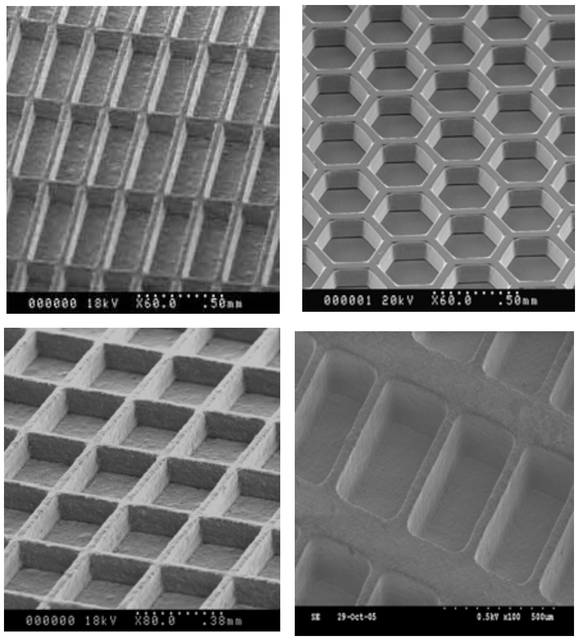


Fig. 4. Various types of barrier ribs formed via micro-mold pattern transfer method.

2.2. Processing of barrier ribs with embedded counter electrodes

Using a micro-mold for electrode pattern, barrier ribs with embedded electrode were prepared via the micro-mold pattern transfer method. Fig. 5 shows the microstructure of the barrier ribs formed with electrode embedded. Ag electrode pattern was formed on the surface of inner wall of barrier rib and covered with dielectric glass material. The mold pattern transfer route reduced the processing steps of the barrier ribs with counter electrodes embedded very significantly.

Using the counter electrode discharge cells prepared, discharge behavior of the discharge cells were observed using ICCD. As shown in Fig. 6, a typical long gap discharge mode was realized with the cell dimensions of XGA. This suggests a possibility of dramatic enhancement of luminance efficiency at high resolution PDPs.

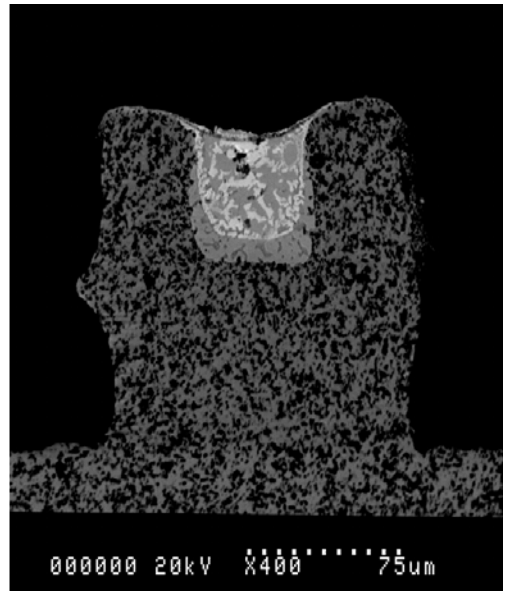


Fig. 5. Cross sectional micrograph of barrier ribs with embedded electrode.

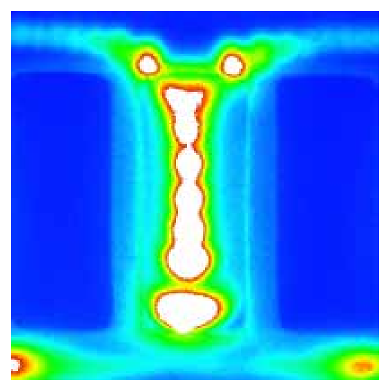


Fig. 6. ICCD image of discharge cell with counter electrode embedded.

3. Conclusion

Parameters that may affect the defects formation in barrier ribs during micro mold transfer process were identified. The solvent and type of UV curable monomers were found to affect the defect formation behavior. Thus, paste with low functional group and low molecular weight was found suitable as a vehicle for UV curable paste micro molding process. In addition, the barrier ribs with counter electrode embedded were successfully prepared via micro mold transfer process.

4. Acknowledgements

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5. References

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