Barrier Rib Patterning Technology for Cost Effective High Resolution PDP

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Abstract

Barrier ribs in the color plasma display panel(PDP) function to maintain the discharge space between to glass plates as well as to prevent optical crosstalk. Patterning of barrier ribs is one of unique processes for making PDP. In this work photosensitive barrier rib pastes were prepared by incorporating binder polymer, solvent, functional monomers photoinitiator, and barrier rib powder. Study on the function of materials for the barrier rib paste were undertaken. After optimization of paste formulation, both photolithographic and transparent soft molding method resulted in fine pattern of barrier ribs with high aspect ratio.

1. Introduction

Barrier ribs in the color PDP(Fig.1) are indispensable to maintain the discharge space between two glass faceplates as well as to prevent optical crosstalk in adjacent cells.[1)]

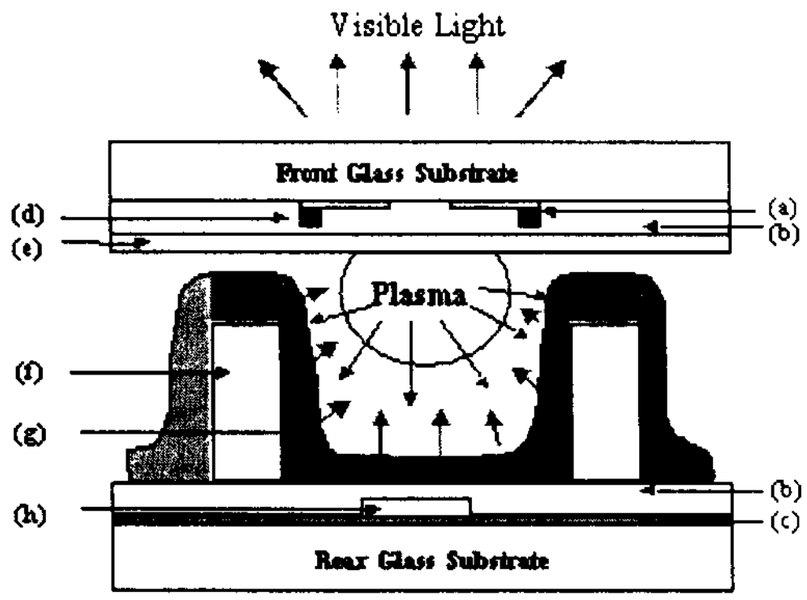

Fig 1. Structure of AC PDP

Several methods(Fig.2) are available for the fabrication of barrier rib pattern for the plasma display panel(PDP) including screen printing, sandblasting and photolithographic method. Currently sand blast method is widely used for the formation of fine pattern of barrier ribs for PDP. As the size of PDP increase over 60 inches and high resolution (XGA grade) is needed, however, photolithographic method is considered to the method of choice for barrier rib patterning in manufacturing of PDP.[2-3)] A Photosensitive barrier rib paste consists of binder polymer, solvent, photoinitiator, UV crosslinkable monomers and/or oligomers, and additives. Each of the components used in the formulation has specific function and has effects on the resulting barrier rib pattern.

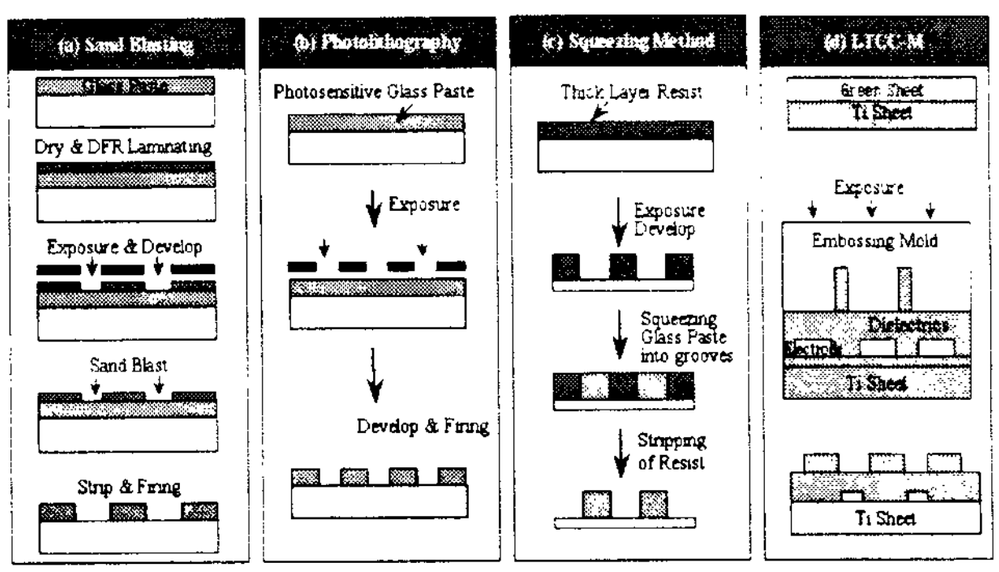

Fig 2. Comparison of Barrier Rib Process

Recently, LTCC-M(Low Temperature Ceramic Cofired on Metal) method was also introduced.[4-7)] In this work we studied a new barrier rib formation technique for PDP utilizing photosensitive barrier rib paste and transparent soft mold. Simple press or LTCC-M methods are highly desirable for the formation of barrier ribs for PDP from the viewpoint of saving valuable raw materials. However, those methods have difficulty in the demolding process. We first made a photosensitive barrier rib paste and used it in the photolithographic method of patterning barrier ribs.

In a second method, transparent soft mold made from silicone resin was used to press the

photosensitive barrier rib paste and then UV was irradiated through the transparent soft mold. After UV curing the soft mold was delaminated by slow winding process. This process minimize the contact area between patterned barrier rib and mold enabling fine patterning of barrier ribs with high aspect ratio.

2. Experimental

2.1. Formulation of photosensitive barrier rib paste

Materials

Hydroxypropyl cellulose(Aldrich, MW 80,000) which is soluble in water was used as binder polymer for photosensitive barrier rib paste. 3-Methoxy-3-methyl butanol (3MMB) obtained from Tokyo Chemical Industry Co. was used as solvent(Tb=175℃) to dissolve HPC binder polymer. UV curable monomers include pentaerythritol triacrylate (PETA), trimethylolpropane triacrylate (TMPTA), trimethylolpropane ethoxytriacrylate (TMPEOTA) tested as trifunctional monomer and tripropylene glycol diacrylate (TPGDA) as difunctional monomer and hydroxyethyl acrylate as monofunctional monmer. EB 600 is an epoxy ester type UV oligomer obtained from SK-UCB. Photoinitiator(HSP-188) was purchased from SK-UCB Co. and used as received. Barrier rib powder used in the paste has an approximate composition of PbO 60.0, SiO_2 10.7, Al_2O_3 29.0wt%, and trace (0.3wt%).

Paste Process.

The components of photosensitive barrier rib paste were mixed with the aid of mechanical stirrer and three roll mill(Exact Co., Germany). First binder polymer(HPC) was dissolved in the 3MMB solvent with mechanical stirrer for 8-12hr to the extent which did not have any gels or coagulums. UV curable monomers and photoinitiator were added to this solution and the resulting mixture was stirred for 2hr. To this mixture was added barrier rib powder and the slurry was mixed with mechanical stirrer for 10-30 min. The mixture slurry was then placed on the three roll mill and ground for 2-3 hr until a homogeneous paste with desired rheological property was obtained. [8),12)]

2.2 Photolithographic Method of Patterning Barrier Ribs for PDP

The process of obtaining fine pattern of barrier rib by photolithographic method is shown in Fig.3. The barrier rib paste coated glass substrate was dried in a 90℃ convection oven for 20 min. The photomask was placed on top of the dry barrier rib and then irradiated with a UV lamp to a total dose of 500-600mJ/cm^2. The unirradiated barrier rib were developed with water at 1.0 kg/cm^2 pressure for 20-30 sec and then dried in the 100℃ oven for 20 min.. The panel with barrier rib patterned was fired in the high temperature oven which was heated up to 550℃ for 30min. Barrier rib patterns without any binder polymer and other organic components were obtained through this firing process. [8-11)]

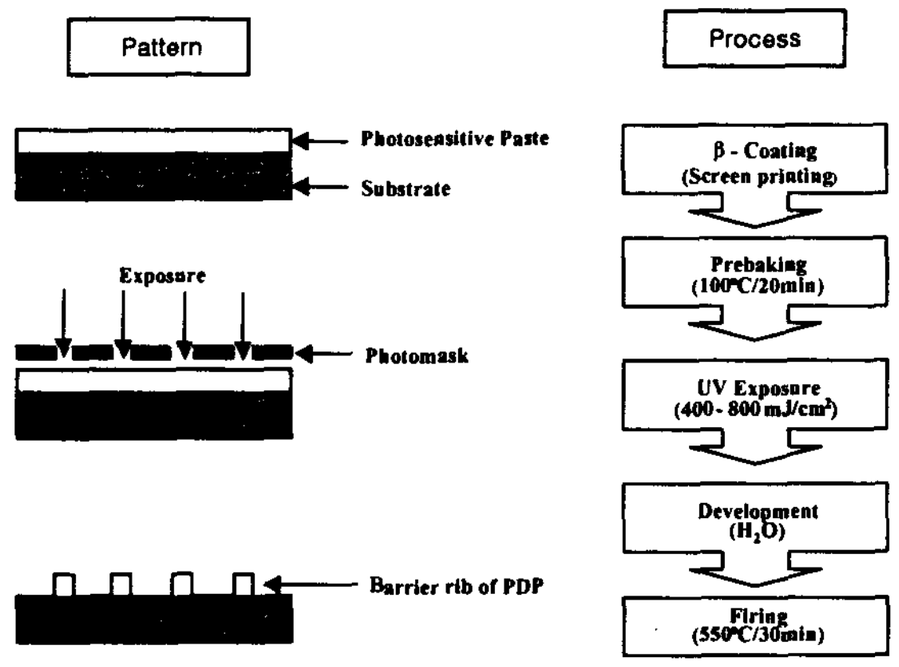

Fig. 3. Formation of PDP barrier rib by photolithographic process

2.3. Patterning of Barrier Ribs by Transparent Soft Mold(TSM) Press

We studied a new barrier rib formation technique for PDPs to obtain barrier ribs with high aspect ratios and to reduce the manufacturing cost. We also have examined this new transparent soft molding (TSM) process so that we can solve demolding problem which the current simple press method and LTCC-M method have had. We developed a photosensitive barrier rib paste which helps the demolding process after UV irradiation due to change in the interfacial area. We also developed a process of obtaining transparent soft mold utilizing photosensitive glass.

Fabrication of transparent soft mold using photosensitive glass base mold

Transparent soft mold was fabricated by pouring a silicone resin into the base mold made with photosensitive glass. Fig.4 shows the fabrication of

the base mold and transparent soft mold using photosensitive glass and silicon resin.[13-14)]

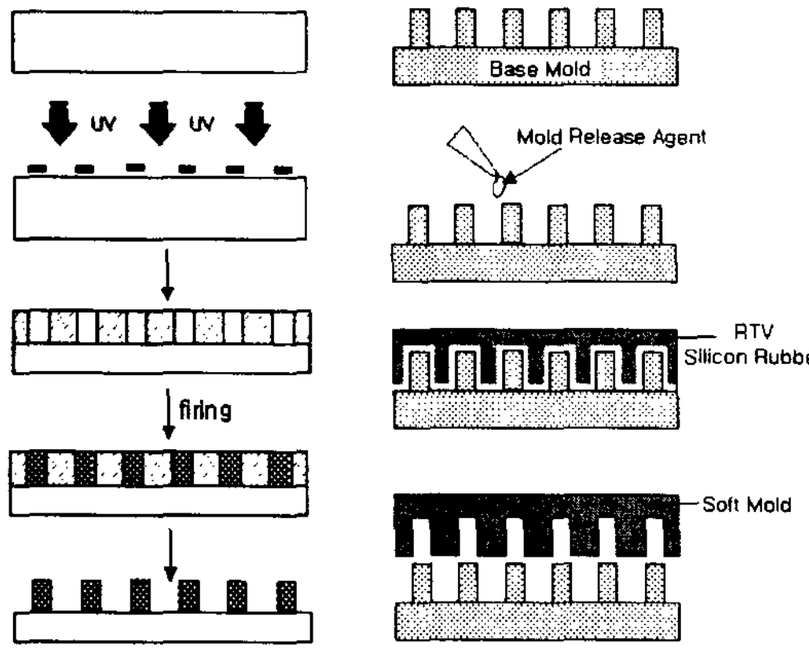

Fig 4. Fabrication of the base mold and transparent soft mold using photosensitive glass and silicon resin

Room temperature cure type silicone resin (SH-9555) was poured on the base mold made of photosensitive glass. It was subjected to vacuum for 30 min to remove air bubbles. It was then cured at room temperature for about 12 hrs. The soft mold formed was released from the base mold by slow winding process.

Barrier rib patterning by TSM process

The formation of barrier rib by a new TSM process using photosensitive barrier rib paste is shown in Fig. 5. The photosensitive barrier rib paste was formed on a coated glass substrate and dried in a 90℃ convection oven for 20min. The transparent soft mold was placed on top of the dry barrier rib layer and then irradiated with a UV lamp to a total dose of 500~600 mJ/㎠. After demolding, the barrier rib shaped paste was fired in a high temperature oven, which was heated up to 550℃ for 30min. A PDP rear panel with barrier rib forming patterned without any binder polymer or other organic components was obtained through this firing process. The transparent soft mold was rinsed in ethanol, washed thoroughly using an ultrasonic machine for reuse.

3. Results and Discussion

3.1. Photosensitive Barrier Rib Paste Formulation

The main components of barrier rib paste include binder polymer, solvent, functional monomers, photo-initiator, and barrier rib powder. The photopolymeriza-tion and developing mechanisms of barrier rib paste

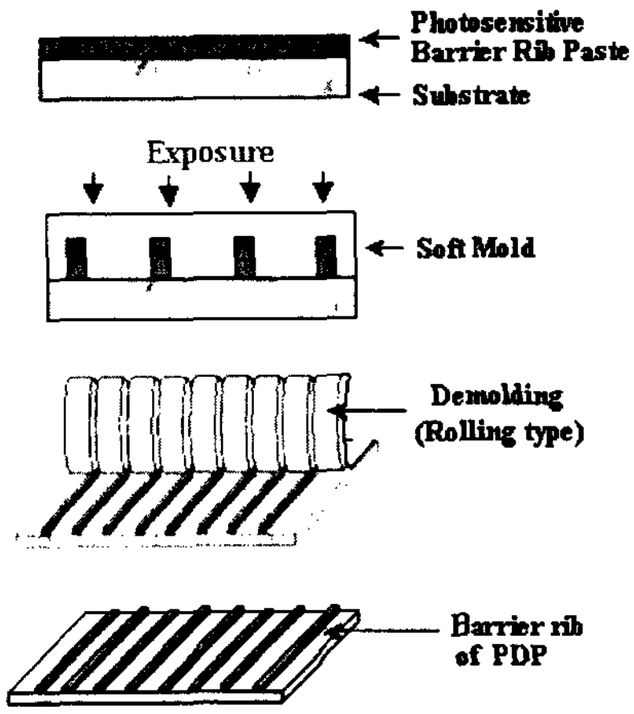

Fig 5. Formation of PDP barrier rib by TMS process

are shown in Fig. 6. The binder polymer itself is not photosensitive. The multifunctional monomers dispersed in the paste are converted to a three dimensionally crosslinked composite polymer by the action of photoinitiator. [8)]

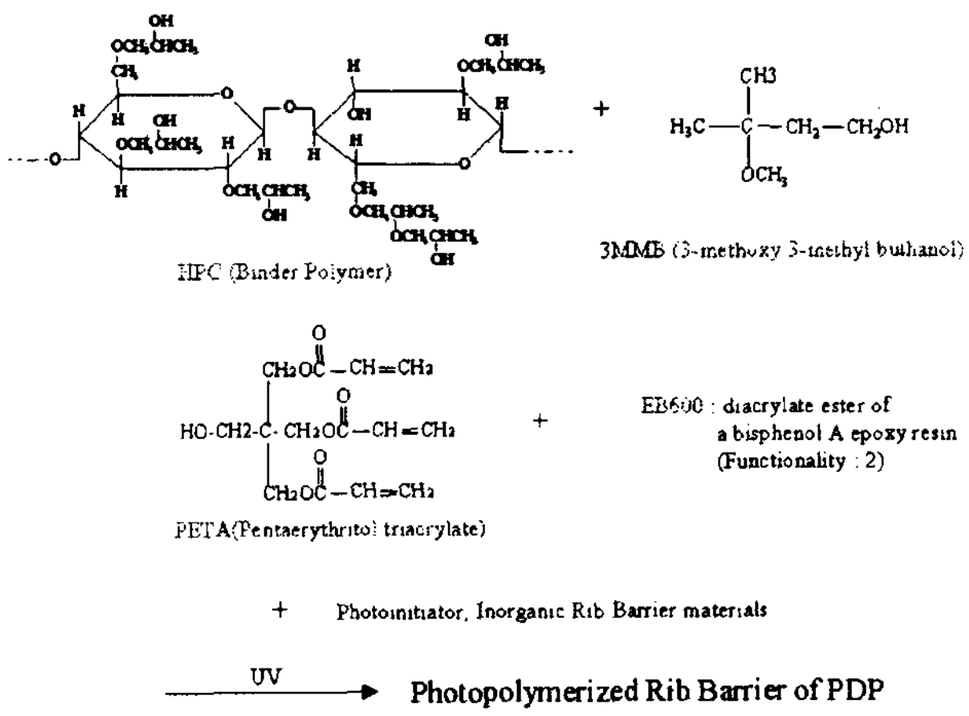

Fig 6. Photopolymerization and developing mechanisms of barrier rib paste

In the unexposed area, however, the acidic binder polymer is converted to a carboxylated form and the whole mixture of barrier rib including unreacted monomers and UV oligomers is washed away when developed with the aqueous alkaline solution.

In order to select the proper monomer/oligomer system, several formulations were tested. As shown in Table 1 and Fig. 7 the PETA/EB 600 in 1:1 ratio gave optimum patterning property.

Table 1. Photosensitive barrier rib formulation

Sample No.	Binder	Solvent	Monomer/ Oligomer	Initiator	Additive	Inorganic Powder
KBR-1	HPC 5.5%	3MMB 22.0%	PETA/HEA 11.0%(3:2)	HSP188 1.4%	0.1%	60%
KBR-2	5.5%	22.0%	PETA/EB600 11.0%(1:1)	1.4%	0.1%	60%
KBR-3	5.5%	22.0%	TMPEOTA/EB600 11.0%(1:1)	1.4%	0.1%	60%

(a) KBR-1 (b) KBR-2 (c) KBR-3

Fig 7. Patterning property of barrier rib

3.2 Photolithographic process.

The photolithographic processes such as screen printing, drying, UV exposure, and development were tested utilizing the optimum photosensitive barrier rib paste(Table 2). Fig. 8 shows the SEM image of barrier obtained with the optimized paste formulation and photolithographic process. [8-9)]

Table 2. Photolithographic Process Conditions

Process	Parameter	Optimum Condition
Screen printing	Viscosity(cps)	27,500 cps
	Mask(mesh No.)	325
Drying	Temp/Time	90℃/20min
Exposure	Dose	300mJ/cm^2
	Gap	300μm
Development	Medium/Time	H_2O/35sec

※ Typical Photosensitive Barrier Rib Paste :
Binder polymer(16.1%), Solvent(63.3%), Monomer(16.1%)
Photoinitiator(1.6%), Additive(0.7%), Powder(50.0%)

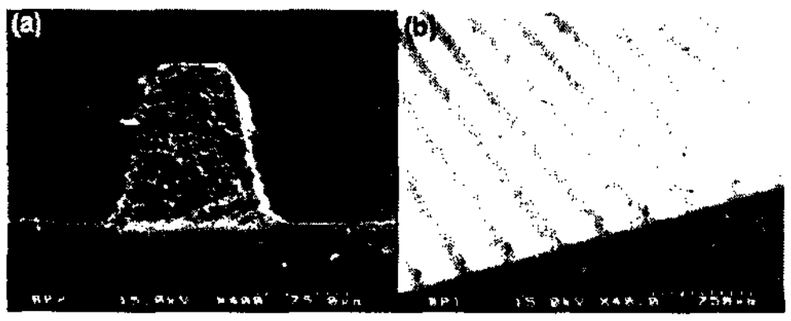

Fig 8. SEM photographs of barrier ribs (a) cross section, (b) top view

3.3 Transparent Soft Molding (TSM) process

Transparent soft mold was fabricated by pouring a silicone resin into the base mold made with photo-

Table 3. Fabrication condition of photosensitive glass base mold

Step	Condition
UV Exposure	Expose Dose : 1000~3000 mJ/cm^2
Firing	1 step : 3℃/min to 500℃ 2step : 5℃/min to 600℃ 3step : keeping at 600℃ for 1hr
Etching	10wt% HF Aq. soln.
Drying	100℃/10min

photosensitive glass. Table 3. shows the fabrication condition of the base mold using photosensitive glass.

The photosensitive barrier rib paste was coated on the glass substrate and dried in a 90℃ convection oven for 20min. The transparent soft mold was pressed on top of the dry barrier rib layer and then irradiated with a UV lamp to a total dose of 500~600 mJ/cm^2. It was found that the pressure of soft mold and softness of the barrier rib layer controlled by percent dryness had significant effect on the patterning of barrier ribs. The soft mold was then removed from the pressed barrier rib by winding up and fine pattern of barrier rib was obtained. Exposure to ultraviolet ray under the pressed state helps reduces the interfacial adhesive force between the soft mold and the photopolymerized barrier rib. After demolding, the barrier rib was fired in electric furnace, which was heated up to 550℃ for 30min. Fig 9 shows the SEM photographs of barrier ribs obtained by TSM process.

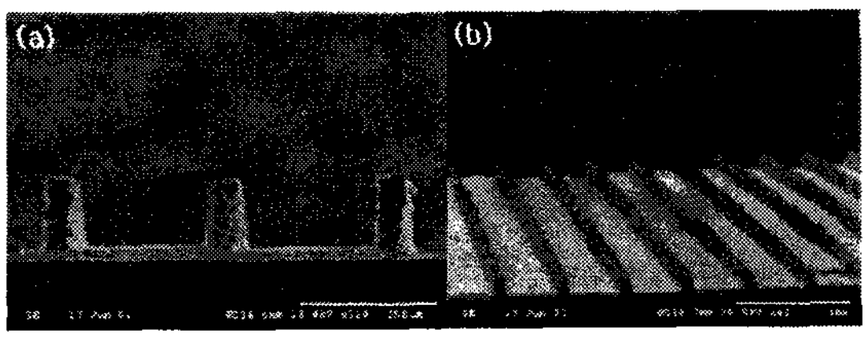

Fig 9. SEM photographs of barrier ribs (a) cross section, (b) top view

4. Conclusion

Both photosensitive barrier rib paste formulation and photolithographic process were developed for the fine patterning of barrier rib with high resolution. (1)The photosensitive barrier rib paste and photolithographic process are especially suitable for large size (over 60 inch) and high resolution (XGA grade) plasma panel display. (2) Barrier ribs can be formed with high resolution up to 130㎛ in height, 60㎛ in width and 350㎛ in pitch by the soft mold process, utilizing photosensitive barrier rib paste. (3)

The photosensitive barrier rib paste makes the demolding easy due to reduced interfacial forces and shrinking of paste materials.

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