Recent Advances with the 3M PDP High Resolution Rib Replication Process

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Abstract

3M has developed a Precision Replication Process for the production of PDP Barrier Ribs and other display devices. This process, is fast, clean and capable of producing very high resolution (FHD and beyond), high aperture ratio and fine cell structures. Recent advances in materials and process features will be discussed.

1. Introduction

Presently, PDP manufacturers face multiple challenges to maintain a strong position in the field of Large Area TV Displays. While PDP TVs feature many superb visual properties and offer great value to the consumer, ever increasing customer expectations for quality and feature improvements are coupled with demands for lower costs and greater value.

In particular, the competitive pressure from the wide scale availability of 1080p capable LCD TV's is a serious threat to the PDP Industry. It is a significant problem that no PDP manufacturer has yet introduced a 40" class PDP TV offering full high definition (FHD - 1920 x 1080) resolution. Recent market analysis shows 40" class PDP's loosing market share to the widely available 1080p capable LCD's.

The PDP industry has consistently underestimated the importance of high resolution over the past 5 years. Even now, future display requirements are in fact forming for even higher (QFHD – 3840 x 2160) and 8Kx4K resolution displays.

Amongst the technical challenges to be resolved are the economic production of a fine feature rib structure, increased aperture ratio and luminous efficiency [1] [2] [3] [4] and compatibility with environmental requirements such as RoHS.

2. Process Description

All presently practiced processes used to fabricate barrier rib plate discharge cell microstructures are subtractive processes. Subtractive means that material is machined away by various means (chemical or mechanical etching or photo-lithographically) until the desired microstructure is formed. This is a slow and often low yield process leading to the production of much waste materials (frit, blast media, photoresist…) and energy inputs.

Alternately, 3M has developed a new "Additive" fabrication methodology for the production of fine structures such as PDP Barrier Rib's. An additive process provides inherent design flexibility, simplicity and economies of operation beyond those achieved with conventional processes [4] [5] [6]. Material consumption energy, labor and capital are reduced by more than 50%.

The 3M process (Fig 1) is a lamination molding process. It is based upon the development of a unique set of materials (3M Barrier Rib paste and Precision Sheet Mold) and the 3M rib replication process. Major process steps would include the following:

Steps 1-2 Required once at initial setup of process

1.) Initial registration & alignment of sheet mold
2.) Initial registration of glass plate fiducials

Steps 3-6 Comprise Process Cycle

3.) Coating of glass frit paste onto glass substrate	30 sec
4.) Lamination of sheet mold onto substrate	30 sec
5.) Paste light cured (through mold or glass)	30 sec
6.) Mold stripping (mold is reusable for next cycle)	30 sec
Total Cycle Time	**~2 min**

7.) Conventional debinding and sintering processing.

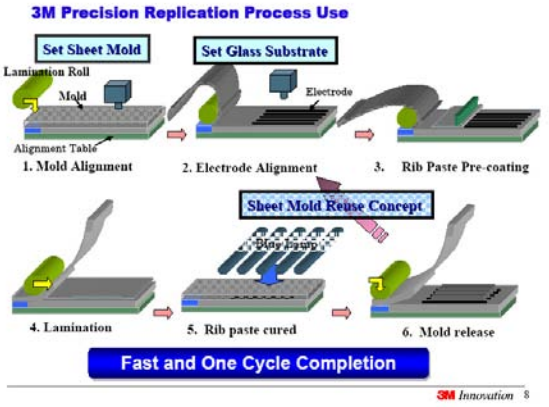

Fig. 1. 3M Precision Replication Process Map

This simple 4 step process yields a green cured ceramic microstructure which incorporates a dielectric layer over the address electrodes. Process cycle time is minimally invariant with respect to panel size or resolution. Typical cycle time is ~2 minutes. Equivalent sandblasting and chemical etching process times can exceed 200 minutes and comprise 10-15 yield-robbing process steps.

3. Process Materials Performance

Sheet mold and paste materials compatibility, precision and quality are key elements of the 3M Barrier Rib process. Novel and proprietary manufacturing processes enable the accurate production (Fig 2) of large format sheet molds.

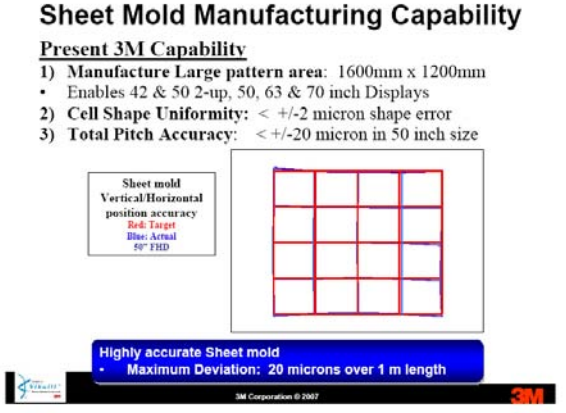

Fig. 2. Sheet Mold Precision Forming Metrology

Economic use of the process is assured through the reusability of the precision replicated sheet molds. Careful selection of materials ensures long term compatibility and the preservation of sheet mold dimensional precision.

4. Multi-panel Production Compatibility

The economic production of PDP modules requires the ability to process multiple Barrier Rib plate panels simultaneously. Panel production configurations can consist of simple 1 dimensional arrays comprising 2 and 3-up strips and more recently 2 dimensional arrays of 4, 6 and 8-up production, Some PDP OEM's are planning new production processes that anticipate 10-up production of 42" panels. 8-up and 10-up production would utilize huge mother glass substrates with typical dimensions of 2x3 meters.

Despite these huge dimensions, the 3M process can be used effectively with multi-panel production. While it is almost impossible to envision a thin, flexible plastic sheet mold which could be dimensionally accurate over size scales of 3 meters, the process can be economically and accurately broken down into smaller elements.

3M has developed the ability to produce 2-up sheet molds with precision. Shown below (Fig.3.) is a metrology map of a typical 42" 2-up FHD sheet mold. We describe this layout as a series configuration. Two such molds can be utilized to meet a 4-up production requirement; four such molds can complete an 8-up configuration.

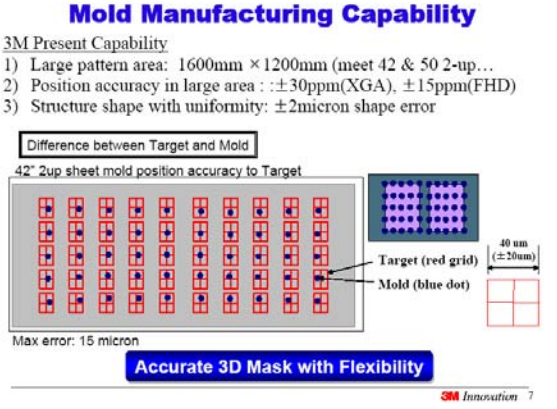

Fig. 3. 42" 2-up Sheet Mold - Typical Metrology

Alternately, multi-up production can be completed by the use of multiple 1-up sheet molds and a multiple-headed precision lamination machine. Such a

machine configuration provides the lowest cost production configuration and highest reliability and flexibility.

5. Multi-panel Production Laminator Designs

Our basic machine design concepts for a 1-D (strip type) multi-headed laminator is shown (Fig. 4.) below.

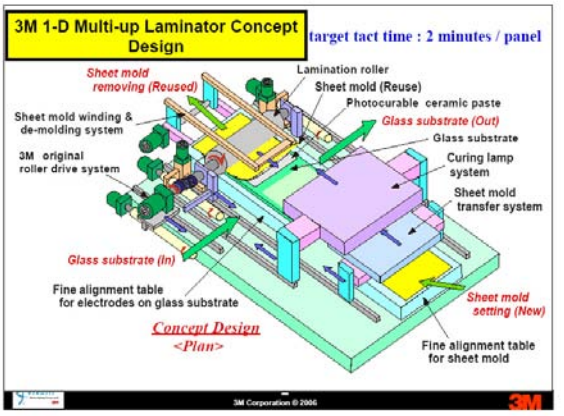

Fig. 4. 1-D (strip type) Multi-panel Lminator

Our more advanced machine design concept for a 2-D (X x 2 panel array type)is shown (Fig. 5.) below.

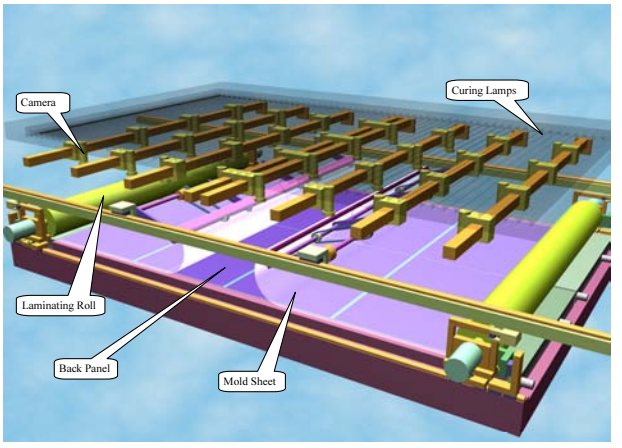

Fig. 5. 2-D Multi-up Multi-headed sheet mold laminator

Key elements of this design include the ability to use either 1-up or 2-up sheet molds, the feeding of individual sheet molds from a sheet mold magazine and the individual sheet mold alignment & clamping mechanisms. Production using this process concept would follow the following process steps:

Step 1 Required once at initial setup

1.) Load sheet molds and align to machine datum

Step 2 Completed previously on other equipment

2.) Pattern coat glass frit paste onto mother glass

Steps 3-7 Process Cycle

3.) Register mother glass to machine datum
4.) Laminate individual sheet molds to mother glass
5.) Cure paste
6.) Delaminate sheet molds
7.) Inspect finished panel patterns
Automatically adjust sheet mold positions as needed
Replace individual sheet molds as needed

6. Summary

The 3M Rib Replication process provides many features and benefits to the PDP Industry and the consumers which we serve. Improved display quality, aperture ratio, resolution, and manufacturing productivity and cost are shown to be possible with this process. Methods of scaling the process to the multi-panel production needs of the industry have been shown.

7. References

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