

Advances and New Challenges in LCD

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Abstract

Even though the TFT-LCD industry gained enough momentum that has been built up in past 10 years, the industry faces new challenges in order to maintain the 'true mainstream display' position in near future. The technical challenges can be summarized in two fold; one is image quality upgrade for different application area. Cost competitiveness is the other big issue in LCD for the continued leadership position in display industry. In this paper, we describe the technology advancement and the technical challenges in LCD to achieve these goals..

1. Introduction

Recent activities in the LCD industry are changing from the traditional role of LCD for notebook PC and desktop monitor use. The growth of notebook PC market is showing a limitation. The replacement ratio of desktop CRT monitors with LCD monitors is already reaching near 30% this year. Further increase in replacement ratio directly depends on the cost and the performance level of LCD monitors. LCD-TV is another growing important area for TFT-LCD business because of its potential market size. The technology level required for LCD-TV is different from that of notebook and desktop monitors in the area of color, screen brightness and dynamic response for motion picture. Therefore, the emphasis has changed and the scope has moved from the narrow focus of the traditional computer display market to providing high quality video images as well.

In summary, the burden on LCD is getting heavier in order to achieve the 'true mainstream display' title. The LCD technology progress built up for previous 10 years need to reshape for both cost reduction and performance upgrade.

2. LCD Technology Evolution

The technology has made a significant progress in

recent years in the area of front of the screen (FOS) improvement and panel manufacturing technology. Fig. 1 illustrates the FOS improvement during the past 10 years in the area of contrast ratio, screen brightness and power consumption.

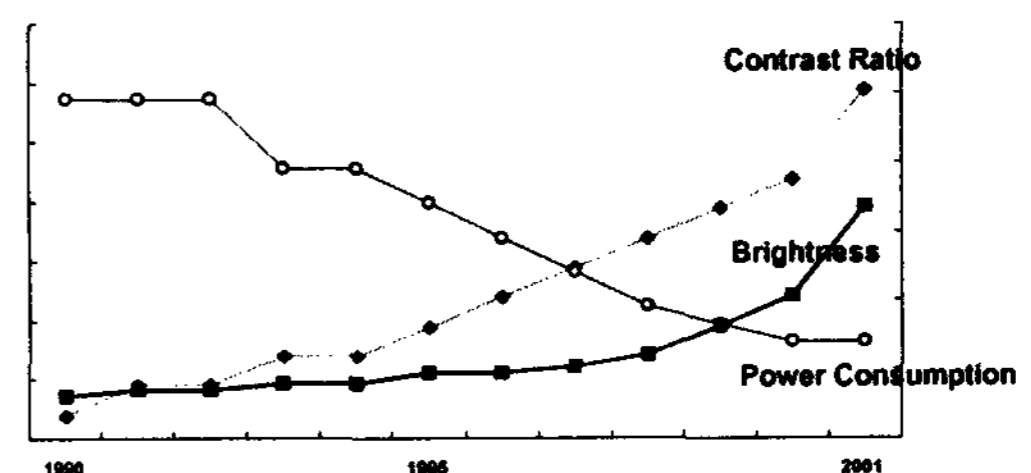


Fig.1 Continuous LCD performance upgrade

There has been also a visible trend in larger direct view displays continue to add the size line ups from 12.1" to 14.1" and now days to 15" for notebook application. For desktop monitor application, the panel size is rapidly shifting from 15" to 17".

The trend in increasing panel size helps the LCD industry in two ways; first one is that the trend contributed the market size increase by consuming more mother glasses, the other one is that it gives LCD a opportunity to differentiate from other display technologies because LCD is less sensitive to the size and resolution.

To prepare for the coming LCD-TV market, 30" panels are becoming popular and even in the largest 40 inch LCD-TV, challenging the dominance of PDP

technology in this size area. The size increase trend will continue in the future.

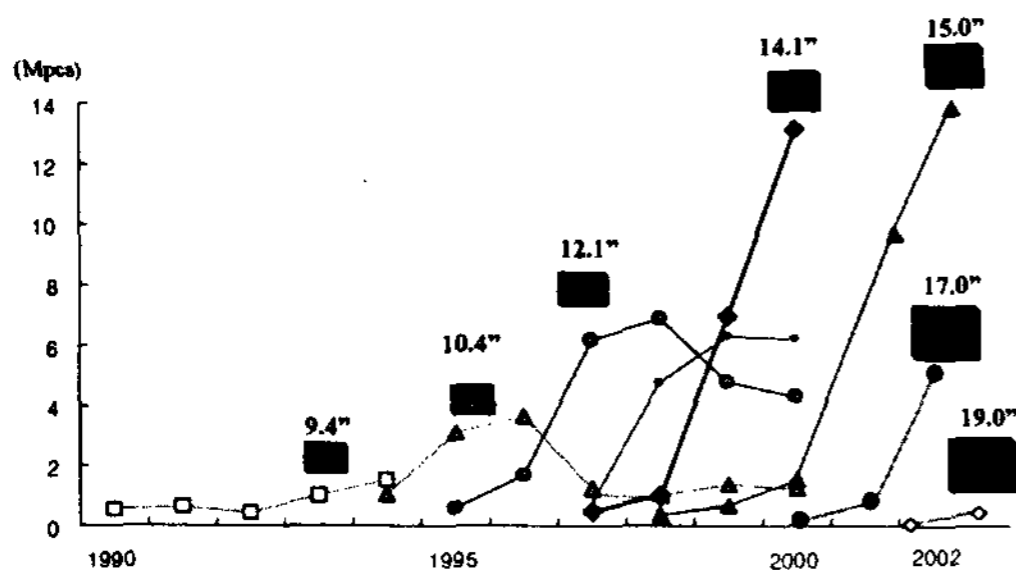


Fig. 2 Panel size upgrade in every 2 years

LCD-TV open a doorway of hope for LCD suppliers, but this business demands many new technologies on the table, including video quality for reducing motion artifact and super bright screens to satisfy those eyes that have been trained to watch CRT TVs for decades long.

Until recently, the performance of LCD-TV was considered not satisfactory especially in the area of motion picture reproduction, long life bright back light system and screen size. However, the TFT-LCD technology has made a significant progress in recent years in the area of video quality performance, high brightness and high color saturation. These performance improvements were possible after extensive R & D effort in the liquid crystal response time improvement, color filter material and back light efficiency improvement. In parallel, the manufacturing technique advancement in fabricating larger mother glass size is another driving force to penetrate large size panel market and significantly reduced panel cost with higher yield achieved.

Now LCD is challenging the traditional territory of CRT based TV over 20 inches and even to PDP sizes near 40 inches.

3 Preparation for Expansion

3.1 LCD's Core Competence

Based on the device physics point of view and the proven performance level demonstrated more than 15 years, the core competence of TFT-LCD compared

to other FPD technologies, such as PDPs and OLEDs, summarized in the following areas;

1. 15 years of proven device technology
2. Advance in manufacturing technology
3. Advantage in low voltage driven devices
4. Strong infrastructure built up for 15 years
5. LCD cost down speed is faster than expected

3.2 Cost Reduction Approach

Panel Cost Down Approach

- | | |
|---------------------|---|
| Productivity | <ul style="list-style-type: none"> - Larger Glass Size - Glass area utilization - Process Simplification <ul style="list-style-type: none"> TFT Process reduction (7- 5- 4 mask step) Automation : LC & Module line - Improve Cost of Ownership <ul style="list-style-type: none"> Shorten TAT (Turn Around Time) Shorten Transportation distance |
| Cost saving | <ul style="list-style-type: none"> - Reduce number of parts - Material reduction <ul style="list-style-type: none"> Spin coating · slit coating Recycling |

Summary of Cost Effective Manufacturing

- (1) **High Volume Production**
 - Cost burden divide by number of panels per glass
- (2) **High Yield mfg. Skills for large size**
- (3) **Reduced process for cost down**
- (4) **Materials cost saving**
- (5) **New Process & Materials development**

3.2.1 Productivity enhancement

For the past 10 years, mother glass size increased dramatically as illustrated in Fig. 3. Accordingly, the number of panels out of a mother glass increases, which in turn contributed the overall panel cost down more than any other factors. The manufacturing technology to process the larger mother glass also improved accordingly reaching higher production

yield even with the larger glass size.

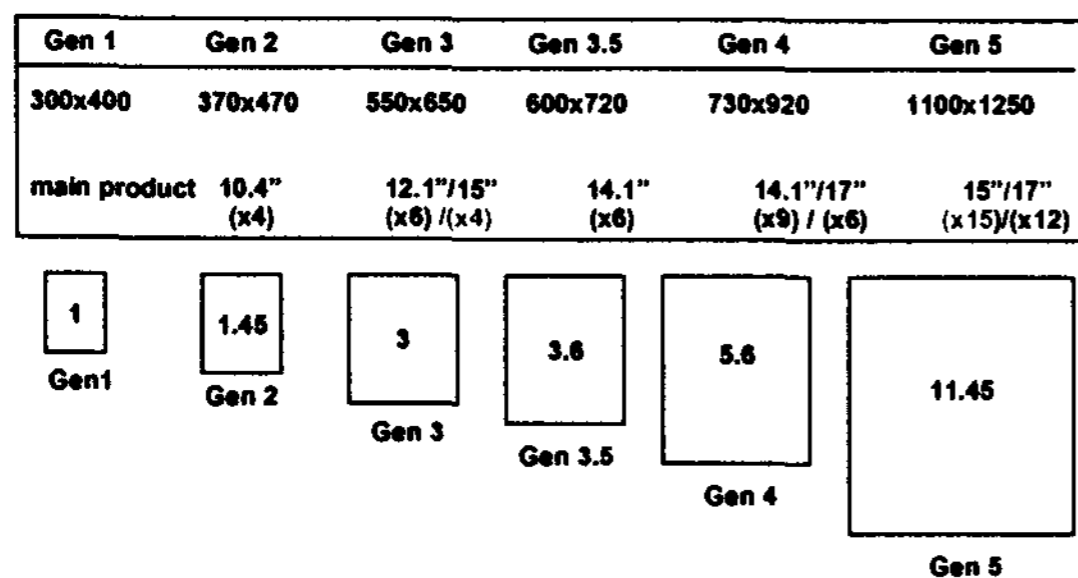
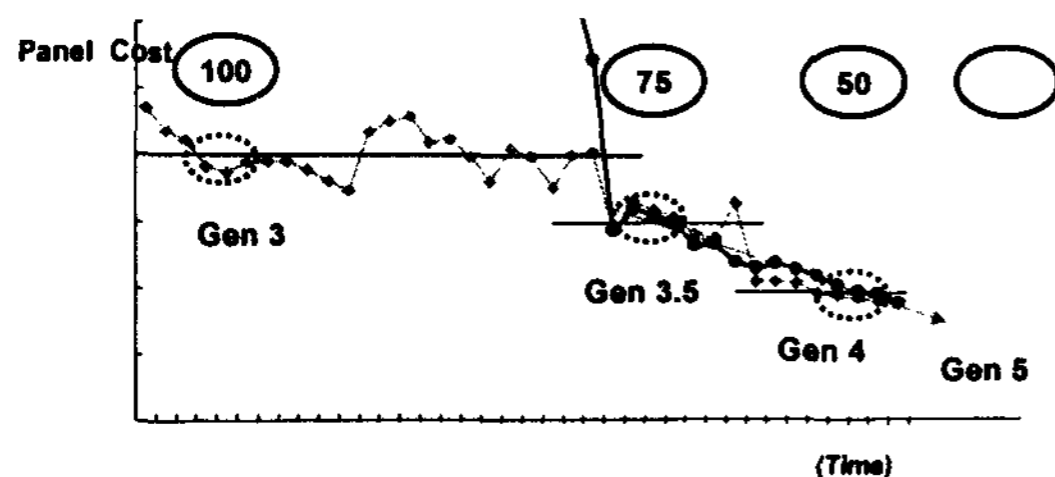


Fig 3 Mother glass size evolution

The effect of mother glass size on panel cost reduction due to the productivity enhancement is illustrated in Fig.4.



Fig, 4 Mother glass size effect on panel cost

3.2.2 New Technologies for Cost Saving

A series of recent technologies related to cost reduction, simplified process and reduced components architecture in package is listed;

1. 4 mask step process
2. One drop filling liquid crystal process
3. RSDS (reduced swing differential signal) driving method

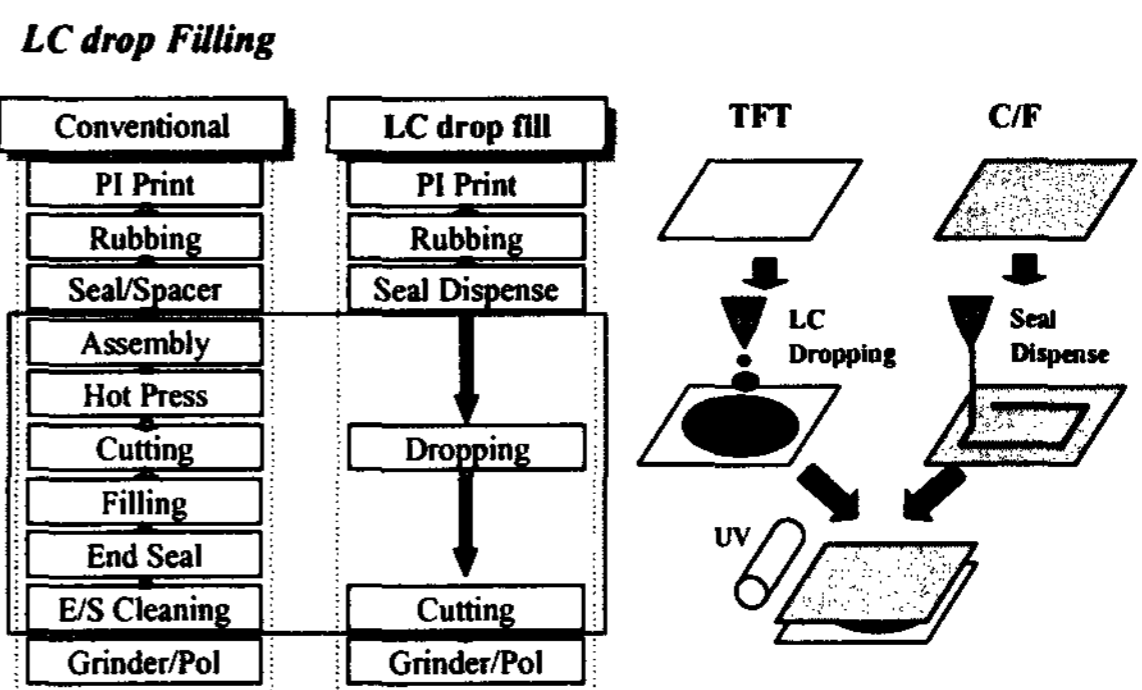


Fig 5 One drop fill method – The liquid crystal process innovation

3.3 CRT Replacement

The complete replacement of CRT is coming. The CRT replacement with LCD is just a beginning stage even today's replacement rate reaches near 30%. In order to achieve near 100% CRT replacement rate, the production of LCDs needs to be increased more than 3 times from the current world wide production level.

4 Conclusion

We discussed the technical approaches in LCD industry for the performance upgrade and for the ultimate cost structure that can compete with CRT. With this speed of technical evolution, it would be certain that LCD to become a firm mainstream display position before 2005 in terms of volume and cost/performance. It is expected that more than 50% of CRTs will be replaced by LCDs by end of 2004.

Based on cost reduction effort in LCD industry, full replacement of CRT is a matter of time. However, the replacement rate and timing depends on the LCD industry's control in investment scale and technology development speed.