

Liquid crystal display panel fabricated in dual mode

Yaping Wang^{a*}, Aiping Mo^b and Qingfeng Jiang^c

^aAnson IC Design House, No. 31, 5th Street, Haitang, Luoxi New City, Panyu, Guangzhou, Guangdong, People's Republic of China;

^bCenter for Translation Studies, Guangdong University of Foreign Studies, No. 2, Baiyun Dadao Bei, Baiyun District, Guangzhou, Guangdong, People's Republic of China; ^cDepartment of International Business, Guangdong Teacher's College of Foreign Language and Art, No. 463, Sougouling Road, Tianhe District, Guangzhou, Guangdong, People's Republic of China

(Received 30 August 2011; Revised 20 November 2011; Accepted for publication 21 November 2011)

The current panels for liquid crystal display (LCD) TV sets are all characterized by pins placed on two sides. To manufacture one type of panel, a dedicated mask is needed, and the production line should be started once. Moreover, the whole panel needs to be removed if a dead pixel is found. If the panel, however, will first be fabricated with pins placed on four sides and then divided by a cross-cut into four equal-sized panels with pins placed on two sides, one set of masks can be used to manufacture two types of LCD panels, which was referred to by the authors as *dual mode*. In this paper, the concept of the dual mode and its differences from the conventional way of producing panels are introduced. Its advantages in boosting production efficiency, improving the product's good rate, and lowering the production cost are also described based on case studies. Of particular importance is the fact that the dual mode is very suitable for the trial production of very-large-area LCD TV sets.

Keywords: LCD panel; panel cut; dual mode; mask; large-area panel

1. Introduction

All liquid crystal display (LCD) panels for TV sets are produced with pins placed on two sides of the panel. At present, to manufacture a particular type of panel, a dedicated mask is needed, and the production line should be started once. This conventional method, using one set of masks to manufacture one type of LCD panel, is termed *LCD panel single-mode fabrication* in the following text. As the one drop fill (ODF) [1] system is applied in LCD panel production, fabricating LCD panels with pins placed on four sides has become possible in engineering. If an LCD panel is first fabricated with pins placed on four sides, as shown in Figure 1(a), and then divided by a cross-cut into four equal-sized panels with pins on two sides, as shown in Figure 1(b), then one set of masks can be used to manufacture two types of LCD panels. This method, involving the use of one set of masks to manufacture two types of LCD panels, is termed *LCD panel dual-mode fabrication* in this paper. Although the panel with pins on four sides can be cut in different ways into different types and can thus be referred to as a *panel fabricated in multi-mode*, this will not be discussed in this paper due to its complexity.

The technical core of the LCD panel fabricated in dual mode is that the patterns of thin-film transistor (TFT) arrows of four small-area panels are embedded to form a pattern of TFT arrows in a large-area panel. Below are some of the differences in process and structure between panels

fabricated in dual mode and those fabricated in single mode.

- (1) *Parasitic resistance and capacitance (RC)*: For cost saving, in dual mode, the material and process for producing small-area panels are adopted for fabricating large-area panels. Therefore, the parasitic RC [2] on bus lines may be too large to be displayed in large-area panels. At this point, bus lines or bilaterally driven ICs can be widened or thickened [3] to eliminate the influence of an overlarge RC.
- (2) *COM line*: In the single-mode method, COM lines are bilaterally connected to the COM pole on the color film (CF) substrate glass with conductive paste. The COM lines on small-area panels fabricated in dual mode, however, can be connected to the COM pole on the color film (CF) substrate glass on the side where the pins have been placed, which will double the COM line resistance. Despite this, the pixel capacitor charging time would not be affected because the COM lines are very wide [2].
- (3) *Test circuits and patterns*: To facilitate the monitoring quality of the panel during and after the manufacturing process, test circuits and patterns are placed on the substrate glass, outside the display area. In dual mode, the small-area panel is cut after the completion of the test. Thus, in this mode,

*Corresponding author. Email: anson@anson-tech.com

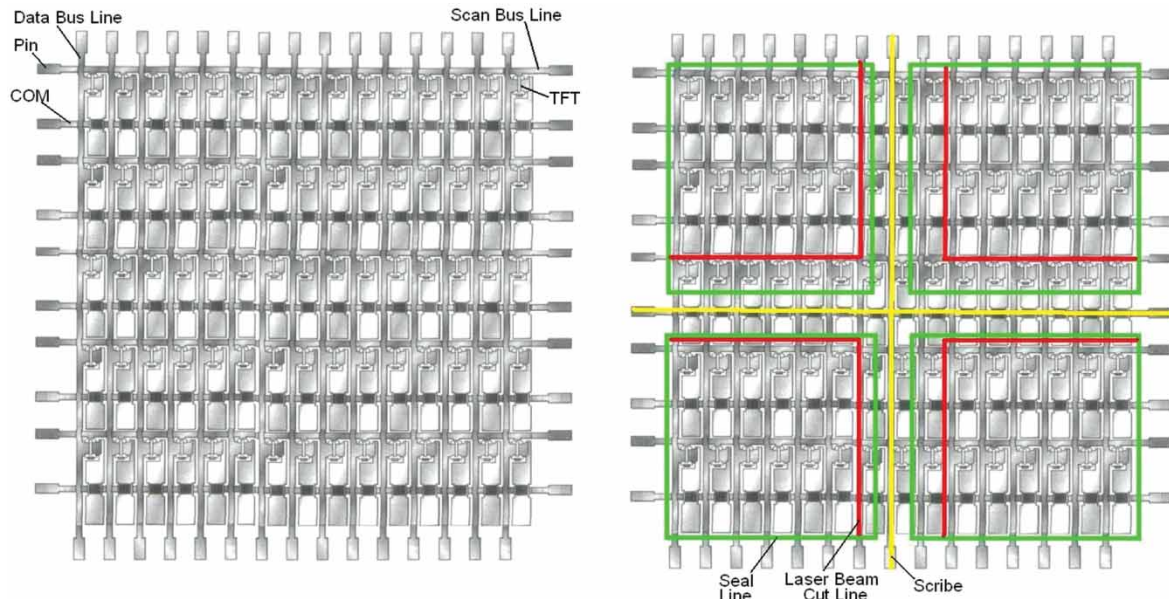


Figure 1. Panel fabricated in dual mode: (a) One 5×5 -pixel panel with pins on four sides. If the panel is cut in the way shown in (b), four pieces of 2×2 -pixel panels can be obtained.

the test circuits and patterns can be placed on the substrate glass, outside the large-area panel display area [4].

- (4) *Prevention of bus line exposure to open air*: In dual mode, for the small-area panel, the part of the bus lines exceeding the display area should be cut off with a laser beam, as shown in Figure 1(b).
- (5) *Panel sealing*: In dual mode, part of the sealant will be applied to the TFT surface on the small-area panel. As the TFT surface non-flatness is low, it will not exceed the requirement for the substrate glass. Moreover, the sealant is soft before the application of heat pressure thereto. Therefore, no changes need to be made in the panel-sealing process [5].
- (6) *Pin arrangement*: As shown in Figure 1(b), there are two types of scan pin arrangements for small-area panels fabricated in dual mode. Before using a conventional IC bonding machine, the program should be modified.

2. Analysis and discussion of dual-mode applications

Figure 1(a) is a panel with 5×5 pixels fabricated in dual mode. If the panel is cut crosswise, as shown in Figure 1(b), it will become four 2×2 pixels, representing a quarter of the area of the small panels. In the dual-mode panel-manufacturing method, as the two kinds of panels need only one set of masks, the production line is started only once, and if there is a dead pixel on the large-area panel, three smaller-area panels can still be obtained. Therefore, the dual-mode LCD panel manufacturer will help improve the production efficiency and the good rate of the product.

Table 1. Parameters of 55- and 26-in. panels fabricated in dual mode

Parameters	55-in. panel	26-in. panel
Display area (mm^2)	1213.8×682.08	573.72×322.56
Pixel size (mm)	0.14×0.42	0.14×0.42
Resolution	2890×1624	1366×768
Pin	Four sides	Two sides
Driver IC	Possibly bilateral	Single lateral

The two cases below involve a panel with the real area fabricated in dual mode.

2.1. Case 1: 55- and 26-in. panels fabricated in dual mode

Among the common area panels, the production output of the 55-in. panel is low and that of the 26-in. panel is high. The main parameters of the 55- and 26-in. panels fabricated in dual and single mode are listed in Table 1. The two panels use the same materials and process that are currently being used for producing the 26-in. panel. The production sequence is as follows: producing 55-in. panels with pins placed on four sides, and if there is a dead pixel, or if the 55-in. panels have already been produced, cutting the 55-in. panels crosswise to make 26-in. panels.

2.1.1. Analysis and discussion

Although the glass substrate consumption for the production of a 55-in. panel is equal to that for the production of four 26-in. panels, because the production output of a 55-in. panel is low and the cost of switching the production line is higher,

overall, the price of a 55-in. panel is higher than that of four 26-in. panels, which can be seen in DisplaySearch. In the dual-mode method, because 55- and 26-in. panels are fabricated using the same process and because the good rate of the 55-in. panel is the same as that of the 26-in. panel, overall, the cost of one 55-in. panel should be lower than that of four 26-in. panels.

Unlike a cathode ray tube TV set, the viewing the ‘presence’ of an LCD TV set is an important indicator of viewing quality. The higher the panel resolution is, the closer the viewing distance and the better the viewing presence will be. Table 1 shows that the 55-in. panel fabricated in dual mode has a higher resolution, and its cost is lower than that of the one that had been fabricated in single mode. Due to its higher resolution and lower cost, the 55-in. panel fabricated in dual mode has a higher price–performance ratio.

2.2. Case 2: 111- and 55-in. panels fabricated in dual mode

In the current panel markets, there are very few 111-in. panels, while 55-in. panels are relatively common. The main parameters of the 111- and 55-in. panels fabricated in dual and single mode are listed in Table 2. The two panels use the same materials and process as those that are currently being used for producing 55-in. panels. The production sequence is as follows: 111-in. panels with pins placed on four sides are first fabricated, and if there is a dead pixel or if the 111-in. panels have already been fabricated, the 111-in. panels should be cut crosswise to come up with 55-in. panels.

2.2.1. Analysis and discussion

The scan lines in the 111-in. panel are very long. To fabricate a 111-in. panel in single mode, the expensive low-resistance materials and special processes should be adopted. While in dual mode, as the bilaterally driven IC, parasitic resistance, and capacitance on the scanning lines are reduced by half, 111-in. panels can be produced using the conventional 55-in. panel materials and processes, thus reducing the 111-in. panel production cost.

As fabricating a 111-in. panel in single mode results in an extremely low production level, the price of such a panel is very high. In dual mode, however, the 111- and 55-in. panels are fabricated simultaneously, and the mask can be

shared. Thus, the cost of the 111-in. panel is significantly reduced.

3. Summary

In dual-mode LCD panel manufacturing, the large- and small-area panels are always produced together, but for different pairs of panel types, the effect of cost reduction is different. For example, where the production output of two panel types is very large, as is the case with the 22- and 46-in. panels fabricated in dual mode, the difference in the manufacturing cost per unit between the single and dual modes is small. There are two best situations for the application of the dual mode: one concerns the pairs of panel types to be fabricated in dual mode. For example, there could be a panel type with a small production output and another with a large production output. The other situation involves a common panel type produced simultaneously with a rare panel type. Compared with the current LCD panel manufacturing methods, the dual-mode LCD panel manufacturing method has the following advantages:

- (1) It can improve the production efficiency of LCD panels. In dual mode, the production line is started only once for producing the two kinds of panels.
- (2) It can help in production and maintenance cost savings for a set of masks. In dual mode, one set of masks can be used to fabricate two kinds of LCD panels.
- (3) It can improve the good rate of larger LCD panels. In dual mode, the good rate of larger-area LCD panels is the same as that of small-area panels.
- (4) It can be used for market piloting for very-large-area LCD panels. In dual mode, the production cost of very-large-area LCD panels is very low, which can facilitate the market testing of their real demand at an appropriate price.

The results of the comparison of the applications of the panels fabricated in single and dual mode are listed in Table 3.

Table 3. Comparison of the single- and dual-mode applications

Item	Single mode	Dual mode
One set of masks	Fabricate one panel type	Fabricate two panel types
Start production line once	Fabricate one panel type	Fabricate two panel types
Losses caused by the bad rate	–	Large-area panel equal to quarter-area panel
Low-cost production of large-area panel	No	Yes
Lower market piloting price	No	Yes

Table 2. Parameters of 111- and 55-in. panels fabricated in dual mode

Parameters	111-in. panel	55-in. panel
Display area (mm ²)	2449.44 × 1380.96	1209.6 × 680.4
Pixel size (mm)	0.21 × 0.63	0.21 × 0.63
Resolution	3888 × 2192	1920 × 1080
Pin	Four sides	Two sides
Driver IC	Bilateral	Single lateral

4. Conclusion

It can be seen in the above analysis and discussion that the dual-mode LCD panel manufacturing method has the advantages of boosting the production efficiency, improving the good rate of the products, and lowering the production cost. In terms of the market piloting of the large-area LCD panels, the dual-mode method has a significant advantage. As the manufacturers do not know the precise market demand and prices, they usually need to produce only a small number of samples to test the market, but as the total number of samples produced is limited, the price will be very high. As the price is high, the buyers will be few, making it difficult to test the market's real needs. As the cost of a large-area panel manufactured in dual mode, however, is very low, the manufacturers can test the real market demand at the appropriate price. Further, as the panels fabricated in dual mode are obviously superior to those fabricated in

single mode, in the future, this mode of production is likely to become the usual LCD panel production method. Further, the 8.5-generation LCD panel production line should be able to fabricate panels in dual mode.

References

- [1] H. Kamiya, SID International Symposium on Digest of Technical Papers, June, Vol. 32, No. 1, p. 1354, 2001.
- [2] C.-H. Lin, Seventh International Conference on Power Electronics and Drive Systems (PEDS'07), Article No. 4487926, p. 1618, 2007.
- [3] K. Song, SID International Symposium, Vol. 36, No. 1, p. 479, 2005.
- [4] Y.-R. Huang, International Display Manufacturing Conference and Exhibition (IDMC'05), p. 660, 2005.
- [5] B.C. Jiang, Int. J. Prod. Res. **43** (1), 67 (2005).