A Repair Technology Trends of TFT-LCD Production

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Abstract

TFT-LCD panel makers have been enlarging size of TV screens, and 50-inch TFT-LCD is one of the main stream products already. To have more improved resolution, productivity and lower manufacturing cost, new TFT-LCD factories adopt large mother glass, new TFT structure and new process/materials. Along with these technology evolution, laser repair system should equip with upgraded performance and additional functions on user's demand. Laser repair technology is reviewed and newly developed repair technology is being introduced.

1. Introduction

Over the past several years TFT-LCD industry has grown rapidly and even now play the leading role in FPD market. With advances in resolution, viewing angle, response time, brightness and need for larger glass, panel makers have made efforts to achieve lower manufacturing cost and superior performance of the products. For that reason, panel manufacturers have developed tools of the inspection or test to find different type of defects and methods to repair effectively, also repair system suppliers improved machine continuously with this requirements[1].

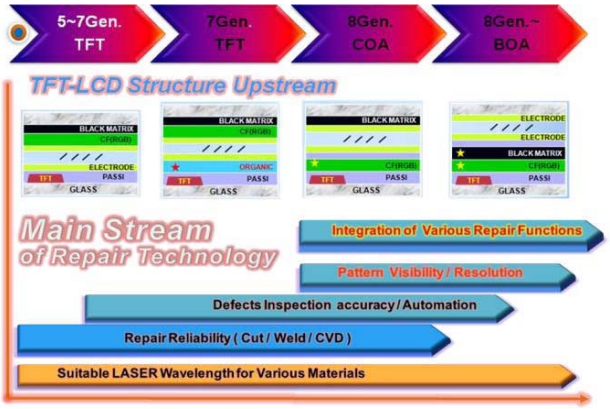


Fig. 1. Challenge of Repair technology with TFT development trend.

In this paper, we report on most recent advances in both technologies to repair different type of defects generated in panel production and a trend of system for this. Generally, repair machines are widely used in TFT-array and color filter, cell/module processes. Most of the repair system use laser beam to cut shorts or to connect open defects in TFT LCDs. Also, tape grinding and ink dispensing technology have been applied to repairing defects such as residue, particle and void in color filter process[2].

Fig.1 shows the main issues and challenges of the repair system with TFT technology trends. Especially, TFT structures are getting more complex and required the machines with various automatic functions including the pattern visibility for high quality repair process.

2. Current Repair – TFT Array panel

The majority of array repair system uses laser beams for cutting and welding process on TFT circuit (Fig.2). Typically, Nd-Yag lasers are used for these processes. We can select suitable wavelength(Infrared ; 1064nm, Green ; 532nm, UV ; 355/266nm) for panel structure and materials and therefore, it enable us to do finer ablation repair on defects in TFT array. In production, IR and Green wavelength are commonly used and then UV is used mainly for selective repair process such as organic materials or transparent layers.

Fig. 2(a) shows the cutting method on the short defect or residue in the pattern, and SEM image of actual repaired line. Fig. 2(b) shows the method of turning into dark pixel effectively by simply welding the area between pixel electrode and gate metal layer. Actually cut and weld repair is very easy and fast process, and therefore, it is used as basic method that can prevent pixel from abnormal working.

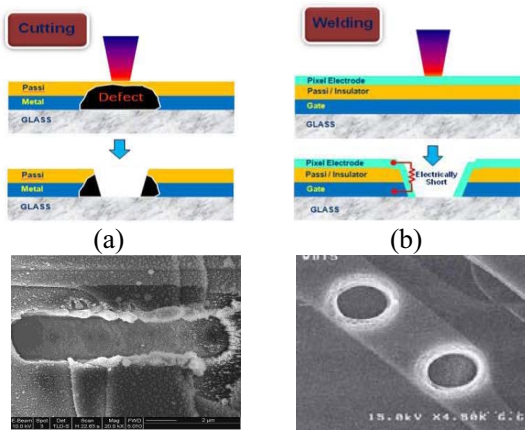


Fig. 2. Conventional Cut/Weld repair ; (a) Cutting , (b) Welding.

During TFT panel manufacturing, open line defects is created often in the gate or data pattern and it's fatal. In this case, defects can be repaired by LCVD(Laser-assisted Chemical Vapor Deposition) method. The repair of open defects is far more difficult because it requires the deposition of a third material on the glass to complete the circuit, and thus the process and system become much more complex[3]. Fig. 3 shows LCVD repair technology by CW-Laser(UV) and metal carbonyl precursors such as Cr(CO)6, Mo(CO)6, W(CO)6. Mostly LCVD process achieved metal line width of less than 10um for repair. Film deposition occurs through two different types (photolytic and pyrolytic) reaction, namely, "hybrid deposition mechanism". Fig. 4 shows the shape of actual circuit repair on the open line and FIB-SEM analysis image.

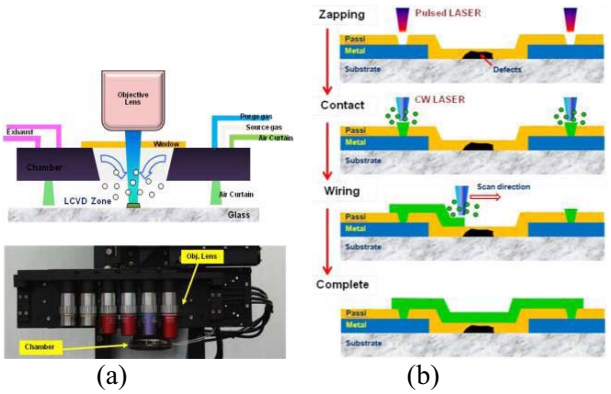


Fig. 3. Laser Assisted CVD Repair for open defects; (a) LCVD mechanism & System image, (b) Operation flow for repair.

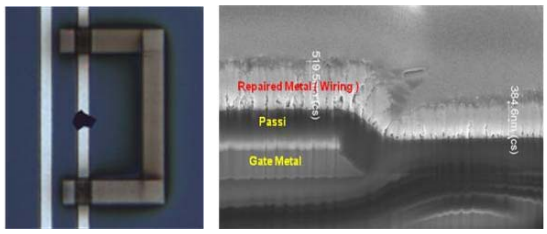


Fig. 4. LCVD Repair image & FIB-SEM analysis.

Especially, LCVD can be executed in atmospheric process without separate substrate heating units and operator can also view process in real-time through optical subsystem and monitor.

A various defect types in color filter process create such as protrusion, particles and void or pinholes. In case of protrusion defects, it can be repaired with mechanical method by grinding tape such as Fig. 5. Besides void and pinhole can be repaired by using dispense technology. Fig. 6 shows the repair method UV curing type color inks and dispenser controllable for pico-liter level chemicals.

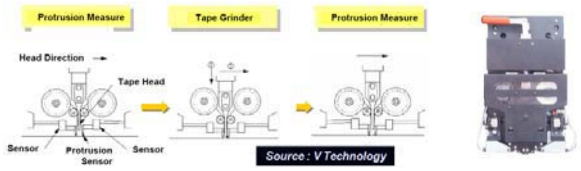


Fig. 5. Polishing Head and Protrusion grind sequence.

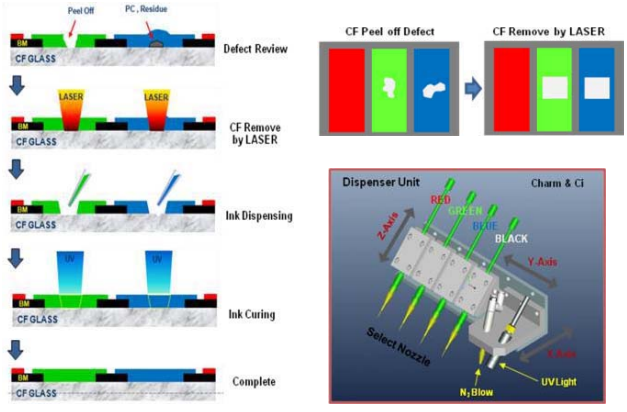


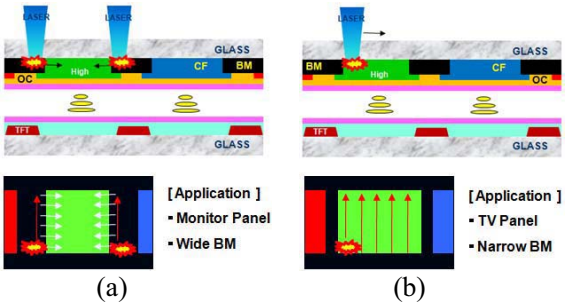
Fig. 6. Schematics of Color ink repair flow & Tools.

Especially, the efforts to integrate in the existing array repair system with these repair technologies and

new separate systems for color filter panel is being made according to the change in panel structure trends (COA ; Color filter on Array, BOA ; Black matrix on Array) recently.

3. Current Repair – Cell & Module panel

In the latest fashion, high pixel repair technology on the Cell or Module panel is worthy of notice in TFT-LCD product's point of view. Until now most of panel manufacturers have been suffered from serious yield loss caused by high pixel defects. These can be confirmed only after cell process and cannot be repaired by electrical cutting or welding method. But this defects can be repaired normally by making dark pixel by a unique technology of laser ablation.



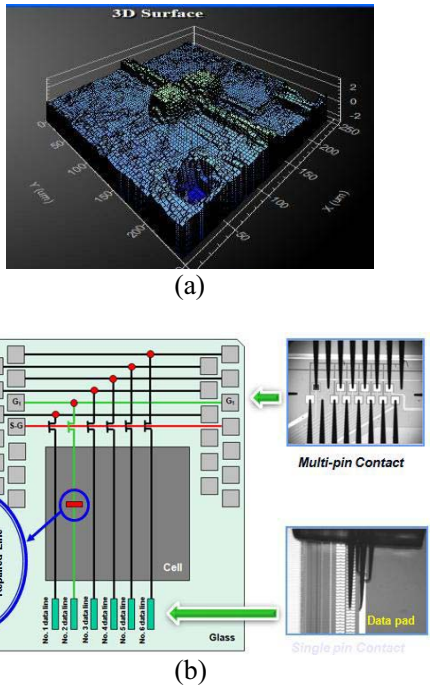
(a) (b)

Fig. 7. High pixel repair on cell panel ; (a) BM Spread method, (b) Color filter carbonization method.

Fig. 7 shows two type repair method for high pixel defects using in work place. In case of organic BM around pixel pattern enough to spread, pixel turns dark during laser ablation on BM layer directly. If it is made of a metallic BM or organic BM not enough to spread, pixel turns similarly dark during laser ablation on color filter layer. A repair system consists of pulse and continuous type laser for all kind of panel. Also this repair method can be applied to the same defects after attached polarizer film to cell panel so that it is expected that the impact on both repair technology and panel yield management will be huge.

4. Current Repair – Additional functions

Advanced functions is being integrated in addition to precision, productivity and stability of repair process with above-mentioned various repair technologies and systems. First, Automated Optical Inspection(AOI) function offer more precise information of defect on panel by being equipped with the system and this affects development of fully automated repair technology enormously without process of judgment of defects or repair works by operator. Secondly, non-contact 3D-surface profiler and analysis function can be equipped. Fig. 8(a) shows the result of the surface profile on the panel. In particular, it is effective function with color filter repair tools (such as grind or ink repair). The others, OSI(Open/Short Inspection) function can be applied in repair systems. This used to confirm whether repaired line is normal interconnect status after performing locally LCVD repair on the open defects. Thus the system is equipped with the electrical probing and measuring tools. Fig. 8(b) shows the measuring scheme and probe unit for the OSI operation.



(a)

(b)

Fig. 8. Additional function for repair performance; (a) 3D-Analysis, (b) OSI(Open/Short Inspection)

4. Summary & Futures

Until now the repair technologies have been contributed much to improvement of the panel productivity and competitiveness of panel makers while the TFT-LCD manufacturers increased the panel production and the glass size rapidly. However, as previously stated, current repair technologies have yet

to reach complete performance to meet user's requirements. In fact, it is very difficult that all kind of defects in the panel can be repaired. Nevertheless, the repair system for the TFT-LCD will overcome existing level of single function configuration to be advanced into configuration of integrating each different function in the machine. The repair system company, Charm&Ci, already reached a remarkable level of function integration and will soon make further accomplishment under the name of "Multi-functional or Universal". With these challenges and trends, we think, repair technology can be progressed much more excellently beyond current repair performance for the FPD products.

5. References

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