Belt Source and In-Line Manufacturing Equipment for Very Large-Size AMOLED

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Abstract

The inline manufacturing equipment using a combination of the belt source and LPS source which is innovatively designed is introduced for the large-size AMOLED. The features of the inline system include 60sec TACT time, 19 numbers of chambers, non-substrate bending and easy application to very thin TFT substrates for the 4^{th} - 8^{th} Generation AMOLEDs.

1. Introduction

In current, the cluster type of manufacturing equipment as shown in figure 1 is widely used for the OLED devices and the substrate size is limited to 20 inch (or 370x470mm). However, the cluster type equipment can no longer be used for the large-size AMOLED manufacturing (e.g, 40 inch or 730x920, 50 inch or 1100x1300mm). The reasons are 1) the point source provides very low material utilization as of 5-10%, 2) the thin and large TFT substrates are seriously bent by 70mm for 4G and 180mm for 5G, 3) the enlarged vacuum robot can no longer transfer or handle large-size substrates. [1]

(Figure 1) Cluster type manufacturing equipment

For the inline type equipment using a linear source, the material usage is still as low as 20% and the thermal shock on the substrate and shadow mask becomes seriously worse during manufacturing. Also, the glass carrier with holder and chuck assembly for preventing glass/mask bending is too heavy to move. Furthermore, the carrier needs to bring back for recycling purpose.

In order to solve those problems, the newly developing LPS and belt sources shown in figure 2 were introduced in elsewhere. In this thesis, we propose the inline manufacturing system for the large size AMOLED using the LPS and belt sources. [1]

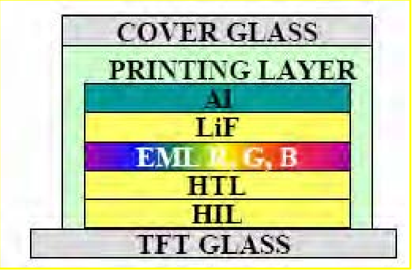
(Figure 2) LPS source and belt source

2. In-Line Manufacturing System

2-1 Manufacturing Processes

The device structure of AMOLED is shown in figure 3. On a TFT substrate, the multilayer of HIL, HTL, EML, LiF, and Al is formed and a polymeric layer exists for the passivation, covering by a bare glass at the top for physical protection.

(Figure 3) AMOLED structure

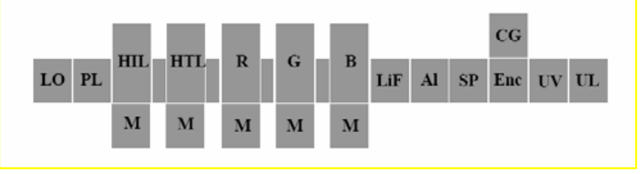


In manufacturing of AMOLED, TFT substrate previously cleaned by wet processes is loaded, plasma-pretreated, organic film deposited, LiF and metal film processed, and after that, screen printed for passivation, glass covering processed, and finally UV curing processed. Beside, effective unloading of the panels and insertion of cover glass, and periodic mask switching process are required. [1]

2-2 In-line Manufacturing System

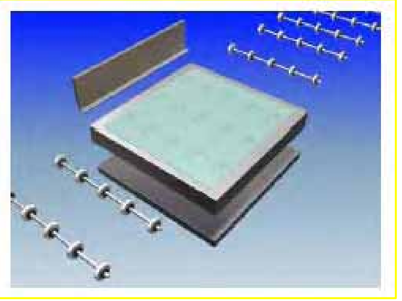
As shown in figure 4, the in-line type equipment for large-size OLED manufacturing consists of a number of chambers designated for the loading of glass substrate (LO), pre-treatment (PL), organic depositions (HIL, HTL, RGB), metal depositions (LiF,Al), screen printing (SP), encapsulation (Enc), UV curing (UV), cover glass loading (CG), mask cassette (M) and glass unloading (UL). These isolated chambers are connected in a row with gate valves in between each chamber. [2]

(Figure 4) Inline manufacturing system



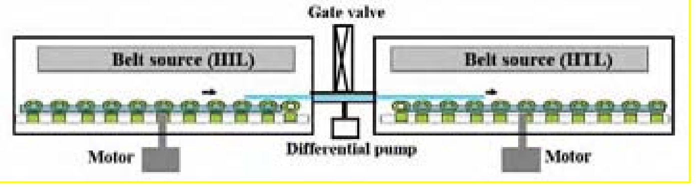
It is possible for the large size substrate without bending to transfer through whole chambers by rollers as shown in figure 5. This roller method uses “non-contact magnetic rolling” technology proven in LCD process and then, there will not be any particles generated by a friction that is caused between the rollers and magnet bar. Furthermore, there will not be any vibration and glass bending during transferring. [3]

(Figure 5) Roller transferring of the substrate



The gate valves are kept open during manufacturing as shown in figure 6 and they are closed for isolation maintenance of a certain chamber. To prevent the cross-contamination, a differential pump could be used between chambers.

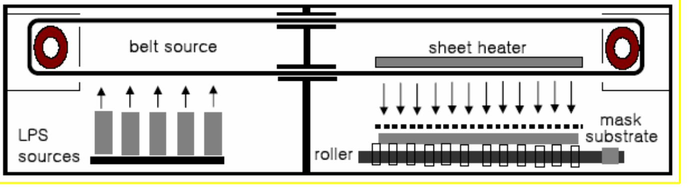
(Figure 6) Cross transfer of the substrate



Note that a loading chamber is directly connected to wet cleaning system as not in a conventional system. The remote plasma is highly recommended for pretreatment process because it is already proven in 7G LCD manufacturing. [4]

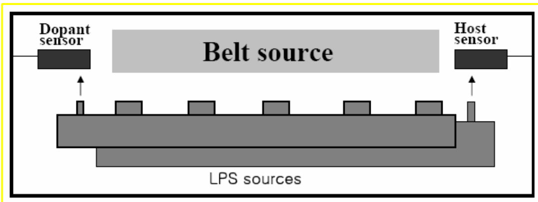
The structure of an organic deposition chamber is shown in figure 7. The primary and the secondary deposition areas are separated not to be cross contaminated and the belt roller and substrate roller area would be isolated by a baffle to be differentially pumped. Then, the particle generation is suppressed. Also, there is a source tray which can conveniently recharge the LPS sources for reuse.

(Figure 7) Structure of organic deposition chamber



The rate monitors can be located as shown in figure 8. The thickness sensors for host and dopant are at the right and left side respectively for preventing the cross interferences. [5]

(Figure 8) Thickness sensors for host/dopant



The downward deposition for LiF layer can be done by use of evaporation cells and the Al layer is deposited by use of several microwave sputters for ion damage free and for longer use. Note that the microwave sputter is known as more efficient than RF sputter for metallic deposition in OLED processes.

The screen printing process is usually performed in low vacuum chamber and therefore an extra buffer chamber would be placed between high vacuum Al deposition chamber and SP chamber to save the time for pumping operation. The CG chamber has a glass cassette to provide the cover glass continuously during manufacturing. For the covering encapsulation, there is a glass transferring assembly for the large-size cover glass not to be bent and to move from CG chamber to Encapsulation chamber.

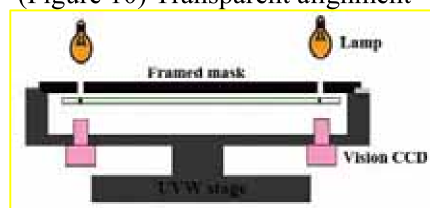
(Figure 9) Mask switching by cross rollers

The UV lamps and a properly thick quartz plate are installed at the top area of the UV chamber and a careful design is required for the quartz plate not to easily brake. The unloading chamber has a panel cassette in. The metal mask such as shadow mask or framed mask needs to periodically replace because they are contaminated by depositing species. As shown in figure 9, the cross rollers can switch the used mask to new one. [5]

2-3 Alignment Mechanism

The transparent method for mask and substrate alignment is shown in figure 10. The lamp light emitted from the top penetrates marks of mask and substrate for the align images to be more stable compared to the reflective method used in a conventional system. [5] When we use the reflective method, the scratch carved unintentionally on the mask surface makes often difficulties for the aligning speed and its stability.

(Figure 10) Transparent alignment



3. TACT Time

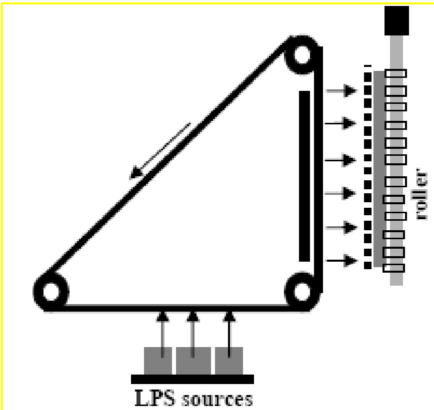
The TACT time of the manufacturing system is decided by the longest process time during manufacturing. Assuming that HIL layer's thickness is as 600 Å, 60sec will be taken in primary deposition by speed of 10 Å/s. As the TACT time in our case would be considered as a sum of heating time of belt plate (30sec), mask alignment (20sec) and substrate transferring into the secondary deposition chamber (10sec), the TACT time is then estimated as 60sec. [5]

4. Belt Sources

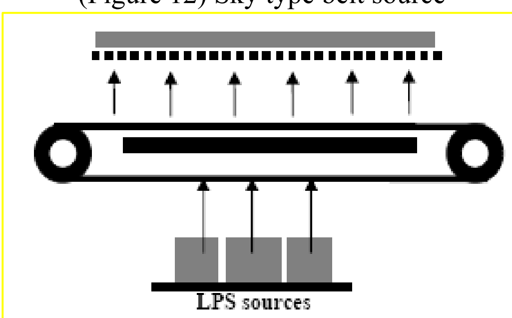
In order to continuous use of the LPS source and metal plane source, we propose the belt source made by thin metal plate shown earlier. There are multiple LPS sources located under the left side of the belt source and, after primary deposition to belt plate, the belt moves to right side for Gaussian circles to sublimate to TFT substrate as explained earlier. The TFT substrate will be transferring by the rollers assembly so that the large-size substrate won't be bent and it would be easily shadow mask aligned.

As another application of the belt source, there would be vertical type belt source shown in figure 11 and the substrate will be vertically transferred during manufacturing for the wall-direction deposition processes. As shown in figure 12, the belt source can sublimate for sky direction deposition as further application for the 370x470mm substrate. [5]

(Figure 11) Vertical type belt source



(Figure 12) Sky type belt source



5. Conclusion

Based on our discussion, there are numbers of advantages for inline manufacturing system with combined use of LPS and belt source as listed below;

(a) High material utilization (60-80%).
(b) High organic film uniformity (<3%).
(c) Fast TACT time (<2min.).
(d) No substrate holder used.
(e) No substrate carrier or shuttle used.
(f) No magnet chuck for shadow mask needed.
(g) No revolver point sources used.
(h) No vacuum robots used.
(i) No substrate bending existed.
(j) No substrate chuck used.
(k) No thermal damage existed.
(l) Less shadow effect.
(m) Stable mask-sub. alignment.
(n) No particle problem arise.
(o) Minimized number of chambers.
(p) Direct connection to wet cleaning system.
(q) No substrate inversion for passivation.
(r) Less space occupied.
(s) Very thin substrate possible.
(t) Substrate size independent concept.

6. Acknowledgements

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7. References

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