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

Chang-Hun Hwang[*ab], Yongki Kim[ab], TaeHee Lee[a], SinJae Yu[a], SungSu Kim[a], Kee-Hyun Shin[c], Sung-Hoo Ju[d], and Janghyuk Kwon[*e]**

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 4th - 8th Generation AMOLEDs.

Keywords : AMOLED, in-line equipment, belt source, LPS source, TACT time

1. Introduction

Nowadays, the cluster type of manufacturing equipment as shown in Fig. 1 is widely used for the OLED devices, and the substrate size is limited to 20 inch (or 370×470 mm). However, the cluster type equipment can no longer be used for the large-size AMOLED manufacturing (e. g, 40 inch or 730×920, 50 inch or 1100×1300 mm) due to the following reasons are 1) the point source provides very low material utilization as of 5 ~ 10 %, 2) the thin and large TFT substrates are very bent by 70 mm for 4 G and 180 mm or 5 G, 3) the enlarged vacuum robot can no longer transfer or handle large-size substrates. [1]

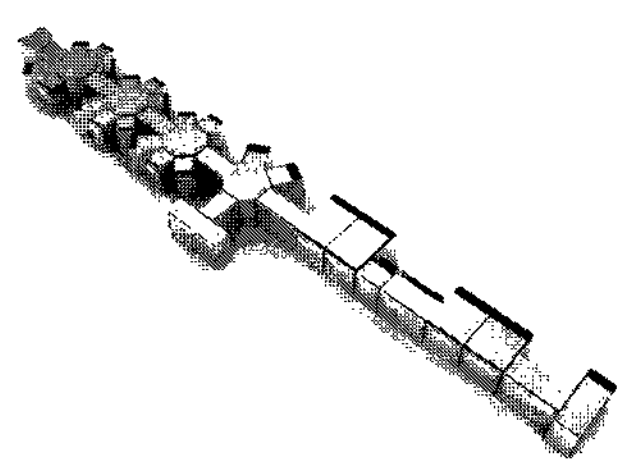

Fig. 1. Cluster type manufacturing equipment.

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 much 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 be brought back for recycling purpose.

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

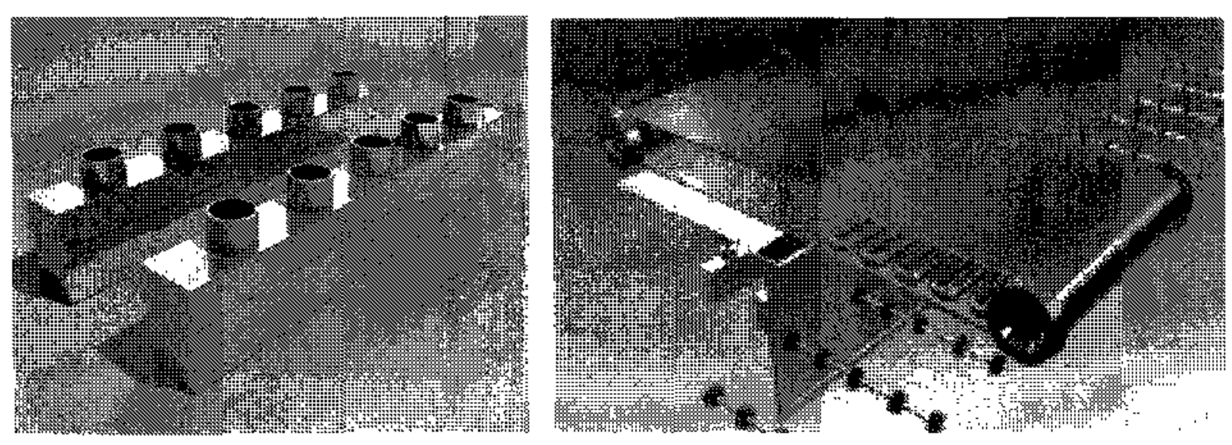

Fig. 2. LPS source and belt source.

2. In-Line Manufacturing System

2-1. Manufacturing Processes

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

Manuscript received November 10, 2006; accepted for publication December 15, 2006.
This work was supported by IBRIDGE co., Ltd. and author specially thanks IBRIDGE's engineers for their innovative endeavor and patience.
* Member, KIDS; ** Student Member, KIDS
Corresponding Author : Chang-Hun Hwang
a OLED Division, IBRIDGE Co., Ltd., Kyunggi-do, South Korea.
b OLEDON, Kyunggi-do, South Korea.
c Dept. of Mechanical & Aerospace Engineering, Konkuk Univ., Seoul, Korea.
d Dept. of Advanced Materials Science & Engineering, Daejin Univ., Kyunggi-do, Korea.
e Dept. of Information Display, Kyung Hee Univ., Seoul, Korea.
E-mail : chriss_hwang@oledon.com **Tel** : +032 611-0390 **Fax** : +032 662-9535

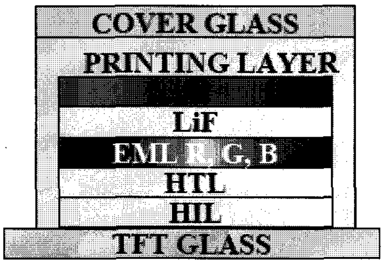

Fig. 3. AMOLED structure

To manufacture a AMOLED, TFT substrate previously cleaned by wet processes is loaded, plasma-pretreated, organic film deposited, LiF and metal film processed. Then it is screen printed for passivation, glass covering processed, and finally UV curing processed. In addition, 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 Fig. 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]

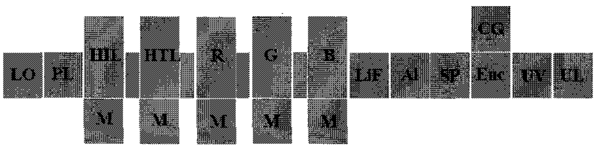

Fig. 4. Inline manufacturing system.

It is possible for the large size substrate without bending to be transferred through whole chambers by rollers as shown in Fig. 5. This roller method uses "non-contact magnetic rolling" technology proven in LCD process. By this method no particle is generated by a friction caused between the rollers and magnet bar. Furthermore, there will not be any vibration and glass bending during transferring. [3]

The gate valves are kept open during manufacturing as shown in Fig. 6 and they are closed for isolation maintenance

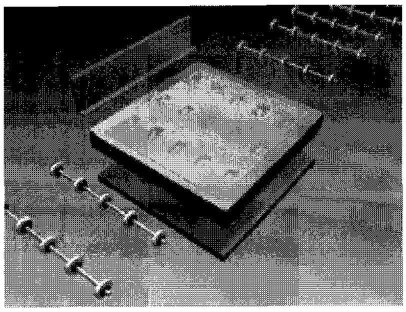

Fig. 5. Roller transferring of the substrate.

of a certain chamber. To prevent cross-contamination, a differential pump could be placed between chambers.

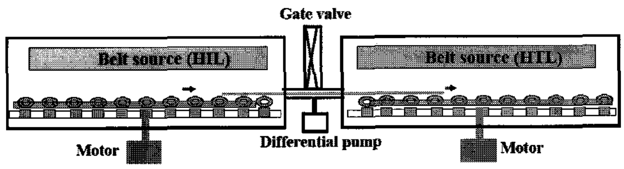

Fig. 6. Cross transfer of the substrate.

Note that a loading chamber is directly connected to wet cleaning system which is contrary to the case of a conventional system. The remote plasma is highly recommended for pretreatment process because it is already proven in 7 G LCD manufacturing. [4]

The structure of an organic deposition chamber is shown in Fig. 7. The primary and the secondary deposition areas are separated so that they do not become 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.

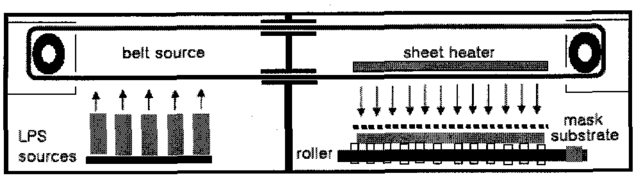

Fig. 7. Structure of organic deposition chamber.

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

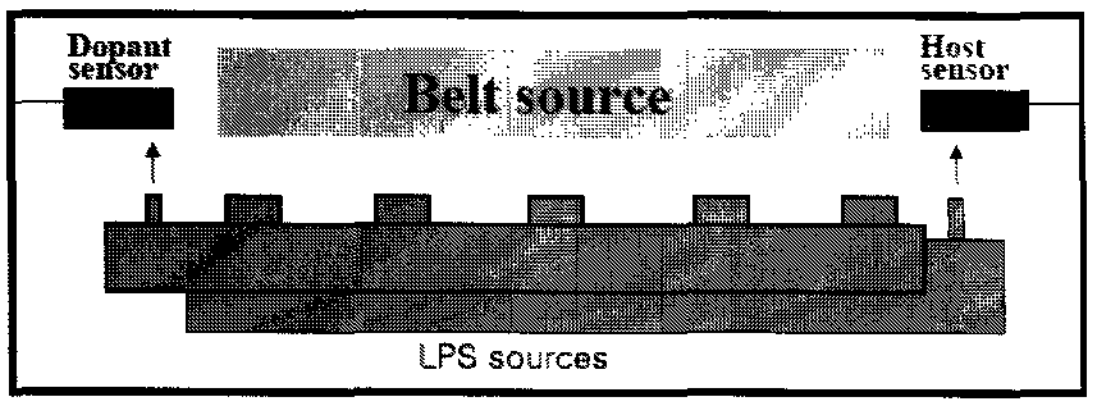

Fig. 8. Thickness sensors for host/dopant.

The downward deposition for LiF layer can be done by use of evaporation cells and the Al layer is deposited by using several microwave sputters for ion damage free and for longer use. Note that the microwave sputter is known to be a 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 is normally placed between high vacuum Al deposition chamber and SP chamber to minimize 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 so that is not bent and to move from CG chamber to Encapsulation chamber.

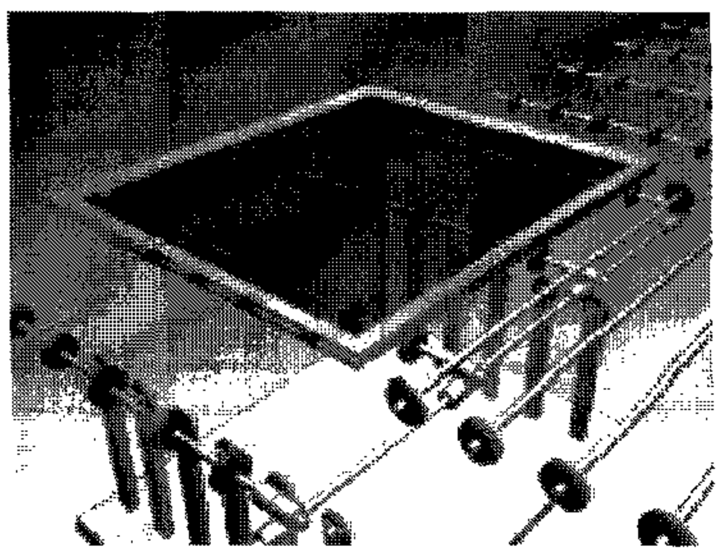

Fig. 9. Mask switching by cross rollers.

The UV lamps and a properly thick quartz plate are installed at the top area of the UV chamber. The UV chamber needs to be carefully designed so that the quartz plate does not break easily. The unloading chamber has a panel cassette in. The metal mask such as shadow mask or framed mask needs to be periodically replaced because they are contaminated by depositing species. As shown in Fig. 9, the cross rollers can replace the used mask with a new one. [5]

2-3. Alignment Mechanism

The transparent method for mask and substrate alignment is shown in Fig. 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 it difficult to align speed and maintain stability.

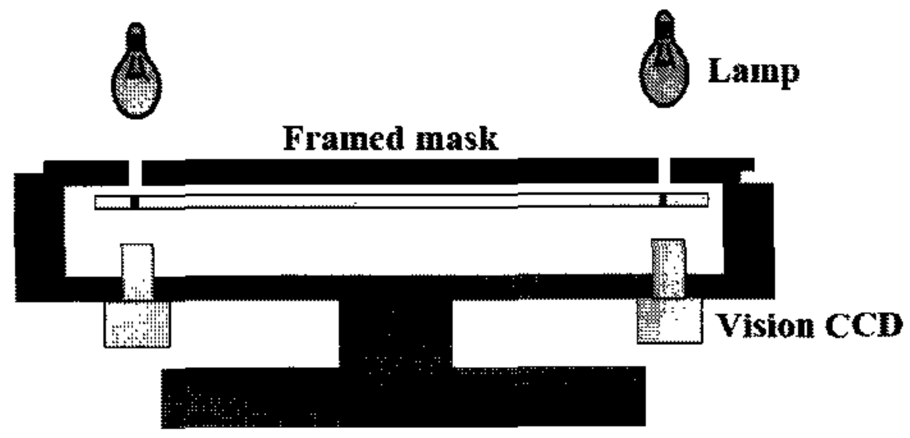

Fig. 10. Transparent alignment

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 600 Å, 60 sec will be spent in primary deposition at a speed of 10 Å/s. As the TACT time in our case would be considered as a sum of heating time of belt plate (30 sec), mask alignment (20 sec) and substrate transferring into the secondary deposition chamber (10 sec), the TACT time is then estimated as 60 sec. [5]

4. Belt Sources

In order to continuously use 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 transferred by the rollers assembly so that the large-size substrate is not bent and it would be easily shadow mask aligned.

Another application of the belt source is vertical type belt source shown in Fig. 11. The substrate is vertically transferred during manufacturing for the wall-direction deposition processes. As shown in Fig. 12, the belt source

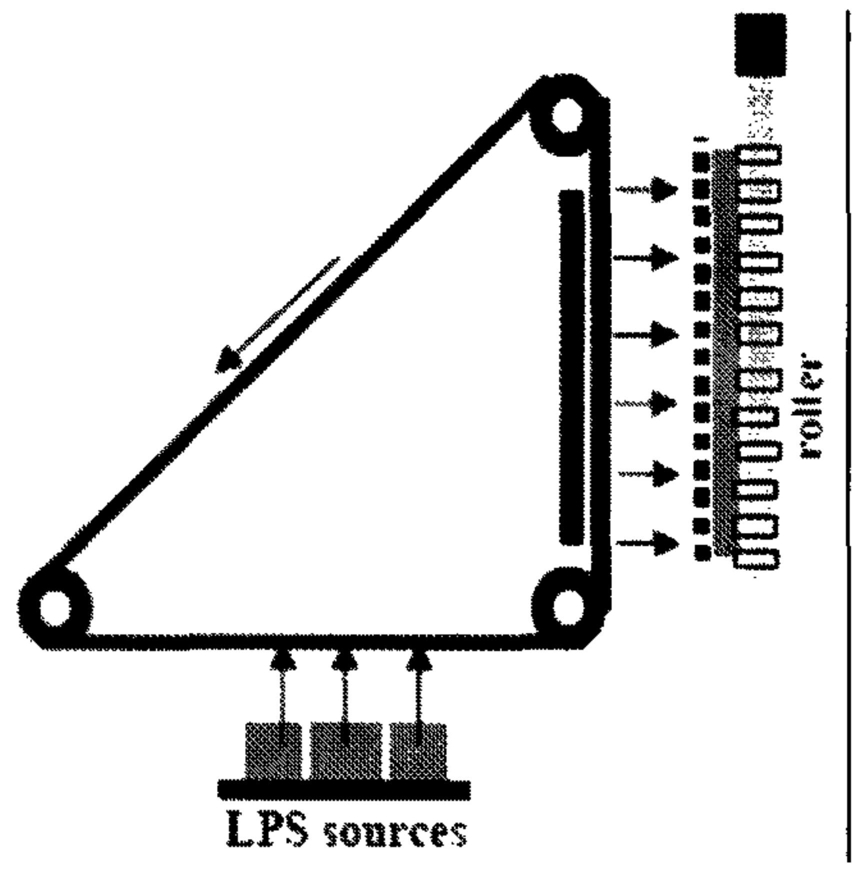

Fig. 11. Vertical type belt source.

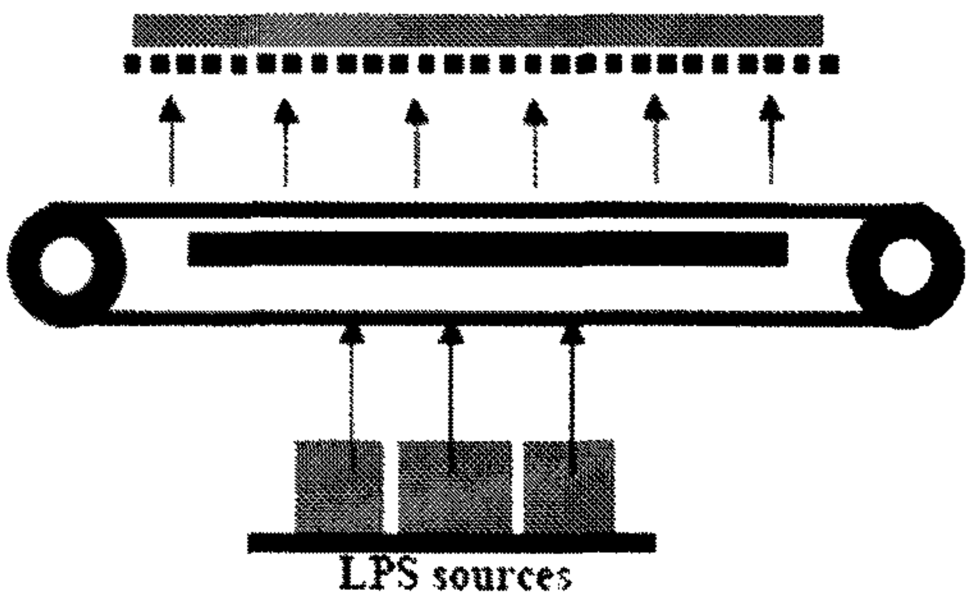

Fig. 12. Sky type belt source.

can sublimate for sky direction deposition. [5]

5. Conclusion

Based on our discussion, inline manufacturing system has many advantages if used in combination with 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. References

[1] C. H. Hwang, Korea patent, 15651(2006).
[2] C. H. Hwang, Korea patent, 15694(2006).
[3] C. H. Hwang, Korea patent, 15701(2006).
[4] C. H. Hwang, Korea patent, 15712(2006).
[5] C. H. Hwang, Korea patent, 20374(2006).
[6] C. C. Hwang, in *SID'06* (2006), vol. **47.3** p. 1567.