Structure of Deposition Chamber using Belt Source Evaporation Techniques in AMOLED Manufacturing

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Abstract

The organic deposition chamber has been developed using belt source evaporation techniques for the first time. The deposition chamber is consisted of the belt source, organic vapor source, and the mask alignment assembly. The rollers operate for the thin metal belt to continuously move with the automatic tension control. It has been proved for the belt source evaporation easy to operate and the alignment of the substrate/shadow mask becomes so simple to use in AMOLED manufacturing industry.

1. Introduction

AMOLED device is expected to pour in the display market and its high productivity in manufacturing is the key issue. The most important factor in manufacturing of AMOLED is the organic deposition tool for high material utilization and high yield. It has been highly expecting for the new way of deposition techniques to come in this reason.

In order to realize the high productivity of AMOLEDs, the organic deposition tool, which is main process, should handle the large size substrate. Recently, the new concept technology for the deposition process what is called the belt source [1,2] has been developed. The belt source is shown in figure 1. The belt source uses thin metal plate such as tantalum and the organic vapor emitted from the LPS source is deposited on the metal bottom. The deposited metal belt transfers to the substrate and warm up to re-evaporated the organic vapor toward the substrate at the bottom. Note the thin and large size substrate won't be bent in performing deposition processes.[3,4]

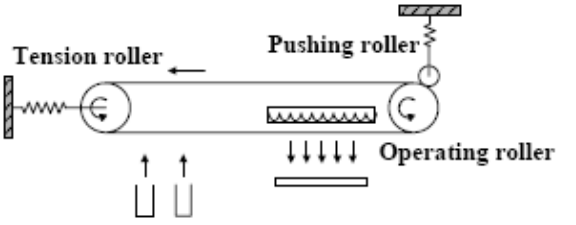

Fig. 1. Belt source evaporation

In this report, the structure of the deposition chamber with the belt source assembly, and how to operate the thin metal belt, and the mask alignment assembly are introduced.

2. Structure of Deposition Chamber

The belt source chamber is consisted of 1) metal belt operation, 2) organic vapor source, and 3) mask/substrate aligning as shown in figure 2. The cryogenic pump is installed at the chamber bottom and there are gate valves at both sides of the chamber. Inside the chamber, the separation wall divides for the area of the organic sources and the area of the substrate table. [5]

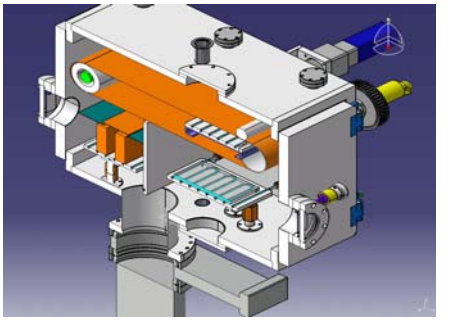

Fig. 2. Belt source chamber

As shown in figure 3, the belt covers two main rollers to move in a continuous way. For two rollers, the right side roller ("operating roller") rotates for belt moving and the left side roller ("tension roller") rotates for the belt tension to control. The "pushing roller" is placed at the upper side of the operating roller.

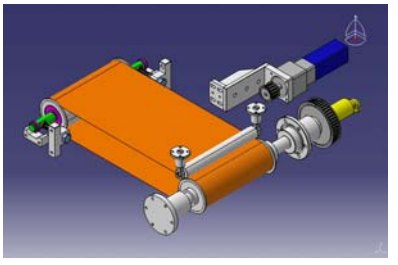

Fig. 3. Rollers for belt operation

The operating roller as cylindrical shaped roller has empty inside for cold water to flow in and out as shown in figure 4. Then, when the belt moves, the warmed belt touches the surface of the operating roller to be cooled rapidly. The operating roller is rotating by electrical gears and its rotating speed controls the position and moving speed of the belt. The ferromagnetic is used to seal between the vacuum chamber and the roller axis and the rotary joint is used for the cold water to supply to inside of the operating roller.

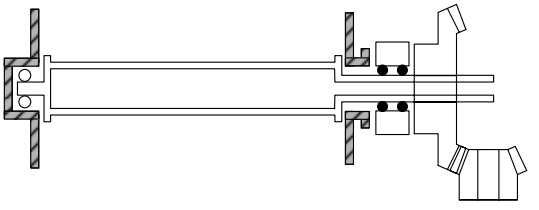

Fig. 4. Operating roller

The pushing roller is properly pushed down by the spring at the back to nearly contact the surface of the operating roller, and is freely rotating, as shown in figure 5. Once the thin belt moves between the pushing roller and the operating roller, the friction force of the belt helps to move without slip. [6]

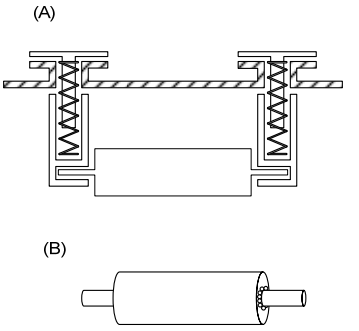

Fig. 5. Pushing roller

The tension roller compensates for the thin metal belt to extend and to bend during operations. As shown in figure 6, the cylindrical roller has spring assembly on its axis to freely move back and forth, and it is freely rotating at the same time. Once the belt is bent or is extend by the heating or cooling processes, the tension roller keeps it to be balanced automatically as flat.

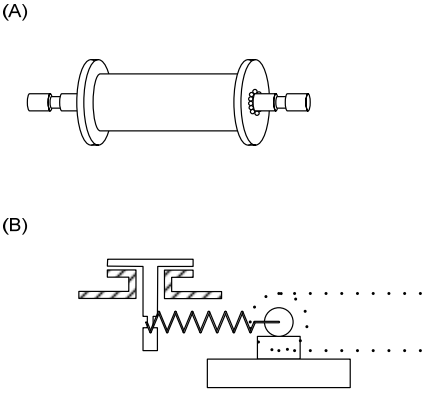

Fig. 6. Tension roller

The sheet heater is made to heat up the belt surface for the organic film to re-evaporate. It has Ta wires to form in a way of jig jag for the thermal radiation to widely emit as shown in figure 7. There is a reflector at the back of the Ta wires and a cooling water jacket to cover the back side of the sheet heater.

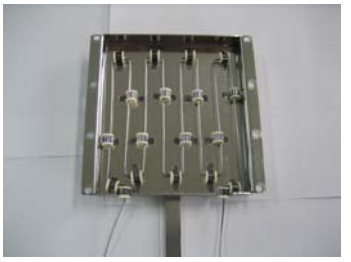

Fig. 7. Sheet heater

The substrate table has water lines inside for the substrate to keep cold as shown in figure 8. It also moves up and down for the TS (Target to Substrate distance) to optimize during belt source evaporation.

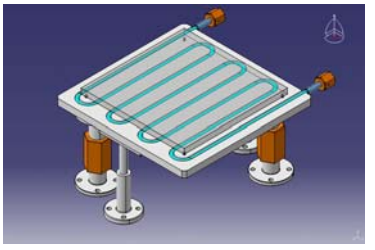

Fig. 8. Substrate table

The shadow mask is fixed at certain height and the substrate table moves in z direction by z-axis cylinder as shown in figure 9. Once the substrate approaches to a mask, the table moves precisely back and forth by UVW stage connected to lower of the substrate table. There are four light sources at the top to shine the key marks of the substrate through the key holes of the mask, and four CCD cameras are located at the lower area of the table assembly to recognize the mark images. This process is called “transparent alignment” and the accuracy of the fine alignment has been improved and its operation becomes fast compared to conventional alignment. Note the conventional tool uses “reflective alignment”.

The aligning sequence of the mask/substrate is summarized as; glass insertion → pre alignment → table up → fine alignment → table up to approach to the mask. It is so simple. The major specification of the alignment is listed in table 1.

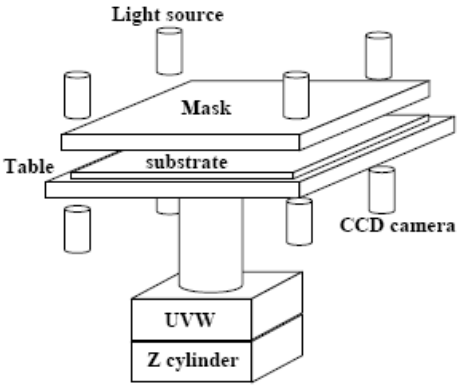

Fig. 9. Mask/substrate alignment

Table 1. Specification of the alignment

Camera Type	1392 x 1040 Pixel Camera
F.O.V	4.5 x 6.0 ㎜
Working Distance	310.0 ㎜
Depth of Focus	Pre 1.6 ㎜ /Fine 0.2 ㎜
Resolution	1 ㎛
Accuracy	Pre Align ±100㎛ Fine Align ±3㎛
Retry	3times
Align Time	Vision 10sec Matching 50sec

The crucible of the LPS source is shown in figure 10. It has sensor nozzle and vapor opening. The organic gas emits through the sensor nozzle is detected on the QCM for the rate PID operation and the main organic flux emits through the linear shaped opening to deposit on the belt surface. The crucible is warmed up by the wire heater around the crucible and the housing covers the wire heater assembly so that the heat radiation stagnates inside the source assembly.

Fig. 10. LPS source crucible

The major specification of the belt source deposition chamber is listed in table 2.

Table 2. Specification of the belt source module

Belt source material	Ta, STS304
Substrate size	Up to 8G
LPS source	1 host, 1 dopant
Mask alignment	3㎛ ~ 100 ㎛
Film uniformity	< 3%
Material usage	> 50%
Ultimate pressure	10-8 Torr
Module material	STS304
Belt speed	1 ~ 300mm/s
Belt operating temperature	RT ~ 300℃
TS	100mm
Substrate temperature	< 30℃
Shadow Mask temperature	< 40℃

3. Application

The belt source evaporation can be applied for the sky direction deposition as shown in figure 11. Once the belt source replaces the revolver type of point sources in conventional equipment, the material usage improves and the deposition process becomes so easy because the substrate will not be rotated to get the high film uniformity. Furthermore, the mask alignment, substrate holder, and vacuum robots used in cluster type of manufacturing tools keep operating same as used.

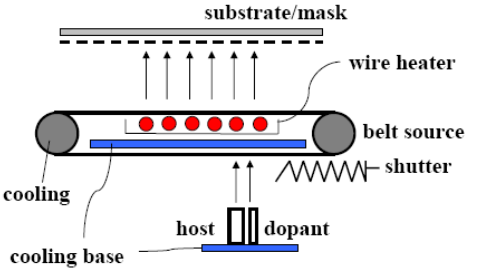

Fig. 11. Belt source for sky direction

4. Conclusion

In this report, the belt source deposition chamber has been introduced. The deposition chamber is consisted of the belt source, organic vapor source, and the mask alignment assembly. The rollers operate for the thin metal belt to continuously move without occurring belt tension. It has been proved for the belt source evaporation easy to operate and the alignment of the substrate/shadow mask becomes so simple to use in AMOLED manufacturing industry.

5. References

[1] C.H. Hwang, plane source and inline type manufacturing system for large scale AMOLED, SID06, vol. 47.3(2006)
[2] C.H. Hwang, YK Kim, KH Shin, SH Ju, JH Kwon, Belt source and in-line manufacturing equipment for very large-size AMOLED, IMID, P1403(2006)
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