# In-line System for Large Scale OLED Manufacturing using Nozzle Source

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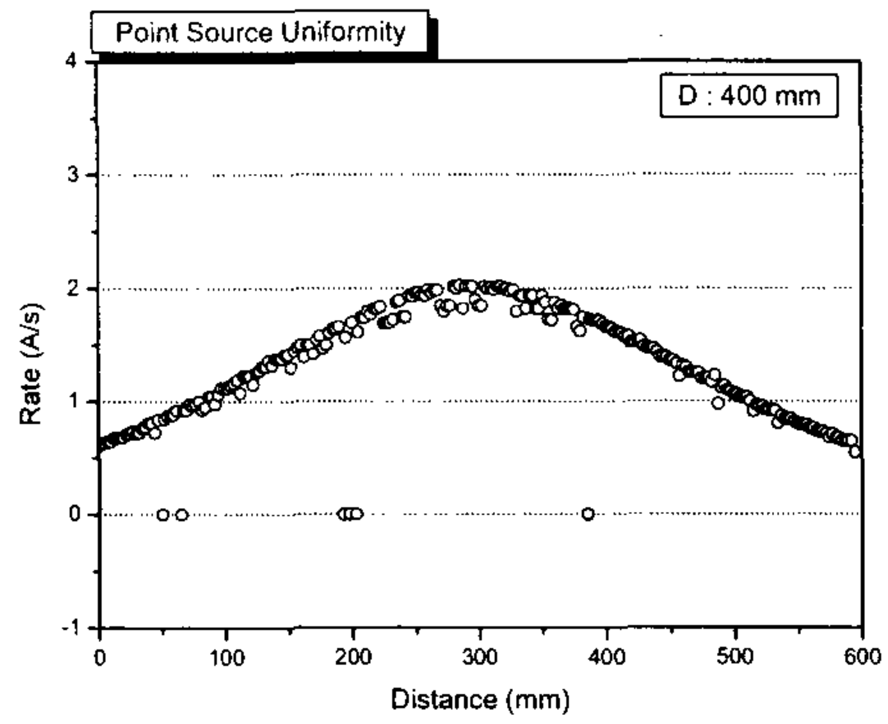
## Abstract
When manufacturing large sized OLED devices, the evaporation source is the most important technology. The nozzle source maintains the uniformity of the large-size deposited organic thin film at the 2-3% level and its usage is only 0.8 gram/hour. The in-line manufacturing deposition system combining with an encapsulation system is proposed.

## 1.Objectives and Background
When manufacturing large-scale OLED devices, the evaporation source should guarantee the thickness uniformity of less than 5% and the thermal stability for the continuous use. The point source used in a conventional system does not give flat flux uniformity (as shown in figure 1) and the following thickness uniformity is not suitable for a large size substrate. In order to solve this problem, the substrate is placed far from the source and is also slanted and rotated.(1)

However, when the substrate is even larger, the substrate-to-source distance should be longer and the usage of the organic compounds becomes much lower. Furthermore, the shadow effect becomes more serious for the large size substrate that is caused by angles between the shadow mask and the point source.(6)

How fast the deposition processes can be done in a low vacuum pressure system and how high the thickness uniformity for a large size substrate can be obtained are hot issues in the manufacturing industry.

<Figure 1> Flux uniformity of the point source



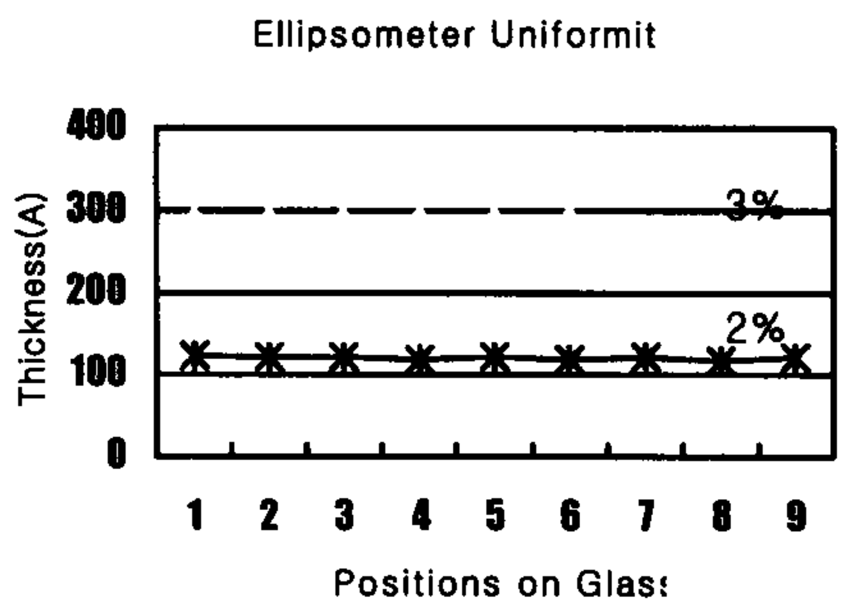

Other than this, the cross contamination should be minimized, and the bending of the glass substrate and the metal mask should be suppressed during the deposition processes. In general, the OLED device manufacturing industry requires 3 minutes TACT time and the whole processes of 1 hour. Here, we introduce the nozzle source that has recently been developed for the large size substrate and we propose the in-line deposition system for large scale OLED device manufacturing.(13)

## 2.Results
The nozzle source has a rectangular crucible where it is filled with the organic chemicals and on top is a slit nozzle.(6) The organic gas is emitted through this slit nozzle to deposit. The nozzle structure has been designed through simulation and the capacity was 300cc in the initial stage. The nozzle width in a few mm was comparable to the mean free path of the organic gas. It was intended for a sufficient amount of gas molecules to be stagnated inside the crucible. Then, the gas flux emitted from the nozzle is

precisely controlled in order to maintain the thickness uniformity of the deposited organic film at the 2-3% level.[14,15]

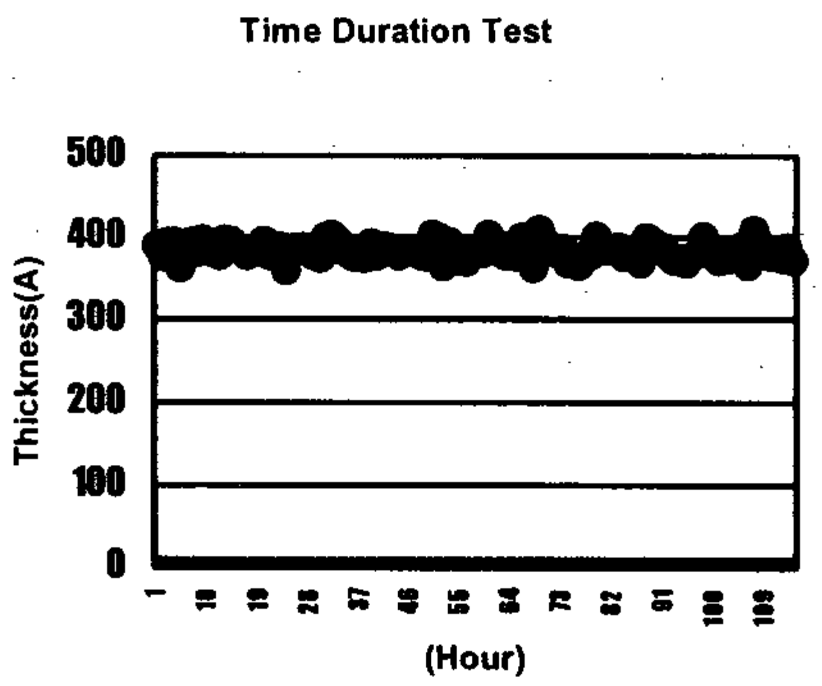
The nine pieces of silicon wafer attached to the 370mmX470 glass substrate were deposited. The thickness measured by an ellipsometry is shown in figure 2. For the Alq3, the thickness uniformity was 3.3% and the deposition rate was 2A/s and the shutter opening of 150mm. For the NPD, the thickness uniformity was 2.0% and the deposition rate was 2A/s and the shutter opening of 50mm. The scanning speed was 15mm/sec. The usage was measured by 0.8gm/hr. Note that the 150 gram is enough for the continuous use of 150 hours.

<Figure 2> Thickness uniformity




In order to do the time duration test of the nozzle source, the deposition rate was maintained to 5A/s by the temperature control and the flux uniformity was measured by the scanning sensor. The uniformities look the same during the 150 hours. The thickness measured every five hours for 150 hours are shown in figure 3.

<Figure 3> 150hours test

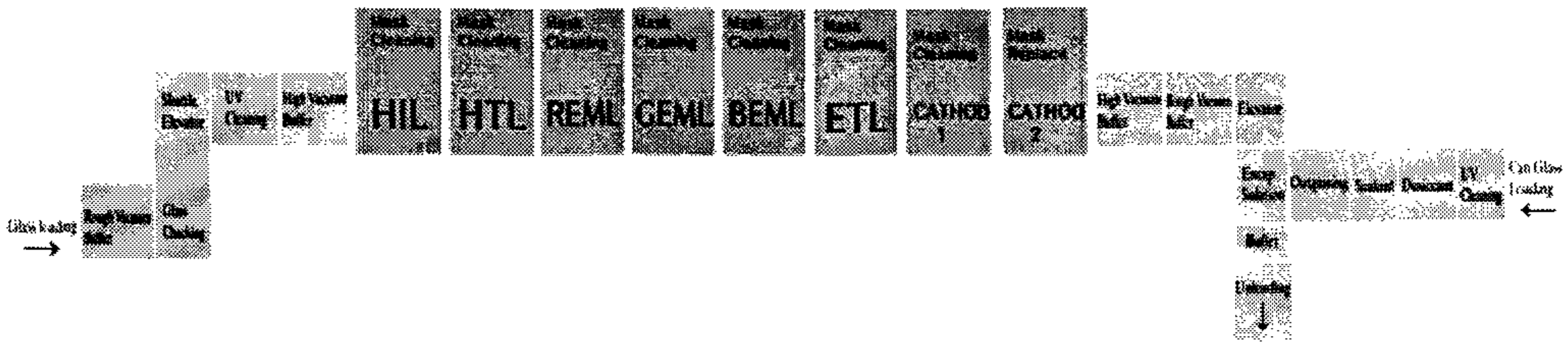



The in-line system using the nozzle source for large scaled OLED manufacturing is shown in figure 4.[2,3] From the left side of the system, an ITO glass enters to be chucked to the holder. The shuttle will carry the holder to the deposition chamber through the UV cleaning process. Inside the deposition chamber, a framed mask is raised up and aligned to the glass. Then, the shuttle moves back and forth to scan the glass about the nozzle source. Note that the nozzle source is placed at the bottom of the deposition chamber. Once the deposition process is finished, the shuttle will leave the framed mask and move to the next chamber. The whole deposition processed will be made in the same way. The mask used in the deposition process can be in-situ cleaned in the plasma chamber where connects to the deposition chamber.[9,10,11,12]

The linear structure of the encapsulation process is connected to the right side of the deposition system. During the deposition process, the cover glass is introduced to the encapsulation chamber through desiccant and sealant processes. In the encapsulation chamber, a panel glass and a cover glass are facing each other to be diaphragm encapsulated. Finally, the large size OLED panel is de-chucked from the holder. Note that there is only single glass chucking and single de-chucking process during the whole process.

If the deposition rate of a nozzle source is 3A/s, the TACT time can possibly be less than 3 minutes with a shuttle speed of a few cm/s. Fourteen deposition related chambers from UV cleaning to encapsulation take less than 1 hour if each process takes 3 minutes. Note that the mask cleaning process and the cover glass loading process will not be

<Figue 4> In-line system using nozzle source for large-scale OLED manufacturing




considered for the whole process time because they are processed simultaneously with the deposition process.

## 3.Impact

By using an in-line manufacturing deposition system using the nozzle source combined with an encapsulation process system, the number of process operations can be minimized and the whole process of the large-scale OLED manufacturing can be achieved in 3 minutes TACT time and in less than one hour. We hope that this in-line manufacturing system for large sized OLED devices creates interest and further progress in Display Device Manufacturing industry.


## 4.Acknowledgements

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