TPS Analysis of NPB organic thin film for Belt Source Evaporation in AMOLED Manufacturing

Chang Hun Hwang
OLEDON Co., Ltd., Kyunggi-do, South Korea
Phone: 011-1714-9523, Email:chriss_hwang@oledon.com

Abstract

TPS (Temperature Programmed Sublimation) technology is known to research for the plane evaporation of the organic film.[5] Using TPS technology, the plane source evaporation of NPB organic film has been studied for the first time. The NPB organic film consists of nano scale film phase and bulk phase on a substrate. The 400 Å in film phase thickness of NPB sublimates at the 175 ℃ of the Ta made metal plate. It was proved that the sublimation temperature of the organic film has much lower than that of the organic powder. (130 ℃ is lower for Alq3 and 90 ℃ is lower for NPB.)

1. Introduction

The OLED (Organic Light Emitted Device) industry meets its transition time from PMOLED to AMOLED. In order to role for the AMOLED technology as post-TFT LCD devices, the most important factor is the highest productivity in manufacturing industry. In particular, it is necessary for the manufacturing equipment for large-size AMOLED and high organic material utilization to be developed so that the AMOLED regards as the next generation display. [1,2]

To realize the high productivity of the AMOLED devices, the organic evaporation technology for the large size organic film, as a main process technology, needs to be critically developed. Regarding this issue, the belt source evaporation technique has been proposed to develop as new concept of vacuum thermal evaporation as shown in figure 1.[1] The belt source is a kind of thin metal made plane source.

The organic molecules evaporating from the LPS sources [2] are deposited on the lower area of the belt plate during moving. This procedure is often called as “Top-down deposition”.

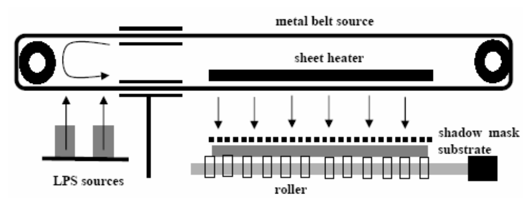

Fig. 1. Belt source evaporation

This process gives high film uniformity (2%) and high material utilization (68%) for the large size substrate and the high speed deposition process can be realized. [3,4] Particularly, because the substrate is transferring via a roller, the large size substrate will not have any bending trouble as in conventional system and it brings us simple structure in a deposition chamber for pattering organic films without substrate chuck and shadow mask chuck assemblies.[3]

In addition, the TPS function in belt source evaporation can identify the nano scale organic film phase on a substrate and help us to decide the optimum thickness of the organic layers.[5]

In this thesis, using TPS technology, the plane source evaporation of NPB organic film is reported.

2. Experiments

As shown in figure 2, the NPB powder filled in LPS source crucible evaporates to deposit on Ta (Tantalum) metal plane. The Ta plate was 0.1mm in thickness and its size was 100mmX100mm. The distance between the LPS source and the metal plate was fixed at 100mm. The sheet heater has been connected to a temperature controller and the heating speed of the metal plate was then adjusted as 0.1℃/s.

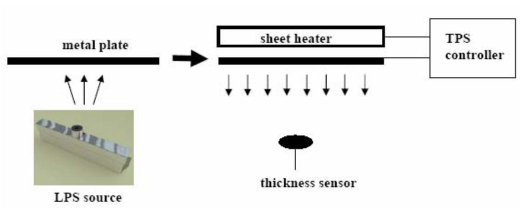

Fig. 2. TPS experiment

The sheet heater consists of Ta wires to "radiatively" warm up the metal plate and the heating temperature was measured at the center and side of the metal plate. The heating speed was then programmed in a TPS controller and the thickness sensor was located at the 100mm lower center of the metal plate to measure the downward sublimation signals of the organic films. The distance between the metal plate and the sensor was fixed at 100mm.

3. Results & Discussion

The automatic PID function in rate controller maintains 3 Å/s in rate stability for the vapor rate of the NPB material in LPS source. (Figure 3)

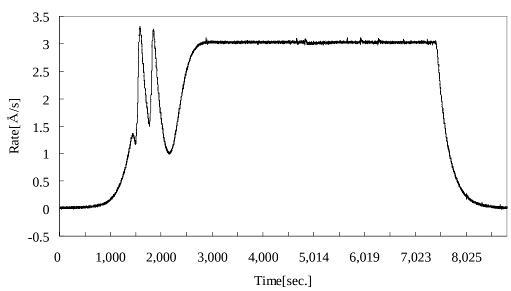

Fig. 3 Automatic PID tune

The sublimation signal of the NPB organic film with 400 Å thickness was obtained as shown in figure 4. The heating speed of the metal plate was 0.1℃/s. The peak rate for the film phase was measured as 0.4 Å/s at the 175℃ of the heating temperature and 0.2 Å/s at 185℃ for the bulk phase.

Note that the vapor temperature of NPB is known to be 265℃ in high vacuum of 10^{-7}Torr. That is, the NPB organic film is sublimated at lower temperature than NPB powder material. Note that it was measured for the Alq3 film phase at 130℃.[5] That is, the sublimation temperature of the NPB organic film at 40℃ higher than the Alq3 film.

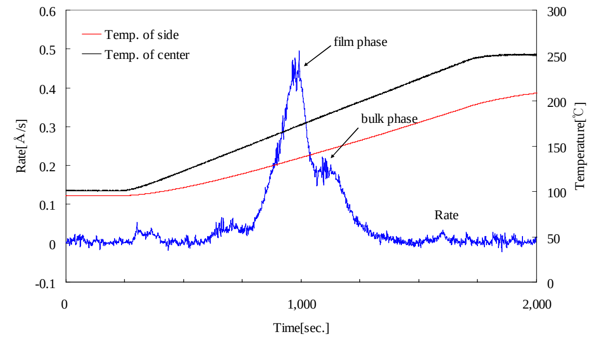

Fig. 4. TPS signal for 400 Å

The sublimation signal of the NPB organic film with 800 Å thickness was obtained as shown in figure 5. The heating speed of the metal plate was 0.1℃/s. The peak rate for the film phase was measured as 0.5 Å/s at the 180℃ of the heating temperature and 0.4 Å/s at 200℃ for the bulk phase.

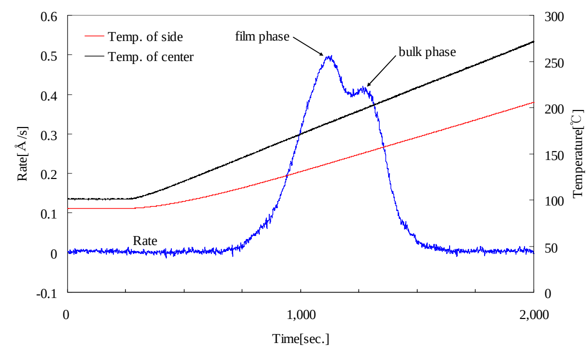

Fig. 5. TPS signal for 800 Å

The sublimation signal of the NPB organic film with 2,000 Å thickness was obtained as shown in figure 6. The heating speed of the metal plate was 0.1℃/s. The peak rate was measured as 1.6 Å/s at the 210℃ of the heating temperature. The film phase and bulk phase were not well resolved in this case, however, this peak rate was assigned as bulk phase based on the Alq3 study. [5] For NPB film, the bulk phase is more dominated over the film phase in 2,000 Å.

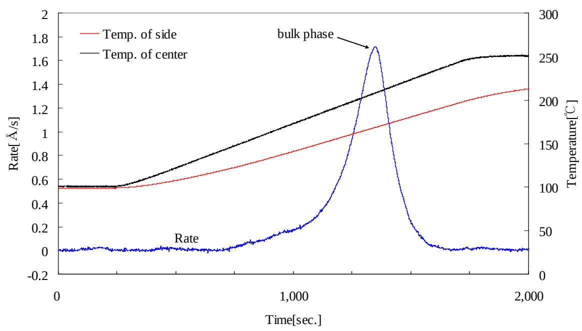

Fig. 6. TPS signal for 2,000 Å

The sublimation signal of the NPB organic film with 8,000 Å thickness was obtained as shown in figure 7. The heating speed of the metal plate was 0.1℃/s. The peak rate was measured as 9.0 Å/s at the 220℃ of the heating temperature. The film phase and bulk phase were not well resolved in this thickness, however, this peak rate was assigned as bulk phase based on the Alq3 study.[5] For NPB film, the bulk phase is much more dominated over the film phase in 8,000 Å.

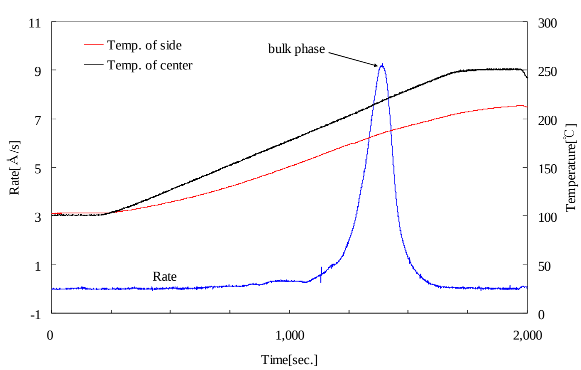

Fig. 7. TPS signal for 8,000 Å

The sublimation temperatures on each NPB organic thickness are summarized in table 1. Note that there are two sublimation temperatures on each. Note that the 400 Å thickness of the Alq3 film has 135/145℃ for film phase and bulk phase, respectively. It is clear that the sublimation temperature of the NPB organic film at 40℃ higher than the Alq3 film. In addition, we conclude that the sublimation temperature of the organic film has much lower than organic powder. (130℃ is lower for Alq3 and 90℃ is lower for NPB.)

Thicknesses (Å)	Sublimation Temperatures (℃)
400	175/185
800	180/200
2,000	210
8,000	220

Table 1. Sublimation temperatures on thicknesses for NPB film

4. Conclusion

Using TPS technology, the plane evaporation of the NPB organic films has been studied for the first time. The NPB film sublimates at the temperature of 175℃ while the Alq3 film sublimates at the 135℃. Note that their vapor temperature is known as 265℃ in high vacuum of $5X10^{-7}$Torr. The sublimation temperature of the NPB organic film is 40℃ higher than the Alq3 film. In conclusion, it was proved that the sublimation temperature of the organic film has much lower than that of the organic powder. (130℃ is lower for Alq3 and 90℃ is lower for NPB.)

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)

[3] C.H. Hwang, YK Kim, KH Shin, SH Ju, JH Kwon, Study of metal plate evaporation using LPS source for AMOLED, IMID, P1385(2006)

[4] C.H. Hwang, How to make the 5th Generation AMOLED, P421, EL2006(2006)

[5] C. H. Hwang, et al., New TPS function for identifying nano scale film phase using belt source evaporation techniques, P53, SID2007.