Doping control of Belt Source Evaporation Techniques for Large Size AMOLED

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

Abstract

In order to understand the doping control for the belt source evaporation, the Alq3 and NPB were co-deposited on the Ta plate to re-sublimate. The very slow heating (0.1℃/s) of the Ta plate shows the separated rate signals of Alq3 and NPB sublimated from the Alq3-mixed NPB organic film on Ta plate. The ratio of the vapor rates of Alq3 and NPB was measured as same as that of each sublimation rates. Therefore, the doping control of the belt source evaporation is of the ratio of the vaporization rates of host and dopants.

1. Introduction

In order to succeed 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.

To realize the high productivity of the AMOLED devices, the organic evaporation technology for the large size organic film 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.[1,2]

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”.

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. 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]

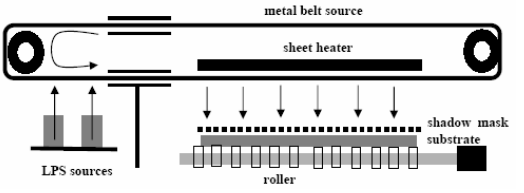

Fig. 1. Belt source evaporation

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.[4]

In this report, the Alq3 and NPB were co-deposited on Ta plate to re-sublimate by very slow heating speed. The vapor rate and the sublimation rate were compared for the doping control of the belt source techniques.

2. Experiments

As shown in figure 2, the Alq3 and NPB powder filled each in two LPS sources evaporates to co-deposit on Ta (Tantalum) metal plate.

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 200mm. The sheet heater has been connected to a temperature controller and the heating speed of the metal plate was then adjusted as slow as 0.1℃/s.

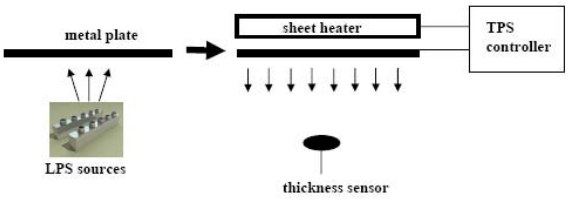

Fig. 2. Sublimation experiment

The sheet heater consists of Ta wires to "radiatively" warm up the metal plate and the heating temperature was measured at the center of the metal plate. The heating speed was then programmed in a TPS (Temperature Programmed Sublimation) 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.[5]

3. Results and Discussion

1) Sublimation of Alq3 film

The vapor rate of the Alq3 was adjusted as 0.5 Å/s to deposit on the Ta plate for 200 seconds. The thickness was 100 Å. The heating speed of the Ta plate was as slow as 0.1℃/s for the organic film to re-sublimate. The sublimation signal is shown in figure 3. The peak rate was 0.25 Å/s at 130℃.

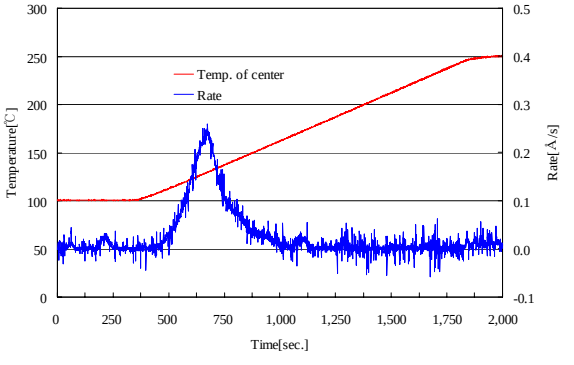

Fig. 3. TPS sublimation of Alq3 film

2) Sublimation of NPB film

The vapor rate of the NPB was adjusted as 5.0 Å/s to deposit on the Ta plate for 200 seconds. The thickness was 1000 Å. The heating speed of the Ta plate was as slow as 0.1℃/s for the organic film to re-sublimate. The sublimation signal is shown in figure 4. The peak rate was 1.5 Å/s at 185℃.

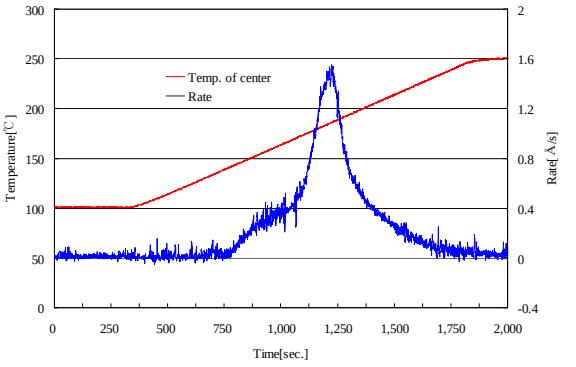

Fig. 4. TPS sublimation of NPB film at 5.0A/s

The vapor rate of the NPB was adjusted as 5.5 Å/s to deposit on the Ta plate for 200 seconds. The thickness was 1000 Å. The heating speed of the Ta plate was as slow as 0.1℃/s for the organic film to re-sublimate. The sublimation signal is shown in figure 5. The peak rate was 1.9 Å/s at 185℃.

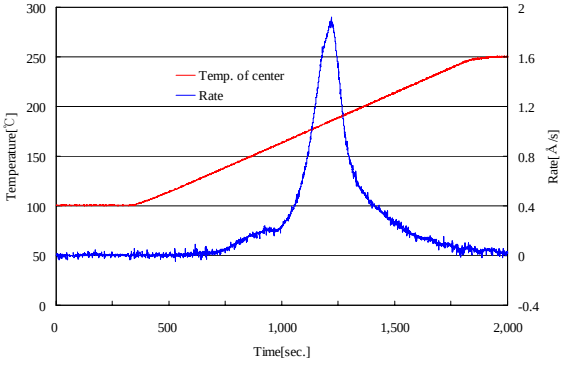

Fig. 5. TPS sublimation of NPB film at 5.5A/s

3) Sublimation for Alq3 mixed NPB film

The vapor rate of the Alq3 was adjusted as 0.5 Å/s and the vapor rate of the NPB was adjusted as 5.0 Å/s to co-deposit on the Ta plate for 200 seconds. (Note the 5.5 Å/s was measured in experiment.) The heating speed of the Ta plate was 0.1℃/s for the organic film to re-sublimate. The sublimation signal is shown in figure 6. The thickness of NPB was 1000 Å and that of Alq3 was 100 Å.

The peak rate of the Alq3 was 0.2 Å/s at 130℃ and that of the NPB was 1.9 Å/s at 185℃.

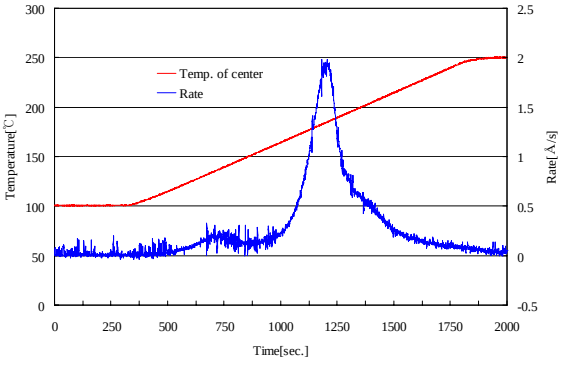

Fig. 6. TPS sublimation of Alq3 mixed NPB film

While the peak rate of the sublimated Alq3 was 0.25 Å/s, the peak rate of the Alq3 sublimated from the mixed organic film (Alq3+NPB) was 0.2 Å/s. While the peak rate of the sublimated NPB was 1.5 Å/s, the peak rate of the NPB sublimated from the mixed organic film (Alq3+NPB) was 1.9 Å/s. That is, the Alq3 rate was decreased while the NPB rate was increased.

Note that the heating speed of 0.1℃/s seems to be slow enough so that most of the Alq3 is escaped from the mixed organic film. The Alq3 peak is almost separated from the NPB peak as shown in figure 6.

The ratio of the vaporization rates of the Alq3 (0.5 Å/s) and the NPB (5.0 Å/s) was as 1:10 and the sublimation rates of them on a mixed film are 0.2 Å/s and 1.9 Å/s, respectively. Therefore, it is concluded that the ratio of the sublimation rates is nearly same as the ratio of the vaporization rates.

This result can be applied to a doping control in belt source evaporation. Note that the heating speed of the metal plate is 5 ~ 10℃/s for occurring the co-sublimation of the host and dopants in real deposition operation of the belt source.

4. Conclusion

In order to see how to control the doping rates for the belt source evaporation, the Alq3 and NPB were co-deposited on the Ta plate to re-sublimate. The very slow heating (0.1℃/s) of the Ta plate shows the separated rate signals of Alq3 and NPB sublimated from the Alq3-mixed NPB organic film on Ta plate.

The ratio of the vapor rates of Alq3 and NPB was measured as same as that of each sublimation rates. Therefore, the doping control of the belt source evaporation is of the ratio of the vaporization rates of host and dopants.

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, SID2007, P53(2007).