Effects of Evaporation Condition on Luminous Characteristics of a Single Layer EL Device

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Synopsis

To fabricate a high-performance organic electroluminescent (EL) device, we investigated an effects of evaporation condition on luminous characteristics of a single layer EL device using organic material Alq_3 (tris(8-quinolinato)aluminum complex). Lower base pressure and faster deposition rate of Alq_3 resulted in higher maximum luminance of EL device.

KEYWORDS: EL device, Single layer, Alq_3, Fabrication condition

1 Introduction

Organic electroluminescent (EL) device is a light emitting diode using organic thin film. Since the proposal by Tang and VanSlyke[1, 2] of a high-performance organic multilayer EL device, it attracted much interest of many workers because of its potential application to the next generation flat panel display driven at low voltage.

Leading corporations have improved the characteristics of the orgnic EL device with greate efforts. Consequently, the stage of producing a display made of the EL device is coming. The details of fabrication condition and manufacture techniques in such corporations, however, have not been revealed. For this reason, it is very difficult for us to fabricate a high quality EL device on a level with the corporations. In addition, the details of light emission mechanism and degradation mechanism of the device are not fully understood.

We investigated the effects of evaporation condition on luminous characteristics of a single layer EL device using Alq_3 as an emission layer, especially on the maximum luminance.

2 Experimental

2.1 Device fabrication

Molecular structure of Alq_3 for an emission layer of organic EL device is shown in Fig. 1. This material is known as a fluorescent material and has good electron transfer capability. We used Alq_3 powder of 95% purity (TOKYO KASEI KOGYO CO., LTD.).

The structure of a single layer EL device used in this study is shown in Fig. 2. The device consists of an emitting Alq_3 layer sandwiched between Indium-Tin Oxide (ITO) and Al electrode. Alq_3 layer and Al electrode were fabricated by conventional vacuum vapor deposition method. The organic material, Alq_3, was deposited onto an ITO coated Corning #7059 glass substrate (MATSUNAMI GLASS IND., LTD.) at a pressure of 10^{-5} Torr at room temparature, using a tantalum boat (KF-1kai, Kojundo

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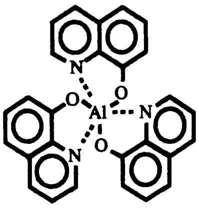

Alq$_3$

Fig. 1 Molecular structure of Alq$_3$.

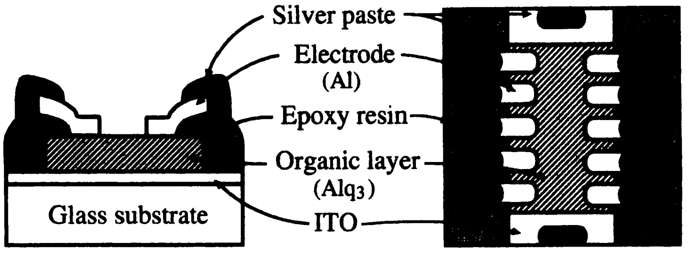

Fig. 2 The structure of EL device.

Chemical Laboratory Co., Ltd.). The upper Al electrode was evaporated on the Alq$_3$ layer using tungsten wire.

2.2 Measurement of EL characteristics

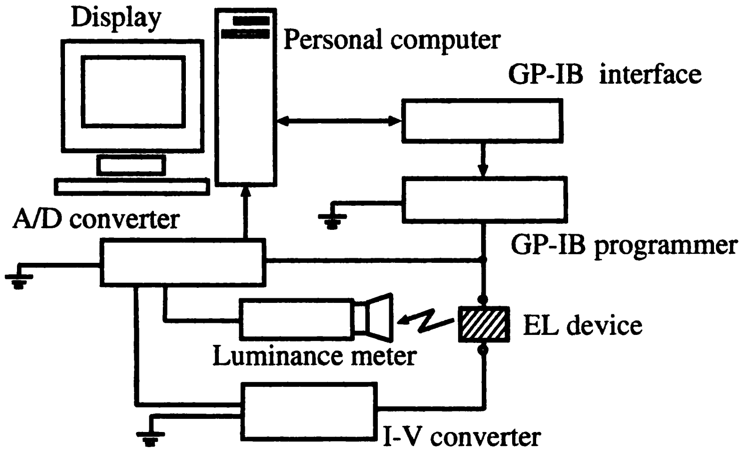

Fig. 3 Schematic diagram of a system for measurement of EL characteristics.

Figure 3 shows a schematic diagram of a system for measurement of current–voltage and luminance–voltage characteristics of the devices. DC voltage which is controled by a personal computer was applied to the devices. Luminance was measured using Luminance Meter (TOPCON Model BM-3, measuring angle 2°). All the measurements including current, applied voltage, and luminance were performed at room temparature in atmosphere in a darkroom .

3 Experimental Results and Discussions

3.1 Base pressure at the startup time of the evaporation of Alq$_3$

We investigated the relationship between maximum luminance and base pressure in a vacuum chamber at the startup time of the evaporation of Alq_3. In order to investigate this relationship, we prepared three kinds of devices under different fabrication conditions. The experimental results were shown in Table 1 and Fig. 5. The maximum luminance of the device (a) was the highest

Table 1 Dependence of maximum luminance on base pressure.

Device	Base pressure P_{base}(Torr)	Maximum luminance L_{max} (cd/m^2)
a	2.80×10^{-6}	32.0
b	7.00×10^{-6}	15.3
c	2.50×10^{-5}	7.1

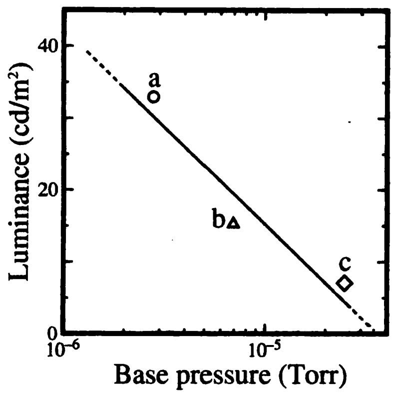

Fig. 4 Dependence of maximum luminance on base pressure.

among them. It shows that the device fabricated under the lower pressure has the higher luminance. This result shows that less residual gas was incorporated in the deposited thin film in the case of the lower pressure in vacuum chamber, which results in less reaction with Alq_3 gas. It means that an emission layer fabricated at the lower pressure has good quality and an EL device with higher maximum luminance is obtained.

3.2 The temporal change of vapor pressure during evaporation

We measured the temporal change of vapor pressure in the vacuum chamber during the evaporation of Alq_3. The temporal change in the case of three devices, shown in Fig. 5, are very similar to each other though the curves have different pressure level on average. Pressure rapidly increases from the base pressure at the evaporation of startup time and then gradually decreases and reaches to less than or equal to the initial level of pressure in every cases. In order to compare each curve, we introduce normalized pressure p,

$$p = \frac{P}{P_{peak}},$$

where P is pressure and P_{peak} is the highest pressure for each curve. Figure 6 shows the teporal change of normalized pressure, p. Initial rising rate of the normalized pressure $[dp/dt]_{init}$ was obtained by using linear regression analysis for the rapidly increasing part of the curves.

The initial rising rate and the maximum luminance of the three kinds of devices were shown in Table 2 and Fig. 7. They show that the maximum luminance increases with increasing initial rising rate.

It is generally considered that large initial rising rate means faster heating up. Therefore, the result shows that faster heating up leads to higher maximum luminance. It means that the fast heating up

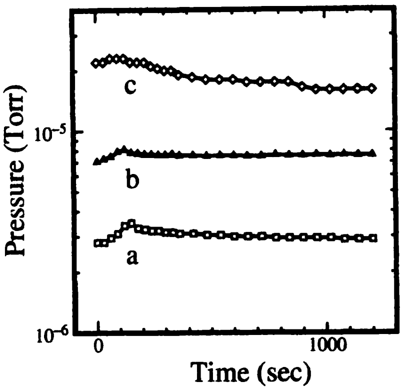

Fig. 5 The temporal change of pressure during evaporation of Alq_3.

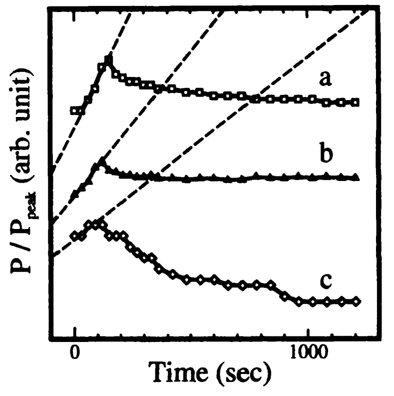

Fig. 6 The temporal change of normalized pressure.

Table 2 Initial rising rate and the maximum luminance.

Device	Initial rising rate $[dp/dt]_{init}$ (sec^{-1})	Maximum luminance L_{max} (cd/m^2)
a	1.96×10^{-3}	32.0
b	1.13×10^{-3}	15.3
c	7.17×10^{-4}	7.1

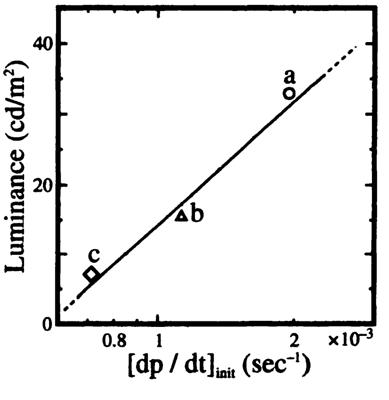

Fig. 7 Initial rising rate and the maximum luminance.

of Alq_3 is important to fabricate a good single layer EL device.

Conclusion

Effects of evaporation condition on luminous characteristics of a single layer EL device having Alq_3 as an emission layer were investigated. The conclusions are summarized as follows :

1. A device with Alq_3 layer prepared at the lower pressure shows better luminous characteristics.
2. The fast heating up of Alq_3 is important to fabricate a good single layer EL device.

References

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2) C. W. Tang, S. A. Vanslyke and C. H. Chen: J.Appl.Phys. **51** (1990) 3610.