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INFLUENCE OF ANTHRECENE DOPING ON ELECTRICAL AND LIGHT-EMITTING BEHAVIOR OF 8-HYDROXYQUINOLINE-ALUMINUM BASED ELECTROLUMINESCENT DEVICES

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ABSTRACT

In order to improve EL performance, anthracene was doped into the 8-hydroxyquinoline-aluminum (Alq_3) light-emitting layer of organic double layered EL cells. The EL cells were fabricated on ITO glass substrates by vacuum deposition. Doping of anthracene to the light-emitting Alq_3 layer was performed by means of co-evaporation. The doping concentration was changed in the range of 5 to 30 wt.%. It was confirmed that anthracene doping of appropriate concentration increased the available current density and brightness of the EL cells. Carrier mobility of the Alq_3 layer was measured by time of flight method. The influence of anthracene doping on the cell performance was discussed.

INTRODUCTION

Electroluminescent (EL) devices based on organic thin layers are of great interest, now a days, because of their possible application as large area light-emitting color displays which are operative at low drive voltages. Tang and VanSlyke^[1] proposed first to use a hole transport later for promoting hole injection into the emitting layer, resulting in a significant decrease in the drive voltage. Many attempts to increase EL performance have recently been made intensively^[2-7]. In order to increase the EL performance, we have tried to dope light-emitting layer with anthracene. This paper describes influence of

anthracene-doping into the emitting layer on the electrical and light-emitting behavior of 8-hydroxyquinoline-aluminum based EL cells.

EXPERIMENTAL

All the EL devices were fabricated on indium tin oxide (ITO) glass substrates by vacuum deposition at a pressure of less than 3×10^{-6} Torr. The structure of the fabricated EL cell is shown in Fig. 1. First, triphenyldiamine derivative (TPD) was deposited on a substrate as about 60nm-thick hole transport layer. Then, 8-hydroxyquinoline-aluminum (Alq_3) was deposited on the TPD layer as

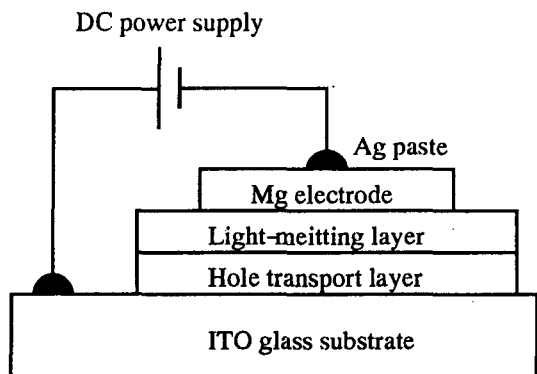


Fig. 1 The structure of the EL cell fabricated in this study.

about 100nm-thick light-emitting layer. The top electrode was also prepared by vacuum deposition of magnesium (Mg) of about 200nm-thick. Doping of anthracene to the light-emitting Alq₃ layer was performed by means of co-evaporation of Alq₃ and the dopant using separate evaporation sources. The doping concentration was changed in the range of 5 to 30 wt. %.

The absorption spectra of undoped and anthracene-doped Alq₃ thin layers were measured to check the doping of anthracene into the Alq₃ layer. Electrical and EL characteristics of the EL cells fabricated were measured by a conventional method^[2]. In order to evaluate carrier mobilities in the undoped and anthracene-doped Alq₃ thin layers, time of flight measurements were carried out. The cells for that purpose were fabricated as follows. First, a SiO thin layer about 170 nm-thick was deposited as a blocking electrode on the ITO glass substrates by vacuum deposition at a pressure of less than 3×10^{-6} Torr. Then, Alq₃ was deposited on the SiO thin layer. Doping of anthracene to the Alq₃ thin films was performed by means of co-evapo-

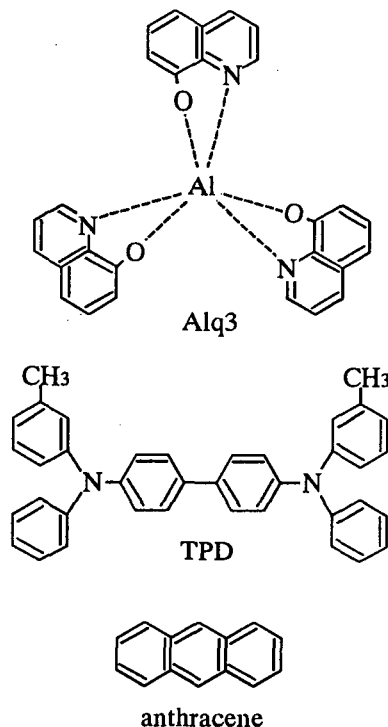


Fig. 2 The molecular structures of the organic materials used in this study.

ration. The top electrode was also prepared by vacuum deposition of gold (Au). A N₂ laser pulse was irradiated onto the Alq₃ thin layer through the ITO glass substrate, and the waveform of the photocurrent was observed with a digital storage scope. All the measurements were made at room temperature.

The molecular structures of organic materials used in this study are shown in Fig. 2.

RESULTS AND DISCUSSION

Current density-voltage characteristics of the EL cells are shown in Fig. 3. It was found that anthracene doping of appropriate concentration to Alq₃ increased the current density of the cells. However, heavy doping, for

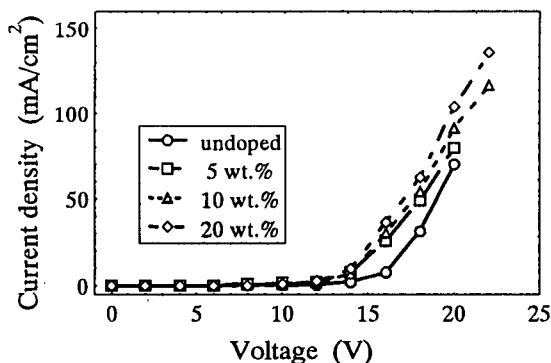


Fig. 3 Influence of anthracene doping on the current-voltage characteristics of the EL cells.

example, more than 30wt.% decreased the current density. Most EL cells were destroyed both electrically and mechanically by applying voltages higher than around 20–22V. It should be noted that anthracene doping increased the available current density in the EL cell. Brightness-voltage characteristics of the EL cells are shown in Fig. 4. Anthracene doping of moderate concentration increased the brightness of the EL cell in the same way as the current density. For example, the brightness increased to 11000cd/m² or more at the doping concentration of around 10wt.%,

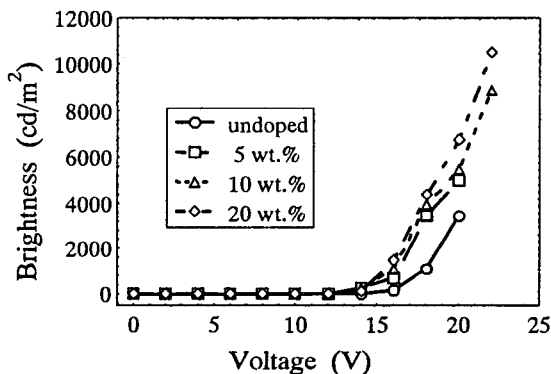


Fig. 4 Influence of anthracene doping on the brightness-voltage characteristics of the EL cells.

but heavy doping decreased the brightness again. This can be ascribed in part to the increase in the current density due to the anthracene doping. However, the extent of the brightness increase due to anthracene doping was much larger than that of the current-density increase due to anthracene doping. This result indicates that anthracene doping increases the light-emitting efficiency of the EL cells. Figure 5 shows the anthracene-concentration dependence of the ratio of brightness (=2000, 3500cd/m²) to (voltage) × (current density), at which the brightness reaches to 2000, 3500cd/m². This ratio corresponds to a relative light-emitting efficiency. This result indicates that anthracene doping of appropriate concentration increases the light-emitting efficiency, but heavy doping decreases it. From the standpoint of the light-emitting efficiency, 5–10wt.% of anthracene doping is most suitable.

EL spectra of undoped and anthracene-doped cells are shown in Fig. 6. The undoped cell showed an emission band centered at around 530 nm, which corresponds to light-green-colored emission. The anthracene dop-

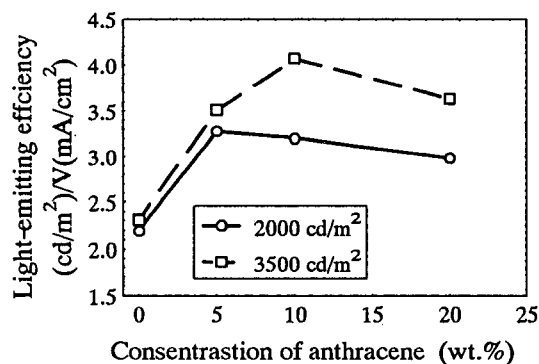


Fig. 5 Anthracene-concentration dependence of the ratio of brightness to (voltage) × (current density) at 2000, 3000 cd/m².

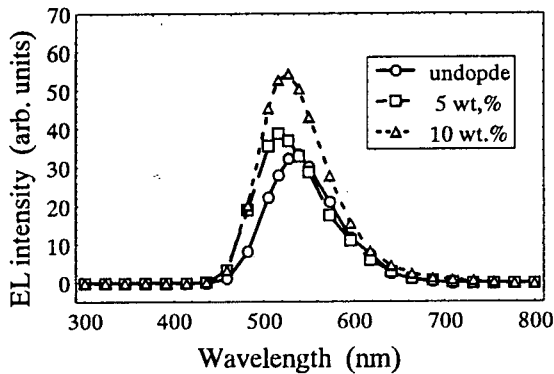


Fig. 6 EL spectra of undoped and anthracene-doped EL cells.

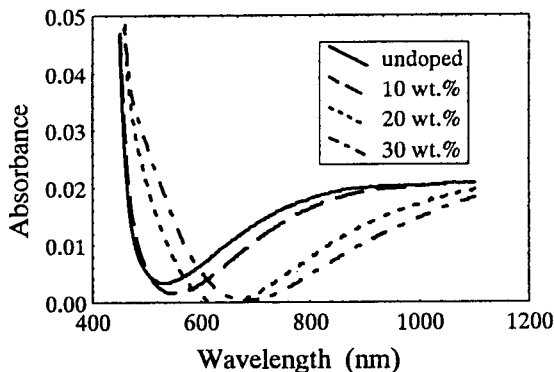


Fig. 7 Absorption spectra of undoped and anthracene-doped Alq₃ thin layers.

ing shifted the emission peak in shorter wavelength direction slightly. This may be attributable to the emission from anthracene. Absorption spectra of undoped and anthracene-doped Alq₃ layer are shown in Fig. 7. The anthracene doping shifted the absorption spectrum in longer wavelength direction. The increase in absorbance in the wavelength region of 500 to 580 nm due to anthracene doping may shift the emission spectrum of the doped cell.

Finally, carrier mobilities of the undoped and anthracene-doped Alq₃ thin layers were measured to clarify the mechanism of in-

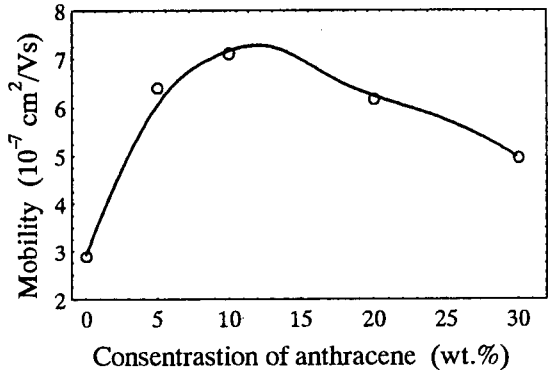


Fig. 8 Carrier mobilities of undoped and anthracene-doped Alq₃ thin layers.

crease in current density (and also brightness) due to anthracene doping. Figure 8z shows the hole mobility of the Alq₃ layer as a function of anthracene concentration. This result indicates that anthracene doping increases the carrier mobilities in the Alq₃ layers, which may be one of the origins of the increase in brightness by anthracene doping. However, the detailed mechanism of the influence of the anthracene-doping on the current density and brightness is ambiguous. Heavily introduced anthracene molecules may interfere carrier transport in the Alq₃ layer.

CONCLUSIONS

Influence of anthracene doping into the light-emitting Alq₃ layer of the organic EL cells was studied and the following results were obtained :

- 1) Anthracene doping increased the current density, the brightness and the light-emitting efficiency.
- 2) The EL spectra was slightly shifted in shorter wavelength direction by anthracene doping.
- 3) The absorption spectrum of Alq₃ layer

was slightly shifted in longer wavelength direction by anthracene doping.

4) Anthracene doping increased the carrier mobility of the Alq3 thin layers.

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