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Transient Properties of Organic Electroluminescent Diodes Using 8-Hydroxyquinoline Aluminum as a Light Source for Polymeric Integrated Devices

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1. Introduction

Recently, organic electroluminescent diodes (OLEDs) utilizing fluorescent dye¹⁾ or conducting polymer²⁾ have been realized to have a long lifetime and excellent durability for flat panel display applications. An additional advantage is that they are for simple to fabricate on various kinds of substrate, including polymer and glass substrates. That is, the mechanical flexibility is one of key advantage of OLEDs. OLEDs can be also expected to be used as a light source device of an optical inter-connector in data communication systems. In particular, the combination³⁾ of OLED and polymer waveguide⁴⁾ will provide huge advantages as regards fabricating optical integrated circuit. The transmission speed is needed to be more than 5~10 Mb/s for transporting the moving picture information. Therefore, it is important to focus on the transient properties of OLEDs.

In this study, we examined the transient properties of OLEDs using 8-hydroxyquinoline aluminum (Alq₃) as the emissive layer for the light source of optical interconnector device using polymer waveguide.

2. Experimental

Two kinds of OLEDs were fabricated as the light sources for the polymer waveguide devices. The typical device consists of an indium-tin-oxide (ITO) - coated glass substrate, 4,4'-bis[N-(1-naphthyl)-N-phenyl-amino]-biphenyl (α -NPD) hole transporting layer and Alq₃ emissive layer, terminated with a silver containing magnesium (Mg:Ag) cathode. The second OLED consists of an emissive layer utilizing dye doped in Alq₃. Figure 1 shows the molecular structures of the organic materials used in this study.

The layer structure was fabricated by organic molecular beam deposition on ITO-coated glass substrates to form the EL devices at a background pressure of about 10⁻⁵ Pa. The organic materials were located into separate Knudsen cells, heated to their sublimation temperature, and subsequently deposited

onto the substrate. The layer thickness of the deposited material was monitored *in situ* using an oscillating quartz thickness monitor. Finally, Mg:Ag cathode was vapor-deposited at a background pressure of 10⁻⁵ Pa onto the organic films. Forward bias condition is defined as the case in which the ITO electrode is positively biased against the Mg:Ag electrode, and negative bias, *vice versa*.

The transient EL measurements were performed by applying the square-wave voltages pulses generated by HP8114A source (Agilent). The optical pulse was observed by using an avalanche photodetector. The EL response and voltage (or current) were simultaneously digitized by a Sony Tektronix TDS3012 oscilloscope. All of the measurements were carried out at room temperature.

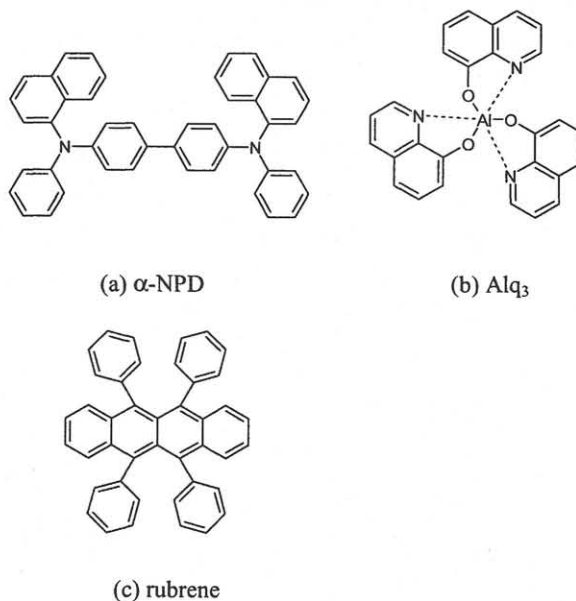


Fig.1 Molecular structure of (a) 4,4'-bis[N-(1-naphthyl)-N-phenyl-amino]- biphenyl (α -NPD), (b) 8-hydroxyquinoline aluminum (Alq₃), (c) 5,6,11,12-Tetraphenyl-naphthacene (rubrene), used in this study.

3. Results

Figure 2 indicates the applied voltage dependence of the rise time in green emitting OLED with Alq₃ and yellow emitting OLED with rubrene as emitting dopant into the Alq₃ emissive layer, where the rise time is defined as the time required to change the optical response from 10% to 90% of its total intensity change. The rise time decreased with increasing the amplitude of applied voltage pulse and also with decreasing the active area of OLED for decreasing the capacity of device. In the case of OLED with rubrene doped in Alq₃, the rise time of the device with the active areas of 0.1 mm² size are estimated to be about several tens ns at 1.0 MV/cm.

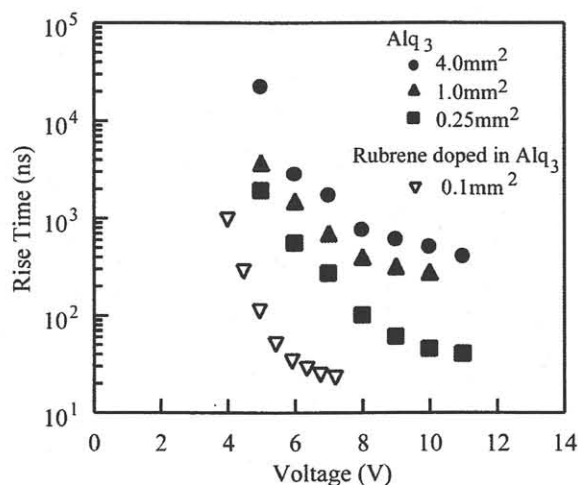


Fig. 2 The applied voltage dependence of the rise time in green emitting OLED with Alq₃ and yellow emitting OLED with rubrene as emitting dopant into the Alq₃ emissive layer.

The applied voltage and optical output characteristics of the OLED with rubrene doped in Alq₃ (0.1 mm²) driven at 100 ns period and duty ratio 0.5 pulse are presented in Fig. 3. We created a clear light pulse by direct modulation of the organic EL. This organic diode can be expected to be utilized as one of the light sources of optical interconnector device driven at more than 10 MHz. In the case of polymer waveguide, the size of square shape core can be estimated to be less than several hundreds square μm for transmitting digital pulses at more than 10 MHz. Another OLEDs with Alq₃ and 4-(dicyanomethylene)-2-methyl-6-(p-dimethyl-aminostyryl)-4H-pyran (DCM) doped in Alq₃ as an emissive layer also have similar response characteristics. For the viewpoints of a light source for polymeric integrated devices, the yellow emitting OLED with rubrene doped in Alq₃ has the advantages of low propagation loss and the high emission intensity because the polymeric waveguide with deuterated - polymethylmethacrylate

(d-PMMA) and UV- cured epoxy resin for the core and the cladding layers, respectively, have the propagation loss at the longer wavelength side.

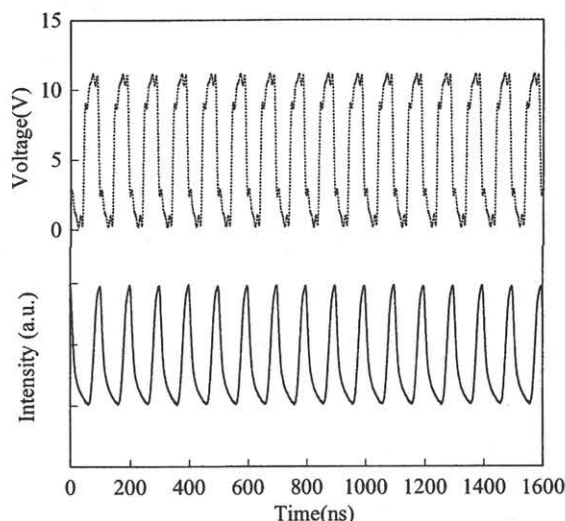


Fig. 3 The applied voltage and optical output characteristic of the 0.1 mm² OLED with rubrene doped in Alq₃ driven at 100ns period and duty ratio 0.5 pulses.

4. Conclusions

We demonstrated the transient properties of OLEDs using 8-hydroxyquinoline aluminum. The rise time decreased with decreasing the active area of OLED. The optical pulse of more than 10 MHz has been obtained from the OLED with the active area of 0.1 mm².

Acknowledgments

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