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Application of Organic Electroluminescent Diodes using 8-Hydroxyquinoline Aluminum doped with Rubrene to the Electro-Optical Conversion Device for Polymeric Integrated Devices

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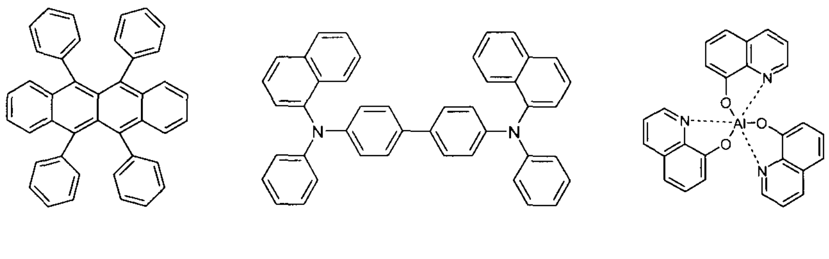
Recently, organic light emitting diodes (OLEDs) utilizing fluorescent dye [1] or conducting polymer [2] have been realized to have a long lifetime and excellent durability for flat panel display applications. In addition, OLEDs can be also expected to be used as an electro-optical conversion device of an optical inter-connector in data communication systems. In particular, the combination [3, 4] of OLED and polymer waveguide [5] will provide huge advantages as regards fabricating optical integrated circuit. For the viewpoints of a light source for polymeric integrated devices, the yellow emitting OLED with 5,6,11,12-Tetraphenylnaphthacene (rubrene) [6] doped in 8-hydroxyquinoline aluminum (Alq_3) 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 [4].

In this study, we have proposed the possibility of application to the electro-optical conversion device using OLED using Alq_3 doped with rubrene for transmitting the signals of moving picture as the initial step to fabricate the polymer integrated circuits.

The typical device consists of an indium-tin-oxide (ITO) - coated glass substrate, 4,4'-bis[N-(1-napthyl)-N-phenyl-amino]- biphenyl (α-NPD) hole transporting layer, Alq_3 doped with rubrene emissive layer and Alq_3 electron transporting layer, terminated with a silver containing magnesium (Mg:Ag) cathode. 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 Knuden 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.*



(a) rubrene　　(b) α-NPD　　(c) Alq_3

Fig.1 Molecular structure of (a) 5,6,11,12-Tetraphenylnaphthacene (rubrene), (b) 4,4'-bis[N-(1-napthyl)-N-phenyl -amino]- biphenyl (α-NPD), (c) 8-hydroxquinoline aluminum (Alq_3), used in this study.

The transient EL measurements were performed by applying the voltages pulses generated by HP8110A source (Agilent Technology). The optical pulse was observed by using a photomultiplier tube detector (Hamamatsu Phtonics). The measurement for transmitting the signals of the moving picture was performed by using the optical transmission and receiver equipments ZL271-275 (Melco Technorex). The EL response and voltage were simultaneously digitized by a Sony Tektronix TDS3054 oscilloscope. All of the measurements were carried out at room temperature.

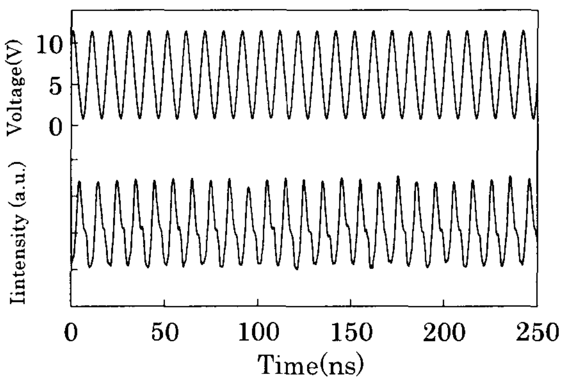


Fig. 2　The applied voltage and optical output characteristic of the 0.02 mm^2 OLED with rubrene doped in Alq_3 driven at 10ns period and duty ratio 0.5 pulses.

The transmission speed is needed to be more than several MHz for transporting the moving picture information. Therefore, it is important to focus on the transient properties of OLEDs for high modulation driving. The applied voltage and optical output characteristics of the OLED based on the Alq_3 doped with rubrene driven at 10 ns period and duty ratio 0.5 pulse are presented in Fig. 2. We created clear light pulses by direct modulation of the OLED with Alq_3 driven at the applied voltage pulses of 100MHz. This organic diode can be expected to be utilized as one of the light sources for transmitting the digital pulses driven at about 100 MHz.

This system as shown in Fig. 3(a) transmits high quality NTSC video and audio signals over standard multimode optical fiber. OLED based on Alq_3 doped with rubrene as an emissive layer was used for generating optical pulses as electro-optical conversion processing. The system employs pulse frequency modulation (PFM), in which the pulse width is kept constant and the pulse generation cycle is varied, to ensure error-free transmission. The base band frequency of PFM is 20MHz. The transmission bandwidth of video signal is from 50 Hz to 4.2M Hz. The typical PFM modulation frequency of carrier wave is about 20 ± 5MHz as shown in Fig. 3(b). It should be noted that the output NTSC signal is agreement with the input NTSC signal as shown in Fig. 3(c). These results show the OLEDs can be used as the electro-optical conversion device for transmitting the signals of moving picture.

In conclusion, we demonstrate the application of OLED to the electron-optical conversion device for transmitting the signals of moving pictures. The OLED base on the rubrene doped in Alq_3 as the emissive layer can be expected to be utilized as one of the light sources for transmitting the digital pulses driven at about 100 MHz.

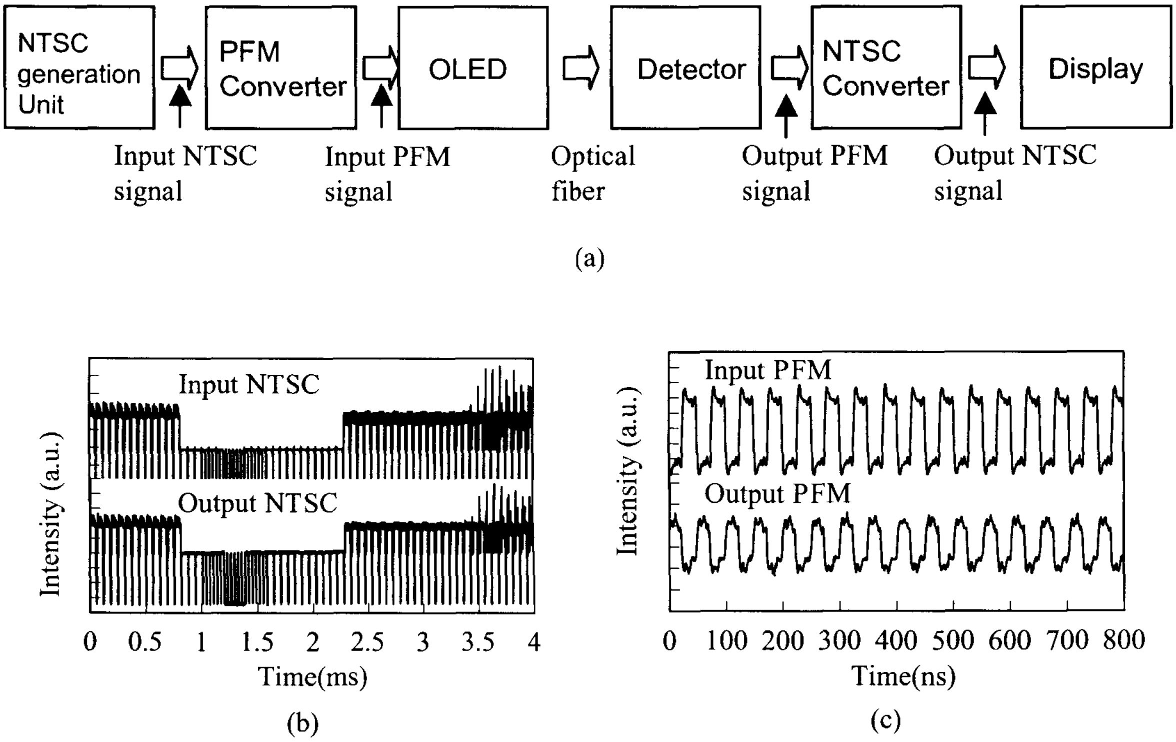


Fig. 3 (a) The schematic of system using the OLED for transmitting the signals of the moving picture, and the input and output (b) NTSC and (c) PFM signals obtained from this system.

Acknowledgments

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