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High Speed Operation of Organic Electroluminescent Devices and Photo Detectors

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1. Introduction

Organic light emitting diodes (OLEDs) utilizing fluorescent dye or conducting polymer have attracted great interest because they have advantages for thin film flat-panel display. An additional advantage is that they are simple for fabrication on various kinds of substrates, including polymeric substrates, especially polymeric waveguide. Polymeric devices have attracted with regard to their use for flexible optical circuits and optical interconnection. The combination of polymer waveguide and optical devices (OLED and OPD) will realize a flexible optical integrated circuits [1, 2]. In this paper, we discuss high speed operation of OLED and photo detectors for application of optical inter-connection. Fabrication of OLEDs utilizing starburst molecules by wet process is also discussed.

2. High speed operation of Organic Electroluminescent Devices and Photo Detectors

2.1 Organic electroluminescent devices for high speed operation fabricated by wet process

Highly emissive OLEDs fabricated by wet process are discussed. Two kinds host materials are tested for OLED fabricated by spin coating method. The device consists of poly (ethylene dioxythiophene) : poly(styrene sulfonic acid (PEDOT:PSS) as hole transporting layer, emissive layer of mixed materials and terminated with cesium and silver. The layer thickness for PEDOT:PSS and emissive layer are 35 nm and 95 nm, respectively. Two kinds of host materials for the emissive layer, methoxy-substituted 1,3,5-tris[4- (diphenylamino) phenyl]benzene (TDAPB), and poly(*n*-vinylcarbazole) (PVCz) were employed as host materials, and were prepared by spin coating. 2-(4-biphenylyl)-5-(4-*tert*-butylphenyl)-1,3,4,-oxadiazole (*t*-Bu-PBD) and rubrene were mixed as electron transporting and

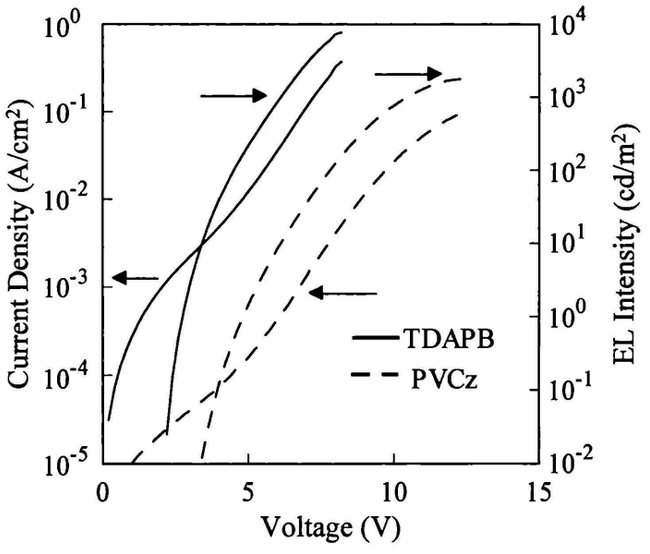

Figure 1. Emission characteristics of OLED fabricated by wet process.

emissive materials, respectively. The molar ratio for the emissive layer is as follows; TDAPB: t-Bu-PBD: rubrene = (100:72:1.65), PVCz: t-Bu-PBD: rubrene = (100:72:1.65).

As is shown in Fig. 1, the OLED with TDAPB emit higher luminance compared with that of PVCz in EL intensity. This will be due to the energy transfer between host materials and emissive materials.

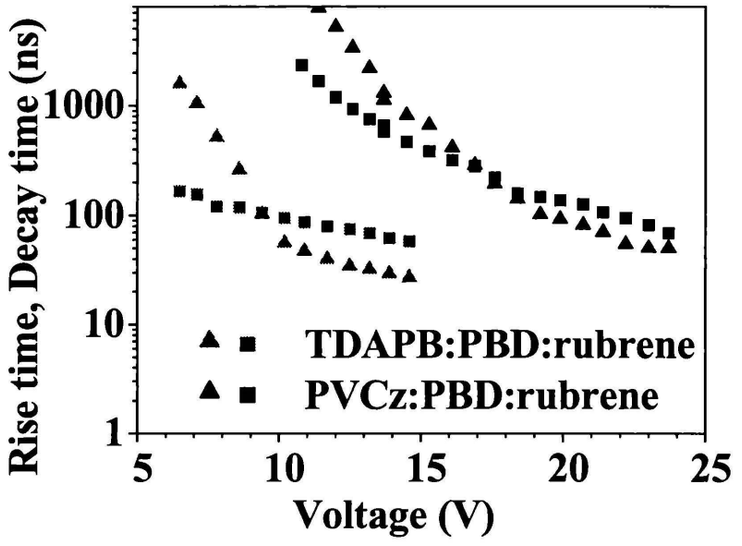

Figure 2. Pulse response characteristics of OLED fabricated by wet process. Symbols are for rise time (▲) and decay time (■).

Pulse responses characteristics are shown in Fig. 2 for a device with 100 μm circle active layer which was driven by a 10μs repetition voltage pulse. The result shows that the device with TDAPB shows faster response compared with that with PVCz. Since the device with TDAPB has lower threshold voltage than that with PVCz, it coincides with the carrier conduction in the emissive layer.

Using the device with TDAPB as a light source for electro-optical conversion, moving picture signals are successfully transmitted using 5-m-long polymeric optical fiber with 1mm in diameter. The results show that the device fabricated by wet process can be also used as a light source for the polymeric integrated device.

2.2 Organic photodetectors for high speed operation

Single-hetero structure organic photodetector using CuPc (copper phtalocyanine) and BPPC (N, N'-bis(2,5-di-tert- butylphenyl)-3,4,9,10-perylenedicarboximimide) are examined for high speed operation. The devices consist of single heterostructure of CuPc and BPPC were fabricated on indium-tin-oxide (ITO)-coated glass substrates. The organic layers were grown by organic molecular deposition system (OMBD) with a base pressure of about $2x10^{-5}$ Pa. To examine the relation between a film thickness and a high-speed response, we achieved a systematic variation of the total active layer thickness in the range of 40-120 nm.

CuPc shows high absorption in the long wave length (α= 1.27 x 10^5 cm^{-1} at λ= 645 nm) and the corresponding penetration depth was d = 78 nm. Figure 4 shows frequency response spectra of ITO/ CuPc 20 nm/ BPPC 20 nm/ Ag with different reverse bias voltages of 0-4 V under a red pulsed LED (645 nm).

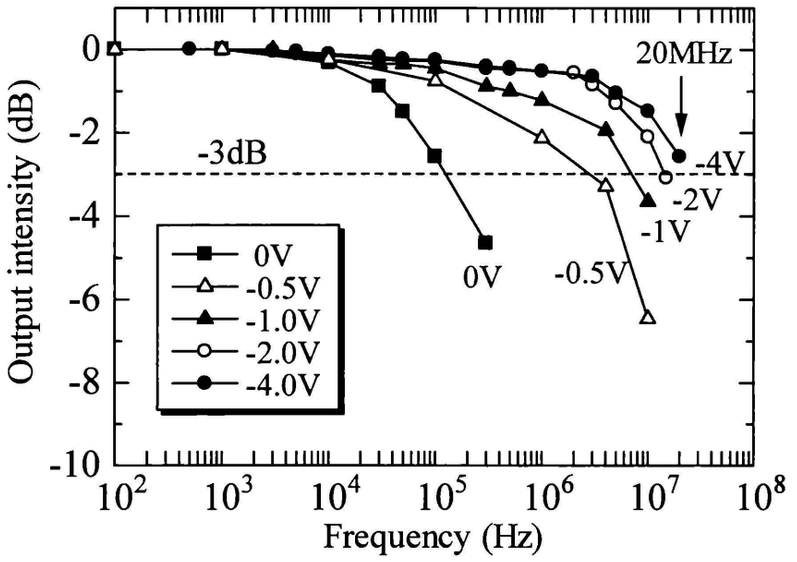

Figure 3. Frequency response of CuPc 20nm / BPPC 20nm photodetector with an active area of 0.03mm^2 performed with a red pulsed LED.

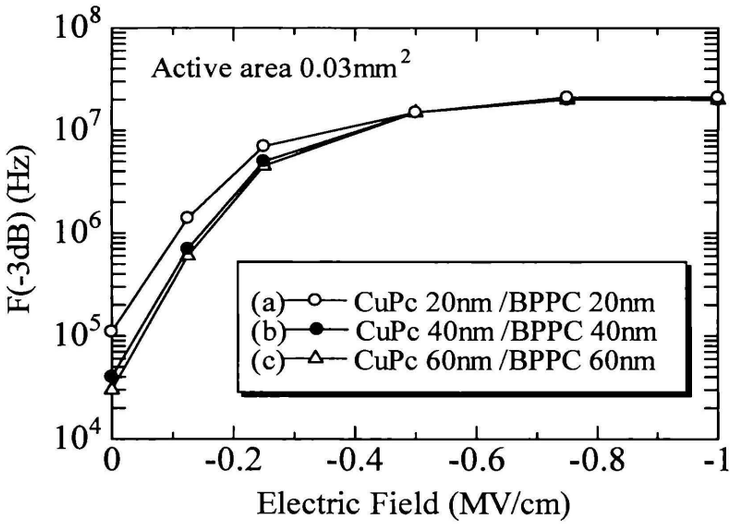

Figure 4. The cut-off frequency dependence on the total active layer thickness of 40, 80, 120 nm.

In Fig.4, the dependence of the cut-off frequency on the active layer thickness of (a) ITO/ CuPc 20 nm/ BPPC 20 nm/ Ag, (b) ITO/ CuPc 40 nm/ BPPC 40 nm/ Ag, (c) ITO/ CuPc 60 nm/ BPPC 60 nm/ Ag are shown. -1 MV/cm in Fig.5 corresponds to -4 V for device(a), -8 V for device(b) and -12 V for device (c). The response time has been gradually increased with application of a reverse bias field and obtained more than 20 MHz bandwidth above 0.75 MV/cm in all devices. In the low electric field, it has found high-speed response in thin layer device compared with thicker layer device. The result shows the improvement of carrier recombination in organic layer.

3. Summaries

In summary, high speed operation of OLEDs fabricated by wet process is discussed as a light source for the polymeric integrated device. Both the OLEDs with low molecular and polymeric materials can be used as a light source for transmitting moving picture signals. Organic photo detectors are also discussed for high speed detectors.

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