Color-tunable polymer light-emitting displays by controlling voltage

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Abstract

We report a novel observation of reversible color adjustability in polymer light-emitting diodes (PLED) fabricated with a single material. When we controlled applied bias of PLED, we found that the devices change their emission color. Moreover, this process is reversible. This result exhibits a new possibility of voltage-tunable color PLED.

1. Objectives and Background

Recently polymer light-emitting diodes (PLED) receive a considerable attention because of their advantages such as low cost, flexibility, large area, and easy color-tunability [1-2]. In particular, the voltage-tunable color PLEDs is important since it would enable voltage controlling of picture elements for displays. In recent years, several kinds of voltage-tunable PLED, such as multilayer- or blend-based LEDs have been investigated. These are mostly based on electric field-induced quenching of emitting states [3.4] or voltage evolution of the recombination zone in active layers [3-5]. In such devices, however, it is difficult to obtain high purity color because the emission spectra are widely distributed throughout the visible-range. Therefore, it is of particular interest to obtain a voltage-tunable, single-layer PLED without any blends for the voltage controlling of picture elements for large-screen display with improved resolution.

In this work, we report a novel observation of reversible color adjustable in PLED fabricated with a single material by controlling applied voltage. This can be explained in term of change of polymer chain conformation because of elevated temperature of device by joule heating.

2. Results

Utilizing MEH-PPV material, which is the most well known luminescent polymer as an emitting layer, we fabricated typical polymer LEDs with a structure of ITO/MEH-PPV/Al.

Fig 1 shows voltage-induced evolution of electroluminescence. When we controlled applied voltage of PLED from 10 to 18V, we found that the devices change their emission color from orange-red (~590nm) to greenish-yellow (~560nm) [Fig. 1(a)]. Moreover, this process is reversible; when we reduce the operating voltage below 10 V, the typical PLED color for MEH-PPV is recovered [Fig. 1(b)].

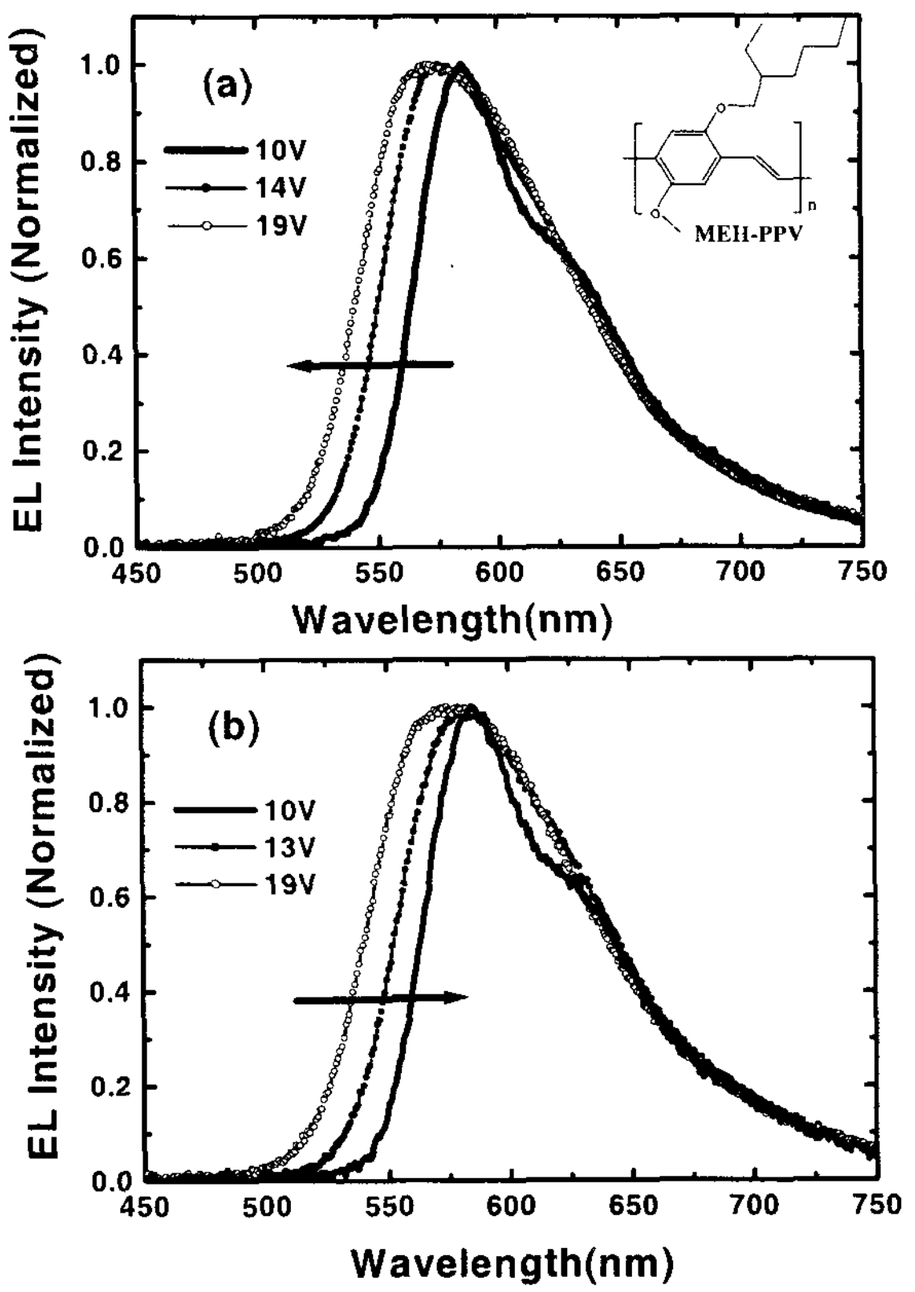

Fig 1. The voltage-induced evolution of electroluminescence obtained with increasing (a) and with decreasing bias-voltage (b)

We further note that almost identical phenomena have been observed in alternative experiments with applying external heat at fixed voltage of 6V as shown in Figure 2. By applying external heat, the photo- and electro luminescence spectra shift their peaks to the shorter wavelength, and then exactly returned back to the original spectral positions in the absence of the external heat. .

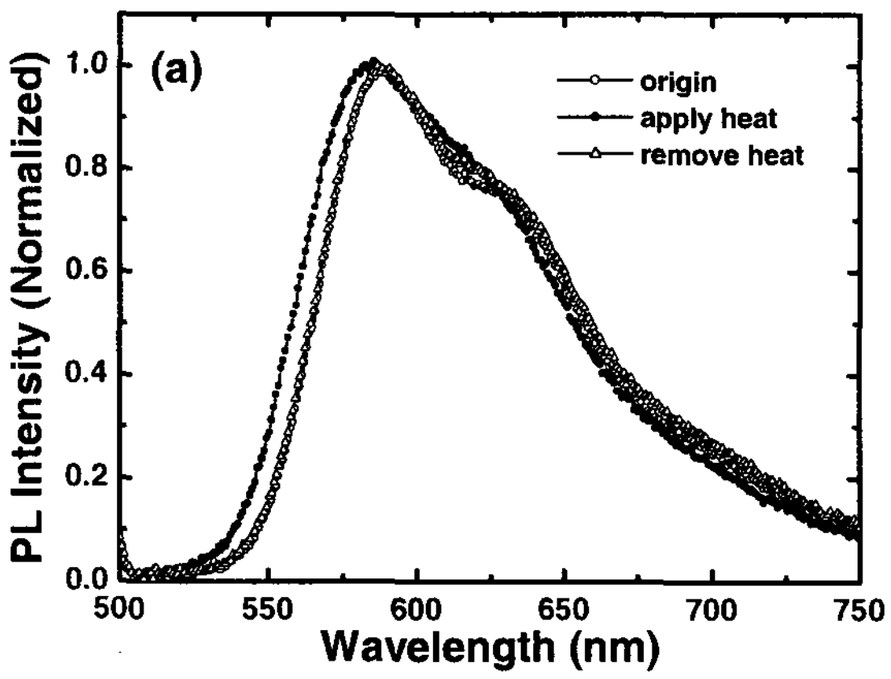

Fig 2. The photoluminescence (a) and electroluminescence (b) spectral changes in the alternative heat-applying measurements.

Since these observations are in excellent agreement with those of Figure 1, we consider that our observations of the color change with the applied voltage are also associated with heat through an operating voltage-induced thermochromism in PLED. At higher voltage, the elevated temperature of the device by joule heating alters conformation of the polymer from rod-like to coil-like by inducing chain torsion. In such a case, the conformation change results in less degree of planarity of the polymer backbone, thereby reducing the effective conjugated length of the main chain and broadening the π - π^* energy gap.

3. Impact

It is of particular interest to obtain a voltage-tunable, single-layer PLED without any blends for the voltage controlling of picture elements for large-screen display with improved resolution. In this paper we report a novel observation of reversible color change in single-layer PLED with single material by controlling applied bias. This result exhibits a new possibility of voltage-tunable color PLED.

4. Acknowledgements

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5. References

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