Study of White Polymer Electrophosphorescent Light-emitting Diode with Heteroleptic Ir-Complex

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Abstract

We demonstrate highly efficient White Polymer Electrophosphorescent Light-emitting Diode using newly developed green and red light emitting heteroleptic iridium complex, Ir-(pq)2tpy, and blue light emitting fluorescent dopant, BczVBi. The best luminous efficiency reached 28cd/A with maximum luminance of 87000cd/m2. The scheme for determining optimum device architecture and dopant concentrations were constructed.

1. Introduction

Polymer light-emitting devices (PLEDs) are promising for application to large-area and fine-pixel displays because polymer film can be prepared by wet processes such as spin-coating [1], screen printing, or ink-jet printing[2,3]. In particular, white-emitting PLEDs have the potential to realize full-color displays by simply using color filters[4].

In this paper, we report on white phosphorescent PLEDs based on double peaked phosphorescent Ir-complex dopant and blue fluorescence dopant. The suitability of the newly developed heteroleptic green and red emitting iridium complex bis(2-phenylquinoline)(2-p-tolylpyridine)iridium(Ⅲ)(Ir-(pq)2tpy) on such device was investigated. Poly(N-vinyl carbazole)(PVK) and 4,4'-Bis(9-ethyl-3-carbazovinylene)-1,1'-biphenyl (BczVBi) were used as polymeric host and blue emitting fluorescent dopant. Bathocuproine(BCP), tris-(8-hydroxyquinoline aluminum)(Alq3), Liq(lithium quinoline), PSS-PEDOT were used as hole blocking layer, electron transporting layer, electron transporting layer, and hole transporting layer, respectively.

2. Experimental

For the study of white light emitting diode, a series of devices, ITO / PSS-PEDOT(30nm) / Ir-(pq)2tpy(x wt%)+BCzVBi(y wt%)+PVK(70nm) / BCP(15 nm) / Alq3(15nm) / Liq(20nm) / Al(100 nm), were fabricated. The schematics are depicted as in Fig.1.

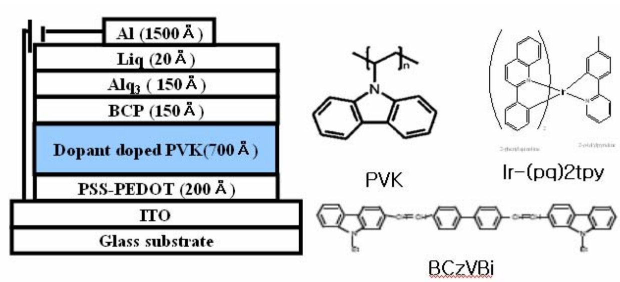

Fig.1. Device structure and chemical structures of materials used in the work.

The ITO glass was chemically cleaned using chloroform, ethanol, distilled water, and isopropyl alcohol. The PLEDs were fabricated by spin coating of polymeric emissive layer and by high vacuum (5×10^{-7} Torr) thermal deposition of organic materials onto the surface of an ITO(30Ω/□, 80nm) coated glass substrate.

Chloroform was used as solvent for emissive layer and the concentration and RPM for spin coating were appropriately adjusted to reach the optimal thickness. Deposition rate for various organic molecules was typically 0.1 nm/sec. After fabrication, the current density–voltage (J-V) and degradation characteristics were measured with a source measure unit (Kiethley 236 and Kiethley 617) The luminance spectrum of the fabricated devices were also measured using a Perkin Elmer LS 50B chromameter. All measurements were performed in ambient conditions under a DC voltage bias.

3. Results and discussion

Fig.2 shows that emission spectrum of PVK has a appropriate spectral overlap with the absorption spectrum of newly synthesized Ir-(pq)2tpy. Efficient energy transfer from PVK to Ir-(pq)2tpy was observed and PVK served as excellent and stable host as described in this paper.

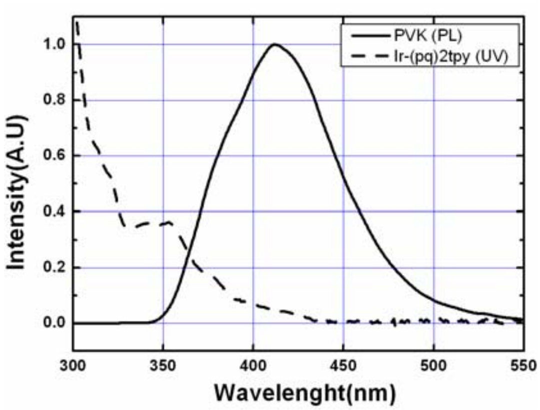

Fig.2. Normalized photoluminescence of PVK and absorption of Ir-(pq)2tpy

The J-V characteristics and luminance-V at various doping ratios of Ir-(pq)2tpy and BCzVBi to PVK are shown in Fig.3 and Fig.4.

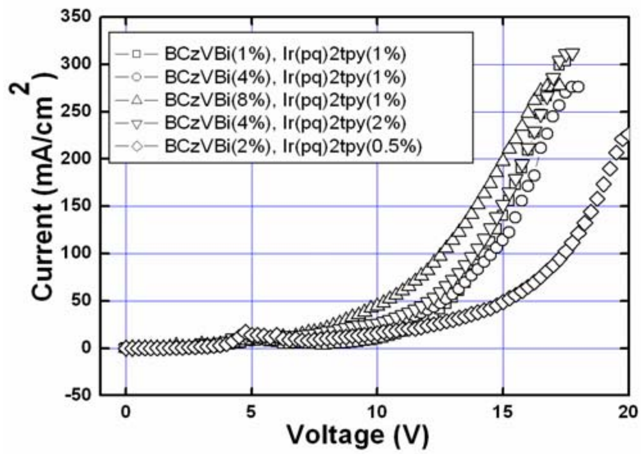

Fig.3. Current density vs. voltage characteristics of devices with various Ir-(pq)2tpy and BCzVBi doping concentrations.

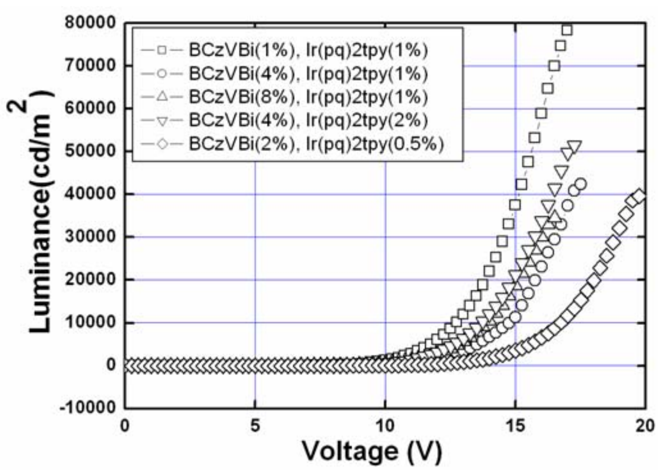

Fig.4. Luminance vs. voltage characteristics of devices with various Ir-(pq)2tpy and BCzVBi doping concentration.

Comparing with the most of previous phosphorescent PLED results reported, the devices showed remarkably high luminance characteristics with the high stability up to nearly 20V. Fig.4 shows that the device with 1wt% Ir-(pq)2tpy and 1wt% BCzVBi has the lowest turn-on voltage with the highest luminance. The luminance reached at 87000cd/m2, and the others also over 40000cd/m2, which corresponded to the best luminous efficiency of 28 cd/A (Fig.5).

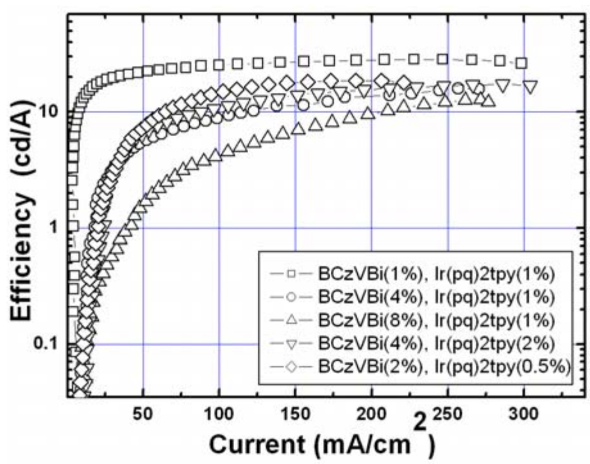

Fig.5. Luminous efficiency characteristics of devices with various Ir-(pq)2tpy and BCzVBi doping concentrations.

The EL spectra from the device made of pure PVK and doped PVK with Ir-(pq)2tpy and BCzVBi are shown in Fig.6. The EL peaks of pure PVK(419nm), blue BCzVBi(437 nm), and Ir-(pq)2tpy(507nm-green and 592nm-red) sited at three primary color regions. White light emission could be expected by optimizing the three basic color intensities.

The normalized EL spectra of [ITO / PSS-PEDOT / PVK+BCzBVi+Ir-(pq)2tpy(in different blend ratios) / BCP / Alq3 / LiF / Al] device at an applied voltage of 15 V are shown in Fig.6. Emission from the device made of PVK and BCzBVi is solely from BCzVBi indicating that the energy transfer from PVK to the fluorescence dopant is efficient. Also no PVK peak in all of the devices shows that full energy transfer occurred.

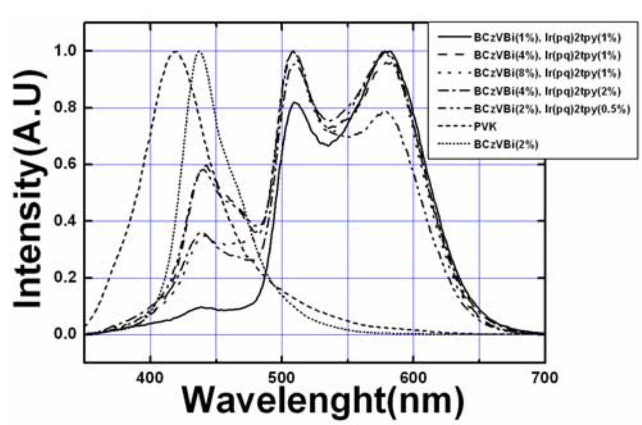

Fig.6. The normalized EL spectra of ITO / PSS-PEDOT / PVK+BCzBVi+Ir-(pq)2tpy (in different blend ratios) / BCP / Alq3 / LiF / Al at an applied voltage of 15 V

Among the devices containing 1wt% Ir-(pq)2tpy with different BCzVBi contents, 4wt% BCzVBi showed the highest blue peak. Increasing BCzVBi content rather lowered the blue intensity. Increasing the concentration of Ir(pq)2tpy from 1wt% to 2wt% while fixing BCzVBi content at 4wt%, red and green peak became excessively increased, while luminance and current characteristics remained almost identical. Comparing the devices with 1wt% Ir(pq)2tpy and 4wt% BCzVBi and the one with 0.5wt% Ir(pq)2tpy and 2wt% BCzVBi (letting the dopant ratio identical but the total concentration be half), the shape of the emission spectrum was almost identical as expected: higher luminance and lower turn on voltage was observed for the former, however higher luminous efficiency was observed for the latter due to the lower current density. The scheme for achieving the best dopant concentrations can be judged from the above results and further experimental verifications. More details of it will be presented in the presentation.

4. Summary

We demonstrate White Polymer Electrophosphorescent Light-emitting Diode adopting green and red double peaked phosphorescent heteroleptic Ir-complex, Ir-(pq)2tpy, and the blue fluorescence dopant, BCzVBi, using PVK as host. Optimum device architecture and the scheme for determining optimum dopant concentrations were constructed. The maximum luminance of 87000cd/m2 and the luminous efficiency of 28cd/A could be achieved.

5. References

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