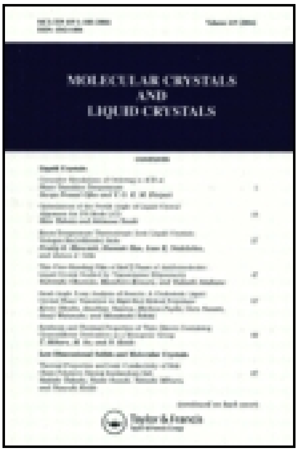

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The Doping Effect of Long Afterglow Phosphorescent Pigments in the Polymeric Light-Emitting Diodes

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The Doping Effect of Long Afterglow Phosphorescent Pigments in the Polymeric Light-Emitting Diodes

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We have fabricated polymeric light-emitting diodes(PLEDs), utilizing inorganic phosphor based on Strontium Aluminate as dopant. It was used the two types of polymeric LEDs as follows: 1) ITO/PVK/Al and 2) ITO/phosphor doped PVK/Al. The EL onset voltage is about 6.5 V for the latter device, lower than the former with a voltage of 12 V. By doping with inorganic the phosphor, the maximum luminescence value is about 23 times higher than the pure PVK device.

Keywords: Afterglow ; Strontium Aluminate ; PVK ; PLEDs

INTRODUCTION

The efficiency of organic light-emitting diodes (OLEDs) can be improved by the introduction of a fluorescent dye. Phosphorescent dyes also offer a means of achieving improved light-emission efficiencies, as emission may result from both singlet and triplet states [1]. In spite of the advances in phosphorescent doping of vacuum-deposited OLEDs, only a limit number of PLEDs which is incorporate phosphoresent dopants have been reported [2,3]. Molecularly doped polymer devices are convenient devices architecture to study phosphorescent PLEDs due to the relative ease of preparation and availability of carrier transporting polymeric and molecular materials [4]. In molecularly doped PLEDs, either inert or carrier transporting polymer is doped with molecular materials, which are chosen to show efficient emission and/or carrier transport.

In this study, we tried to doping method to achieve good efficiency of electroluminescence (EL). We choose a long afterglow phosphor which is strontium aluminate as a dopant in the PVK-based LEDs.

EXPERIMENTAL

PVK as emissive host material was used in this study. The PVK-based EL device was made by using PVK as emitter and long afterglow phosphorescent pigment based on Strontium Aluminate (BG) as an inorganic dopant. The content of dopant was 6.5 wt%.

The EL devices have been fabricated by spin coating of PVK and PVK doped with BG onto an ITO glass substrate. Al cathode was deposited onto the polymer film, using a vacuum evaporation. Photoluminescence (PL) spectra were recorded by time resolved photoluminescence spectrometer (IRY1024/RB, Princeton Instrument).

The current-voltage–luminance characteristics were measured with a Keithley 2400 source meter and a Keithley 2000 multimeter equipped with a Newport 1835-c optical meter. EL spectra were recorded on a PTI Quanta master model c-60SE spectrofluorometer. All devices were measured under atmosphere.

RESULTS AND DISCUSSION

Figure 1 shows the normalized photoluminescence spectra of PVK, BG and BG(6.5 wt.%)-doped PVK films excited at 325 nm. The PL band for PVK film was observed around 417 nm. The PL spectrum of BG phosphor exhibited two peaks at 415 nm and 490 nm.

Two emission peaks are observed from the BG-doped PVK film at 420 nm and 504 nm, respectively. The peaks were contributed from both BG phosphor and PVK. The red shift of the emission bands was observed. The emission peak of 420 nm is the highest peak among them, and we could observe greenish blue emission from the EL device.

Figure 2 shows the current density - voltage characteristics for the EL devices with PVK and BG-doped PVK under the forward bias condition.

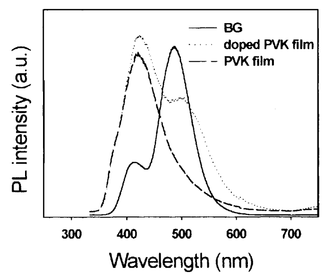

FIGURE 1. Photoluminescence spectra of PVK, BG and BG-doped PVK films.

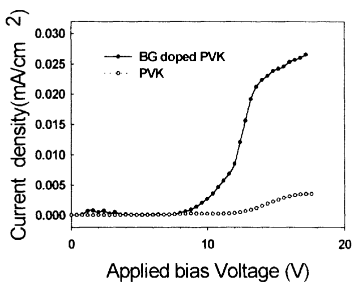

FIGURE 2. Current density – voltage characteristics of EL devices; (a) ITO/PVK/Al, (b) ITO/BG-doped PVK/Al

The current density in the PVK-based device increased, however, in the BG-doped PVK device superlinearly increased with increasing applied voltage. The devices had a turn-on voltage below 12 V and 6.5 V, respectively. By doping with BG in PVK film, the EL device exhibited lower turn-on voltage than pure PVK device.

Figure 3 shows the dependence of EL intensity on applied voltage. Comparing the emission intensity of the BG-doped PVK and the pure PVK devices, the maximum luminescence value of the former device is about 23 times higher than the latter device. It means that BG-doped PVK based device is effective to enhance the emission from the PVK emissive layer.

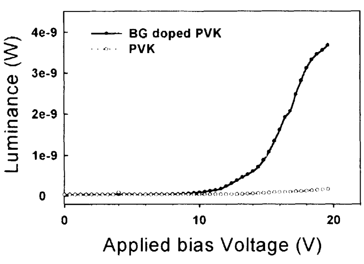

FIGURE 3. Emission intensity – applied voltage characteristics of EL devices ; (a) ITO/PVK/Al, (b) ITO/BG-doped PVK/Al

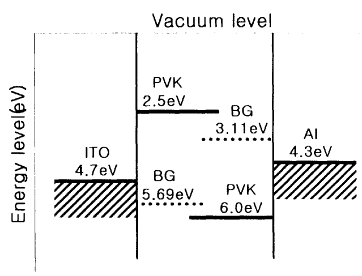

FIGURE 4. Schematic model of the energy level of Ip and Ea for EL materials

The results of the enhanced emission from the BG-doped PVK device are explained using the energy band diagram of the materials, which is shown in Figure 4. Cyclic voltametry and optical absorption measurements were used to examine the energy levels of these materials. Electrons injected from Al cathode move to the LUMO states of the PVK emissive layer. The injected holes from the ITO anode are transferred to the HOMO states of the PVK emissive layer. Energy barriers exist at the interface of PVK, i.e., 2.5 eV for electrons and 6.0 eV for holes. On the other hand, the phosphor has low HOMO level of 5.69 eV. The difference between the Fermi level of the ITO film and the HOMO level of the PVK film is 1.3 eV, while PVK and Al is 1.8 eV. These relatively big energy gaps mean that it need strong power to move holes and electrons. By doping of the phosphor, the phosphor reduced the height of energy barrier between anode and cathode like stepping stones.

CONCLUSIONS

Single-layered EL device with PVK and long afterglow phosphorescent pigment, BG, based on Strontium Aluminate as emissive host and dopant is efficient to obtain remarkably enhanced blue emission.

The EL onset voltage is about 6.5 V for the phosphor doped PVK device, lower than the pure PVK one with a voltage of 12 V. The maximum emission intensity of BG-based PVK device reached 23 orders magnitude higher than that of pure PVK device.

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