Influence of hole and electron transport layers on the device performance of polymer based triplet emitter systems

A. Wedel,
H. Krüger, S. Janietz, M. Thesen, S. Kreissl
Fraunhofer Institute for Applied Polymer Research, Geiselbergstr. 69, 14476 Potsdam, Germany

Introduction

The application of organic light emitting diodes (OLEDs) as backlights and indicators elevates them as important topic in the rapidly developing field of flat panel display technologies and lighting. OLEDs have many advantages over LCD display technology that include: Low voltage and power consumption, OLED technology only needs 2 to 10 volts, which is less than what conventional backlight LCDs require. The most highest efficient OLEDs consisting of small molecules were realized by the use of multilayer structures with triplet emitters and doping of separated electron-, emitter- and hole transporting materials. In order to transfer the small molecule approach successfully to solution based polymer light emitting diodes (PLEDs) it is of crucial importance that the previously deposited layers become insoluble for the preparation of the following layers.

Results and Discussion

Polystyrene (PS) as matrix material was used for phosphorescent emitters to obtain high efficient phosphorescent polymer light emitting diodes (PhPLED). PS fulfils mainly two purposes in this system. It acts as inert matrix material (no emisson) and it is responsible for the solution-based processes of the PhPLED. For efficient devices it was necessary to mix the PS with different electron transporting materials, e.g. 2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (TBPO) and hole transporting materials – triarylamines (e.g. TPD). Another way is the chemical linking of the electron- and hole transport materials to the PS backbone. Efficiencies of about 54 cd/A were realized with double layer systems consisting of hole transport layer and emitting layer with electron transport material.

Experimental Details

The entire OLED preparation starting from the careful substrate cleaning until the encapsulation was done using clean room and glove box facilities. Optimization procedures have been applied on different steps of the device preparation, e.g. the deposition conditions of the different layers constituting the devices and the configuration of the electrodes. The spin coating parameters were adjusted to control the thickness (40 - 80 nm) of the different layers because the thickness has a great influence on the electrical properties and efficiency of an PhPLED. A thin CsF layer was vacuum-deposited to separate the following calcium (25 nm) layer from the organic layer and to improve the efficiency. Finally, a silver metal layer (100 nm) was vacuum-deposited on the top of the device before encapsulation. The current-voltage characteristics of the OLED devices were measured with a Keithley 236 source-measure unit (Keithley Instruments). Simultaneously the brightness was recorded to obtain the efficiency. The lifetime tests on the encapsulated devices have been performed in ambient atmosphere.

Conclusions / Summary

We are able to prepare multilayer PhPLEDs with high efficiency and brightness and moderate liftimes. Thin layers of hole transport material increase the efficiency drastically. The PhPLEDs may serve multiple functions in separating layers: Both electron and hole transport and light emission. The electron transporting polymer and the hole transporting polymer may be in one or two layers. In some cases, very thin buffer layers are sandwiched between the transport polymers and the cathode and anode, respectively, to facilitate charge injection.