

Oriented PFO Films Dye-Doped for Whitening of Polarized EL Devices

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1. Introduction

We have been studying the production of oriented films of various polymers by means of the friction transfer technique [1]. This method allows the fabrication of oriented films of poly(9,9-dioctylfluorene) (PFO), known for its strong luminescence properties. Subsequent processing of these PFO films, by controlled thermal treatment, further improves their orientation as well as their surface smoothness [2]. These highly oriented films can then be used to produce polarized electroluminescence (EL) devices [3].

A self developed method, called vapor transportation method [4], has also been applied to dope functional dyes into polymeric materials. This doping process allows the dispersion of dyes into the polymer matrix with good control of dye aggregation. The method has been successfully used for whitening EL devices produced by doping red dyes into spin coated (non-oriented) PFO films [5].

Here we report on the combination of vapor transportation and friction transfer methods, for doping linear fluorescent dyes into oriented polymer films. The ultimate aim is to produce white polarized EL devices by doping an orange dye into the blue emitting oriented PFO film in a way that the dye orientation is parallel to the orientation of the PFO film.

2. Experimental

To produce the oriented thin films of PFO a block of the polymer is slid directly onto the substrate at well controlled temperature, speed, and load conditions. In this way the polymer molecules naturally orient themselves on the substrate, usually in the direction of the sliding movement, forming an oriented PFO film. Subsequent thermal treatment at 180°C is performed to further improve orientation and surface smoothness.

Doping of the 6T dye into the oriented PFO films, by means of the vapor transportation method, is performed as described in the following. The dye and the oriented polymer film are loaded together, without contact, into a glass tube. The whole system is evacuated and then the glass tube is closed/sealed forming an ampoule. Finally this sealed system is heated in an oven at about 180°C for 13 hours, causing the 6T dye to sublime and diffuse into the PFO film.

EL devices are then produced with these 6T doped polarized PFO films in the following way. After the PFO (about 50 nm) are deposited (by the friction transfer

method) directly on an indium-thin-oxide (ITO) coated glass substrate and the 6T doping is performed, the sample is inserted into a vacuum chamber. Then a 50 nm thick 2,2',2''-(1,3,5-Benzinetriyl)-tris(1-phenyl-1-*H*-benzimidazole) (TPBi), which is an electron transport and hole-blocking layer, is evaporated on top of the doped film at 2×10^{-4} Pa. Finally, 90 nm thick magnesium-silver (Mg:Ag, 10:1) is deposited as a cathode.

Polarized photoluminescence (PL) spectra are obtained using a Hitachi F-4500 spectrophotometer, in which non-polarized light is used for excitation with excitation wavelength set at 390 nm. The polarized EL spectra are detected with a charge coupled device camera (BWTEK BTC112).

3. Results and Discussion

Fig. 1 shows the polarized PL spectra of the sexithiophene (6T)-doped PFO oriented film. The peaks around 430nm and 450nm are from PFO while those around 510nm and 550nm are from 6T. It can be seen that the fluorescence from PFO with parallel polarization to the friction direction is much stronger than that with orthogonal polarization. This polarization of fluorescence originates from the uniaxially oriented PFO main chain along the friction direction. The peak from 6T also exhibits high polarization similar to the fluorescence from PFO. This suggests that the 6T molecules are aligned in the polymer chain direction in the oriented film.

These oriented PFO/6T doped films have been used for the production of EL devices. It can be seen from the EL spectra shown in figure 2 that, for both PFO (peaks around 430 and 450nm) and 6T (broad peak between 510 and 550 nm), the electroluminescence with parallel polarization to the friction direction is much stronger than that with orthogonal polarization.

One can also see, by comparing the spectra shown in figures 1 and 2, that there is a very good agreement between PL and EL results, where both PFO and 6T show excellent polarization. These results also indicate that by doping the orange emitting 6T into the blue emitting PFO the whitening of the EL device is possible with excellent polarization of the emitted light.

It was also observed (data not shown) that the doping of 6T into the PFO films leads to a significant increase of the efficiency of the devices. Thermal treatment conditions have also been observed to have a strong influence on the color stability of the EL devices produced with these doped films.

4. Conclusions

Whitening of the emission of EL devices was performed by doping orange emitting 6T into blue emitting oriented PFO films. The excellent orientation of PFO and of the doped 6T leads to very good polarization of the light emitted by these EL devices.

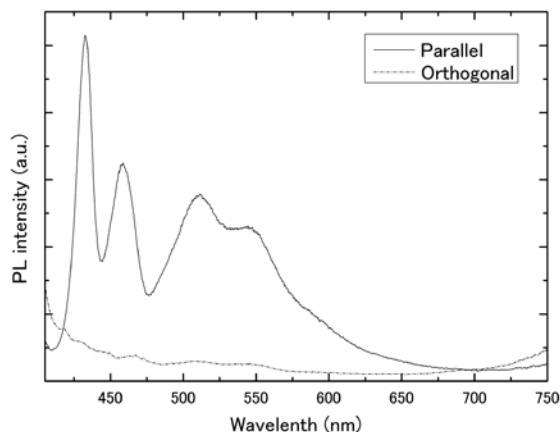


Fig. 1 Polarized photoluminescence spectra of 6T-doped PFO oriented film.

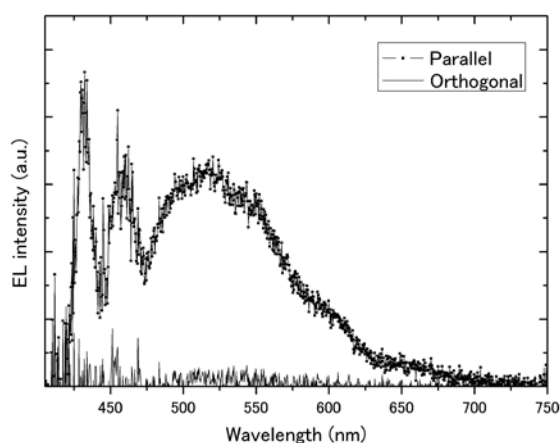


Fig. 2 Polarized electroluminescence spectra of device produced with 6T-doped PFO oriented film.

References

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