High reverse intersystem crossing efficiency using exciplex formation

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Organic light-emitting diodes (OLEDs) can open the door to new optoelectronics including flat-panel displays and lighting applications. To enhance electroluminescence (EL) efficiency of OLEDs, various emission materials based onto fluorescence and phosphorescence have been widely developed. Although OLEDs using fluorescent materials have achieved a high reliability, the internal EL quantum efficiencies are limited to approximately 25 % under electrical excitation due to the exciton branching ratio of singlet excited states. In contrast, OLEDs using phosphorescent materials have achieved the internal EL quantum efficiency of almost 100%. However, the selection of practically useful phosphorescent materials has been limited to Ir and Pt complexes. Therefore, since both fluorescence and phosphorescence used OLEDs have advantages and disadvantages, respectively, the use of a novel light-emitting mechanism has been expected to avoid the shortcomings.

Recently, we proposed potential mechanism to enable the internal EL quantum efficiency of 100% without phosphorescent materials by using up conversion from triplet to singlet excited states.1) To realize the highly reverse intersystem crossing efficiency, the small energy gap between singlet and triplet excited states is required. It can be achieved by separating the highest occupied molecular orbital (HOMO) from the lowest unoccupied molecular orbital (LUMO). In this study, we demonstrate that radiative-exciton production efficiency exceed the fluorescent limitation of 25% by using high reverse intersystem crossing efficiency of exciplex states.

We investigated the transient photoluminescence (PL) decay curves of 50mol% 4,4’,4”-tris[3-methylphenyl(phenyl)amino] triphenylamine (m-MTDATA) doped into 2-(biphenyl-4-yl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (PBD) films. In addition, we measured the current – voltage – luminescence characteristics of OLEDs, consisted of ITO / m-MTDATA / 50mol% m-MTDATA doped into PBD / PBD / LiF / Al.

The PL peak wavelength of a m-MTDATA:PBD composite film located at around 540 nm, which is significantly red-shifted compared to those of the m-MTDATA and PBD neat films, respectively. This is due to the exciplex formation at the m-MTDATA/PBD interface. We obtained the EL quantum efficiency of 2 %, while the PL quantum efficiency was 20 %. These results suggest that the radiative-exciton production efficiency of 50 % is realized due to the high reverse intersystem crossing efficiency of the exciplex states.

Reference

1. A. Endo, M. Ogasawara, A. Takahashi, D. Yokoyama, Y. Kato, and C. Adachi, Adv. Mater. 4802-4806, 21 (2009).