White organic light emitting diodes show improved performance

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Novel fluorescent and phosphorescent materials and optimized device configuration enable enhanced pure-white-light generation.

Organic light-emitting diodes (OLEDs) operate by passing an electric current through a fluorescent or phosphorescent organic layer, resulting in photon emission at a certain wavelength specific to the emitter. OLEDs continue to draw attention in scientific and industrial contexts as promising candidates for the construction of large-area full-color flat-panel displays due to their ease of fabrication and convenience for many applications.

White OLEDs (WOLEDs) have attracted significant interest because of their demonstrated applicability in full-color displays with color filters, as backlights for liquid-crystal displays, and for paperlike illumination sources. To enter the lighting market, however, several critical problems must be solved: they should be more power efficient, reliable, and cost-effective. One possible solution uses fluorescent or phosphorescent emitting materials that are characterized by high power efficiency and stability, while optimization of the device configuration is also seen as a useful approach to produce commercially competitive lighting.

WOLEDs are usually constructed by fabricating a device that emits and mixes light of either three primary colors (red, green, and blue) or only blue and yellow (or orange) in a suitable ratio. Therefore, development of high-efficiency monochromatic emitters and an optimal configuration would improve device performance.

We have synthesized high-efficiency fluorescent and phosphorescent materials and fabricated high-performance OLEDs.1-3 For instance, production of high-brightness yellow OLEDs was achieved using fluorescent silole as the high-efficiency emitter.1 Employing a novel iridium-complex material2,3 we successfully constructed4 phosphorescent WOLEDs with a maximum luminance of 15,460cd/m² and a power efficiency of 8.1lm/W. In addition, we investigated the use of certain novel fluorene materials for blue emission5.

Also, a derivative of 6,6′-(9H-fluoren-9,9-diyl)bis(9,9-dihexyl-9H-fluoren-2-yl)quinoxaline) (BFLBBFQYQ) was synthesized and characterized. Exciplex (excited-state complex) emission and chromism (a reversible color change induced by an external stimulus) were observed after UV irradiation in a blend of BFLBBFQYQ and N,N′-biphenyl-N,N′-bis-(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine (TPD) film and in polar solvent, respectively.6,7

Furthermore, low-energy emission bands from 530 to 600nm originate from the photoluminescence (PL) spectra of...
BFLBBFLYQ-evaporated films deposited with fluorenone defects. The latter were introduced through thermal oxidation and photo-oxidization. In most cases, highly-efficient WOLEDs can be produced by a careful control of both host material and dopant through co-evaporation, particularly for red, blue, and yellow light-emitting materials. Meticulosous dopant-concentration control is normally imperative to produce pure white light. This is time consuming, complicates fabrication, and reduces reproducibility. It also invariably wastes organic functional materials. Therefore, we concentrate on optimizing device configuration and developing novel materials for energy transfer, aimed at creating high-efficiency devices using non-doped layers.9–13

Förster resonance energy transfer occurs in fluorescent materials if a singlet state in the host matrix is equivalent to the corresponding energy level of the dopant. The PL spectrum of 1,2,3,4,5,6-hexakis(9,9-diethyl-9H-fluoren-2-yl) benzene (HKEthFLYPb) starburst material exhibits good overlap with the absorption of N,N′-di(naphthalen-2-yl)-N,N′-diphenyl-benzene (NPB), and part overlap with the absorption spectrum of tris(8-hydroxyquinolino) aluminum (Alq) (see Figure 1). Therefore, efficient Förster energy transfers from HKEthFLYPb to NPB and Alq do occur.11

We also constructed WOLEDs by mixing blue and yellow-green light based on novel HKEthFLYPb material, which showed a current efficiency from 1.8 to 1.4cd/A from 5.5 to 15V with Commission Internationale de L’Eclairage (CIE) chromaticity (x,y) coordinates (0.29, 0.36) at 8V.12 Pure white emission with CIE coordinates (0.33, 0.33) was obtained by inserting an ultrathin layer of rubrene as yellow emitter.13

We have developed high-performance rigid and flexible OLEDs based on novel fluorescent/phosphorescent materials and optimized their configuration to promote growth into the commercial market.14 We are now focusing on developing organic optoelectronic devices (including solar cells and OLEDs) with higher efficiencies and longer lifetimes.

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References

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