Topics

Organic Electrophosphorescent Devices : Extremely High-Efficiency Light Emission

Masamichi Ikai, Special Research Lab.

In an organic electroluminescent (EL) device, an organic thin film of about 100 nm thick is sandwiched between electrodes (of which at least one is transparent) to emit light. Since it has such features as (1) self-luminescence, (2) wide viewing angle, (3) high luminance and contrast and (4) high response speed, it is considered to be the most promising flat panel display in the next generation to replace liquid crystal displays. For power saving, improvements in the electric to light conversion efficiency are desired.

Organic molecules are excited in two states, singlet excitation and triplet excitation. Light emission from the singlet excited state is called fluorescence and that from the triplet excited state is called phosphorescence. The generation ratio of these two states is 1:3. The use of phosphorescence will greatly increase the conversion efficiency [1]. However, there have been few organic materials that emit phoshorescence at room temperature and most of the organic EL devices in the past used fluorescent materials.

Recently, an organic EL device using a green phosphorescent material featuring a high light emission efficiency at room temperature ($Ir(ppy)_3$: iridium complex) was reported [2]. To make the most of the characteristics of this phosphorescent material, we have made improvements as shown in (A) and (B) below to dramatically improve the conversion efficiency.

(A) Use of hole transporting organic material (TCTA) as the host for a phosphorescent material ($Ir(ppy)_3$) to improve the conversion efficiency in the high luminance (high current density) region.

(B) Use of fluorobenzene-based electron transporting material (CF-X/CF-Y) having high ionization potential to improve the hole and electron recombination probability by confining the holes injected from the anode within the emitting layer.

Fig. 1 shows the molecular structure of each organic material as the key to highly efficient light emission. By using TCTA as the host for a phosphorescent material and CF-X (or CF-Y) as the hole block layer, the light emission efficiency in terms of external quantum efficiency reached 19.2% (or 18.2%), corresponding to a conversion efficiency of greater than about 90% near the theoretical limit [3]. Since the theoretical limit of the external quantum efficiency is about 5% for conventional fluorescent EL, the efficiency is apparently very high. The difference is conspicuous when comparing the brightness of actually fabricated fluorescent and phosphorescent EL panels (**Fig. 2**). Attention should be paid to the fact that a highly efficient emission ismaintained even in the high luminance region. There in no report that the conversion efficiency is maintained above 75% at around 10,000 cd/m^2, several times the brightness of fluorescent lamps.

These devices will be effectively used as power-saving display devices for car navigation, portable telephone and PDA (personal digital assistant) terminals.

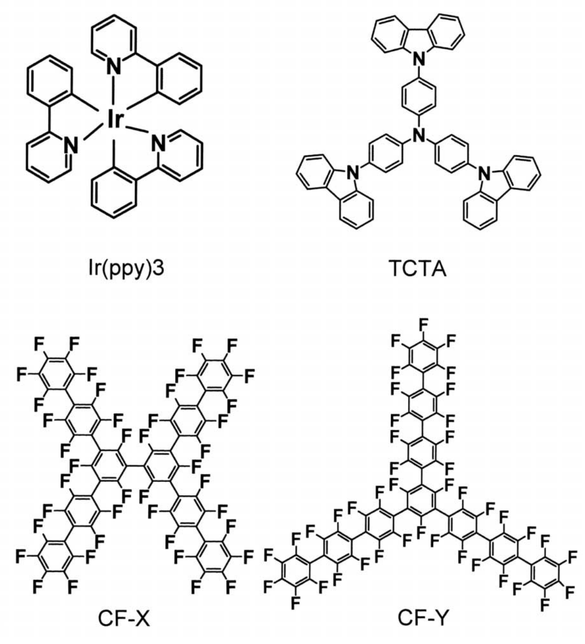

Fig. 1 Chemical structures of $Ir(ppy)_3$, TCTA, CF-X and CF-Y.

References

1) Baldo, M. A., et al. : Nature, **395**(1998), 151
2) Baldo, M. A., et al. : Appl. Phys. Lett., **75**(1999), 4
3) Ikai, M., et al. : Appl. Phys. Lett., **79**(2001), 156

(Report received on June 28, 2001)

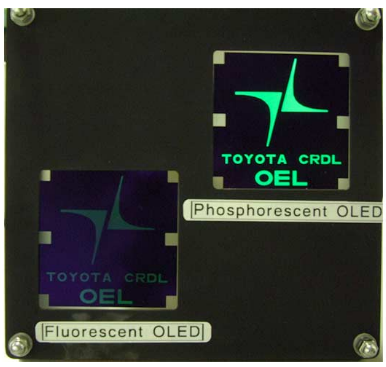

Fig. 2 Demonstration of organic light-emitting device (OLED) panels for the comparison between fluorescent- and phosphorescent- OLEDs. (Panel size : 80mm x 80mm each)