Optical Properties of a Novel Dye in Yellow Florescent Organic LEDs

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Abstract -- *In this paper, time-resolved PL, lifetime and crystallization of a novel organic, 2,8-di(t-butyl)-5,11-di[4(t-butyl)phenyl]-6,12-dipehnylnaphthacene, which is considered to be potential candidate to substitute the conventionally used 5,6,11,12-tetraphenylnaphthacene for a higher efficient yellow-color organic LED, were investigated. The PL intensity will reduce when the irradiation time increases because of photo-quenching. It is shown that oxidation is the dominant reason for photo-quenching. In addition, TBRb has two lifetimes. The short one is ~5ns and the long one is ~31ns. They are considerably contributed by the short PL peak and long PL peak respectively. Furthermore, we first report, to the best knowledge, crystallization of TBRb at low temperature of 11K and with irradiation.*

CONTENT

Archetypical 5,6,11,12-tetraphenylnaphthacene (rubrene) has been widely investigated for more than two decades [1-4]. Recently, a novel derivative of Rb has been synthesized which is 2,8-di(t-butyl)-5,11-di[4(t-butyl)phenyl]-6,12-dipehnylnaphthacene, hitherto named as tetra(t-butly)rubrene (TBRb) has the potential as replacement for rubrene as yellow fluorescent in organic LED [5]. Yellow is one of the more sensitive color to human and generally preferred by most customers, hence, a stable and efficient yellow is very desirable.

Our results show that the PL intensity of TBRb is generally higher than that of Rb at various temperatures from 300K to 11.5K. The feature of PL spectrum is maintained in 1.8×10^{-9}M TBRb solution, i.e. no aggregation effects is observed in the evaporated TBRb film. Both TBRb and Rb display the presence of two lifetimes. The short one is about 5-6ns while the long one is greater than 30ns. In order to investigate the transmissions contributed to the two lifetimes, time resolved PL has been studied. The time-resolved PL measured at delay time of 68ns is used to investigate the short lifetime case. There are two peaks including ~560nm and ~600nm in the PL spectrum. This means that two transitions are involved in the short lifetime photon relaxation. Similarly, two transitions contribute to the long lifetime photon relaxation. However, the short wavelength transition, i.e. ~560nm contributes more in the fast radiative recombination while the long wavelength transition, i.e. ~600nm contributes more in the slow recombination. While crystallization of organic material is often reported any thermal annealing (>300K), we first report, to the best knowledge that report the crystallization in low temperature at 11K and at the pressure of 1×10^{-5}mbar with irradiation of laser (wavelength = 325nm) as shown in Figure 10. It may be possible that the laser heat up sample for crystallization. The crystallized structure of TBRb is different to and larger than that of Rb.

In conclusion, the optical properties of TBRb and Rb in various temperatures have been investigated in this paper. We report that the PL of TBRb is about 5 times higher than that of Rb, i.e. TBRb should be able for making a brighter organic LED. Both TBRb and Rb have two lifetimes; the short one is ~5ns while the long one is > 30ns. There are two PL peaks for both the short and long lifetime photon relaxation. However, the photon with wavelength of ~573nm shall primarily correspond to short lifetime relaxation while the wavelength of ~583nm shall correspond to the long lifetime relaxation. When wavelength increases and temperature decreases, the lifetime increases. Finally, crystallization of TBRb and Rb is obtained during the irradiation by 325nm laser at 11K.

REFERENCES

[1] Y. Sato, *Semiconductors and Semimetals*, Academic Press, San Diego, CA, p.209, (2000).
[2] Y. Hamada, T. Sano, K. Shibata, K. Kuroki, "Influence of the Emission Site on the Running Durability of Organic Electroluminescent Devices", *Jpn, J. Appl. Phys*, vol.34, pp.L824-846 (1995).
[3] Y. Sato, T. Ogata, S. Ichinosawa, Y. Murata, "Characteristics of organic electroluminescent devices with new dopants", *Syn. Met.*, vol. 91, pp.103-107 (1997).
[4] H. Aziz and Z. D. Popovic, "Study of organic light emitting devices with a 5,6,11,12-tetra-phenylnaphthacene (rubrene)-doped hole transport layer", *Appl. Phys. Lett*, vol. 80, pp 2180-2182 (2002).
[5] Y.S. Wu, T.H. Liu, C.Y. Iou, C.H. Chen, "A New Yellow Fluorescent Dopant for High-Efficiency OLEDs" at 2002 International Conf. on the Sci. and Technol. of Emissive Displays and Lighting (EL 2002), Ghent, Belgium, Sept 23-26 (2002).

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