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Effect of the optical properties of poly-TPD on the performance of organic LED

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【Introduction】 Conductive polymer plays an important role in the thin film transistor, organic light-emitting diode (LED), hybrid organic/quantum dot LED and solar cells for natures of high conductivity, good solubility, and homogenous morphology. Poly(N,N'-bis(4-butylphenyl)-N,N-bis(phenyl)benzidine) (poly-TPD) (Figure 1) thin film has been widely used as a hole transport layer in LEDs, based on high hole mobility and LUMO-energy level as an effective electron blocking material. The carrier transfer in poly-TPD is considered as the hopping through π-electron among conjugated structure, whose model would be affected by molecular conformations in the thin film.

Here, we prepared poly-TPD thin films on which different treatments were conducted, i.e. UV exposure, annealing. The spin-coating condition was also altered, such as the solution concentration. From measurements of photoluminescence (PL) spectra and PL decay, we investigated the molecular conformations of poly-TPD and electronic structures. In addition, organic LEDs composing of poly-TPDs as an emissive layer were fabricated and the diode property was examined by changing the parameters. Thus, it was found that the change of poly-TPD molecular conformation, induced by film conditions, are responsible for the electronic performance of organic LEDs.

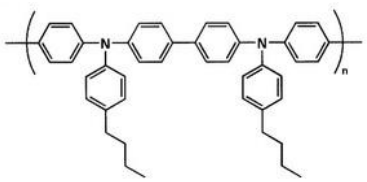

Figure.1 The molecular formation of poly-TPD.

【Experiment】 Poly-TPD thin films and organic LEDs were deposited on pre-cleaned indium-tin-oxide (ITO) coated glass substrates. The ITO substrates were cleaned in flat panel display detergent solution with a sonicator and treated with a UV ozone cleaner. Poly-TPD thin films were deposited onto the substrate by spin-coating from o-dichlorobenzene solutions with different concentrations in an argon-filled glove box. After spin-coating, several procedures, i.e. UV irradiation in air, or thermal annealing in argon were conducted. Organic LEDs consisted of ITO/poly(3,4-ethylenedioxythiophene): poly (styrenesulfonate) (PEDOT:PSS)/poly-TPD/Al, of which PEDOT:PSS layer was also deposited by spin-coating, and Al layer was prepared by vapor deposition under vacuum. PL spectra and PL decay of poly-TPD films as well as current-voltage (*I*-*V*) curves of LEDs were measured in air ambient.

【Result & discussion】Figure 2(a) shows UV-exposed time-dependent PL spectra of poly-TPD thin films. The spectrum of poly-TPD without UV irradiation composes of two luminescence bands at 416 and 457 nm, corresponding to the monomer and excimer, respectively. On the contrary, a PL band ascribed to monomer at around 421 nm is observed in all UV irradiated poly-TPD films. [1] The PL decay curves of poly-TPDs monitored at 421, 416 and 457 nm are displayed in Figure 2(b). The time profile is characterized by double exponential functions. Fast and slow components have been attributed to monomer and excimer of poly-TPD, respectively. [2] The data measured at 421 nm is obtained from the poly-TPD film after UV irradiation and does not show slower component. As a result, it was revealed the UV irradiation promotes monomer formation in poly-TPD films, based on both spectra and time profile measurements.

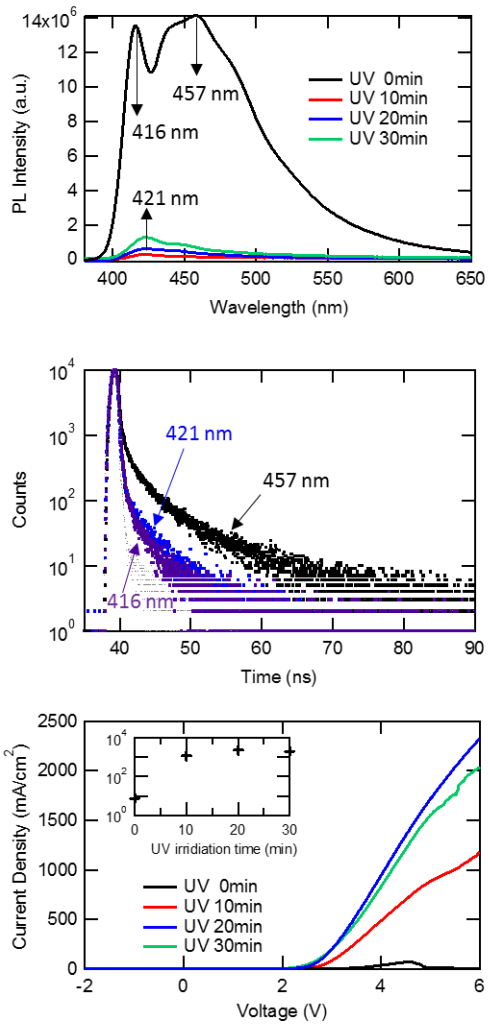

Figure.2 (a) PL spectra and (b) PL decay of poly-TPD films, and (c) *I-V* curves of corresponding ITO/PEDOT:PSS/poly-TPD/Al organic LEDs. Inset: Current density at 6V as a function of UV exposure time.

Figure 2(c) presents the *I-V* curves of organic LEDs prepared using poly-TPD. Note that the significant increase of current density after UV irradiation. Namely, current density of the LED consisted of UV-irradiated poly-TPD thin films is 350 times greater than that before UV irradiation. Based on the results of PL spectra, lifetime, and *I-V* curves, it can be concluded that the UV irradiation of poly-TPD film inhibits excimer formation, which results in high current density of organic LED device. The reason why the UV irradiation enhances current density of organic LED is the decease of excimer site as a hole-trapping and the increase of π-electron delocalization among polymer molecules. [2] In addition, the current density enhancements were commonly obtained from organic LEDs fabricated by poly-TPD thin films spin-coated with different concentrations. Consequently, it is found that the reducing of excimer formation in poly-TPD layer improves the electronic performance of organic LEDs.

References:

1. Nayak, Patankar, Narasimhan, Periasamy. *Journal of Luminescence*, **2010**, *130*, 1174.
2. Joshi, Mohan, Dhami, Jain, Singh, Ghosh, Shripathi, Deshpande. *Applied Physics A*, **2008**, *90*, 351.