Extending the Operational Lifetime of Blue TADF-OLED through Ytterbium Doping

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Organic light emitting diodes (OLEDs) are successfully employed in displays providing superior efficiency, contrast, and viewing angle. A remarkable advantage of OLED displays is that they can be made curved, flexible and transparent, thereby significantly expanding their scope of use. However, devices based on phosphorescent or the latest generation thermally activated delayed fluorescence (TADF) emitters suffer from stability issues in the blue range, and thus far are not exploited commercially. The deterioration of these devices, especially noticeable at elevated current densities, is largely due to the presence of long-lived triplet species. Balanced charge carrier transport and broad carrier recombination zone are essential for reducing triplet exciton concentration and suppressing triplet-mediated annihilation processes, which affect the performance and stability of blue-emitting TADF-OLEDs [2]. Doping of organic layers is among the most effective methods to control these features. The doping of electron transport layer (ETL) with metals was demonstrated to be a promising option to facilitate electron injection, transport and improve charge balance [3]. While the case of lithium doping has been well-researched, ytterbium (Yb) doping has received less attention. The existing data is limited to electron injection characteristics, which are favored by the low work function of Yb (2.6 eV) [4].

Herein, the impact of Yb doping of ETL on the blue TADF-OLED performance, and particularly the lifetime, was thoroughly assessed. To this end, a series of OLEDs containing TmPyPB (as ETL) doped at different Yb ratios ranging from 0 to 30 wt% were fabricated and studied (Fig. 1). It was found that the Yb-induced changes in the current density, which also affect device EQE, efficiency roll-off and luminance, result solely from alterations in electron current. The Yb-doping concentrations of 10 wt% or below was shown to reduce current density due to the electron trapping, whereas the higher doping levels indicated Yb-facilitated electron transport.

Most importantly, introduction of Yb extended blue-emitting device lifetime by 2 orders of magnitude compared to the undoped device, so that LT50 of the doped devices reached almost 800 and 50 hours at the luminance of 10^2 and 10^3 cd/m2, respectively. The enhanced device stability was attributed to Yb-assisted triplet exciton quenching, which occurred as a result of the recombination zone being in close proximity to the EML/ETL interface. The reduced triplet density in turn suppressed harmful triplet-mediated annihilation in EML and prolonged device lifetime, however, at the cost of somewhat deteriorated device efficiency.

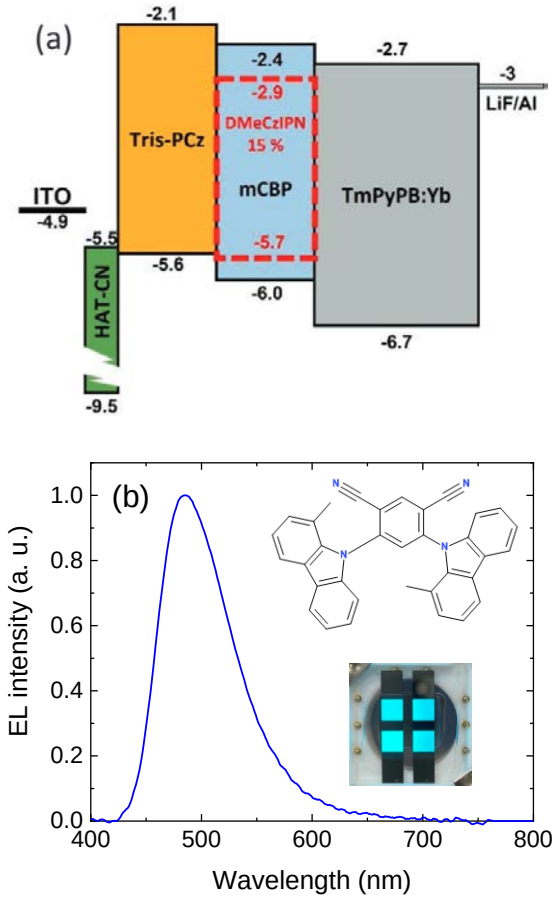

Fig. 1. (a) Schematic representation of TADF-OLED structure; (b) device EL spectrum with the chemical structure of employed blue TADF emitter DMeCzIPN and the picture of Yb-doped OLED device shown in the inset.

Keywords: blue OLED, TADF, device lifetime, ytterbium doping.

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