Trap effects on electrical transport in organic semiconductors: the case of OLEDs

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INTRODUCTION

Organic semiconductors have been gaining special attention in recent decades due to their wide applications, ranging from electroluminescent devices, photovoltaics, photodiodes, sensors, etc. However, the existence of energy states acting as traps for electrical carriers, can significantly impact the device's performance. These energy levels of the traps, localized between the HOMO and LUMO levels, can capture and hold/release charge carriers with strong impact in the electrical conductivity. Therefore, a clear decrease in the charge carrier mobility is observed, increased recombination rates, and lower overall device's figures of merit.

In the case of Organic Light Emitting Diodes (OLEDs), the concept of an efficient emitter in the simplest possible structure that can be minimally efficient for practical applications, is, nowadays a challenge. In fact, it is very difficult to make OLEDs with low number of layers that can be technologically competitive as those devices are usually made by wet-deposition process, prone to increase significantly the traps densities. This usual and sometimes abnormally high density of traps poses additional issues. Nevertheless, achieving substantially high external quantum efficiencies (for instance up to 16 – 18 %) with only three or even two organic layers is possible, controlling the molecular conformation and defects densities in the active layer. Although employing highly efficient emitters like Thermally Activated Delayed Fluorescent (TADF) materials, the drawbacks are placed in the electrical properties related to charge transport and recombination. Focusing as the most important target, the idea of a well electrically balanced device should be used for an efficient device structure.

RESULTS AND DISCUSSION

In this work, OLEDs fabricated by solution deposited process with different Thermally Activated Delayed Fluorescence (TADF) emitters, are studied in a trade-off between efficiency and best molecular conformation, analyzing the effects of traps formation and impact in the figures of merit. With the help of theoretical simulations of injection, transport and charge recombination, it is possible to design suitable devices structures, minimizing the trap effects. One way to optimize the molecular conformation in the active layer, is employing different solvents / evaporation rates that impact on the intrinsic defects formation. External quantum efficiencies ranging form 8 – 20% can be achieved and correlated with traps influence.

CONCLUSION

Here, we tried to optimize an OLED active layer deposited using different solvents and tentatively establish an electrical model that can explain the different results. This concept can open a new framework for future development of structurally simple but efficient OLEDs.

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