Efficient perovskite light-emitting diodes with modified hole injection layer

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Introduction and Motivation

Solution-processed metal hybrid perovskites exhibit promising properties such as low defect density, high fluorescence quantum efficiency, and high color purity, which makes them candidates for high-performance light-emitting diodes (LEDs). Since the first room temperature perovskite light-emitting diodes (PeLEDs) were reported by Tan et al in 2014, PeLEDs have been developed rapidly during the past several years . In a typical PeLED device, the perovskite emissive layer is sandwiched between a hole-injection layer (HTL) and an electron transport layer (ETL). Holes and electrons are injected into the perovskite film through HTL and ETL, and then recombine in the perovskite film to create light emission. For efficient PeLEDs, the selection and modification of electron and hole transport materials is very important. Better-matched energy level alignment between the carrier transport layer and perovskite emissive layer guarantee the balanced carrier recombination, which results in enhanced device performance.

Poly (3,4-ethylenedioxythiophene): polystyrene sulfonate (PEDOT:PSS) is a hydrophilic material with good transparency and high conductivity, which is often used as HIL in PeLEDs. However, as the work function of the PEDOT:PSS is 4.9 eV, a large energy barrier is formed between the PEDOT:PSS layer and the $CsPbBr_3$ perovskite film, the valance band maximum of latter is 5.8 eV. Thus the holes injection from PEDOT:PSS to the perovskite emissive layer is not sufficient. In this work, we use poly (sodium-p-styrene-sulfonate) (PSSNa) modified PEDOT:PSS (m-PEDOT:PSS) as HIL to prepare PeLEDs. Compared with the pristine PEDOT:PSS, m-PEDOT:PSS has higher work function, which promotes hole injection and thus balances carrier transport. Meanwhile, m-PEDOT:PSS suppresses the interfacial exciton quenching to the perovskite emissive layer. Our results reveal that the external quantum efficiency (EQE) of green PeLEDs is improved from 5.65% (based on PEDOT:PSS) to 7.81% (based on m-PEDOT:PSS). The work contributes to promote efficient PeLEDs.

Experimental

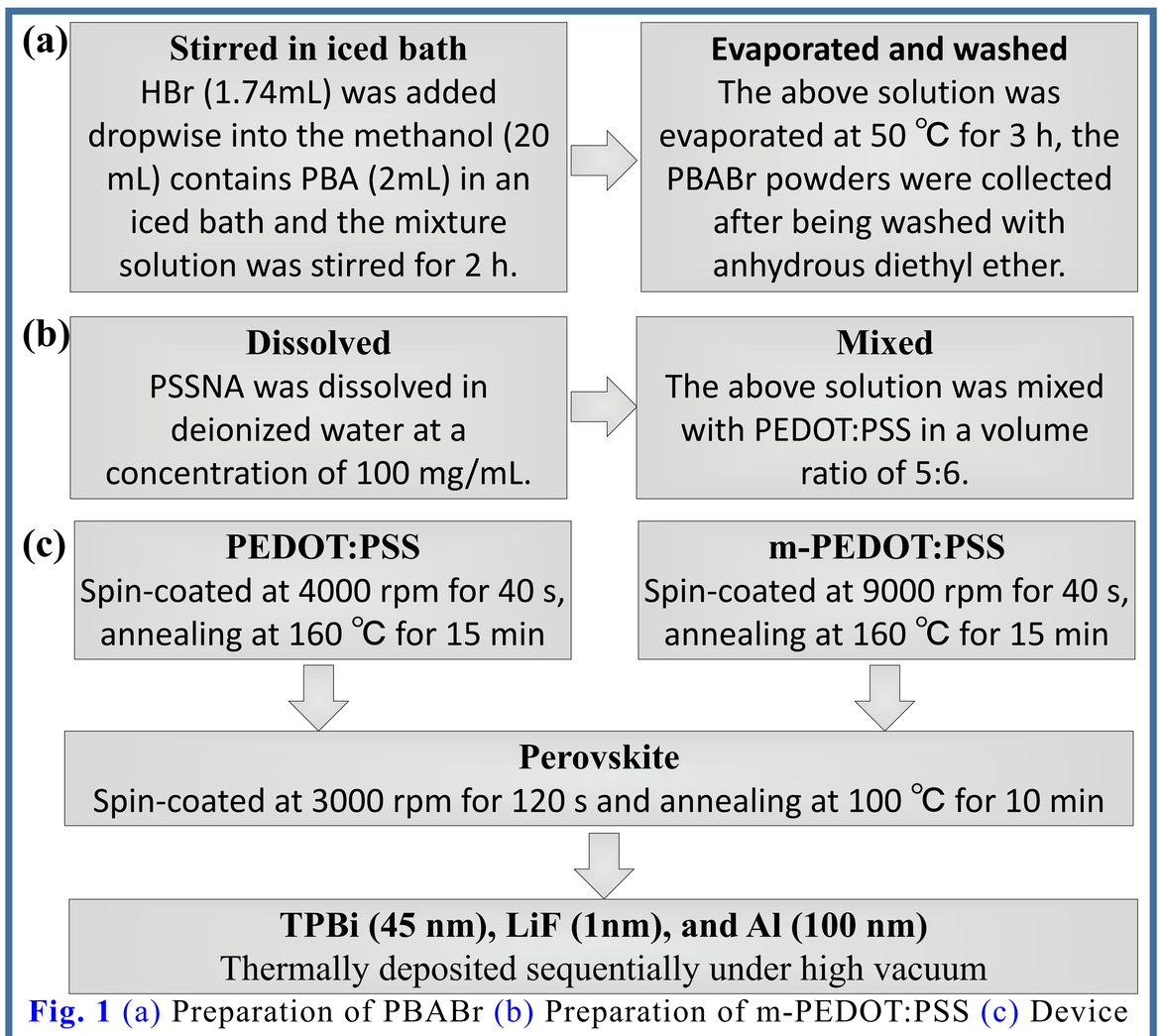

Fig. 1 (a) Preparation of PBABr (b) Preparation of m-PEDOT:PSS (c) Device fabrication .

Results & Discussion

I. Device structure

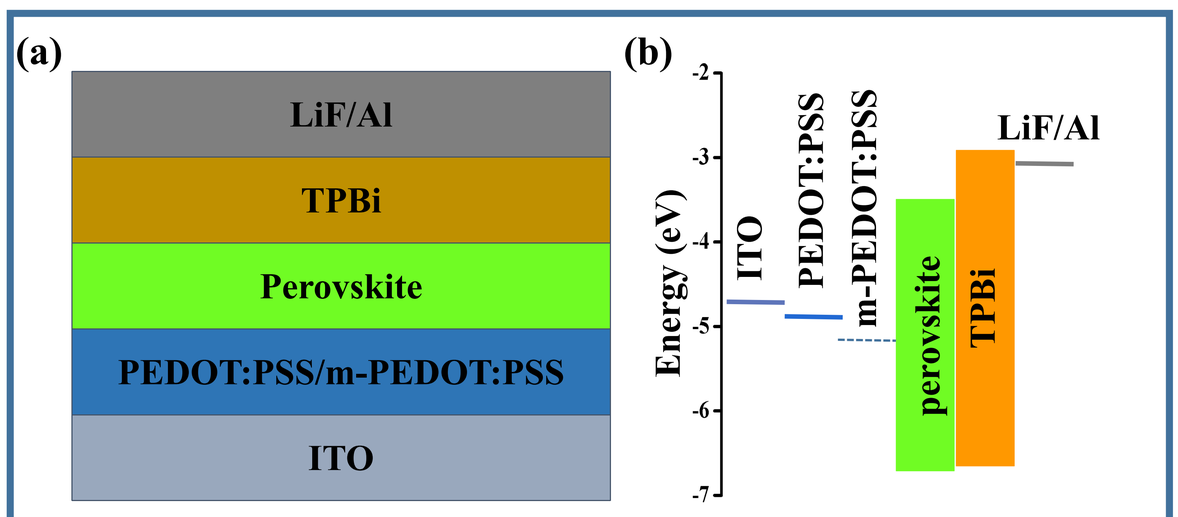

Fig. 2 (a) Device architecture of the PeLEDs (b) Energy level diagrams of PeLEDs.

II. Device performance

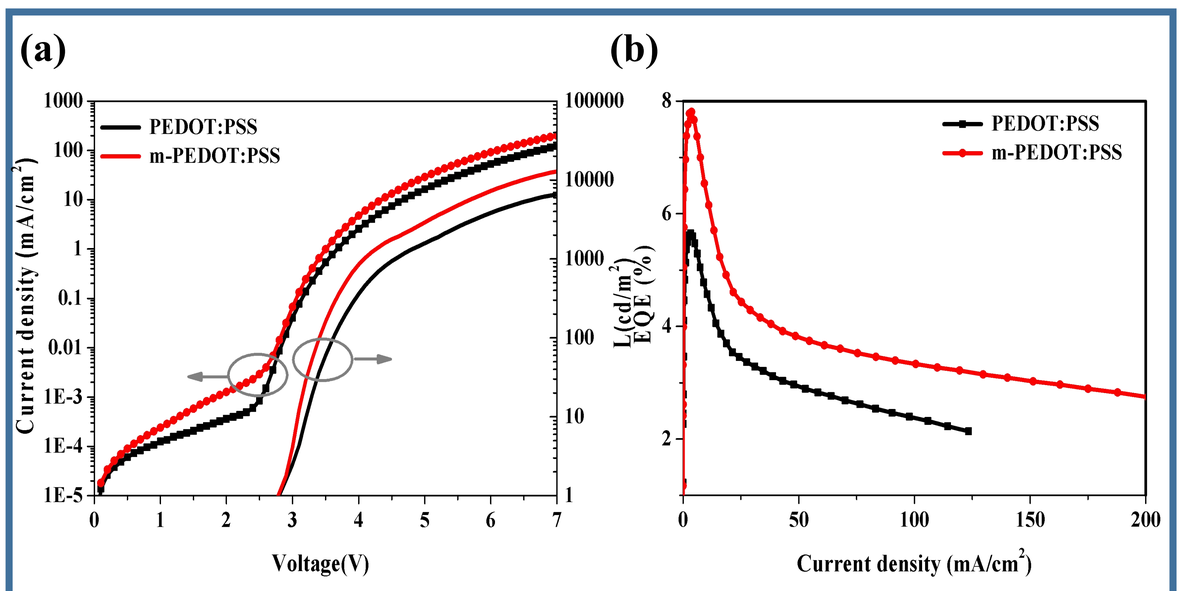

Fig. 3 (a) Current density - luminance - voltage curves of the PeLEDs (b) EQE - current density curves of the PeLEDs.

III. Optical characterizations

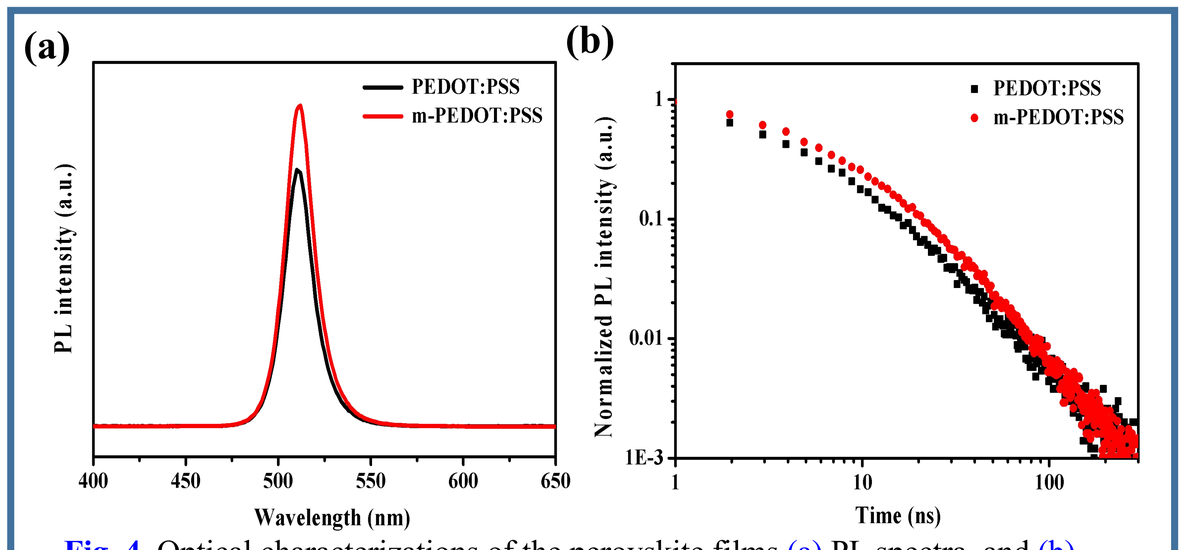

Fig. 4 Optical characterizations of the perovskite films (a) PL spectra, and (b) Time-resolved PL decay of PEDOT:PSS-based and m-PEDOT:PSS-based perovskite films.

Conclusion

In this work, by modifying PEDOT:PSS with PSSNa, a higher working function is obtained, which is beneficial to hole injection. Using m-PEDOT:PSS as the hole injection layer of PeLEDs, more holes and electrons are combined. Besides that, m-PEDOT:PSS also can inhibit the interfacial exciton quenching. The two functions of the m-PEDOT:PSS enable us to prepare PeLEDs with enhanced performance.