Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.
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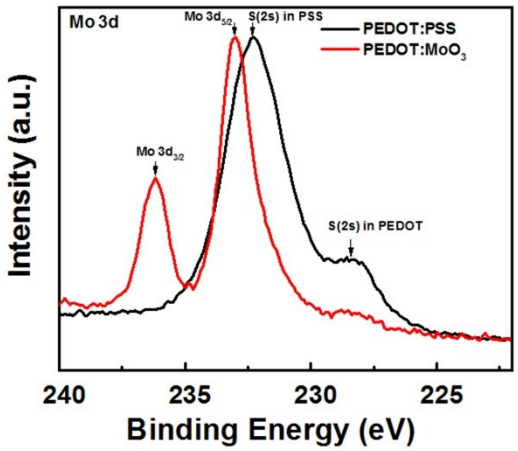

Figure S1. XPS spectra of Mo 3d and S 2s core level for PEDOT:PSS (black line) and PEDOT:MoO_3 composite (red line) films.

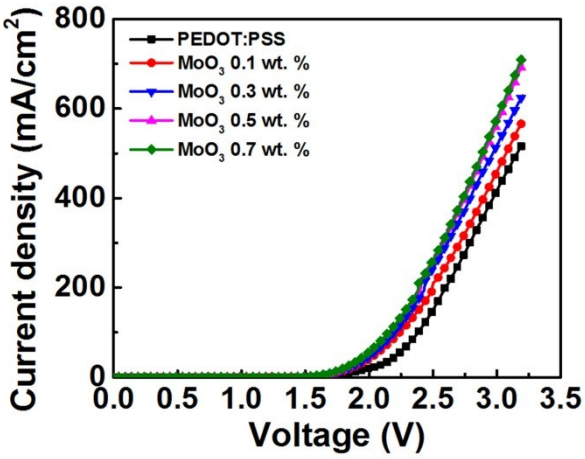

Figure S2. Current density vs. voltage characteristics of hole-only devices using different concentration of PEDOT:MoO_3 composite (0-0.7 wt. %).

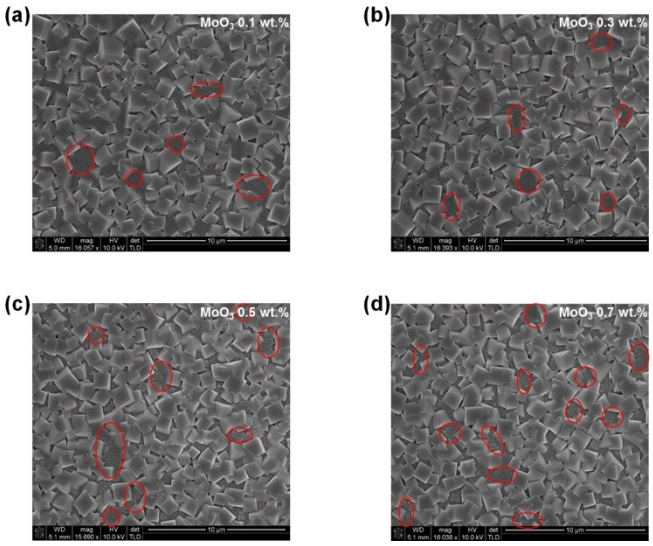

Figure S3. SEM images of the top surface of the $CH_3NH_3PbPbBr_3$ film on different concentration of PEDOT:MoO_3 compsite

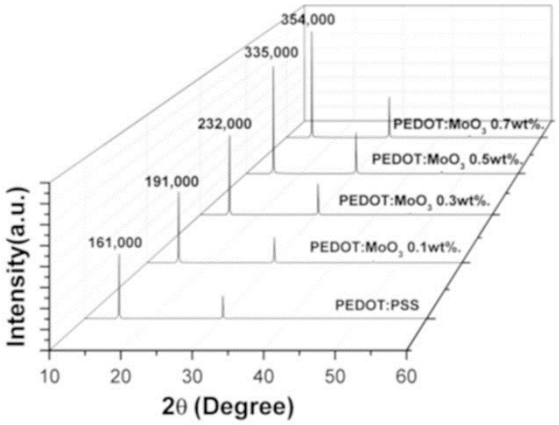

Figure S4. XRD patterns of the $CH_3NH_3PbBr_3$ films prepared on different condition of PEDOT:MoO_3 composite layer (0-0.7 wt.%).

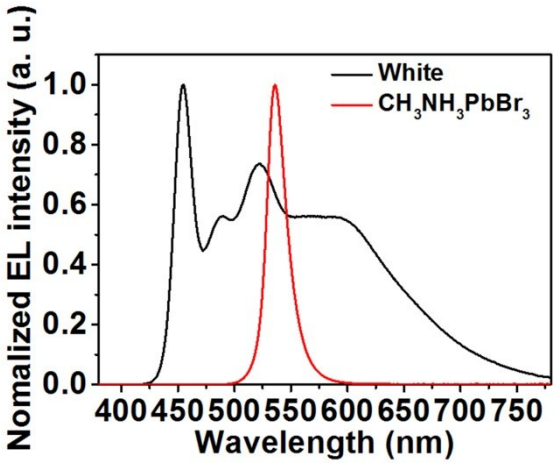

Figure S5. Normalized EL spectra of polymer LED (emissive layer: SPW-111 (white)) (black) and PeLED (emissive layer: $CH_3NH_3PbBr_3$ (perovskite)).

Experimental Section

Materials

The methyl ammonium bromide (MABr) was synthesized as described by previous reported.[21] All reagent were used as purchased without further purification.

PEDOT:MoO_3 composite solution

PEDOT:MoO_3 composite solution was realized by following process. A water dispersion PEDOT:PSS (AI 4083, Celvios) was filtered by 0.45 μm hydrophilic filter (PVDF filter) after ammonium molybdate $(NH_4)_2MoO_4$ (Sigma Aldrich) powder was added into PEDOT:PSS dispersion varying weight percent ratio from 0. 1 wt.% to 0. 7 wt.% under stirring.

Device fabrication

Each layers without HTL was fabricated according to the previous method.[21] The PEDOT:PSS and PEDOT:MoO_3 composite solutions were spin-coated onto ITO/glass substrates as a HTL and then annealed at 145 ^oC for 10 minutes.

Characterisation of PEDOT:MoO_3 composite film and PeLEDs

Characterization of the PeLEDs was performed according to the previous reports.[21] To observe the morphologies of the $CH_3NH_3PbBr_3$ films on the PEDOT:MoO_3 and pristine PEDOT:PSS layers, measurements were taken via scanning electron microscopy. The surface morphologies of the and PEDOT:MoO_3 and pristine PEDOT:PSS layers were measured by means of atomic force microscopy (DI-3100, Veeco Co.). The XPS and UPS spectra of the PEDOT:MoO_3 composite layer were assessed using an ESCALAB 250XI device (Thermo Fisher Scientific Co.)