Supporting Information

Color-tunable, spectra-stable flexible white top-emitting organic light-emitting devices based on alternating current driven and dual-microcavity technology

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The parameters used in the equation (2)

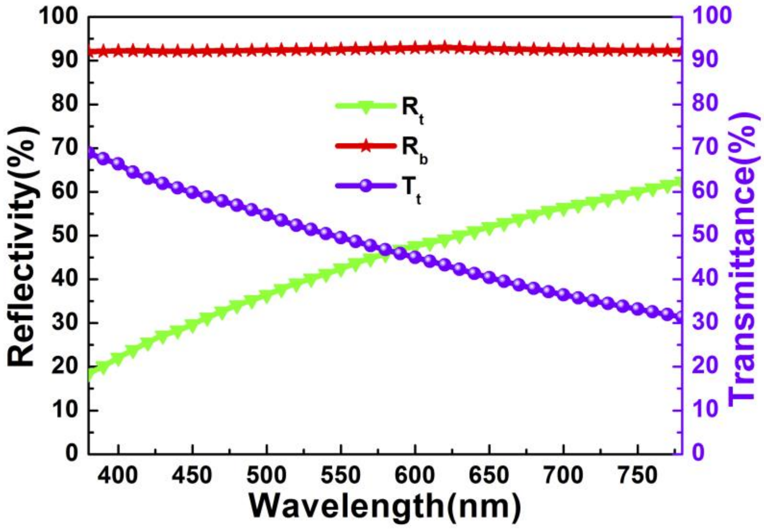

Figure S1. The reflectivity of bottom metal (R_b) and top metal (R_t). The transmittance of the top metal (T_t). In equation (2), z=40 nm and $I(\lambda)$=1 (380 nm ~ 780 nm). Mg films with the thickness of 100 nm and Ag films with the thickness of 18 nm are used as bottom metal and top metal, respectively.

Structure & performance of bicolor device in single cavity

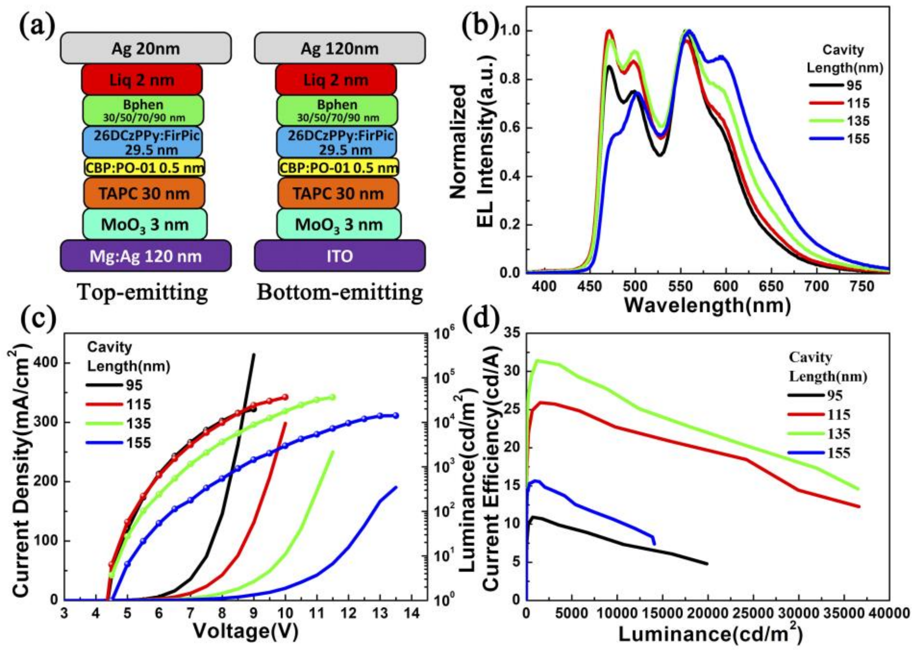

Figure S2. (a) The structures of bicolor top-emitting and bottom-emitting OLEDs consisting of blue and yellow sub-color under different cavity length. (b) The normalized EL spectra of bicolor bottom-emitting OLEDs under different cavity lengths. Two peaks from FirPic and PO-01 can be seen obviously. And the spectra are wider than those of bicolor top-emitting OLEDs because the micarocavity effect is very weak in bottom-emitting OLEDs. (c) J-V-L and (d) current efficiency of bicolor top-emitting OLEDs under different cavity length.

Fabrication progress

As shown in figure S2 (a), charge generation layer which is bottom metal is deposited by shadow mask I. Secondly, hole injection layer (HJL) and hole transport layer (HTL) have been deposited by shadow mask II. As we can see in Figure S2 (b), HJL and HTL of two units have been deposited at the same time. Then, some HTL of yellow unit (HTL_Y), yellow emitting layer (EML_Y) and some electron transport layer of yellow unit (ETL_Y) are deposited by shadow mask III in turn. Then, blue emitting layer (EML_B) is deposited by shadow mask IV. Next, electron transport layer (ETL) and electron injection layer (EJL) are deposited by shadow mask II. At last, electrodes are deposited by shadow mask V. Therefore, most of the same functional layers of two units can be deposited simultaneously, which means this structure design has simplified the fabrication progress.

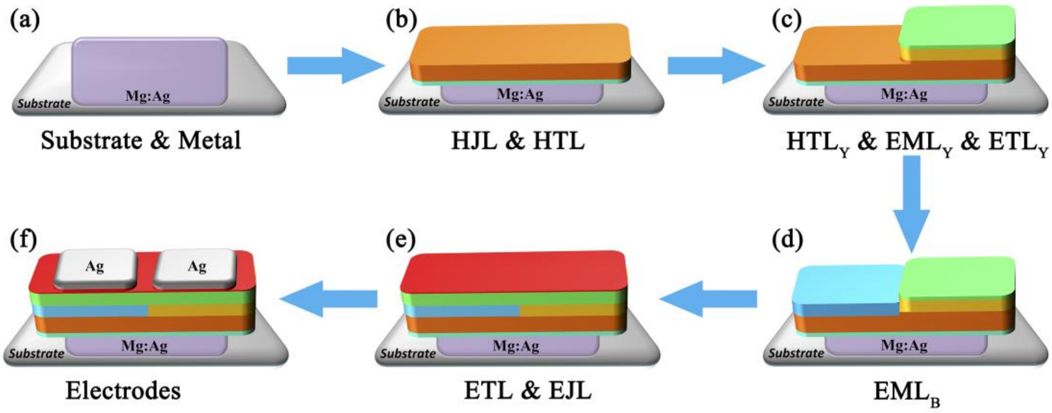

Figure S3. The fabrication process of DMT-OLEDs.

Methods of measurement

For DMT-OLEDs, we define Ag electrode of blue unit is grounded under all DC measurement. The Ag electrode of yellow unit is positively biased when DMT-OLEDs are under forward bias. Similarly, the reverse bias means the Ag electrode of yellow unit is negatively biased. Therefore, forward and reverse bias corresponds to the positive and negative half of the AC cycle, respectively. For single unit, the forward bias means that the electrical potential of Mg:Ag metal is higher than that of Ag electrode in this unit.

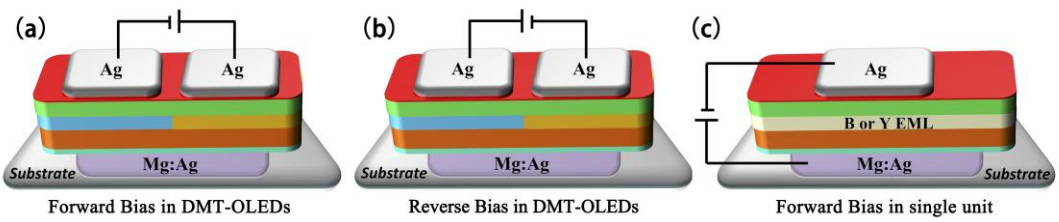

Figure S4. The methods of measurement for DMT-OLEDs and single units.

Spectra of blue and yellow units with out-coupling layer

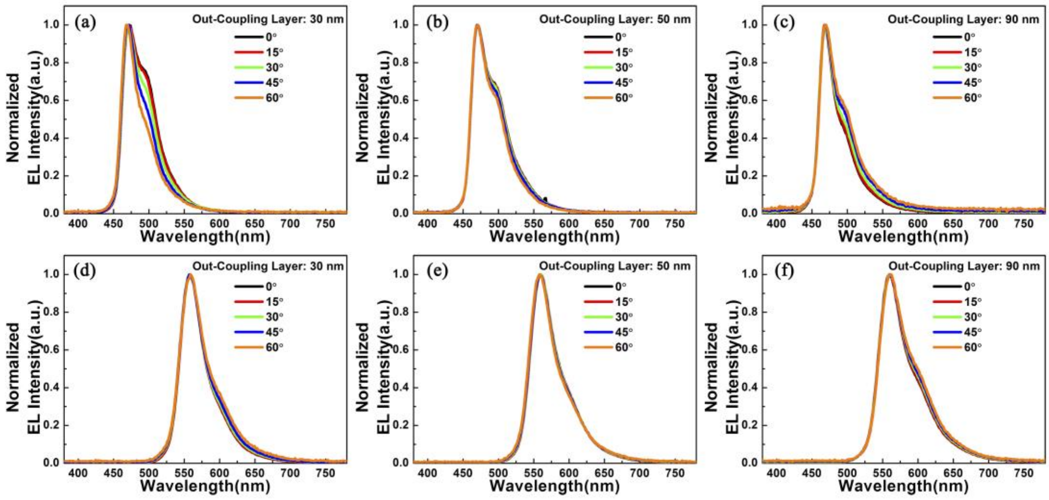

Figure S5. Spectra of blue unit with (a) 30 nm (b) 50 nm and (c) 90 nm out-coupling layer at different viewing angels. Spectra of yellow unit with (d) 30 nm (e) 50 nm and (f) 90 nm out-coupling layer at different viewing angels.

Spectra of white color at different viewing angels

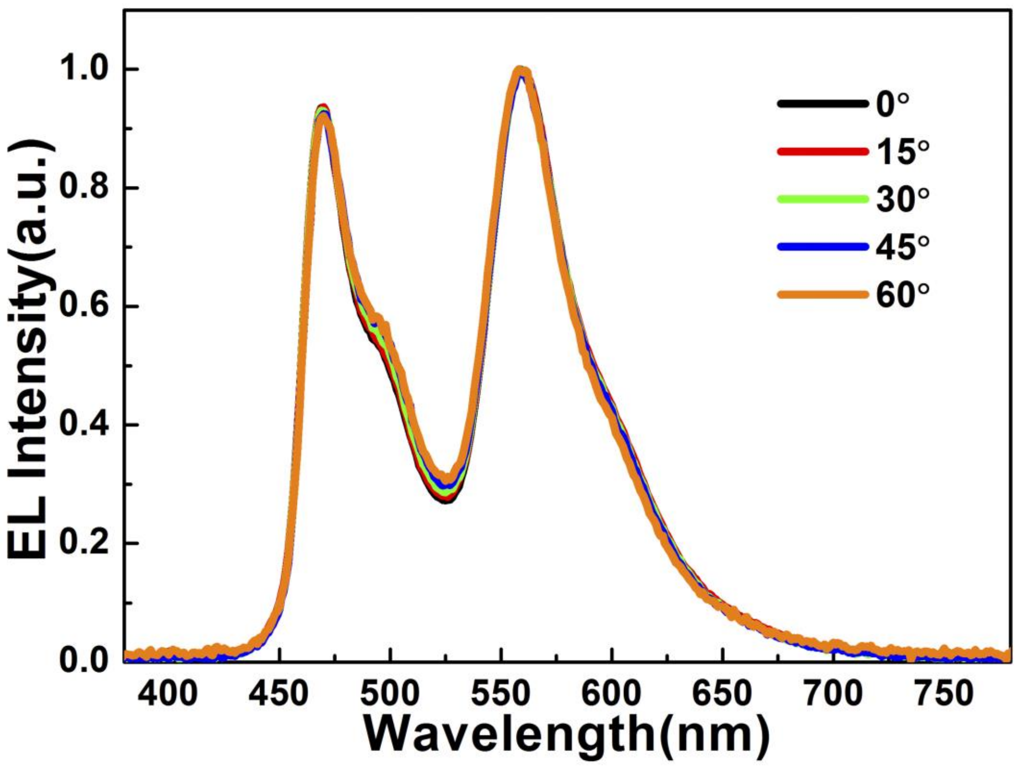

Figure S6. Normalized EL spectra of white color with 70 nm out-coupling layer at different viewing angles.

The current comparison

The structure of device A is ITO/ LiF (5 nm)/ CBP: 10wt% PO-01 (30 nm)/TAPC (50 nm)/MoO_3 (3 nm)/ Mg: 6.7wt% Ag (120 nm). The structure of device B is ITO/ LiF (5 nm)/ CBP: 10wt% PO-01 (30 nm)/Bphen (50 nm)/LiF (2 nm)/ Mg: 6.7wt% Ag (120 nm). LiF layer near the ITO electrode is used to prohibit the charge injection from ITO electrode. Thus, the current in device A and device B is determined by electrons and holes injected from Mg:Ag electrode, respectively. Device A_1 and Device A_2 mean different device in the same substrate of device A. Device B_1 and Device B_2 also mean different device in the same substrate device B.

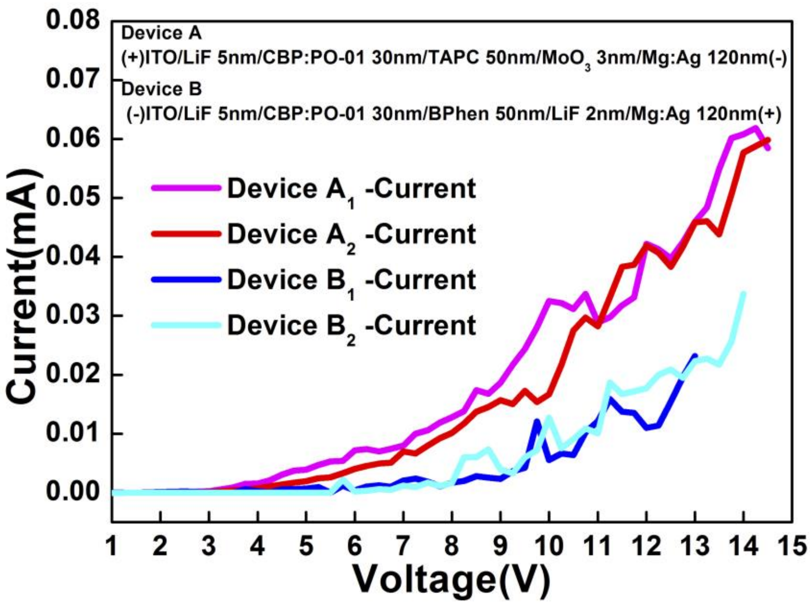

Figure S7. The current comparison of device A and device B.

The structures of the materials used in the device

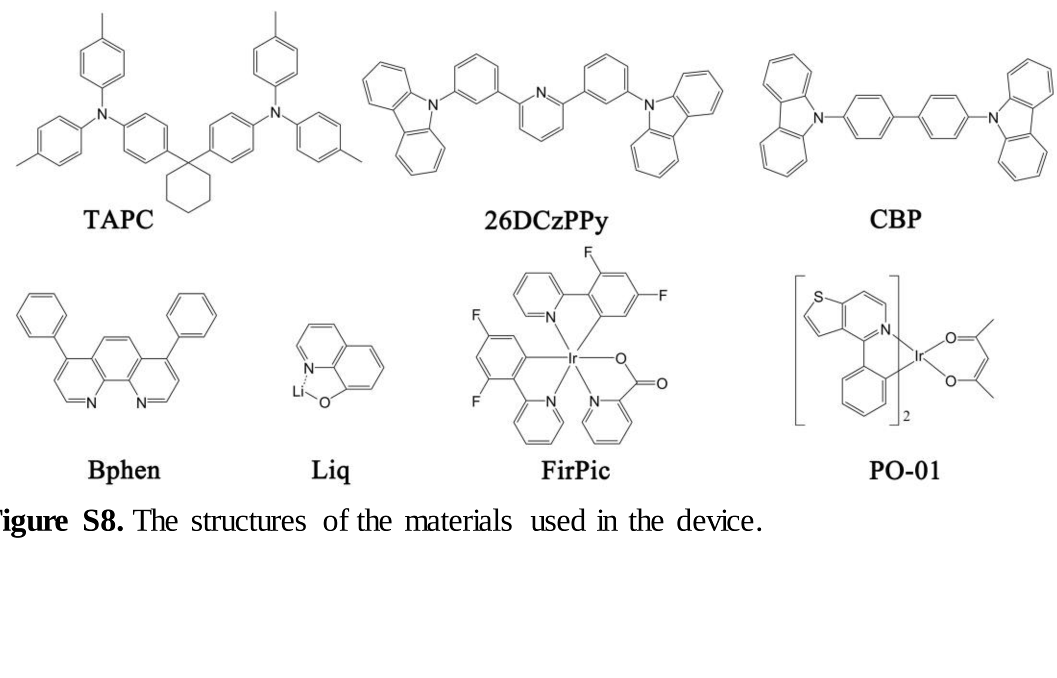

Figure S8. The structures of the materials used in the device.

Movies demonstrating device operation principle

Movie: Square-waves with consistent duty-cycle (50%) are used to drive DMT-OLEDs. The operation frequency is increased step-wise from 1 Hz to 5 Hz, 10 Hz, and 50 Hz.