Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supplementary Information

Discrimination and control of the exciton-recombination region of thermal-stressed blue organic light-emitting diodes

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Experimental

The indium tin oxide (ITO, 10 Ω/sheet, 150 nm, active area was 4 mm^2) coated glass substrate was cleaned with detergent, de-ionized water, acetone, and isopropanol in sequence for 15 min. The cleaned substrates were exposed to UV-ozone for 15 minutes. All the devices were fabricated by thermally depositing the organic layers and cathode onto the ITO coated substrates under a base pressure of below 2.0×10^{-5} mbar. The typical deposition rates of organic materials, lithium-8-hydroxyquinolinolate (Liq) and aluminum (Al) was 0.8, 0.2 and 5.0 Å s^{-1}, respectively.

OLEDs were tested at room temperature (RT), 60°C, 80°C and 100°C for 30 minutes in N2 atmosphere, respectively. The current-voltage-luminescence characteristics were measured by a Keithley 2400 source meter and a PR-650 Spectra Colorimeter. The luminance and spectra were measured in the direction perpendicular to the substrate. The photoluminescence (PL) characteristics were performed on a single-photon counting from Edinburgh Analytical Instruments (FLSP 920) equipped with a continuous Xe-900 Xenon lamp, a μF900 microsecond flash lamp, and a 400 nm light filter.

The SCLC property could be described via the Mott-Gurney equation:

$$J = \frac{9}{8}\varepsilon_0\varepsilon_r\mu\frac{E^2}{L} = \frac{9}{8}\varepsilon_0\varepsilon_r\frac{V^2}{L^3}\mu_0\exp(0.891\gamma\sqrt{\frac{V}{L}}) \quad (1)$$

where ε_0 is the free-space permittivity (8.85×10^{-14} C V^{-1} cm^{-1}), ε_r is the relative dielectric constant (assumed to be 3.0 for organic semiconductors), E is the electric field, μ_0 is the zero-field mobility, γ is the Poole-Frenkel factor, and L is the thickness of each film. The carrier mobility (μ) could be calculated according to the Poole-Frenkel formula:

$$\mu = \mu_0\exp(\gamma\sqrt{E}) \quad (2)$$

By fitting the current density–voltage curves in the SCLC region according to Eq. 1, the values of μ_0 and γ are obtained, thus generating the field-dependent carrier mobility by Eq. 2.

Figure S1. The EL spectra of DCJTB at (a) 4 V and (b) 12 V when annealed at different temperatures.

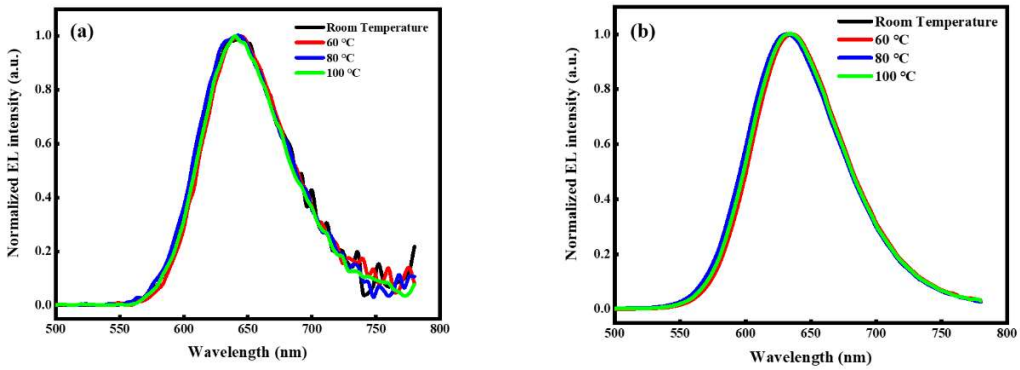

Figure S2. The EL spectra of Rubrene at (a) 4 V and (b) 12 V when annealed at different temperatures.

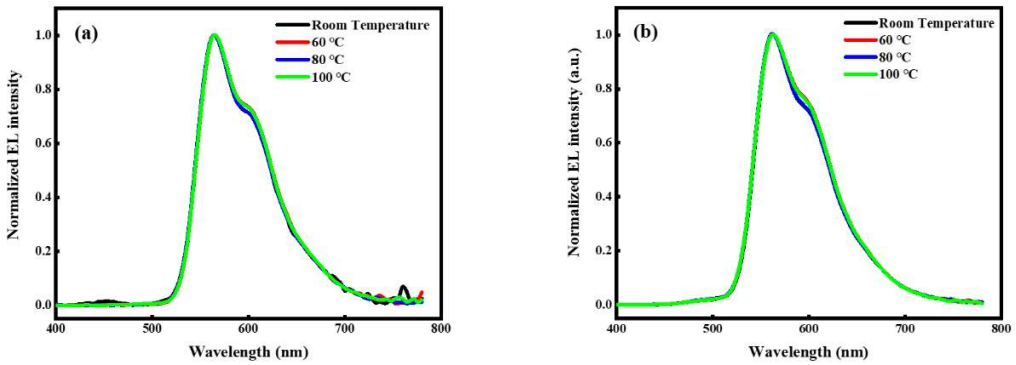

Figure S3. The EL spectra and fitting of peaks of the pristine device tested at (a) 4 V and (b) 12 V when annealed at RT. The EL spectra and fitting of peaks of the optimized device tested at (c) 4 V and (d) 12 V when annealed at RT.

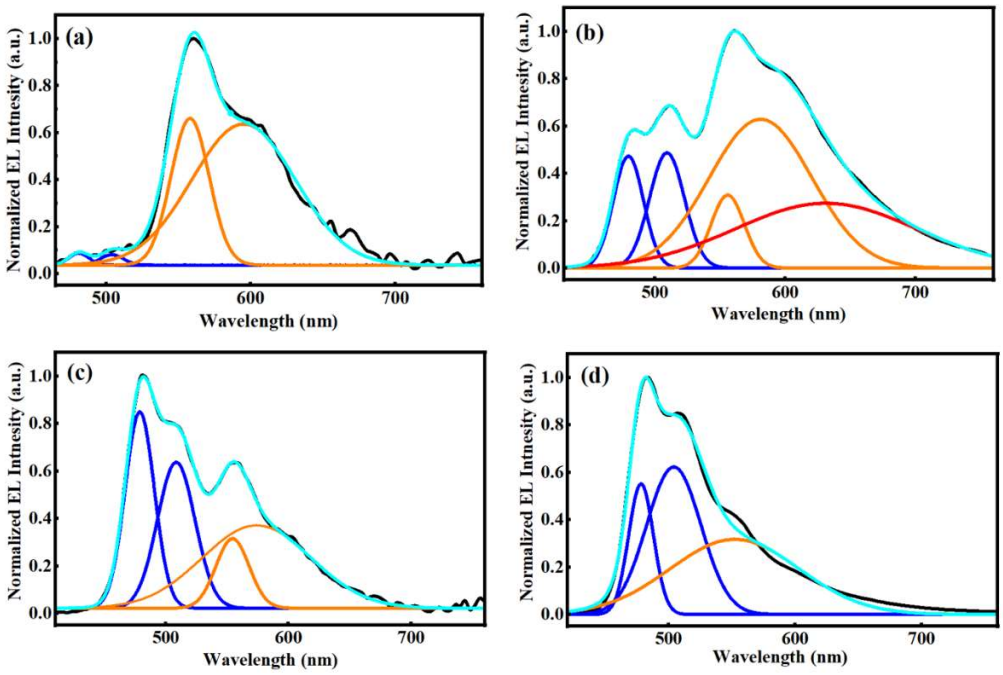

Figure S4. The EL spectra and fitting of peaks of the pristine device tested at (a) 4 V and (b) 12 V when annealed temperature was 60 ℃. The EL spectra and fitting of peaks of the optimized device tested at (c) 4 V and (d) 12 V when annealed temperature was 60 ℃.

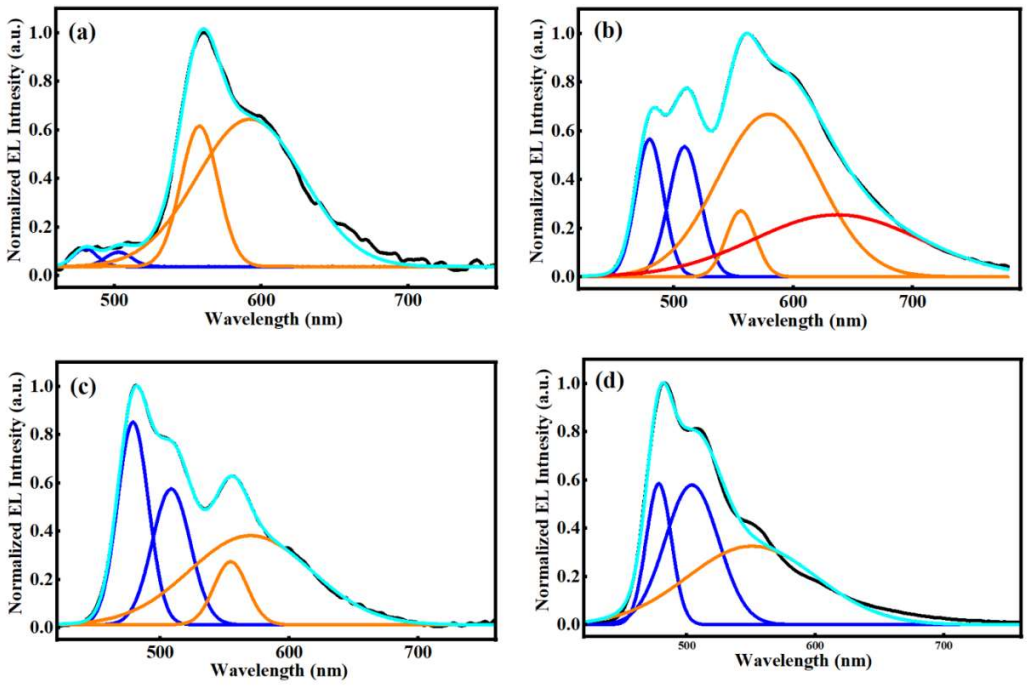

Figure S5. The EL spectra and fitting of peaks of the pristine device tested at (a) 4 V and (b) 12 V when annealed temperature was 100 ℃. The EL spectra and fitting of peaks of the optimized device tested at (c) 4 V and (d) 12 V when annealed temperature was 100 ℃.

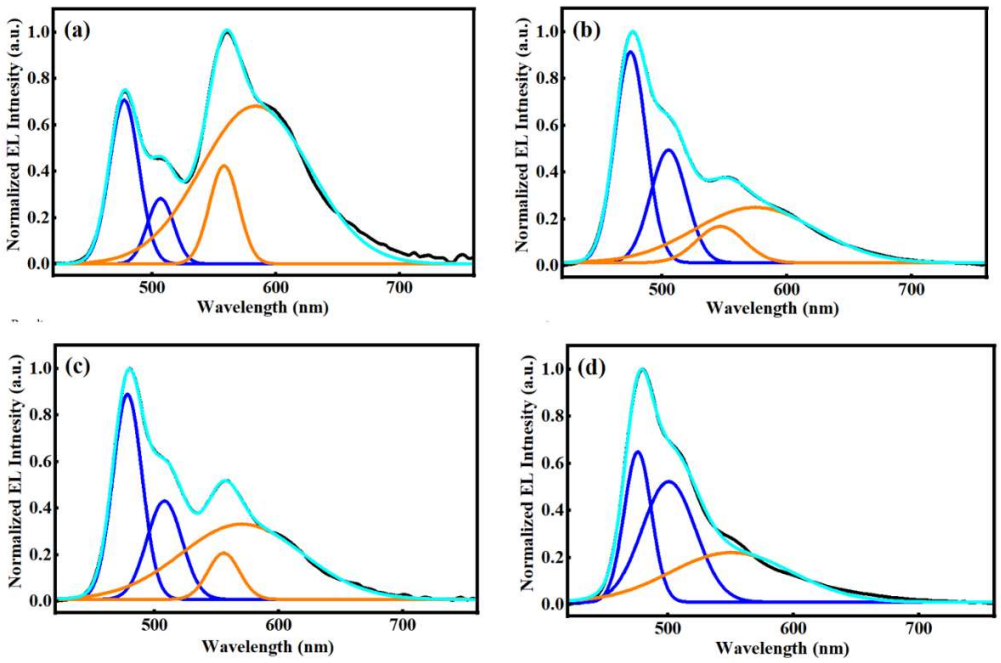

Figure S6. EL spectrum of DSA-ph and absorption spectrum of DCJTB and Rubrene at room temperature.

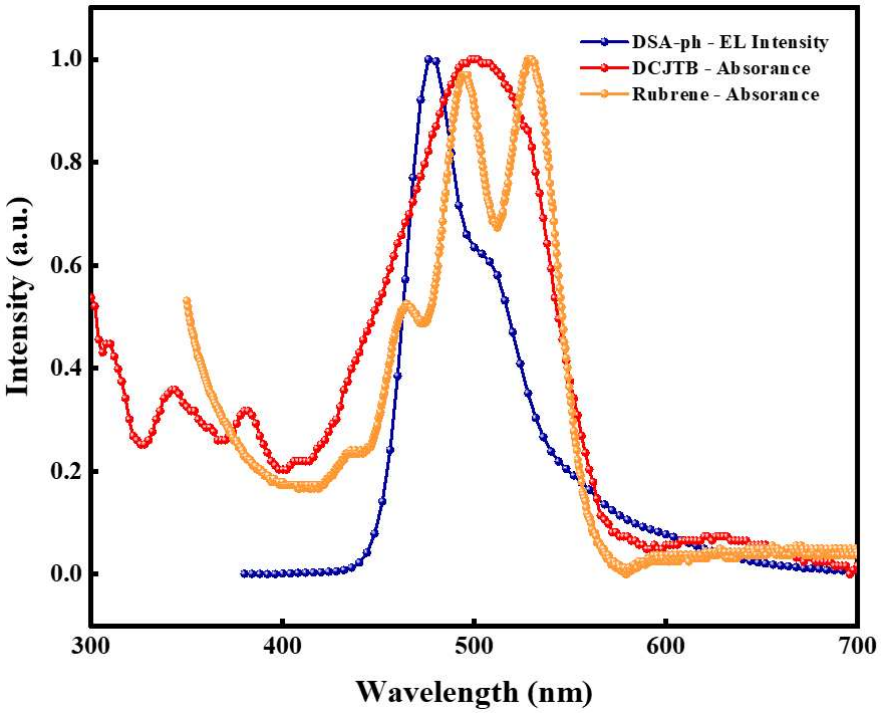

Figure S7. Different color peaks percentage of relative intensity at 80℃.

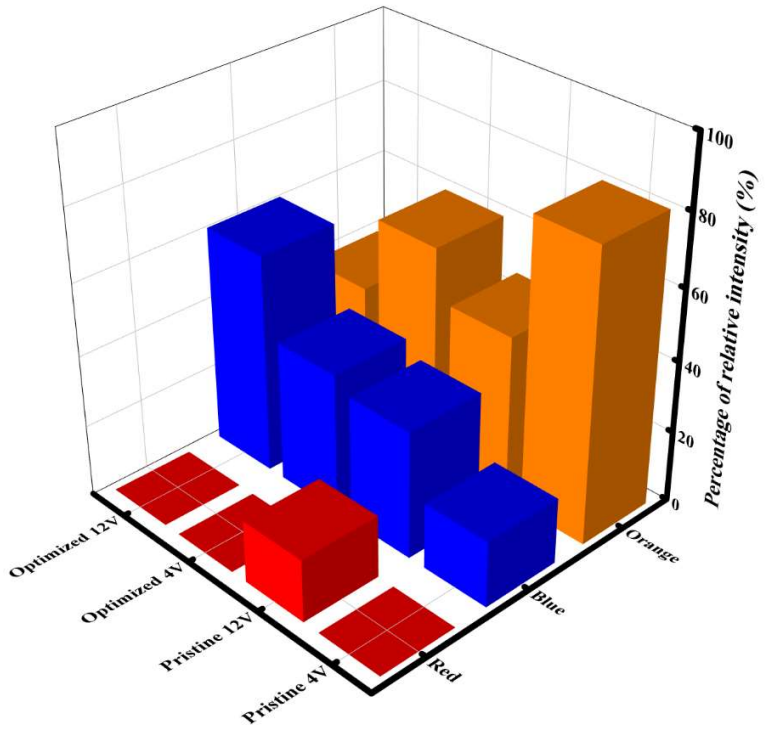

Table S1. Carrier mobility of single-carrier cells at different temperatures

Annealed temperature	Pristine mobility ($cm^2/V\ s$)		Optimized mobility ($cm^2/V\ s$)	
	Hole-only	Electron-only	Hole-only	Electron-only
RT	9.02×10^{-4}	2.71×10^{-5}	2.83×10^{-4}	5.69×10^{-5}
60 °C	1.37×10^{-3}	3.14×10^{-5}	3.75×10^{-4}	5.21×10^{-5}
80 °C	7.94×10^{-4}	9.19×10^{-6}	2.58×10^{-4}	1.27×10^{-4}
100 °C	7.61×10^{-4}	5.99×10^{-6}	3.65×10^{-4}	1.20×10^{-4}

Table S2. Area percentage of different color tested at 4 V and 12 V under 80 ℃.

Emitter	Wave peak (nm)		Area (a.u.)		FWHM[a] (nm)		Area percentage (%)	
	Pristine	Optimized	Pristine	Optimized	Pristine	Optimized	Pristine	Optimized
	4V/12V	4V/8V	4V/12V	4V/12V	4V/12V	4V/12V	4V/12V	4V/12V
Blue	478/476	478/475	16/27	27/18	28/29	28/26	14/23	27/25
Blue side-peak	506/506	508/500	5/15	12/27	23/32	31/52	5/13	13/36
Orange	559/557	557/551	14/1	7/29	29/24	28/117	12/1	7/39
Orange side-peak	590/579	573/-	77/53	53/-	103/121	112/-	69/45	53/-
Red	-/640	-/-	-/21	-/-	-/196	-/-	-/18	-/-

[a] full width at half maxima

Table S3. Electrical characteristics of devices at different temperatures

Annealed Temperature	V_{on} (V)		CE_{max} ($cd \cdot A^{-1}$)		PE(@CE_{max}) ($lm \cdot W^{-1}$)		EQE(@CE_{max}) (%)	
	Pristine	Optimized	Pristine	Optimized	Pristine	Optimized	Pristine	Optimized
RT	3.1	3.2	12.84	10.14	5.04	3.75	6.33	4.86
60°C	3.2	3.2	10.22	10.88	3.38	4.27	5.05	5.21
80°C	3.4	3.2	11.86	12.07	4.96	5.83	5.13	5.44
100°C	3.2	3.2	10.85	13.44	4.63	6.49	4.76	6.01