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Supplementary Information

Absence of delayed fluorescence and triplet-triplet annihilation in organic light emitting diodes with spatially orthogonal bianthracenes

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Materials. TAPC, MADN, CBP, and TPBi were purchased from e-Ray. A nitrogen-phosphorus detector was purchased from Chemipro Kasei. PEDOT:PSS was purchased from Clevious. B3PyPB were prepared according to the literature.[1] PPBA was synthesized by general Suzuki coupling methods. 10,10'-Dibromo-9,9'-bianthracene (Luminescence Technology, 0.618 g, 1.21 mmol), phenylboronic acid (Wako, 0.372 g, 3.05 mmol), $Pd(PPh_3)_4$ (TCI, 50 mg, 0.043 mmol), K_2CO_3 (0.512 g, 3.70 mmol), water (20 mL) and ethanol (10 mL) were mixed in a flask containing nitrogen-saturated toluene (20.0 mL). The reaction mixture was refluxed for 14 h under nitrogen. After it was cooled to room temperature, the reaction mixture was quenched with brine and extracted with toluene. The combined organic extracts were dried with anhydrous $MgSO_4$ and evaporated. The crude product was successfully purified by column chromatography using dichloromethane as the eluent, and then further purified by train sublimation to give yellow crystals. Yield: 44% (270 mg). ^{1}H NMR (400 MHz, CDCl3, δ): 7.72-7.76 (8H), 7.64-7.69 (6H), 7.44 (t, *J* = 7.5 Hz, 4H,), 7.27 (t, *J* = 7.5 Hz, 4H), 7.08 (d, *J* = 8.6 Hz, 4H) ppm. EI-MS (m/z): calcd for C40H26, 506.63; found, 507 [M^+].

Measurement of optical properties. UV-vis absorption spectra were recorded on a Shimadzu UV-3150 spectrometer. PL spectra were measured using a Jobin Yvon Fluoromax-4 fluorometer. PL quantum efficiencies were measured on a Hamamatsu C9920-01 integral sphere system in a nitrogen atmosphere. For measurements of PL-decay profiles, a laser-diode (405 nm, Hamamatsu PLP10-040) with a pulse duration of 100 ps and a repetition rate of 100 kHz was used as the excitation light. The PL-decay profiles were obtained using a time-correlated single-photon counting method.

Device fabrication and characterization. All the devices were fabricated on glass substrates pre-coated with a 130 nm thick layer of indium tin oxide (ITO) with a sheet resistance of 15 Ω/square. The substrates were cleaned with ultra-purified water and organic solvents and then cleaned for 30 min by exposure to a UV-ozone ambient. The organic compounds were successively deposited onto the ITO substrate under a vacuum (~10-5 Pa). LiF and Al were patterned using a shadow mask with an array of openings (2 mm × 2 mm) without breaking the vacuum (~10-5 Pa). All the devices were encapsulated under a nitrogen atmosphere immediately after preparation using epoxy glue and glass lids. The EL spectra were measured using an optical multichannel analyzer (Hamamatsu Photonics PMA-11). The current density–voltage and luminance–voltage characteristics were measured using a Keithley 2400 source measurement unit and a Minolta CS200 luminance-meter, respectively. The transient EL decay was measured using a function generator (Agilent 33220A), an oscilloscope (Tektronix DPO 3052), and an Si photodetector (Hamamatsu Photonics H7826). After applying a forward-pulse voltage, the −2 V of the reverse-pulse voltage was applied. The magnetic field

dependence of EL was measured with an electromagnet (Tamakawa Co. TM-YSV-043). The magnetic field was applied parallel to the substrate and measured every second using a gaussmeter (Lake Shore, 425). The sample was cooled to 77 K using a cryostat (Oxford Instruments, Optistat DN).

Table S1. Photophysical properties of the compounds[a)]

	UV (film) (nm)	PL (neat) (nm)	PLQY (neat) (%)	τ_1 (neat) (ns)	PL (doped) (nm)	PLQY (doped) (%)	τ_1 (C_1)[b)] (doped) (ns)	τ_2 (C_2)[b)] (doped) (ns)	R[b)]
MADN	405, 384, 365, 345	449	41	1.04	433	62	4.54	–	0.998
PPBA	407, 384, 364, 344	443	14	0.95	440	80	3.49 (0.338)	9.56 (0.656)	0.999

a) Doped films were prepared as 1wt% in CBP.

b) Obtained by fitting the following equation: $I = C_1\exp(-t/\tau_1) + C_2\exp(-t/\tau_2)$

Table S2. Performances of the devices.

Emitter		V_{on}[a)] (V)	Current efficiency$_{max,100,1000}$[b)] (cd/A)	Power efficiency$_{max,100,1000}$[b)] (lm/W)	EQE$_{max,100,1000}$[b)] (%)
MADN	non-doped	2.8	3.7/3.3/2.6	4.1/2.9/1.7	4.7/4.2/3.4
	doped	3.6	2.0/1.5/1.2	1.8/0.95/0.54	3.9/2.9/2.2
PPBA	non-doped	3.2	3.8/3.5/2.9	3.6/2.7/1.5	2.7/2.6/2.3
	doped	3.8	5.5/1.9/1.5	5.1/1.1/0.66	11/4.0/3.3

a) At 1 cd m^{-2}; b) Maximum/at 100cd m^{-2}/at 1000 cd m^{-2}

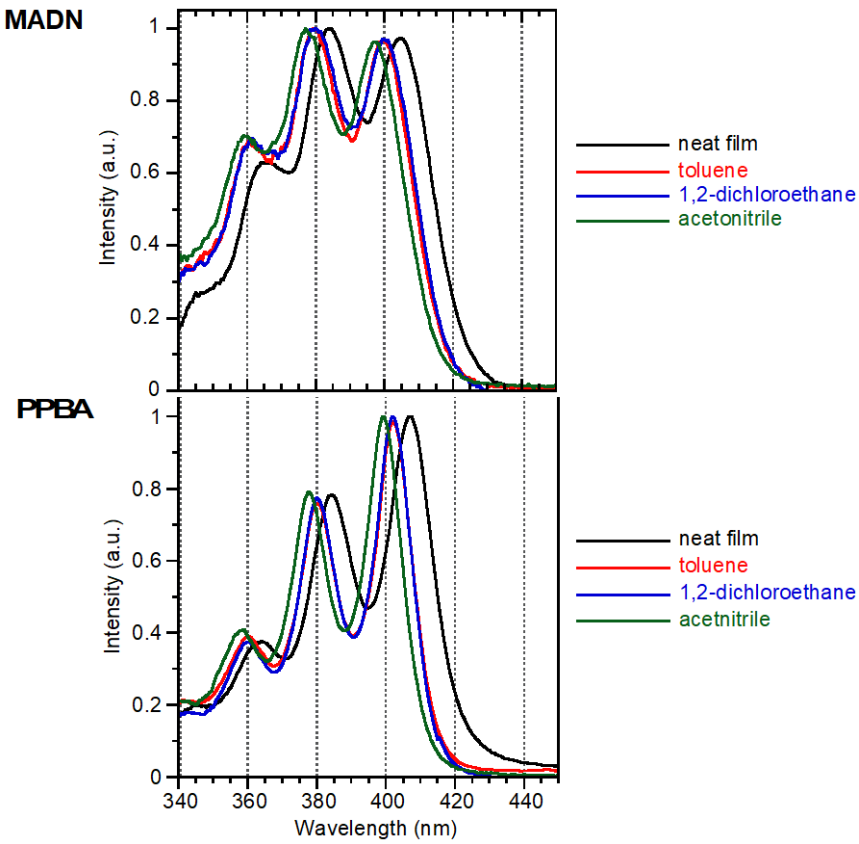

Fig. S1 UV spectra of the compounds.

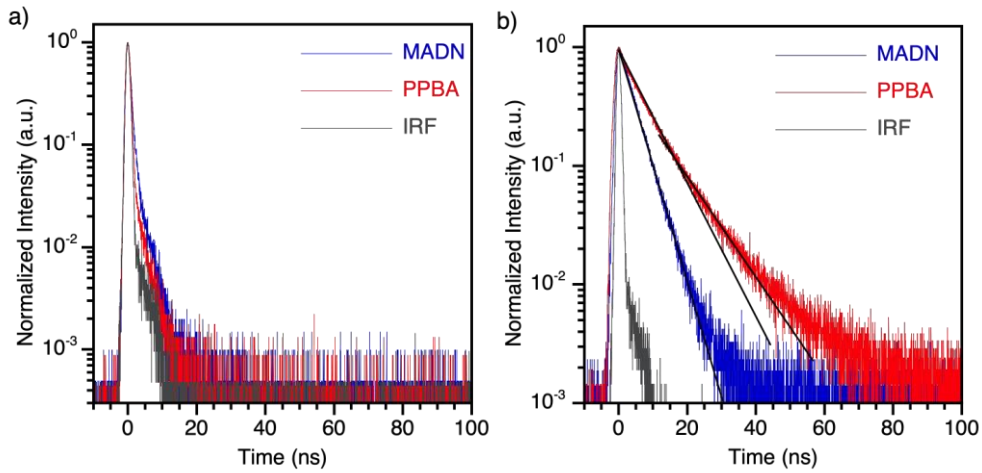

Fig. S2 Transient PL: (a) neat film and (b) 1wt%-doped in CBP. The black lines are guides to the eye.

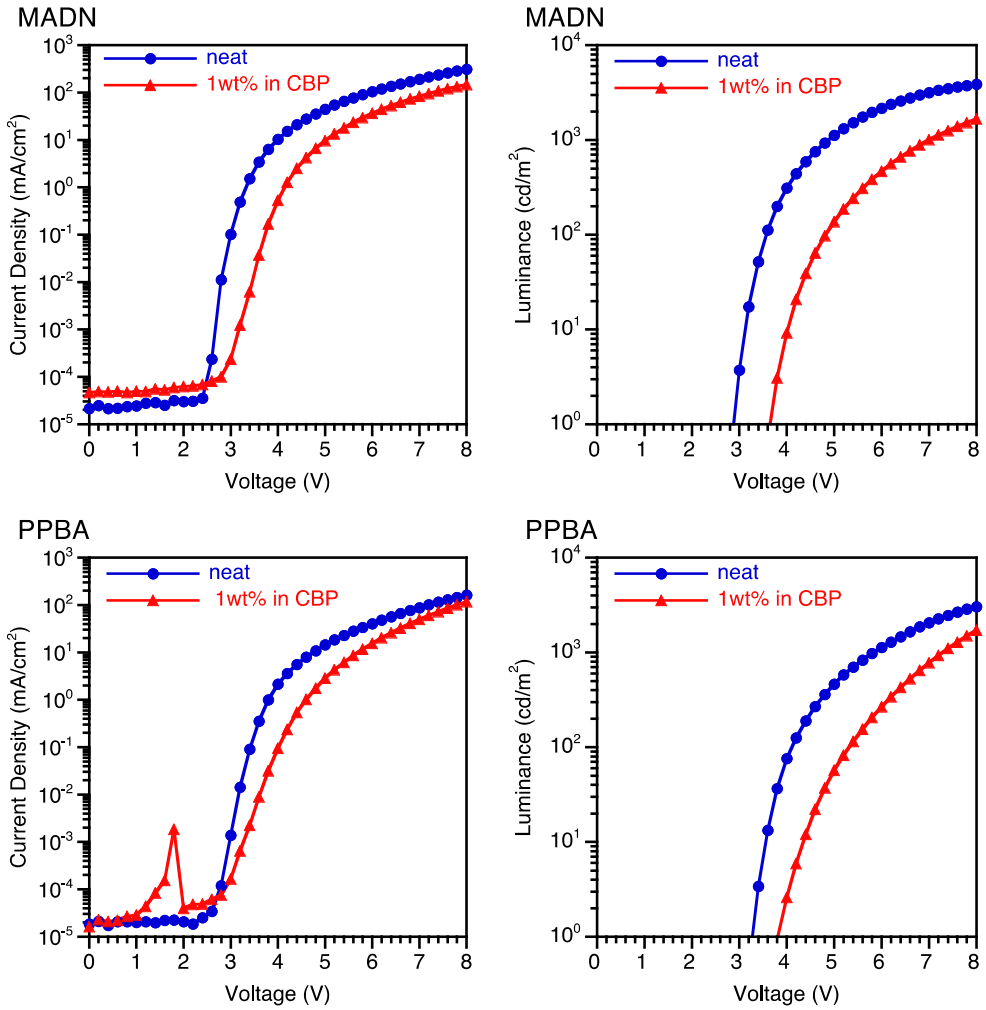

Fig. S3 Current density–voltage and luminance–voltage plots

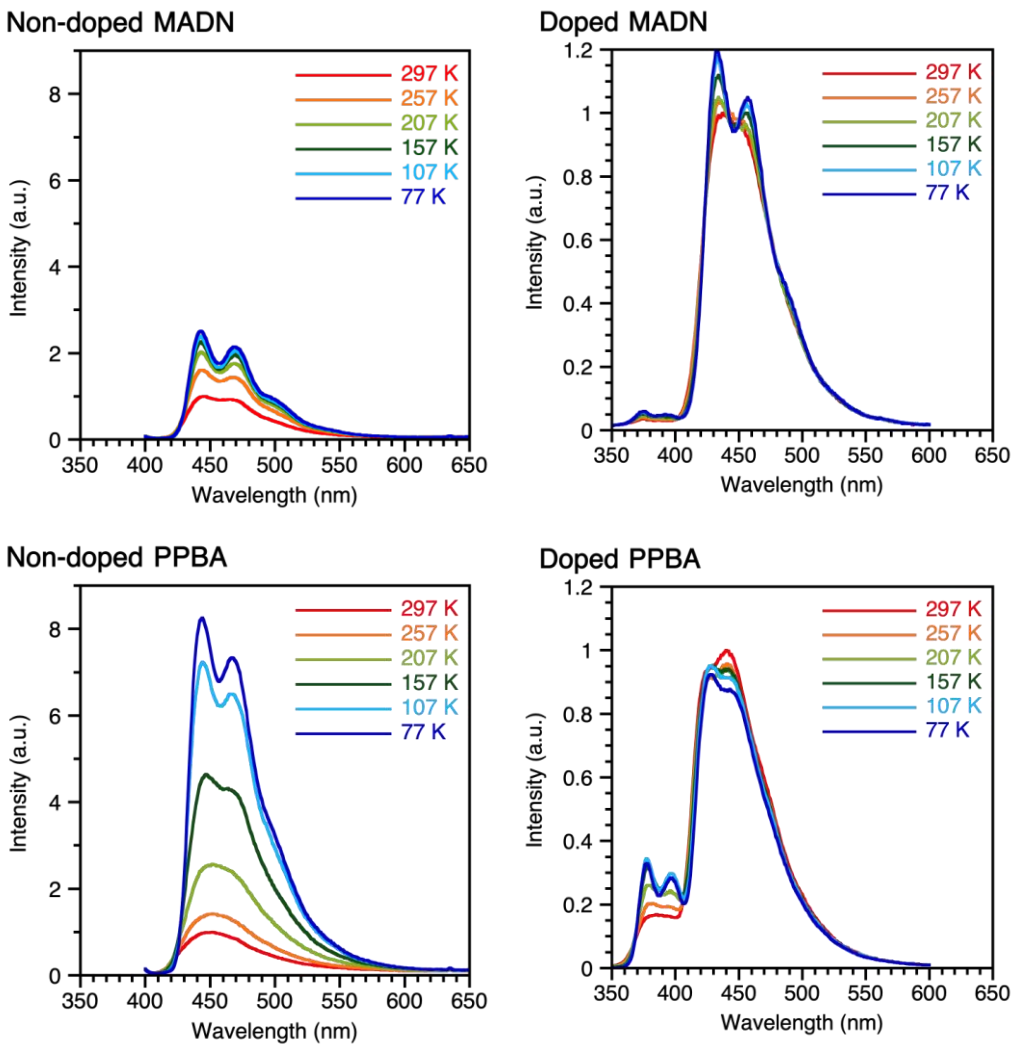

Fig. S4 Temperature dependence of PL

References

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