Supporting Information

Very low lasing threshold of DABNA derivatives with DFB structures

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Table S1. Instruments

Instruments	Brands and Types	Conditions
UV-Vis	Perkin-Elmer Lambda 950-PKA UV–vis spectrophotometer	The light source consisted of Deuterium (D2) and Tungsten Iodide (50W) lamps for the ultraviolet and visible regions.
PL	Horiba Jobin–Yvon FluoroMax-4 JASCO FP-8600 fluorometer	the excitation wavelength was set to the absorption maximum
PL quantum Yield	Hamamatsu Photonics Quantaurus-QY C11347-01	Absolute PL quantum yield. The measurement error for the obtained values on this instrument is ±3%.
Transient photoluminescence decay	Hamamatsu Photonics Quantaurus-Tau C11367-03	
UV/ozone	Nippon Laser & Electronics Lab. NL-UV253	15 min
Laser scanning microscope	Olympus LEXT	
Surface profiler	Bruker Dektak XT	A tip radius of 12.5 µm and a scan resolution of 0.168 µm/point
Variable angle spectroscopic ellipsometry	J.A. Wollam, M-2000U	Different angles from 45°–75° (steps: 5°) An analytical software: J.A. Woollam, WVASE32
SEM	SU8000, Hitachi	

Methods S1. Synthesis

DABNA-NP was prepared by modifying the literature.[S1] The characterization data of the material can be found in another paper.[S2]

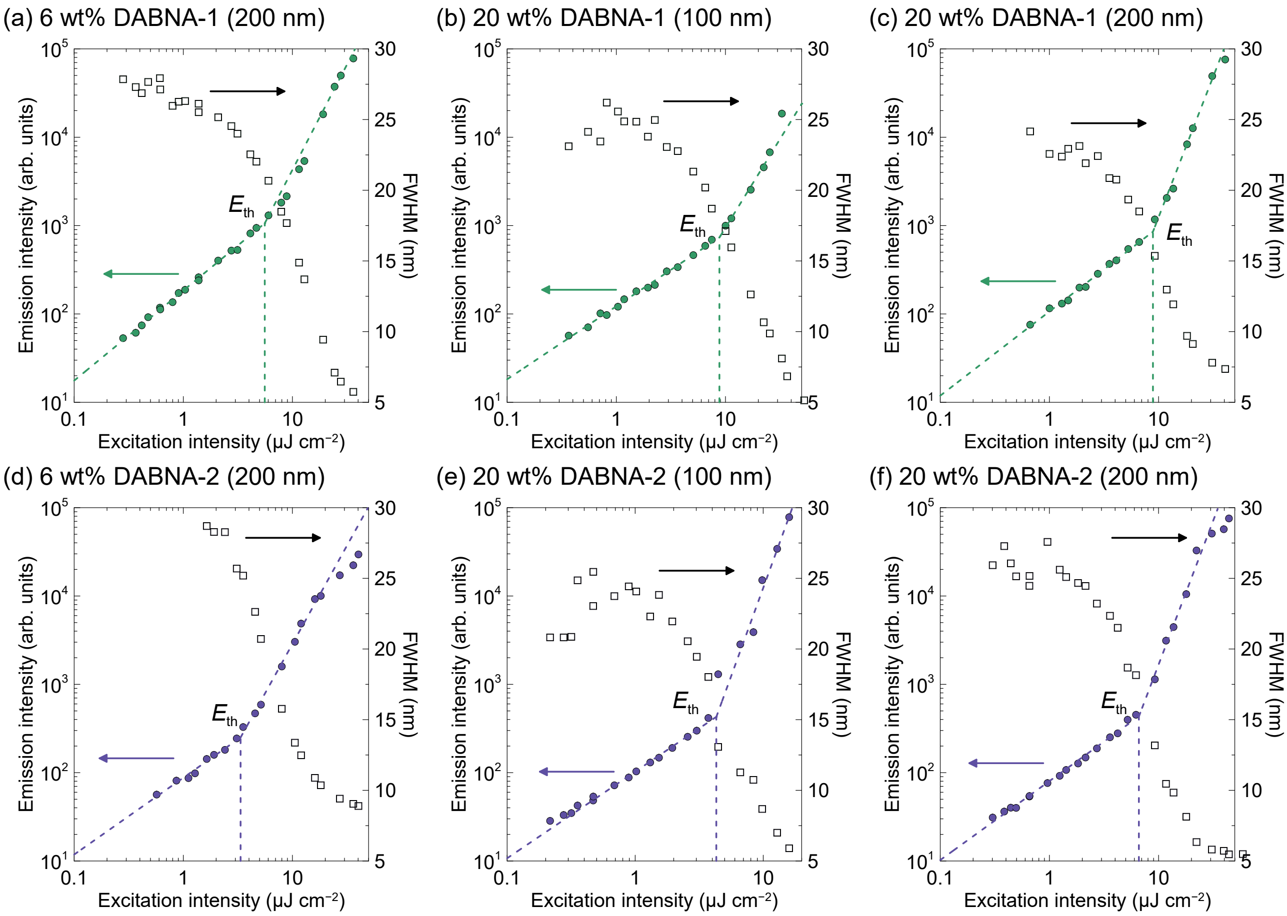

Fig. S1. ASE characteristics of the doped films. Output PL intensity and FWHM values as a function of the excitation energy for (a) 6 wt% DABNA-1 doped film with thickness of 200 nm, (b) 20 wt% DABNA-1 doped film with thickness of 100 nm, (c) 20 wt% DABNA-1 doped film with thickness of 200 nm, (d) 6 wt% DABNA-2 doped film with thickness of 200 nm, (e) 20 wt% DABNA-2 doped film with thickness of 100 nm, and (f) 20 wt% DABNA-2 doped film with thickness of 200 nm.

Table S2. ASE thresholds of DABNA-1 and DABNA-2 doped in mCBP

Compound	Concentration in mCBP	Thickness	E_{th}^{ASE} [μJ cm^{-2}][b]
DABNA-1	6 wt%	100 nm	3.3
	6 wt%	200 nm	5.6
	20 wt%	100 nm	8.8
	20 wt%	200 nm	8.9
DABNA-2	6 wt%	100 nm	2.1
	6 wt%	200 nm	3.3
	20 wt%	100 nm	4.3
	20 wt%	200 nm	6.6

Methods S2. Stimulated emission cross-section (σ_{em})

The σ_{em} spectra were obtained from the following equation:[S3]

$$\sigma_{em} = \frac{\lambda^4 E_f(\lambda)}{8\pi n^2(\lambda) c\tau}$$

where λ is the wavelength, E_f (λ) is the distribution of fluorescence quantum yield in wavelength, $n(\lambda)$ is the refractive index of the active gain layer, c is the speed of light, and τ is the fluorescence lifetime.

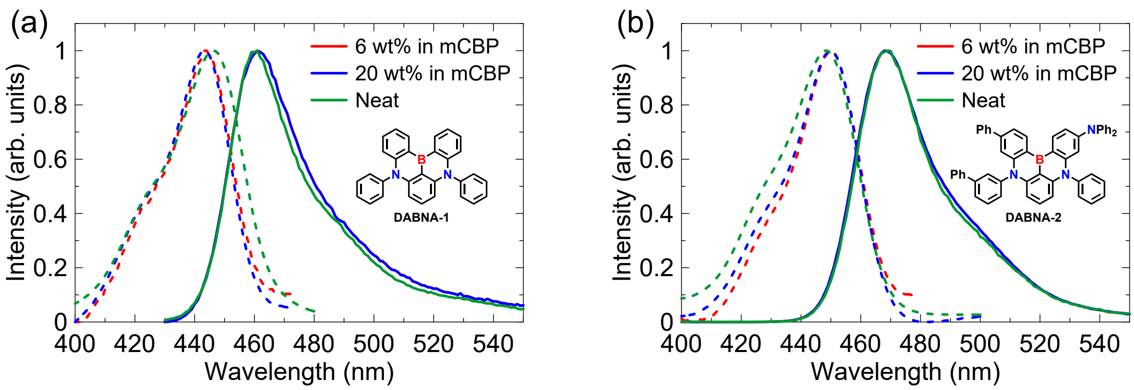

Fig. S2. Normalized UV-Vis absorption (dashed lines) and PL spectra (solid lines) for (a) DABNA-1 and (b) DABNA-2.

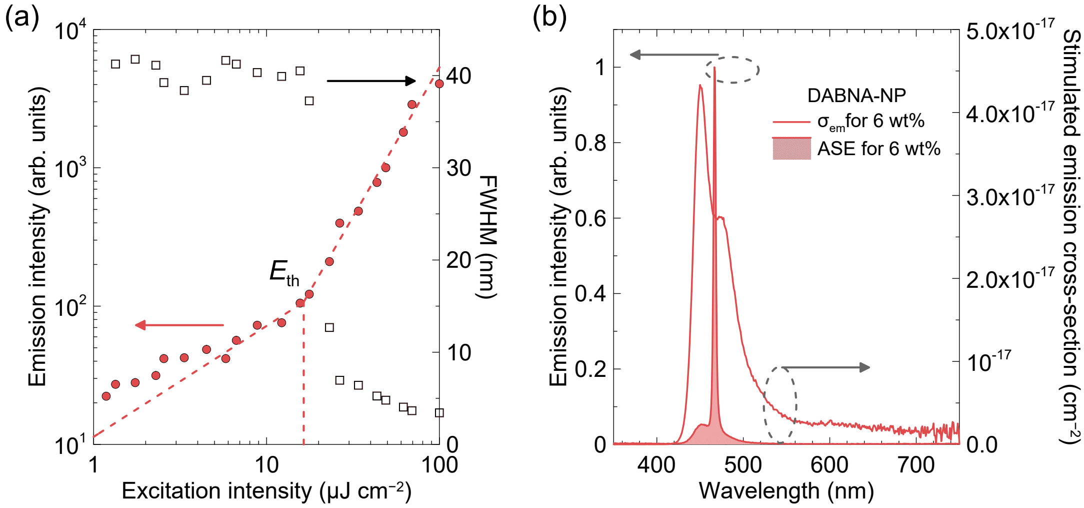

Fig. S3. ASE characteristics of DABNA-NP. (a) PL intensity and FWHM values from edge of the 100-nm-thick films of 6 wt%-DABNA-NP doped mCBP. (b) The stimulated cross-section spectra and PL spectra above the amplified spontaneous emission (ASE) threshold for the films of DABNA-NP.

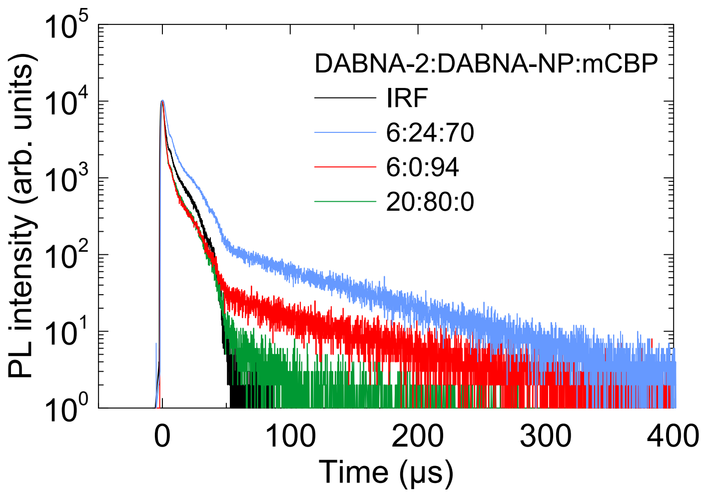

Fig. S4. PL transient decay spectra for the blend films. The delayed fluorescence lifetimes (τ) were 77, 85, and 34 μs for 6:24:70 wt%, 6:0:94 wt%, and 20:80:0 wt% of DABNA-2:DABNA-NP:mCBP, respectively.

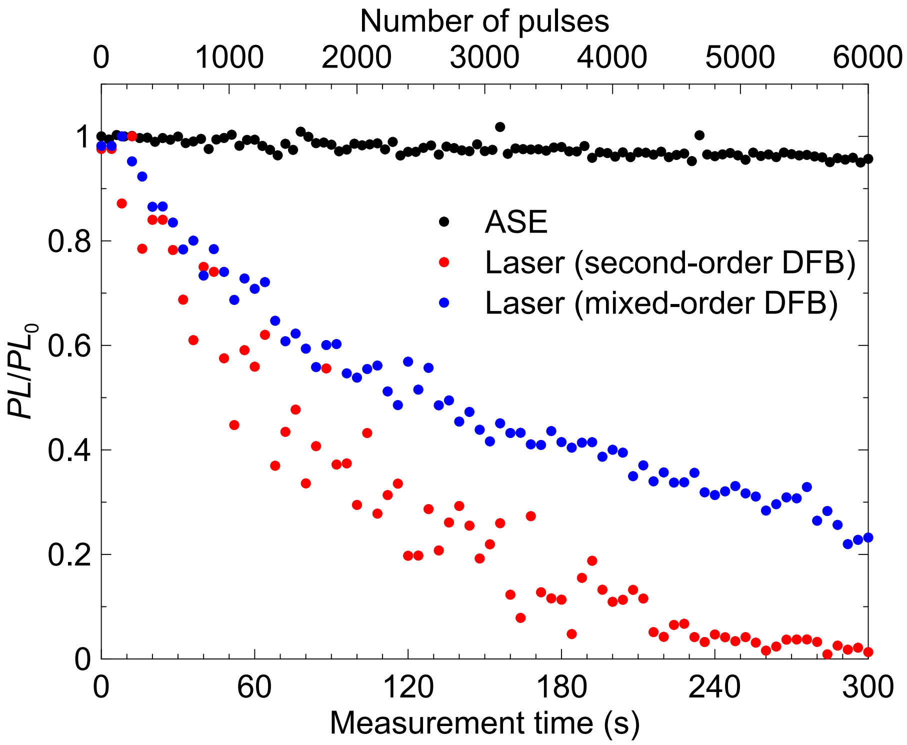

Fig. S5. PL stability. PL intensity normalized to the initial PL intensity for 6 wt% DABNA2 doped mCBP films as a function of operating time. The nitrogen gas laser (337 nm, 0.8 ns pulse, and 20 Hz) was used for the excitation source. The excitation intensity was 1.0 μJ cm^{-2} for lasing, while 20 μJ cm^{-2} for ASE.

Supplementary References

[S1] S. Oda, W. Kumano, T. Hama, R. Kawasumi, K. Yoshiura and T. Hatakeyama, Carbazole-based DABNA analogues as highly efficient thermally activated delayed fluorescence materials for narrowband organic light-emitting diodes, *Angew. Chem. Int. Ed.* 2021, **60**, 2882–2886.

[S2] Y. Wang, Y. Duan, R. Guo, S. Ye, K. Di, W. Zhang, S. Zhuang and L. Wang, A periphery cladding strategy to improve the performance of narrowband emitters, achieving deep-blue OLEDs with CIEy < 0.08 and external quantum efficiency approaching 20%, *Org. Electron.*, 2021, **97**, 106275.

[S3] H. Nakanotani, T. Furukawa, T. Hosokai, T. Hatakeyama and C. Adachi, Light amplification in molecules exhibiting thermally activated delayed fluorescence, *Adv. Opt. Mater.* 2017, **5**, 1700051.