Supporting information for

Lithographic Convex Pattern as a Wavelength-Independent Light

Extraction Structure for Efficient Organic Light-Emitting Diodes

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Scheme S1. The process of fabricating the patterned indium tin oxide (ITO) using establishedlithographytechniques.PEDOT:PSSreferstopoly(3,4-ethylenedioxythiophene):poly(styrenesulfonate).



Figure S2. Optical and morphological characteristics of the etched ITO substrates. (a) The thickness of the ITO convex pattern with different etching time. (b) AFM image of convex ITO. The surface profiles are taken in the direction of the coordinate axes.(c) The sheet resistance and average transmittance parameters of etched ITO with different etching time. (d) Transmission and haze characteristics of the ITO glass substrates with different etching time.



Figure S3. (a) AFM image and (b) height profile of the square convex structures on the ITO surface.



Figure S4. EL performances of the Irtb1 emitter on different ITO substrates. (a) The normalized Electroluminescence spectra. (b) Current efficiency versus current density (CE-*J*) characteristics. (c) Power efficiency versus current density (PE-*J*) characteristics.



Figure S5. Characteristics of the blue organic light-emitting diodes (OLEDs) on planar ITO and convex patterned ITO. (a) Electroluminescence spectra. (b) Current density-voltage-luminance (J-V-L) characteristics. (c) Current efficiency versus luminance (CE-L) characteristics. (d) External quantum efficiency versus luminance (EQE-L) characteristics. (e) Histogram of maximum EQEs of various devices.

Table S1. EL parameters of the blue OLEDs on planar/convex patterned substrates.

Efficiency performance	P-ITO	C ITO	P-ITO	C-ITO
		C-110	w lens	w lens
CE (cd/A) _{max} /Enhancement (%)	23.8/-	30.6/28.6	34.6/45.4	51.3/115.5
PE (lm/W) _{max} / Enhancement (%)	18.2/-	22.5/23.6	26.0/42.9	39.3/115.9
EQE (%) _{max} /Enhancement (%)	17.4/-	23.4/34.5	27.6/85.6	40.0/129.9

In order to illustrate the effect of the convex pattern size on the outcoupling efficiency, we fabricated a ITO convex pattern (denoted to C-ITO 10(10)) with an increased spacing of 10 μ m, while keeping the dimension of 10 μ m. Furthermore, we also fabricated another ITO convex (denoted to C-ITO 20(10)) with an enlarged dimension of 20 μ m, while keeping the spacing of 10 μ m. Note that all the ITO convex matrixes have the same etched depth of ca. 80 nm. The optical images of the different convex patterns are illustrated in Figure S6a.

Blue OLEDs were fabricated on these ITO convex matrix substrates, with the EL spectra, current density–voltage–luminance (*J-V-L*) characteristics, and EQE versus current density characteristics showing in Figure R7c – e. All devices exhibit identical EL spectra and *J-V* curves, indicating that the dimension of the ITO convex pattern has minimal impact on the optical interference and electrical properties. Interestingly, the ITO convex matrix substrates demonstrated improved EQE and luminance compared to the conventional ITO substrate, suggesting their superior light extraction efficiency for OLEDs. Specifically, OLEDs with 10(5), 10(10), and 20(10) ITO convex patterns achieved EQEmax values of 23.5%, 21.9%, and 20.1%, respectively. The results indicate that reducing the spacing between the squared patterns can improve the light extraction efficiency, whereas increasing the dimension of the square patterns leads to a reduction in the light extraction efficiency.



Figure S6 (a) Optical images and (b) the haze of different convex patterned ITO substrates. (c) Normalized electroluminescence spectra, (d) current density-voltage-luminance (*J-V-L*) characteristics, and (e) external quantum efficiency versus current density (EQE-*J*) characteristics of blue OLEDs fabricated on different ITO substrates.



Figure S7. (a) Schematic structures of different OLEDs. (b) Molecular structures of the materials used in OLEDs.



Figure S8. Characteristics of the green OLEDs on planar ITO and convex patterned ITO. (a) Electroluminescence spectra. (b) *J-V* characteristics. (c) EQE-*V* characteristics.



Figure S9. Characteristics of the red OLEDs on planar ITO and convex patterned ITO. (a)

Electroluminescence spectra. (b) J-V characteristics. (c) EQE-V characteristics.



Figure S10. Characteristics of the NIR OLEDs on planar ITO and convex patterned ITO. (a) Electroluminescence spectra. (b) *J-V* characteristics. (c) EQE-*V* characteristics.



Figure S11. Characteristics of the red quantum dots on planar ITO and convex patterned ITO. (a) *J-V* characteristics. (b) CE-*J* characteristics. (c) PE-*J* characteristics. (d) EQE-*J* characteristics. (e) Electroluminescence spectra.



Figure S12. SEM image of the Al electrode of an OLED device prepared on a convex patterned ITO.