Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Supporting Information

Inorganic Cu_2ZnSnS_4 Hole transport layer for Perovskite Light-Emitting Diodes

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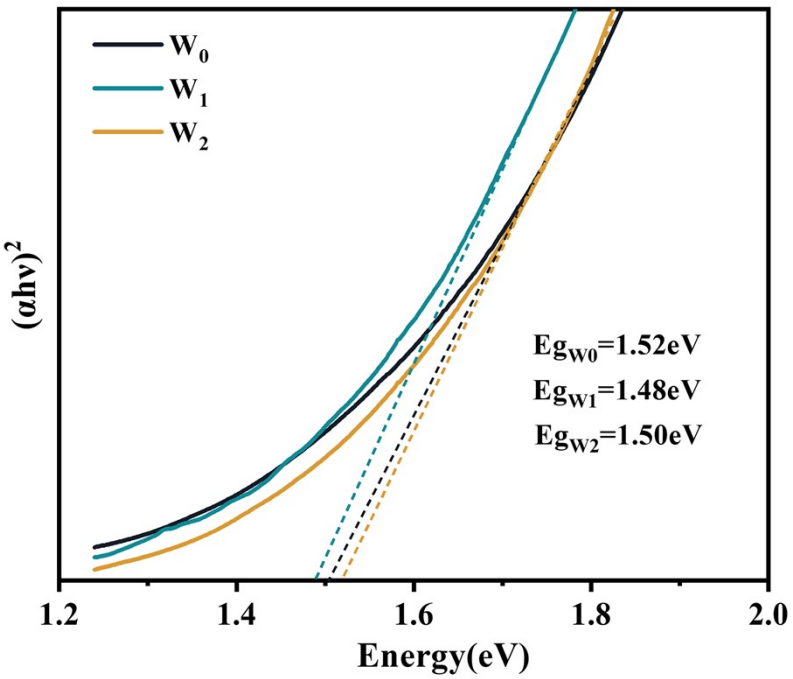

Figure S1. Bandgap spectra of $W_0/W_1/W_2$ films.

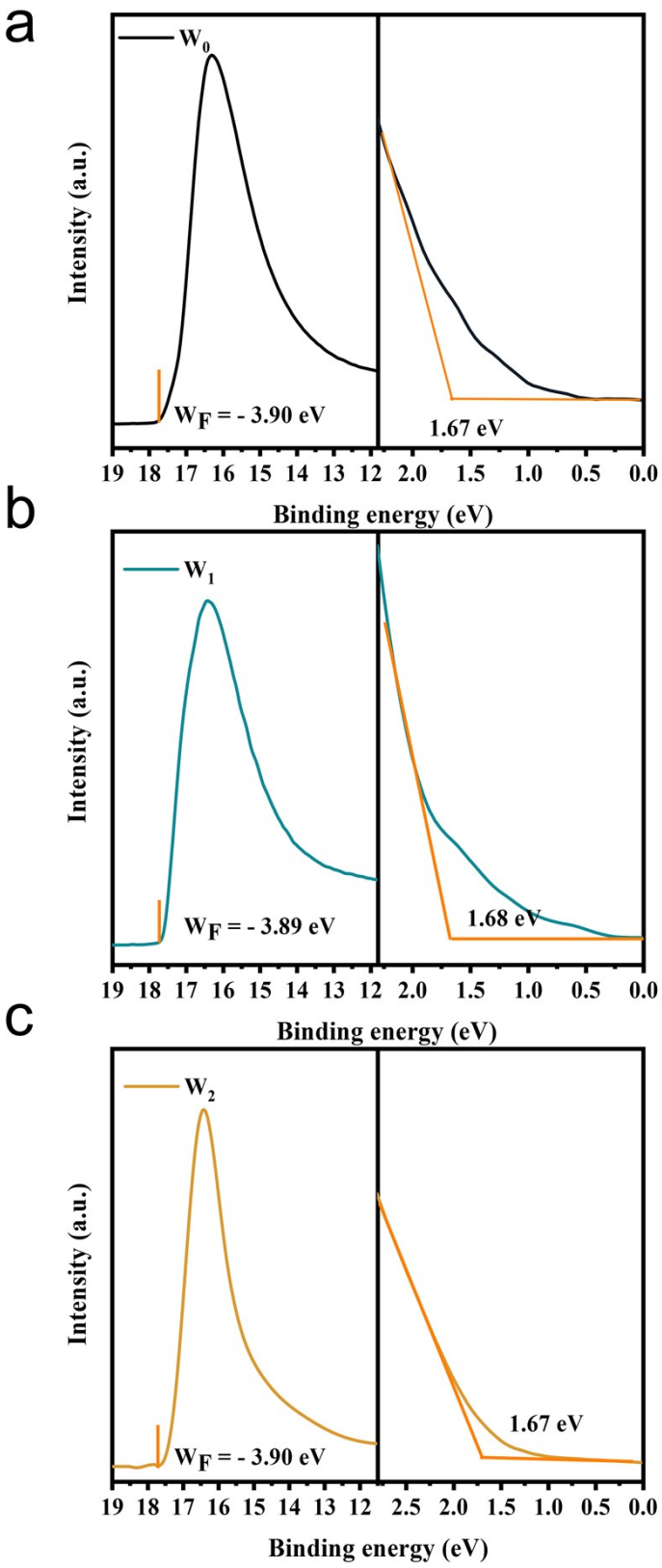

Figure S2. a,b,c) UPS spectra of secondary electron cut-off and valence bands for W_0 /W_1 /W_2 films.

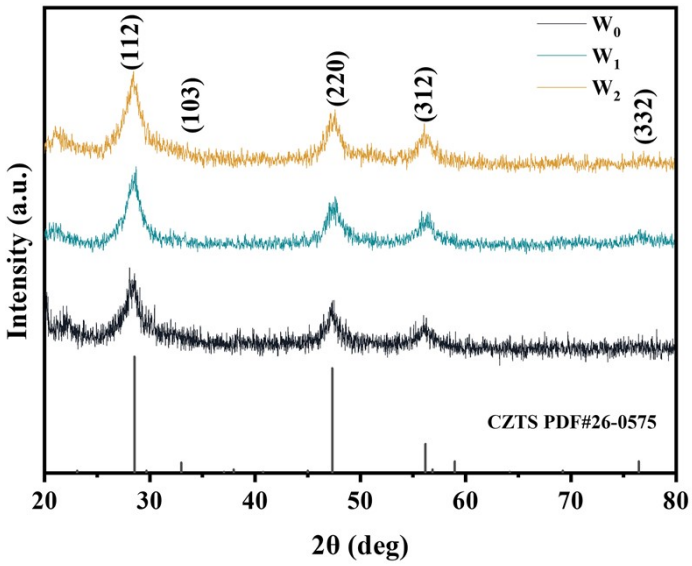

Figure S3. XRD patterns of $W_0/W_1/W_2$ films.

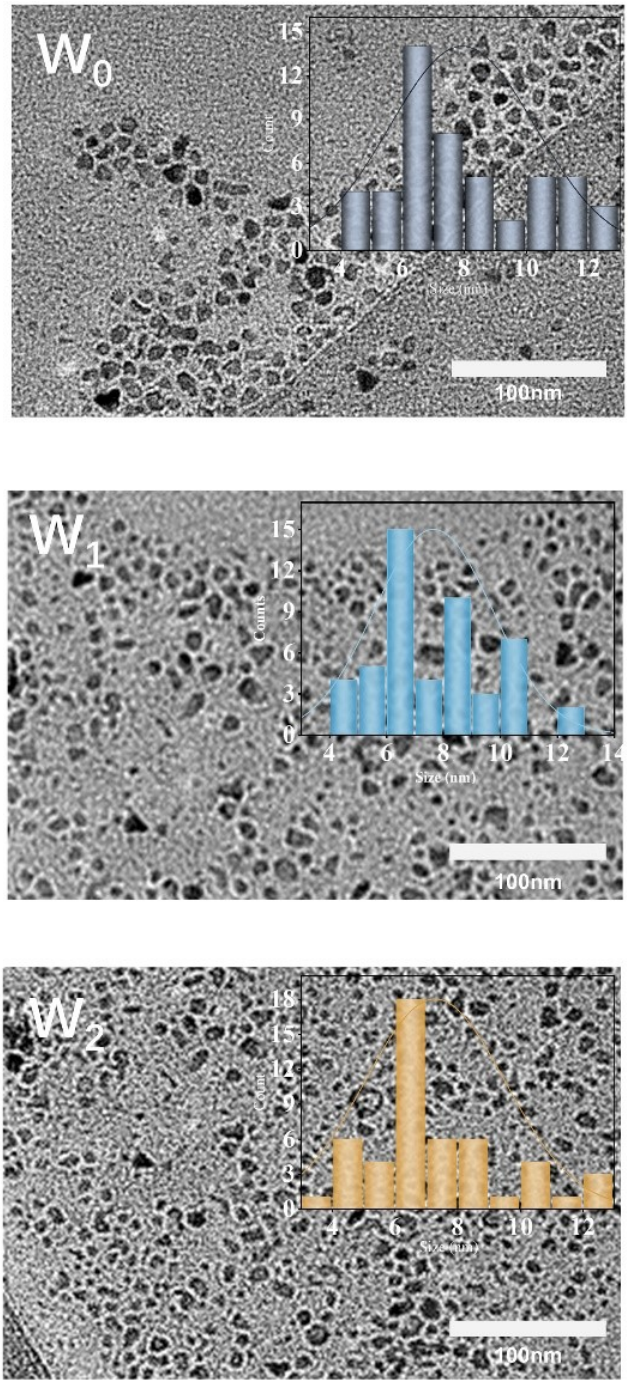

Figure S4. TEM image of $W_0/W_1/W_2$ films.

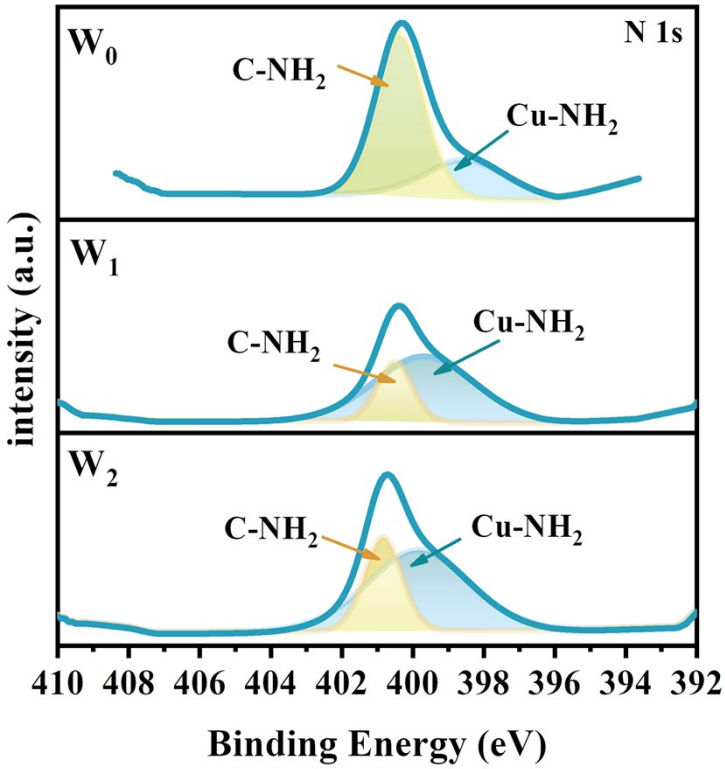

Figure S5. Deconvolution of N 1s core level from the XPS analysis of $W_0/W_1/W_2$ films.

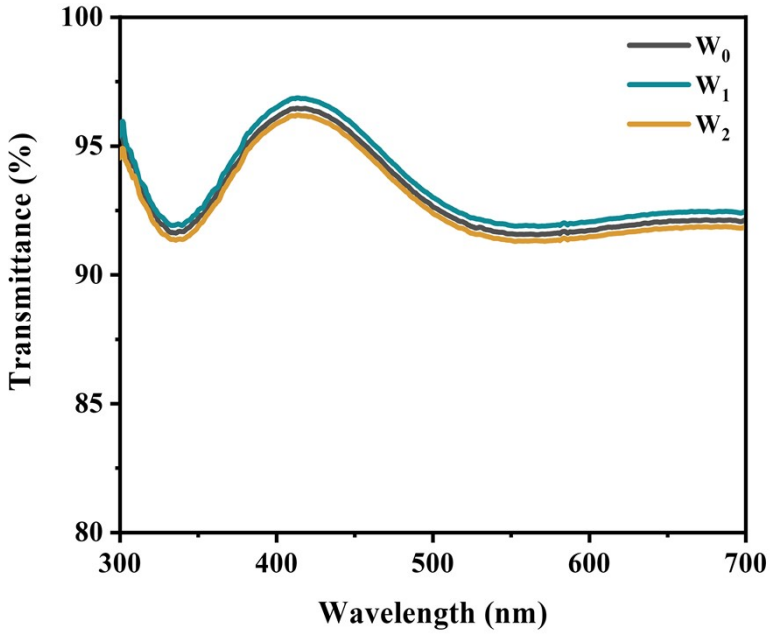

Figure S6. Transmittance spectra of $W_0/W_1/W_2$ films.

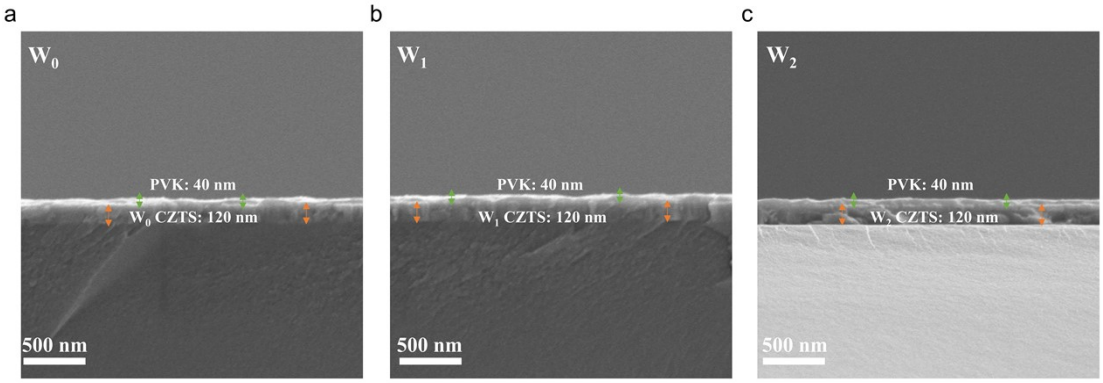

Figure S7. Cross-section SEM images of perovskite films on W_0/ W_1/W_2 CZTS films.

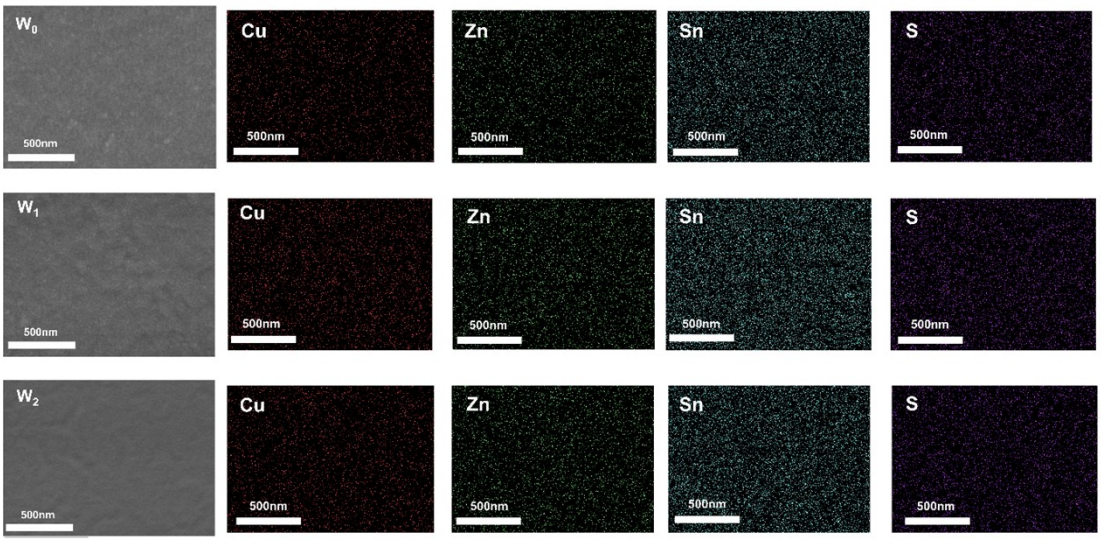

Figure S8. The SEM images and EDS elemental mapping images and the concrete element contents of the $W_0/W_1/W_2$ films.

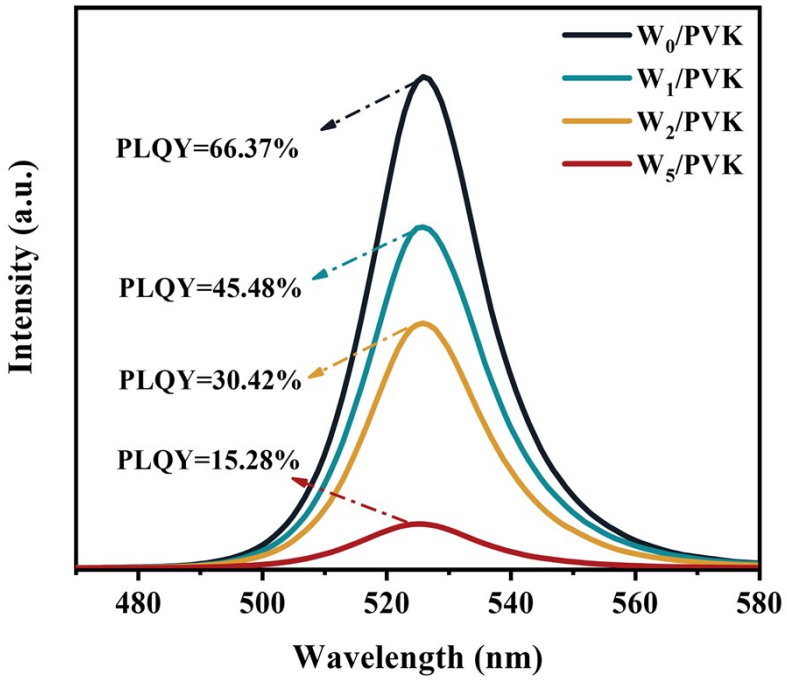

Figure S9. PLQY spectra of the perovskite film on $W_0/W_1/W_2/W_5$ films.

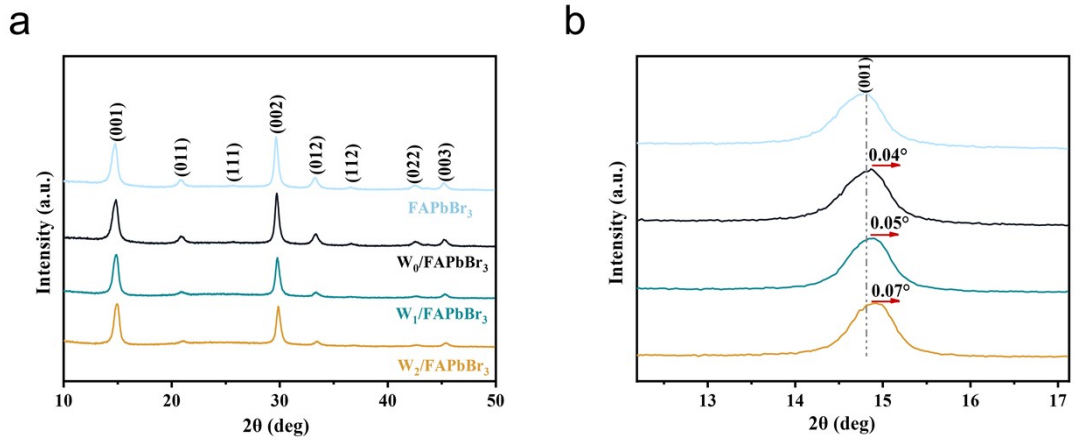

Figure S10. a) XRD patterns of perovskite films on $W_0/W_1/W_2$ films. b) Zoom out XRD peak from 12.5° to 17°.

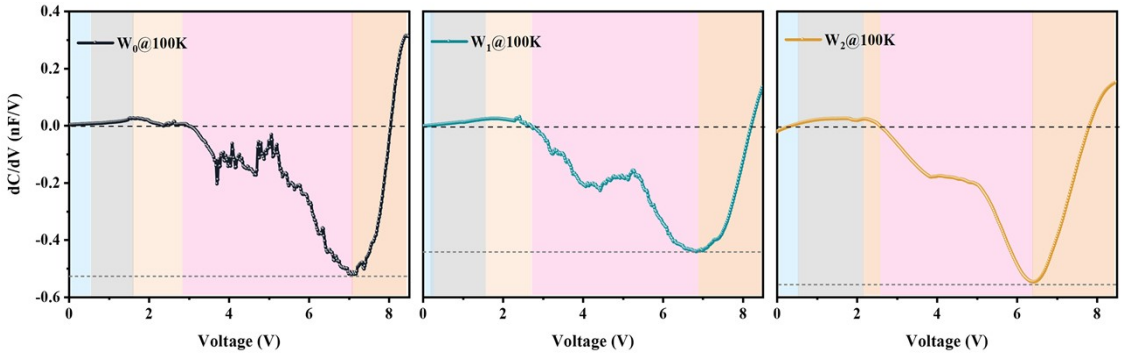

Figure S11. *dC/dV-V* curves of $W_0/W_1/W_2$-based PeLEDs at frequency of 100K.

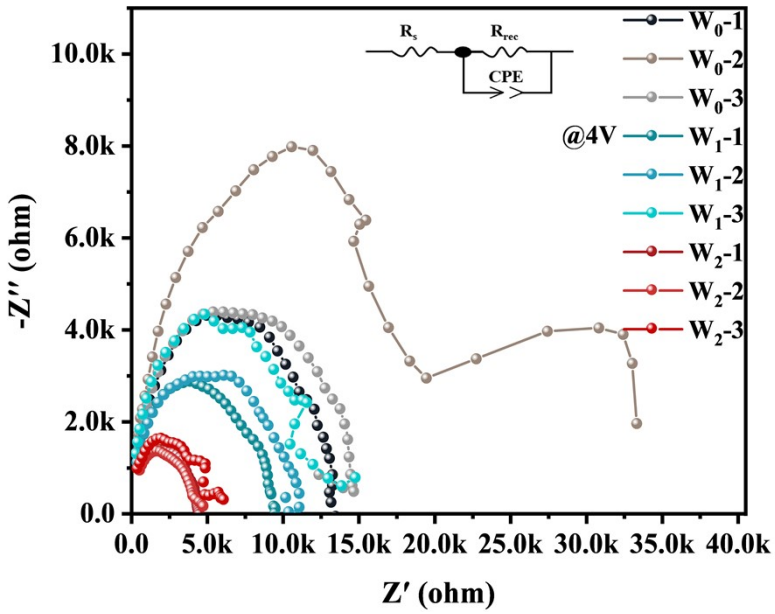

Figure S12. Nyquist plots of impedance spectra of W_0/W_1/W_2-based PeLEDs. Inset shows the equivalent circuit diagram for fitting.

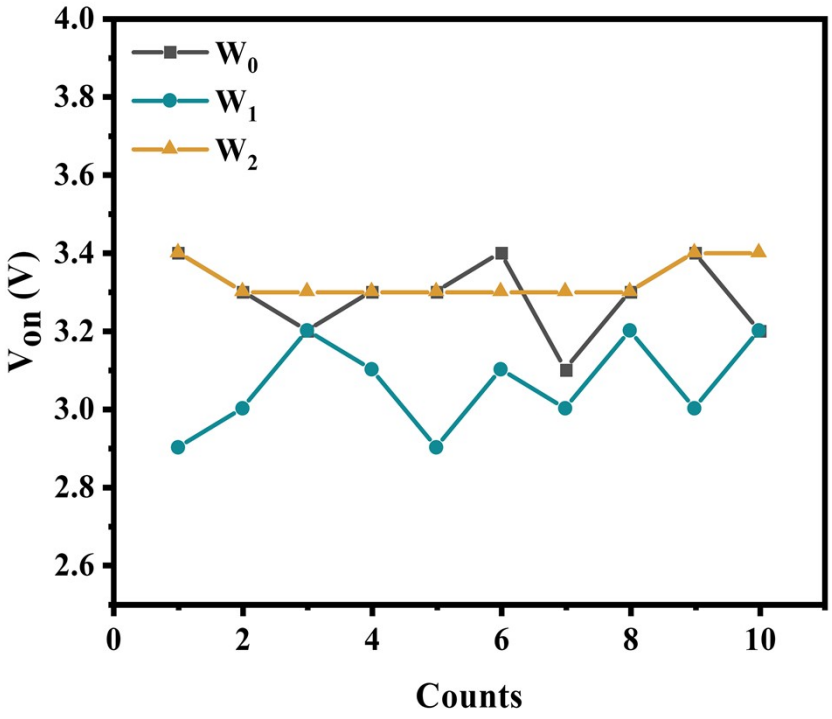

Figure S13. Statistical line chart of V_{on} for ten experiments of $W_0/W_1/W_2$ devices.

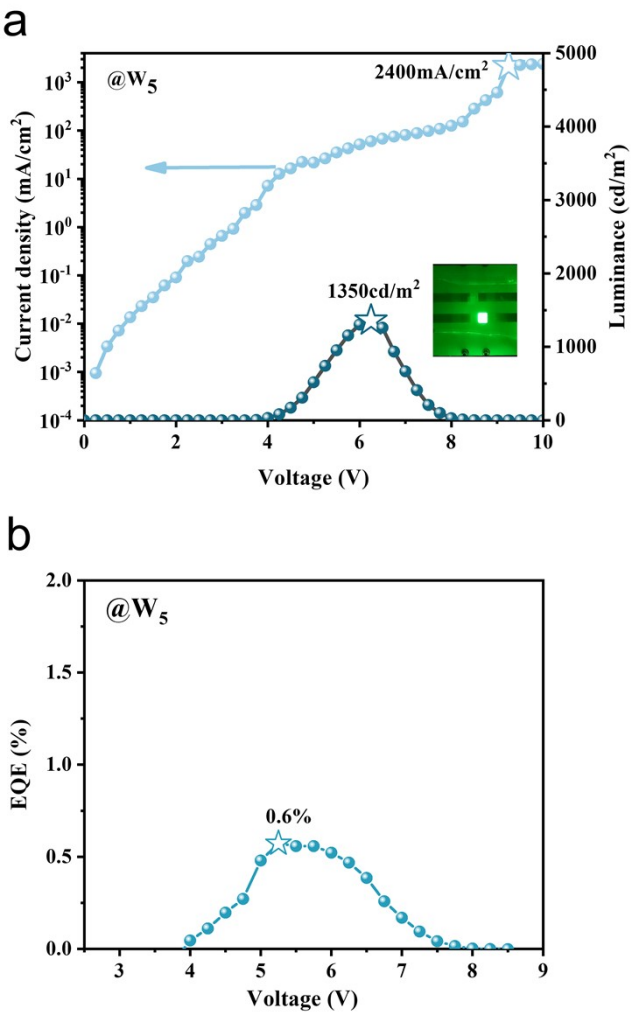

Figure S14. a) Current density-luminance-voltage characteristics curves and b) EQE-voltage curves of W_5–based PeLEDs.

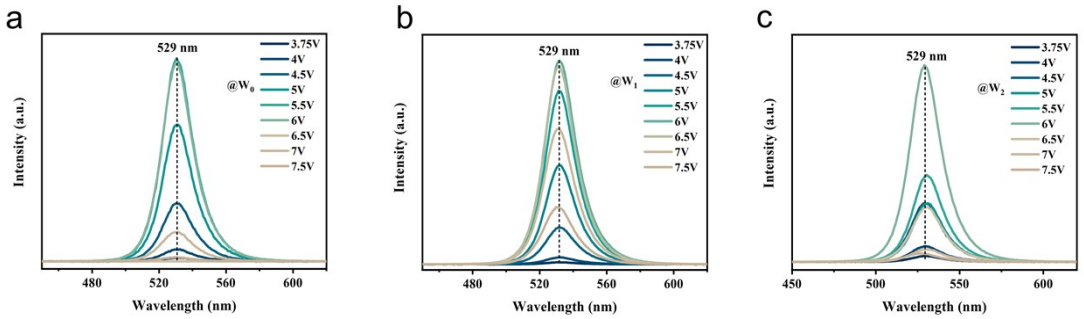

Figure S15. Variational EL spectra with increasing driven voltages of W_0/ W_1/ W_2-based PeLEDs.

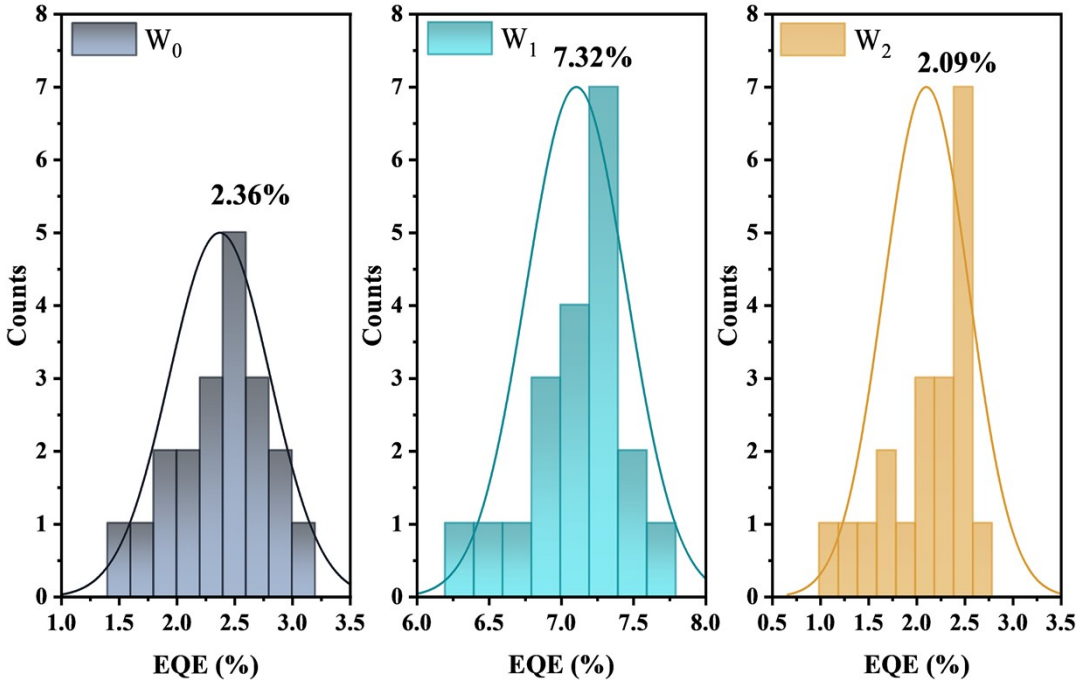

Figure S16. Statistic histogram of EQE of W_0/W_1/W_2-based PeLEDs.

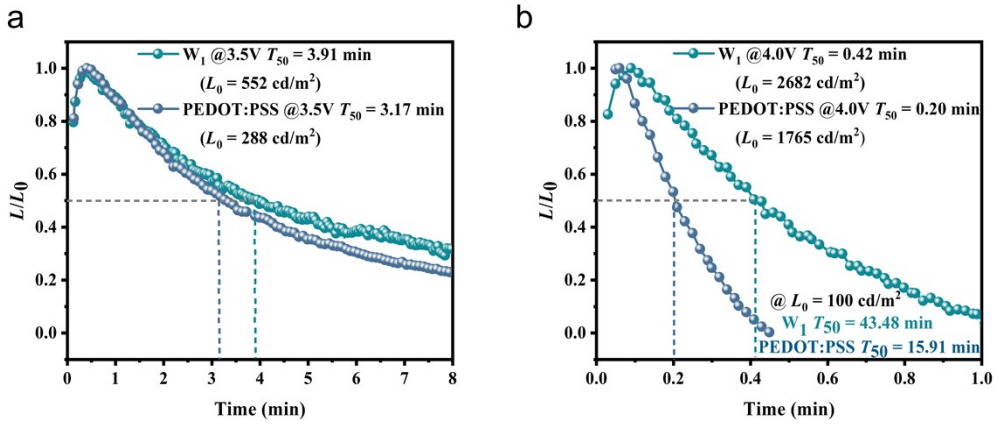

Figure S17. T_{50} measurements of PEDOT:PSS-based PeLEDs and CZTS-based PeLEDs at a) 3.5 V and b) 4.0 V.

Table S1. Fitting values of k_r, k_{nr} Γ_{inh}, γ_{AC}, γ_{LO}, and E_{LO}, E_B of perovskite films deposited on the $W_0/W_1/W_2$ films.

Sample	k_r (× 10^7 s^{-1})	k_{nr} (× 10^7 s^{-1})	Γ_{inh} (meV)	γ_{AC} (eV/K)	γ_{LO} (eV)	E_{LO} (meV)	E_B (meV)
W_0	3.73	1.91	50±3.34	$1.5\times10^{-4}\pm3.2\times10^{-5}$	0.35±0.23	74.27±22.62	180.73±9.02
W_1	3.01	3.63	50±3.61	$1.3\times10^{-4}\pm3.6\times10^{-5}$	0.35±0.16	66.93±16.03	169.16±8.08
W_2	2.70	6.20	50±6.7	$4.5\times10^{-5}\pm8.1\times10^{-5}$	0.21±0.05	45.59±13.09	159.60±7.40