Electronic Supplementary Information

Highly transparent all-perovskite luminescent solar concentrator/photovoltaic windows

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S1. Calculation of photodetector parameters

Responsivity (R), specific detectivity (D^*), and noise equivalent power (NEP) of the Mn:$CsPbCl_3$-3/PS LSC/PV-based photodetectors were calculated by the following equations:[1,2]

$$R = \frac{I_{on} - I_{dark}}{PA_{top}} \quad (1)$$

$$D^* = \frac{RA_{top}{}^{1/2}}{(2eI_{dark})^{1/2}} \quad (2)$$

$$NEP = \frac{A_{top}{}^{1/2}}{D^*} \quad (3)$$

where I_{on} and I_{dark} are the on and off-current of the PSCs, respectively, P is the power of incident UV light, A_{top} is the top-area of the LSCs , and e is the elementary chage.

[1] Z. Cheng, K. Liu, J. Yang, X. Chen, X. Xie, B. Li, Z. Zhang, L. Liu, C. Shan, D. Shen, *ACS Appl. Mater. Interfaces,* 2019, **11**, 34144-34150.

[2] H. Oh, H. J. Kim, S. Kim, J. A Kim, G. Kang, M. Park, *Appl. Surf. Sci.,* 2021, **544**, 148850.

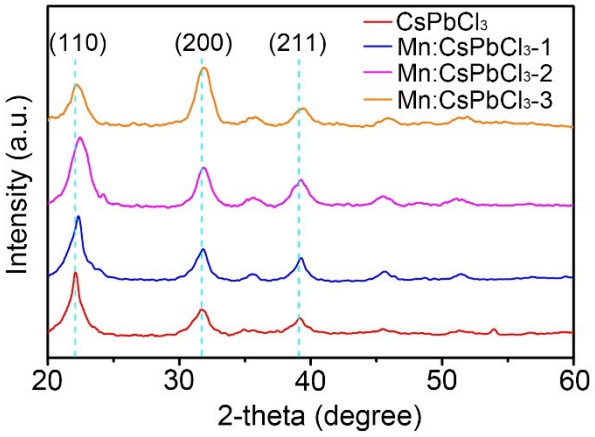

Figure S1. XRD patterns of the $CsPbCl_3$, Mn:$CsPbCl_3$-1, Mn:$CsPbCl_3$-2, and Mn:$CsPbCl_3$-3 NC films.

Table S1. Time-resolved photoluminescence (TRPL) parameters for the Mn:$CsPbCl_3$ and Mn:$CsPbCl_3$-3/PS deposited onto glass substrates fitted using a bi-exponential decay function.[a)]

LSC	a_1	τ_1 [ms]	a_2	τ_2 [ms]	τ_{avg} [ms] [b)]
Mn:$CsPbCl_3$	0.569	0.185	0.431	3.289	1.523
Mn:$CsPbCl_3$-3/PS	0.493	0.374	0.507	4.462	2.447

a)Fit function = $a_1 e^{-t/\tau_1} + a_2 e^{-t/\tau_2}$

b) $\tau_{avg} = (\sum_i a_i \tau_i)/(\sum_i a_i), where \sum_i a_i = 1$

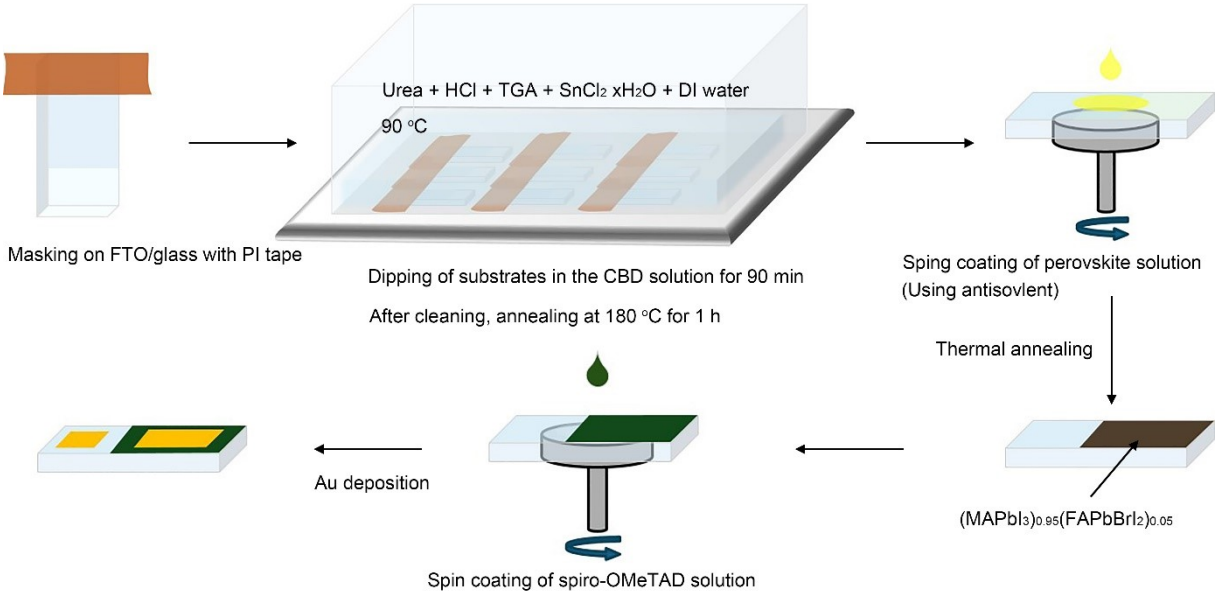

Figure S2. Schematic illustrating the overall process employed to fabricate the n-*i*-p structured PSCs.

Table S2. Parameters of the series-connected PSCs.[1)]

Number of cells	V_{oc} [V]	J_{sc} [mA cm^{-2}]	FF	PCE [%]
1	1.14	23.87	0.774	21.06
4	4.55	5.944	0.772	20.88
8	9.07	2.964	0.769	20.67
16	18.1	1.48	0.765	20.49

1) The values were measured under a standard AM 1.5G illumination of 100 mW cm^{-2}.

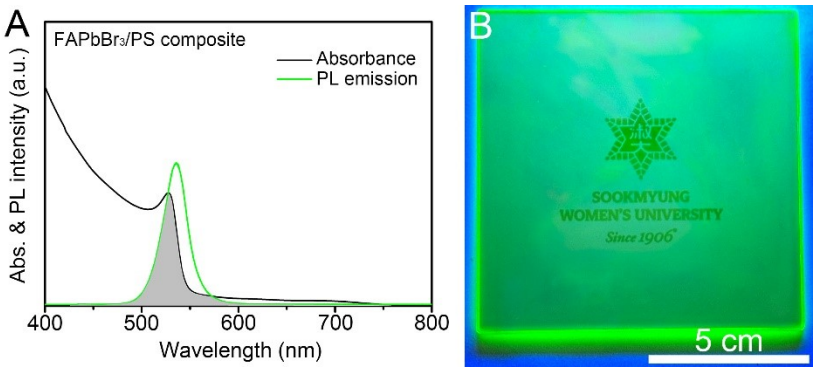

Figure S3. (A) UV-visible absorption and PL emission spectra of the $FAPbBr_3$/PS LSC. The absorption-emission spectral overlap area is indicated in dark gray. (B) Photographic image of the $FAPbBr_3$/PS LSC under UV light illumination at $\lambda = 365$ nm (LSC size = 10 × 10 cm).

Table S3. Comparison of recently reported optical efficiencies of PeLSCs coupled with Si solar cells.

LSC materials	Geometric factor	Optical efficiency [%]	Ref.
$CsPb(Br_{0.25}I_{0.75})_3$-PMMA	12.5	5.88	S1
$MAPbBr_3$/PVP nanofibers	11.06	3.62	S2
Au-doped $MAPbBr_3$ NCs/PMMA	10	1.36	S3
$PEA_2MnBr_2I_2$	25	1.57	S4
Bi-doped $Cs_2Na_{0.6}Ag_{0.4}InCl_6$	10	2.57	S5
Quasi 2D $PEA_2MA_{x-1}Pb_xBr_{3x+1}$	12.5	4.9	S6
$CsPbBr_3$ NCs	20.8	2.1	S7

(S1) H. Guo, P. Xia, S. Huang, H. Sun, C. Lu, C. Liang, X. Zhou, S. Xu, C. Wang, *Adv. Funct. Mater.*, 2024, 2409232 doi.org/10.1002/adfm.202409232

(S2) H. Oh, G. Kang, M. Park, *ACS Appl. Energy Mater.*, 2022, **5**, 15844-15855.

(S3) E. Bagherzadeh-Khajehmarjan, S. M. Shakouri, A. Nikniazi, S. Ahmadi-Kandjani, *Org. Electron.*, 2022, **109**, 106629.

(S4) P. Xia, Y. Duan, X. Hu, C. Lu, S. Xu, C. Wang, *J. Energy Chem.*, 2023, **78**, 188-194

(S5) S. Li, Y. Zhang, Z. song, Z. Zheng, X. Zhang, X. Liu, *J. Mater. Chem. C*, 2024, **12**, 10096-10103.

(S6) X. –F. Liu, B. Sun, X. –Y. Li, Y. Huo, C. Zhang, H. –L. Zhang, *J. Mater. Chem. C*, 2024, **12**, 16627-16635.

(S7) Y. Zhang, W. Zhang, Y. Ye, K. Li, C. Liu, *Sol. Energy Mater. Sol. Cells*, 2022, **238**, 111619.

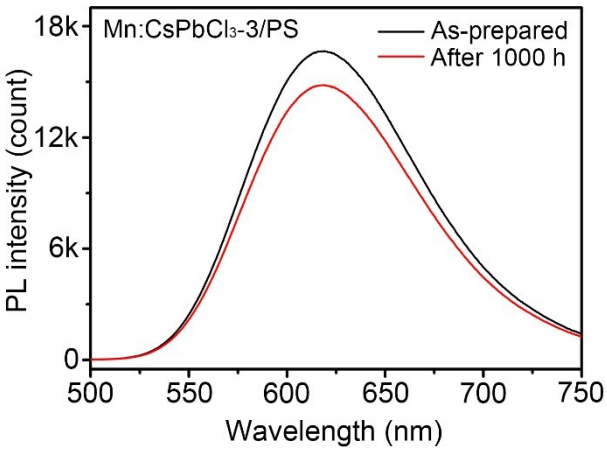

Figure S4. Steady-state PL spectra of the as-prepared Mn:$CsPbCl_3$-3/PS LSC and Mn:$CsPbCl_3$-3/PS LSC exposed to 1 sun illumination for 1000 h (RH = 10% and 25 °C).