Electronic Supplementary Information (ESI)

Semitransparent Polymer Solar Cells Floating on Water: Selected Transmission Windows and Active Control of Algal Growth

Luqi Yin,[a] Yao Zhou,[b] Tong Jiang,[b] Yunxiang Xu,[a] Tong Liu,[a] Na Li,[a] Ke Zhou,*[,c]
Liangmin Yu,[d,e] Cui Guo,*[,b] Petri Murto,[f] & Xiaofeng Xu*[,a]

[a] College of Materials Science and Engineering, Ocean University of China, Qingdao 266100, China.

[b] College of Marine Life Science, Institute of Evolution and Marine Biodiversity, Ocean University of China, Qingdao 266003, China.

[c] State Key Laboratory for Mechanical Behavior of Materials, Xi'an Jiaotong University, Xi'an 710049, China.

[d] Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 266100, China.

[e] Open Studio for Marine Corrosion and Protection, Pilot National Laboratory for Marine Science and Technology, Qingdao 266237, China.

[f] Department of Chemistry, University of Cambridge, Cambridge CB2 1EW, United Kingdom.

* Corresponding authors: X. Xu, email: xuxiaofeng@ouc.edu.cn
C. Guo, email: guocui@ouc.edu.cn
K. Zhou, email: msekzhou@mail.xjtu.edu.cn

Table of Contents

1. Materials

The donor polymer PBDB-TF-T10 was prepared according to the previous literature.[1] The small-molecule acceptor Y6 were purchased from Solarmer Energy, Inc. The four algae (*Chlorella sp*., *A. carterae* and *P. tricornutum* and *Synechococcus*) were cultivated in the labs of College of Marine Life Science, Ocean University of China.

2. Absorbance of materials

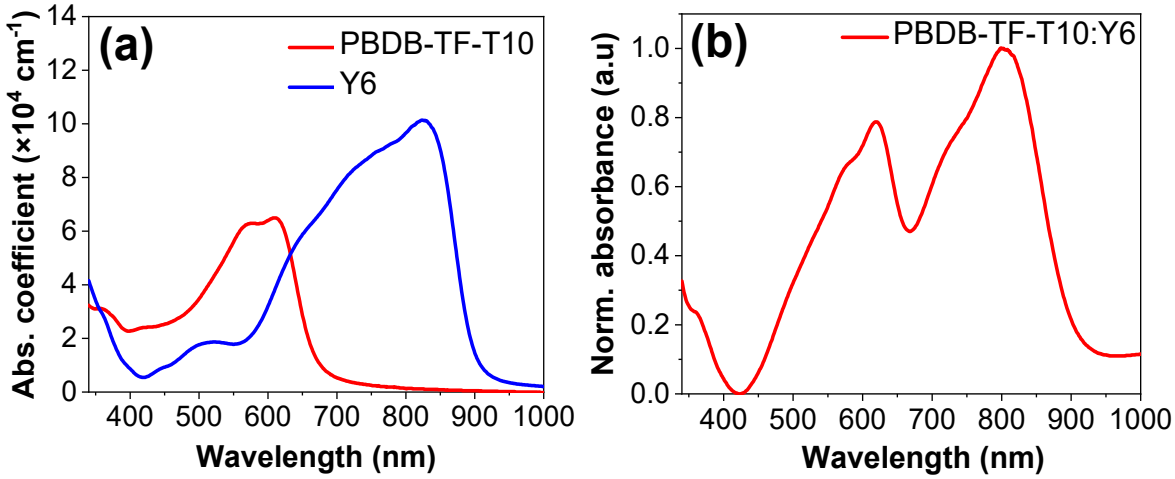

Figure S1. (a) Absorption coefficients of the donor and acceptor in thin films; (b) normalized absorbance of the blend film.

UV−Vis−NIR absorption spectra were measured with a SHIMADZU UV2600 UV−Vis absorption spectrometer.

3. Device structures of PSCs

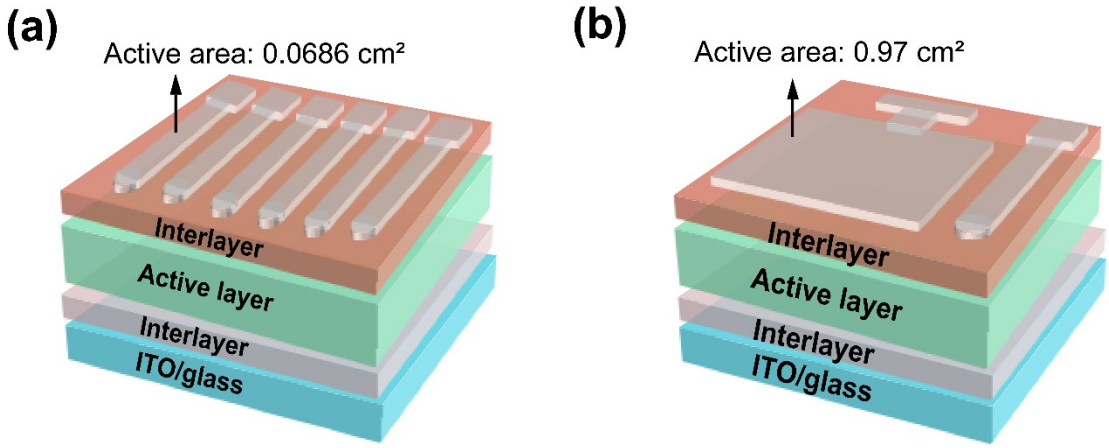

Figure S2. Device structures of (a) small-area and (b) large-area PSCs.

4. *J*–*V* and EQE characterization

All *J*–*V* curves of PSCs were recorded in backward scan direction by using a Keithley 2400 source meter under a solar simulator (Oriel Sol3A, 69920, Newport) with simulated AM1.5G illumination at 100 mW/cm^2. The intensity of light was calibrated by using a Si-based power meter (PT-SI-SRC, Pharos). For the EQE measurements, the photocurrent was measured by using a Keithley 485 picoammeter under monochromatic light (MS257) illumination across the PSCs. The current was recorded as the voltage over a 50 Ω resistance and converted to a EQE profile by comparing the data with a calibrated Si reference cell.

5. Exciton dissociation characterization

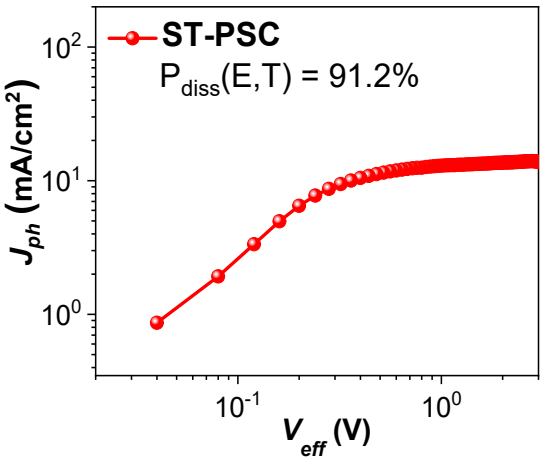

Figure S3. J_{ph} versus V_{eff} of ST-PSC.

6. Space charge limited current (SCLC) mobility measurements

Hole mobility was measured in a hole-only device composed of ITO/PEDOT:PSS/active layer/MoO_3/Ag. The electron mobility was measured in an electron-only device composed of ITO/ZnO/active layer/PDINO/Ag. For the hole-only device, PEDOT:PSS was spin-coated on ITO at 4000 rpm for 30 s and thermal-annealed at 150 ℃ for 20 min. Chloroform solution of the blend were spin-coated at 3000 rpm for 30 s and baked at 110 ℃ for 10 min in a glove box. After that, MoO_3 (8 nm) and Ag (15 nm) were successively vacuum-deposited on the active layers. For the electron-only device, sol-gel ZnO was spin-coated onto the ITO-coated glass at a spinning rate of 4000 rpm for 40 s, followed by thermal annealing at 150 ℃ for 20 min. Chloroform solution of the blend was spin-coated on the layer of ZnO (40 nm) in a glove box. After that, the ethanol solution of PDINO was spin-coated at 3000 rpm for 25 s. Finally, Ag (15 nm) was vacuum-deposited on top of the PDINO film (5 nm).

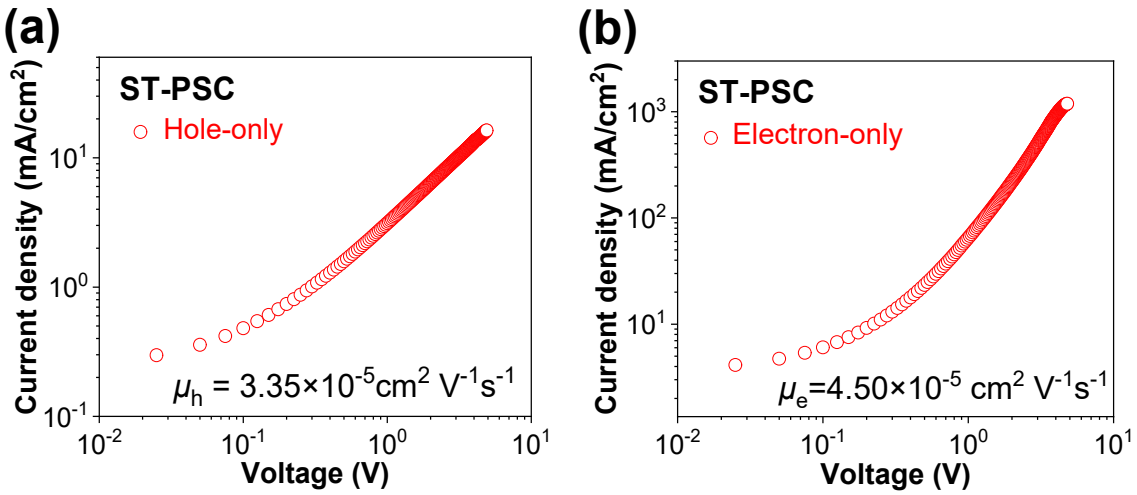

Figure S4. (a) Current density−voltage curves of the hole-only device with the structure of ITO/PEDOT:PSS (40 nm)/PBDB-TF-T10:Y6/MoO_3(8 nm)/Ag(15 nm). (b) Current density−voltage curves of the electron-only device with the structure of ITO/ZnO (40 nm)/PBDB-TF-T10:Y6/PDINO (5 nm)/Ag (15 nm).

According to the Murgatroyd law and using the Equation (S1) to fit the trap-filled region of the J–V curves from the single carrier devices, SCLC mobilities was calculated in a precise way.[2]

$$J = \frac{9}{8}\varepsilon_r\varepsilon_{o\mu}\frac{(V-V_{bi})^2}{L^3}\exp\left(\frac{0.89}{KT}\gamma\left(\frac{\sqrt{V-V_{bi}}}{\sqrt{L}}\right)\right) \qquad \text{(S1)}$$

where J is the current density, ε_r is the relative dielectric constant of the polymer blend (ε_r = 3.6), ε_0 is the free-space dielectric constant, μ is the temperature-dependent mobilities at zero field, L is the thickness of the active layer, $V-V_{bi}$ is the effective voltage, k is Boltzmann constant, T is the absolute temperature and γ is the field enhancement factor.

7. Charge recombination characterization

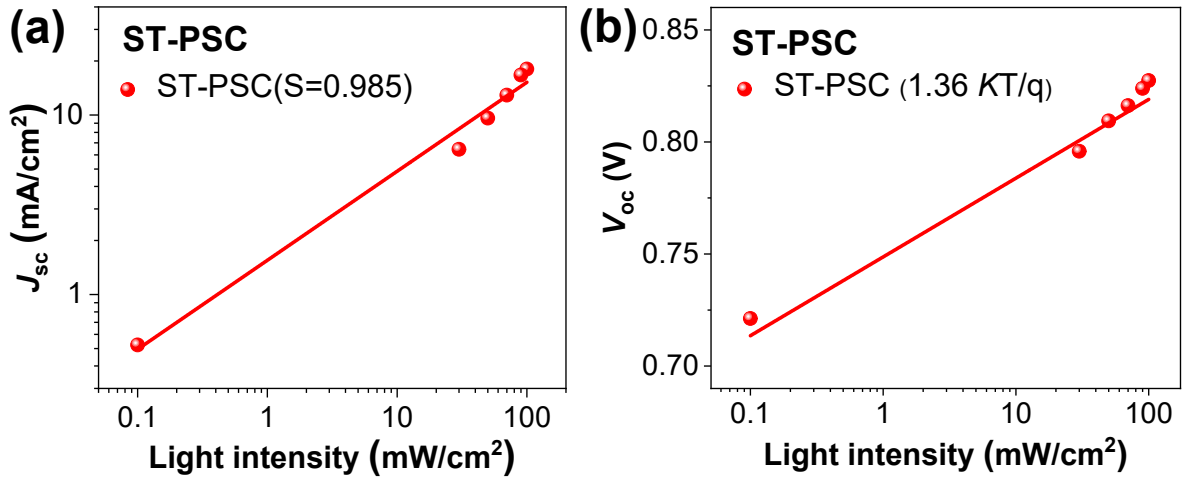

Figure S5. Light intensity dependence of (a) J_{sc} and (b) V_{oc} of ST-PSCs.

8. *J*–*V* curves of large-area PSCs

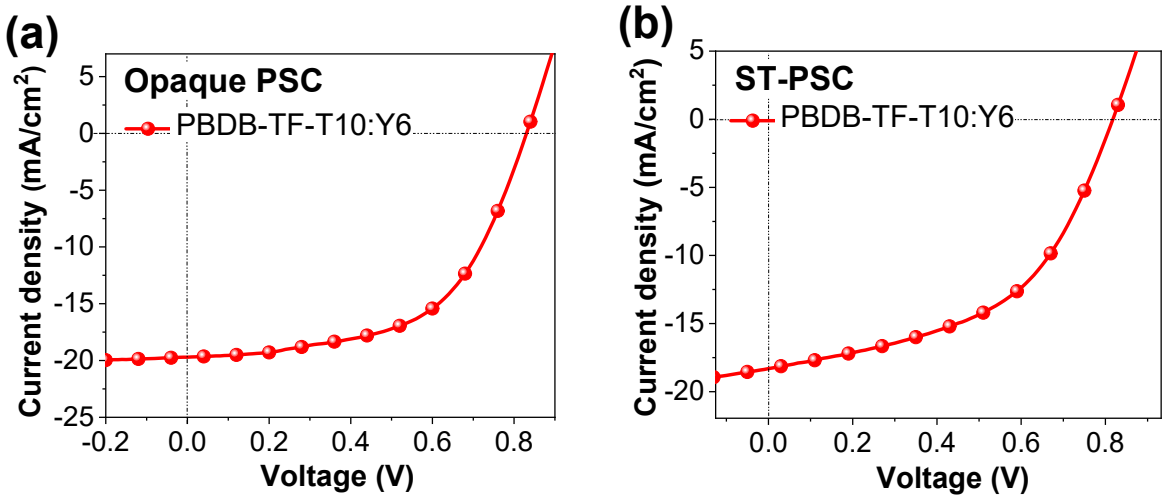

Figure S6. *J*–*V* curves of large-area PSCs.

9. CIE chromaticity diagram

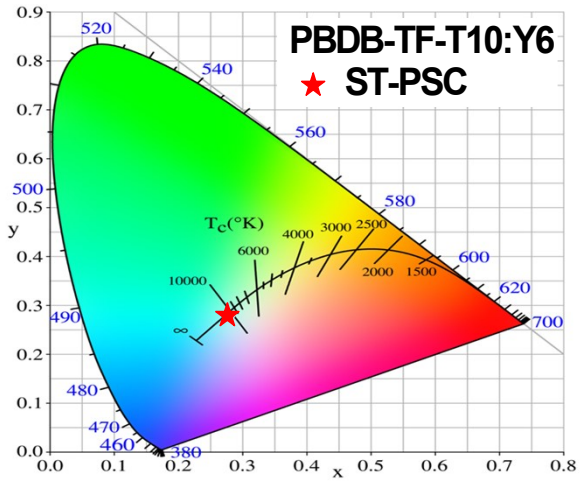

Figure S7. A CIE chromaticity diagram exhibiting color coordinates of ST-PSC.

10. Absorption spectra of photosynthetic pigments

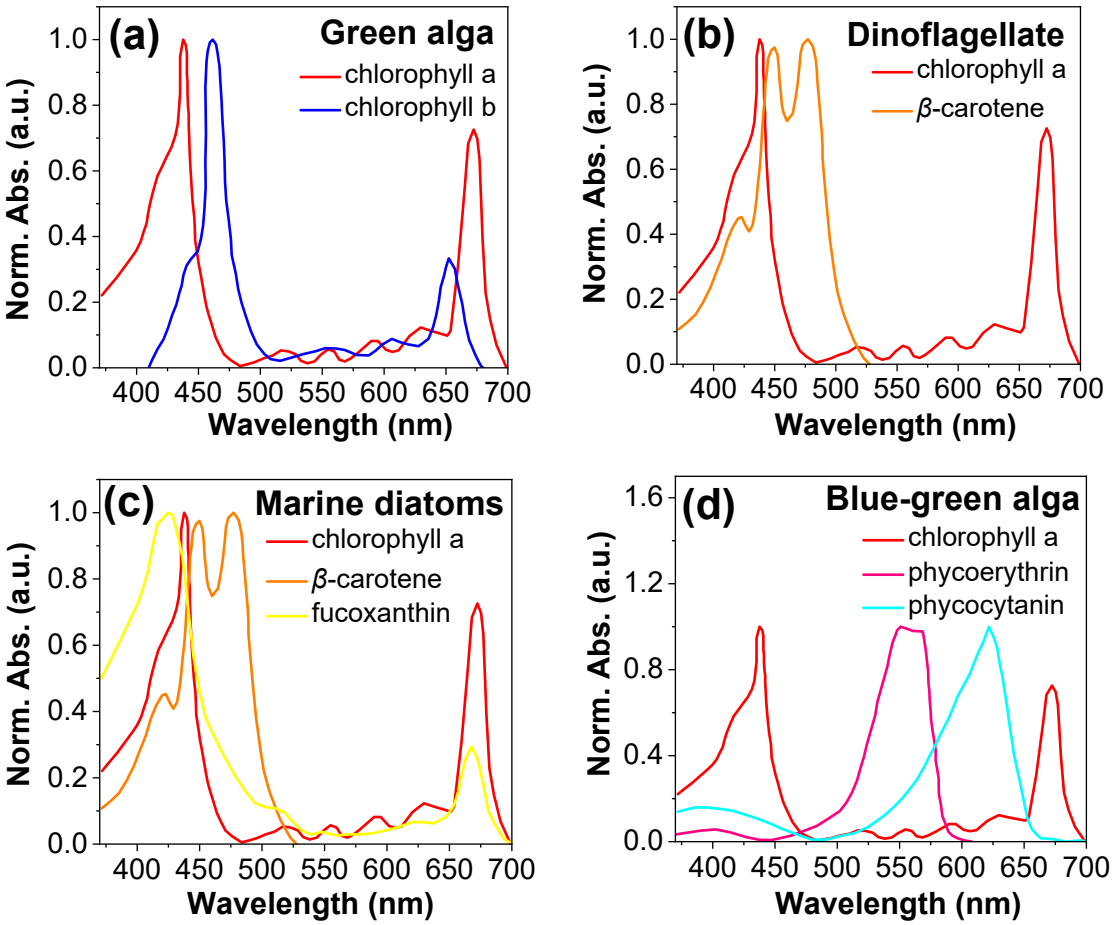

Figure S8. Absorbance spectra of photosynthetic pigments in the algae selected in this study.

11. Absorption spectrum of photosynthetic pigments in *Chlorella sp.*

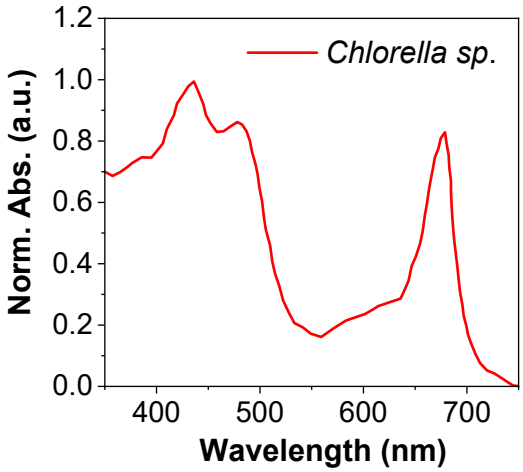

Figure S9. An absorption spectrum of photosynthetic pigments extracted from *Chlorella sp.*.

12. Summary of photosynthetic parameters

Table S1. Summary of F_v/F_m of the four algae under different shading conditions.

algae	conditions	F_v/F_m (initial time)	F_v/F_m (middle time)	F_v/F_m (final time)
Chlorella sp.[a]	Control	0.68	0.60	0.62
	ST-PSC		0.65	0.68
	PSC		0.67	0.70
A. carterae [b]	Control	0.66	0.59	0.62
	ST-PSC		0.59	0.66
	PSC		0.67	0.69
P. tricornutum [c]	Control	0.57	0.62	0.62
	ST-PSC		0.66	0.67
	PSC		0.66	0.68
Synechococcus [d]	Control	0.32	0.34	0.38
	ST-PSC		0.22	0.29
	PSC		0.32	0.35

[a] F_v/F_m of *Chlorella sp.* were recorded at 0 h, 36 h and 72h;
[b] F_v/F_m of *A. carterae* were recorded at 0 h, 40 h and 80 h;
[c] F_v/F_m of *P. tricornutum* were recorded at 0 h, 48 h and 96 h;
[d] F_v/F_m of *Synechococcus* were recorded at 0 h, 60 h and 120 h.

13. Flow cytometric dot-plots of *Synechococcus*

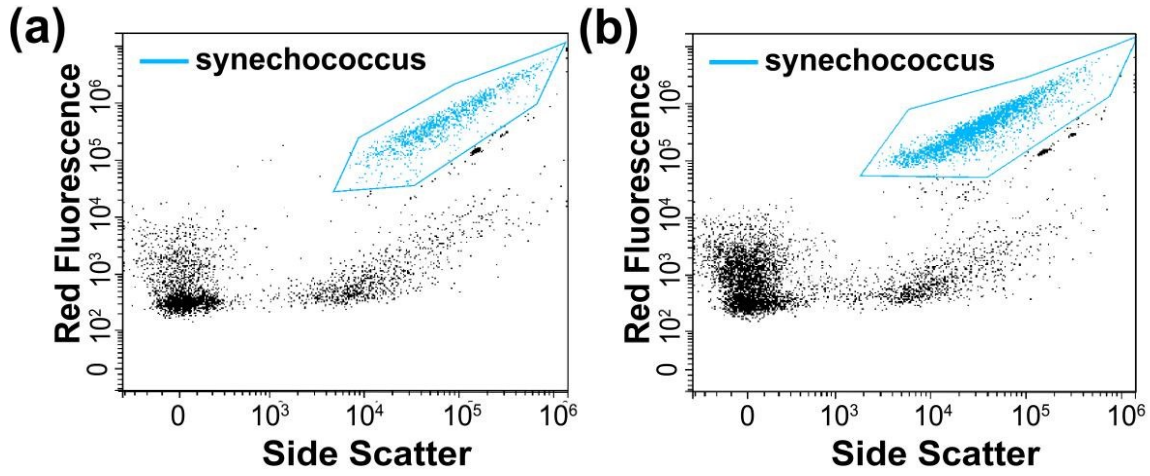

Figure S10. Flow cytometric dot-plots of *Synechococcus* under ST-PSCs at (a) 0 h and (b) 120 h.

14. *J*–*V* curves of integrated ST-PSCs

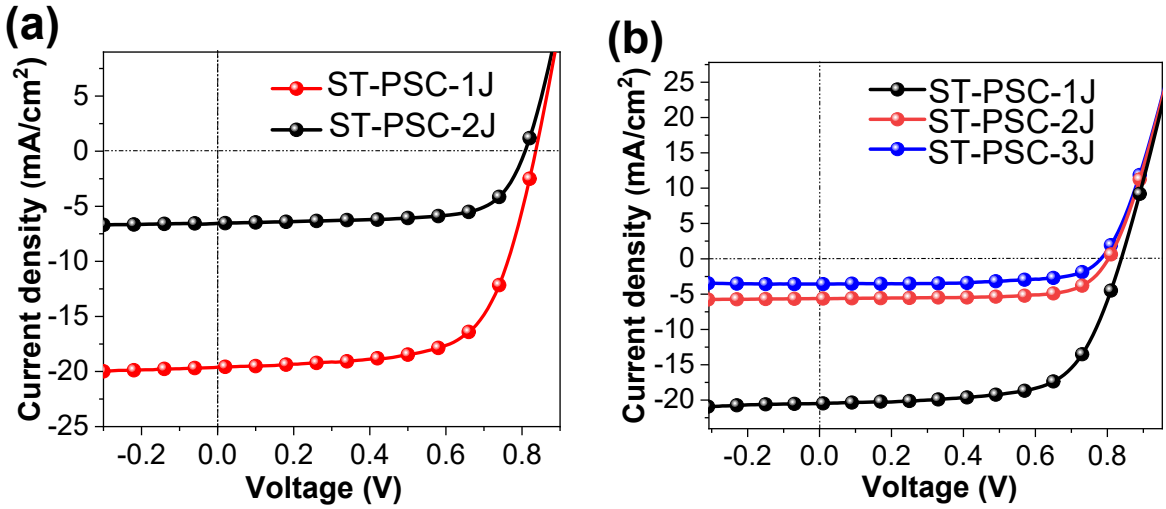

Figure S11. *J*–*V* curses of integrated ST-PSCs based on (a) two junctions and (b) three junctions.

15. Reference

1. Y. Xu, Q. Ji, L. Yin, N. Zhang, T. Liu, N. Li, X. He, G. Wen, W. Zhang, L. Yu, P. Murto and X. Xu, *ACS Appl. Mater. Interfaces*, 2021, **13**, 23993−24004.
2. N. Felekidis, A. Melianas and M. Kemerink, *ACS Appl. Mater. Interfaces*, 2017, **9**, 37070−37077.