

Solar Cells Reporting Summary

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► Experimental design

Please check the following details are reported in the manuscript, and provide a brief description or explanation where applicable.

1. Dimensions

Area of the tested solar cells	☒ Yes	0.0256 cm ²
	☐ No	Explain why this information is not reported/not relevant.
Method used to determine the device area	☒ Yes	The active areas were defined by aperture masks.
	☐ No	Explain why this information is not reported/not relevant.

2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction	☐ Yes	Organic Solar cells exhibit negligible hysteresis effects.
	☒ No	
Voltage scan conditions	☒ Yes	The J-V scans were performed from -0.2 V to 1 V with a voltage step of 20 mV and a delay time of 1 ms.
	☐ No	Explain why this information is not reported/not relevant.
Test environment	☒ Yes	Room temperature in a nitrogen glovebox.
	☐ No	Explain why this information is not reported/not relevant.
Protocol for preconditioning of the device before its characterization	☐ Yes	Provide a description of the protocol.
	☒ No	Without any preconditioning steps.
Stability of the J-V characteristic	☐ Yes	Provide a description of the method used. The stability of the J-V characteristic can be verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 5 for details.
	☒ No	We did not measure the MPP tracking, we conducted the long term stability.

3. Hysteresis or any other unusual behaviour

Description of the unusual behaviour observed during the characterization	☐ Yes	Provide a description of hysteresis or any other unusual behaviour observed during the characterization.
	☒ No	No unusual behaviour.
Related experimental data	☐ Yes	Provide a description of the related experimental data.
	☒ No	No unusual behaviour.

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)	☒ Yes	Provided in Supporting Information.
	☐ No	Explain why this information is not reported/not relevant.
A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator	☒ Yes	Provided in Table 1 and 2
	☐ No	Explain why this information is not reported/not relevant.

For tandem solar cells, the bias illumination and bias voltage used for each subcell	☐ Yes ☒ No	Provide a description of the measurement conditions. This study does not include tandem solar cells.
5. Calibration		
Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	Solar Simulator (model, SS-X50, Enli Technology Co., Ltd., Taiwan) with an AM 1.5 filter was used as the light source. The light intensity was calibrated to 100mW cm⁻² by a certified reference silicon cell (certified by Enli Technology Co., Ltd., Taiwan) Explain why this information is not reported/not relevant.
Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	The light intensity was calibrated to 100mW cm⁻² by a certified reference silicon cell (certified by Enli Technology Co., Ltd., Taiwan) Explain why this information is not reported/not relevant.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	A mismatch factor of 1.011 was used in performance certification by Wuxi Institute of Inspection, Testing and Certification. National Center of Inspection on Solar Photovoltaic Products Quality. Described in supporting information, Figure 29. Explain why this information is not reported/not relevant.
6. Mask/aperture		
Size of the mask/aperture used during testing	☒ Yes ☐ No	The active area of the device was defined by the aperture masks as 0.0256 cm² and 1 cm² for small-area and large-area device, respectively. Explain why this information is not reported/not relevant.
Variation of the measured short-circuit current density with the mask/aperture area	☐ Yes ☒ No	Report the difference in the short-circuit current density values measured with the mask and aperture area. We use 0.0256 cm² and 1 cm² area mask for small-area and large-area devices, respectively. We did not research the variation of the current density with the mask area.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	☒ Yes ☒ No	Certified by Wuxi Institute of Inspection, Testing and Certification. National Center of Inspection on Solar Photovoltaic Products Quality. Explain why this information is not reported/not relevant.
A copy of any certificate(s)	☒ Yes ☐ No	Supported in Supporting Information. Explain why this information is not reported/not relevant.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	10. Explain why this information is not reported/not relevant.
Statistical analysis of the device performance	☒ Yes ☐ No	Provided in Table 1 and 2. Explain why this information is not reported/not relevant.
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions	☒ Yes ☐ No	Operational stability measurements of the OSCs were conducted by using the white light LED array under continuous illumination of the simulating intensity of 100 mW cm⁻² (spectral region: 410–850 nm, Suzhou D & R Instruments, PVL-6001M-32A). Explain why this information is not reported/not relevant.