

Solar Cells Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form is intended for publication with all accepted papers reporting the characterization of photovoltaic devices and provides structure for consistency and transparency in reporting. Some list items might not apply to an individual manuscript, but all fields must be completed for clarity.

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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
☐ No

Electrical measurements (main text), Figure 4a, Figure 4b, Supplementary Figure 55, Supplementary Figure 62, Supplementary Figure 79

Explain why this information is not reported/not relevant.

Method used to determine the device area

☒ Yes
☐ No

Electrical measurements (main text)

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
☐ No

Figure 4a, Figure 4b, Supplementary Figure 62, Supplementary Figure 80 and Supplementary Figure 83

Explain why this information is not reported/not relevant.

Voltage scan conditions

☒ Yes
☐ No

Electrical measurements (main text)

Explain why this information is not reported/not relevant.

Test environment

☒ Yes
☐ No

Electrical measurements (main text)

Explain why this information is not reported/not relevant.

Protocol for preconditioning of the device before its characterization

☒ Yes
☐ No

Electrical measurements (main text)

Explain why this information is not reported/not relevant.

Stability of the J-V characteristic

☐ Yes
☒ No

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.

Certified values were displayed

3. Hysteresis or any other unusual behaviour

Description of the unusual behaviour observed during the characterization

☐ Yes
☒ No

Provide a description of hysteresis or any other unusual behaviour observed during the characterization.

No unusual hysteresis behavior is observed

Related experimental data

☐ Yes
☒ No

Provide a description of the related experimental data.

No unusual hysteresis behavior is observed

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)

☒ Yes
☐ No

Supplementary Figure 57

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
☒ No

State where this information can be found in the text.

Certified values were displayed

For tandem solar cells, the bias illumination and bias voltage used for each subcell	☐ Yes ☒ No	Provide a description of the measurement conditions. Explain why this information is not reported/not relevant.
5. Calibration		
Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	Electrical measurements (main text) Explain why this information is not reported/not relevant.
Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	Supplementary Figure 55 and Supplementary Figure 79 Explain why this information is not reported/not relevant.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	Certified values were displayed Explain why this information is not reported/not relevant.
6. Mask/aperture		
Size of the mask/aperture used during testing	☒ Yes ☐ No	Electrical measurements (main text), Figure 4a, Figure 4b, Supplementary Figure 55, Supplementary Figure 62, Supplementary Figure 80 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. The mask size was not varied
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	☒ Yes ☐ No	Supplementary Figure 55 and Supplementary Figure 79 Explain why this information is not reported/not relevant.
A copy of any certificate(s)	☒ Yes ☐ No	Supplementary Figure 55 and Supplementary Figure 79 Explain why this information is not reported/not relevant.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	Supplementary Figure 61, Supplementary Table 11 and Supplementary Table 14 Explain why this information is not reported/not relevant.
Statistical analysis of the device performance	☒ Yes ☐ No	Supplementary Figure 61, Supplementary Table 11 and Supplementary Table 14 Explain why this information is not reported/not relevant.
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions	☒ Yes ☐ No	Figures 4d-4g, Supplementary Figure 63, Supplementary Figure 65-70 Explain why this information is not reported/not relevant.