

Solar Cells Reporting Summary

Nature Research 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: are the following details reported in the manuscript?

1. Dimensions

- Area of the tested solar cells Yes 0.045 cm² active area, aperture area were used: 0.03 cm².
 No
- Method used to determine the device area Yes Active area: geometric layout. Aperture area: shadow mask layout.
 No

2. Current-voltage characterization

- Current density-voltage (J-V) plots in both forward and backward direction Yes In the J-V graphs in the main text.
 No
- Voltage scan conditions Yes The voltage scan were done both Jsc to Voc and Voc to Jsc. The scan speed is given in the methods section. Dwell time was not applied during the measurements.
For instance: scan direction, speed, dwell times
 No
- Test environment Yes All details about the measurement conditions are added in the methods section.
For instance: characterization temperature, in air or in glove box
 No
- Protocol for preconditioning of the device before its characterization Yes Not used
 No
- Stability of the J-V characteristic Yes Pmpp, Jmpp and Vmpp values were recorded during MPP tracking measurements. In figure 1d is reported the Pmpp
Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.
 No

3. Hysteresis or any other unusual behaviour

- Description of the unusual behaviour observed during the characterization Yes The observed hysteresis is negligible and mostly originated from the FF changes.
 No
- Related experimental data Yes Not relevant
 No

4. Efficiency

- External quantum efficiency (EQE) or incident photons to current efficiency (IPCE) Yes In the main text.
 No
- A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator Yes Fig. 1c in the main text
 No
- For tandem solar cells, the bias illumination and bias voltage used for each subcell Yes Not relevant
 No

5. Calibration

- Light source and reference cell or sensor used for the characterization Yes The intensity of the LED solar simulator was calibrated using a calibrated Si reference cell (KG-3 filter Centronics LCE-50)
 No
- Confirmation that the reference cell was calibrated and certified Yes In the methods
 No

Calculation of spectral mismatch between the reference cell and the devices under test	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Not relevant.
6. Mask/aperture		
Size of the mask/aperture used during testing	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	0.03 cm ² . Confirmed by optical microscopy.
Variation of the measured short-circuit current density with the mask/aperture area	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Our results are always reported with aperture.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Explain why this information is not reported/not relevant.
A copy of any certificate(s) <i>Provide in Supplementary Information</i>	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Explain why this information is not reported/not relevant.
8. Statistics		
Number of solar cells tested	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	30 solar cells tested as shown in Supporting Information
Statistical analysis of the device performance	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	In the supporting information
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions <i>For instance: illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature</i>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	MPP tracking in figure 1. Encapsulation and test conditions reported in methods.