

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
☐ No

0.06 cm²

Explain why this information is not reported/not relevant.

Method used to determine the device area

☒ Yes
☐ No

Measured through a shadow mask with 0.06 cm² area. This information can be found in Supporting Information

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 4b

Voltage scan conditions

☒ Yes
☐ No

Scan direction: forward and backward

Explain why this information is not reported/not relevant.

Test environment

☒ Yes
☐ No

AM1.5G; constant load; 25 °C; without encapsulation; air; RH:30%

Explain why this information is not reported/not relevant.

Protocol for preconditioning of the device before its characterization

☒ Yes
☐ No

Store in a drying cabinet for 48 hours.

Explain why this information is not reported/not relevant.

Stability of the J-V characteristic

☒ Yes
☐ No

Maximum Power Point Tracking

Explain why this information is not reported/not relevant.

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.

Explain why this information is not reported/not relevant.

Related experimental data

☐ Yes
☒ No

Provide a description of the related experimental data.

Explain why this information is not reported/not relevant.

4. Efficiency

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

☒ Yes
☐ No

IPCE values for bias light-free devices were measured in the wavelength range of 300 to 900 nm using IQE200B, Oriel.

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

discrepancies below 3% (26.11mA cm⁻² vs. 25.36mA cm⁻²)

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. Explain why this information is not reported/not relevant.
5. Calibration		
Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	Simulated sunlight at 100 mW cm⁻² (Oriel, model 91192). The intensity of the simulated light was precisely calibrated using an NREL-certified KG5-filtered Si photodiode detector. Explain why this information is not reported/not relevant.
Confirmation that the reference cell was calibrated and certified	☐ Yes ☒ No	Identify the independent certification laboratory. Explain why this information is not reported/not relevant.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	0.2% mismatch Explain why this information is not reported/not relevant.
6. Mask/aperture		
Size of the mask/aperture used during testing	☒ Yes ☐ No	0.06 cm² 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. Explain why this information is not reported/not relevant.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	☒ Yes ☒ No	Identify the independent certification laboratory. Explain why this information is not reported/not relevant.
A copy of any certificate(s)	☐ Yes ☒ No	Certificate copies should be provided in the Supplementary information. Please state the supplementary item number. Explain why this information is not reported/not relevant.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	Approximately 150 solar cells have been measured, with 30 substrates. There are five sub-cells on each substrate. Explain why this information is not reported/not relevant.
Statistical analysis of the device performance	☒ Yes ☐ No	This information can be found in Figure S32 Explain why this information is not reported/not relevant.
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions	☒ Yes ☐ No	Stability tests of the unencapsulated PSCs at MPPT model under continuous simulated illumination (100 mW cm⁻²) in a temperature range of 50–55 °C in N₂ atmosphere. Stability tests of the unencapsulated PSCs under day/night cycling (50 °C in light and 25 °C in dark) in N₂ atmosphere. Explain why this information is not reported/not relevant.