

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	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Methods in the manuscript"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Method used to determine the device area	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Methods in the manuscript"/> <input type="text" value="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	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Fig. 3c"/>
Voltage scan conditions	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Methods in the manuscript"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Test environment	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Methods in the manuscript"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Protocol for preconditioning of the device before its characterization	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Methods in the manuscript"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Stability of the J-V characteristic	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Supplementary Fig. 16, Newport certificated results"/> <input type="text" value="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	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="The device show low hysteresis (Fig. 3c and Supplementary Table 1)"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Related experimental data	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Fig. 3c and Supplementary Table 1"/> <input type="text" value="Explain why this information is not reported/not relevant."/>

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Supplementary Fig. 9e"/> <input type="text" value="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	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="The JSC obtained from the J-V characteristics was found to be consistent with the value integrated from the external quantum efficiency (EQE) spectrum, with a relative difference of less than 3%. (Supplementary Fig. 9)"/> <input type="text" value="Explain why this information is not reported/not relevant."/>

For tandem solar cells, the bias illumination and bias voltage used for each subcell	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;"><i>Provide a description of the measurement conditions.</i></div> <div style="border: 1px solid #ccc; padding: 2px;">No tandem solar cell was reported in this manuscript</div>
5. Calibration		
Light source and reference cell or sensor used for the characterization	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">Methods in the manuscript</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
Confirmation that the reference cell was calibrated and certified	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">Methods in the manuscript</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
Calculation of spectral mismatch between the reference cell and the devices under test	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">It has been calibrated.</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
6. Mask/aperture		
Size of the mask/aperture used during testing	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">0.0737 cm² and 14.625 cm², Methods in the manuscript</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
Variation of the measured short-circuit current density with the mask/aperture area	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;"><i>Report the difference in the short-circuit current density values measured with the mask and aperture area.</i></div> <div style="border: 1px solid #ccc; padding: 2px;">We didn't measure the solar cells with apertures of different sizes</div>
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">Newport</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
A copy of any certificate(s)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">Supplementary Fig. 16</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
8. Statistics		
Number of solar cells tested	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">22 devices were tested (Supplementary Fig. 14).</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
Statistical analysis of the device performance	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">Supplementary Fig. 14</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<div style="border: 1px solid #ccc; padding: 2px; margin-bottom: 2px;">Fig. 4 and Supplementary Fig. 21</div> <div style="border: 1px solid #ccc; padding: 2px;"><i>Explain why this information is not reported/not relevant.</i></div>