

Solar Cells Reporting Summary

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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
☐ No | Described in "Methods" section. The area is 4 mm ² . |
| Method used to determine the device area | ☒ Yes
☐ No | The device area is defined by the overlap of the ITO electrode and metal electrode. |

2. Current-voltage characterization

- | | | |
|--|--|---|
| Current density-voltage (J-V) plots in both forward and backward direction | ☒ Yes
☐ No | J-V plots in forward and backward direction are shown in Supplementary Figure 3. |
| Voltage scan conditions
<i>For instance: scan direction, speed, dwell times</i> | ☒ Yes
☐ No | The solar cells are measured in forward direction. |
| Test environment
<i>For instance: characterization temperature, in air or in glove box</i> | ☒ Yes
☐ No | Described in "Methods" section. The devices were characterized at room temperature (ca. 20-25°C) in air. |
| Protocol for preconditioning of the device before its characterization | ☐ Yes
☒ No | No preconditioning of the device before its characterization. |
| Stability of the J-V characteristic
<i>Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.</i> | ☒ Yes
☐ No | Long-term operational stability tracking at maximum power point under 1-sun light irradiation in air is provided in Supplementary Figure 31 and 32. |

3. Hysteresis or any other unusual behaviour

- | | | |
|---|--|---|
| Description of the unusual behaviour observed during the characterization | ☐ Yes
☒ No | No hysteresis or other unusual behavior was observed during the characterization. |
| Related experimental data | ☐ Yes
☒ No | N/A |

4. Efficiency

- | | | |
|---|--|---|
| External quantum efficiency (EQE) or incident photons to current efficiency (IPCE) | ☒ Yes
☐ No | EQE spectra of cells are shown in Figure 1c. |
| A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator | ☒ Yes
☐ No | Integrated EQE under AM1.5 is comparable to current density under the 1-sun simulator illumination. |
| For tandem solar cells, the bias illumination and bias voltage used for each subcell | ☐ Yes
☒ No | No tandem cells are reported in the work. |

5. Calibration

- | | | |
|---|--|--|
| Light source and reference cell or sensor used for the characterization | ☒ Yes
☐ No | Described in "Methods" section. The light source is XES-40S3, SAN-EI ELECTRIC. |
| Confirmation that the reference cell was calibrated and certified | ☒ Yes
☐ No | Described in "Methods" section. The reference diode is BS-520BK Bunkoukeiki. |

Calculation of spectral mismatch between the reference cell and the devices under test	☐ Yes ☒ No	Mismatch is not calculated.
6. Mask/aperture		
Size of the mask/aperture used during testing	☐ Yes ☒ No	We did not use mask during testing and the effective area was defined by its crossed area of ITO and metal electrodes.
Variation of the measured short-circuit current density with the mask/aperture area	☐ Yes ☒ No	We did not use a mask during testing.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	☐ Yes ☒ No	This work mainly focus on the waterproofness of the devices. We have not certified the efficiency by the independent laboratory.
A copy of any certificate(s) <i>Provide in Supplementary Information</i>	☐ Yes ☒ No	No certification.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	Described in Supplementary Figure 2.
Statistical analysis of the device performance	☒ Yes ☐ No	Statistical analysis are shown in Supplementary Figure 2.
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>	☒ Yes ☐ No	The long-term stability are shown in Supplementary Figures 5 and 6.