

Solar Cells Reporting Summary

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Please check the following details are reported in the manuscript, and provide a brief description or explanation where applicable.

Area of the tested solar cells

- Yes
 No

Report the area of the tested solar cells.

Method used to determine the device area

- Yes
 No

Provide a description of the method and state where this information can be found in the text.

2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction

- Yes
 No

Voltage scan conditions

- Yes
 No

Provide a description of the measurement conditions (e.g. scan direction, speed, dwell times).

Test environment

- Yes
 No

Provide a description of the test conditions (e.g. characterization temperature, atmosphere, humidity).

Protocol for preconditioning of the device before its characterization

- Yes
 No

Provide a description of the protocol.

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.

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.

Related experimental data

- Yes
 No

Provide a description of the related experimental data.

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

- Yes
 No

Provide a description of the technique used.

A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator

- Yes
 No

For tandem solar cells, the bias illumination and bias voltage used for each subcell

- Yes
 No

Provide a description of the measurement conditions.

5. Calibration

Light source and reference cell or sensor used for the characterization

- Yes
 No

Provide a description of the light source and reference cell or sensor.

Confirmation that the reference cell was calibrated and certified

- Yes
 No

Identify the independent certification laboratory.

Calculation of spectral mismatch between the reference cell and the devices under test

- Yes
 No

Provide a value of the spectral mismatch and/or a description of how it has been taken into account in the measurements.

6. Mask/aperture

Size of the mask/aperture used during testing

- Yes
 No

Report the size of the mask/aperture.

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.

7. Performance certification

Identity of the independent certification laboratory that confirmed the photovoltaic performance

- Yes
 No

Identify the independent certification laboratory.

A copy of any certificate(s)

- Yes
 No

Certificate copies should be provided in the Supplementary information. Please state the supplementary item number.

8. Statistics

Number of solar cells tested

- Yes
 No

Report how many solar cells have been tested, specifying the number of individual substrates.

Statistical analysis of the device performance

- Yes
 No

9. Long-term stability analysis

Type of analysis, bias conditions and environmental conditions

- Yes
 No

Provide a description of the type of analysis, bias conditions and environmental conditions (e.g. illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature, bias) for each long-term stability analysis carried out; see ref. 7 and 8 for details.

1. Shrotriya, V. *et al.* Accurate measurement and characterization of organic solar cells. *Adv. Funct. Mater.* **16**, 2016–2023 (2006).
2. Dennler, G. *et al.* The value of values. *Mat. Today* **10**, 56 (2007).
3. Cravino, A., Schilinsky, P. & Brabec, C. J. Characterization of organic solar cells: the importance of device layout. *Adv. Funct. Mater.* **17**, 3906–3910 (2007).
4. Reese, M. O. *et al.* Consensus stability testing protocols for organic photovoltaic materials and devices. *Sol. Energ. Mat. Sol. C* **95**, 1253–1267 (2011).
5. Snaith H. J. The perils of solar cell efficiency measurements. *Nat. Photon.* **6**, 337–340 (2012).
6. Lubber, E. J. & Buriak, J. M. Reporting performance in organic photovoltaic devices. *ACS Nano* **7**, 4708–4714 (2013).
7. Snaith, H. J. *et al.* Anomalous hysteresis in perovskite solar cells. *J. Phys. Chem. Lett.* **5**, 1511–1515 (2014).
8. Grätzel M. The light and shade of perovskite solar cells. *Nat. Mat.* **13**, 838–842 (2014).
9. Zimmermann E. *et al.* Erroneous efficiency reports harm organic solar cell research. *Nat. Photon.* **8**, 669–672 (2014).
10. Beard M.C., Luther J.M. & Nozik A.J. The promise and challenge of nanostructured solar cells. *Nat. Nanotech.* **9**, 951–954 (2014).
11. Timmreck, R. *et al.* Characterization of tandem organic solar cells. *Nat. Photon.* **9**, 478–479 (2015).

A number of international committees develop industry standards on the characterization of photovoltaic technologies (for example ASTM-E44 and IEC-TC 82), which can provide guidance for academic research.

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