

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

Described in the Method section. The cell area is 0.1 cm².

Explain why this information is not reported/not relevant.

Method used to determine the device area

☒ Yes
☐ No

The device area is defined by an opaque aperture mask.

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

Provided in Fig. 5c and 5e and Fig. S14.

Voltage scan conditions

☒ Yes
☐ No

Both the forward and reverse JV curves are scanned at 0.2 V/s.

Explain why this information is not reported/not relevant.

Test environment

☒ Yes
☐ No

Described in Method section (room temperature and ambient air).

Explain why this information is not reported/not relevant.

Protocol for preconditioning of the device before its characterization

☒ Yes
☐ No

Described in Method section (no preconditioning).

Explain why this information is not reported/not relevant.

Stability of the J-V characteristic

☒ Yes
☐ No

We measure steady-state power output (SPO) by measuring the cells at maximum power point for 600 s (Fig. S12, S14 and S16).

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

No unusual behaviour.

Explain why this information is not reported/not relevant.

Related experimental data

☒ Yes
☐ No

We provide both the forward and reverse scans of the cells in Fig. 5c, 5e and Fig. S14.

Explain why this information is not reported/not relevant.

4. Efficiency

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

☒ Yes
☐ No

Provided in the Fig. 5f and Fig.S13.

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

Described in the main text.

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	Described in Method section Explain why this information is not reported/not relevant.
5. Calibration		
Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	Described in Method section Explain why this information is not reported/not relevant.
Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	Described in Method section (the intensity was calibrated with a standard silicon reference cell). Explain why this information is not reported/not relevant.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	The mismatch factor was calculated to be less than 1% and applied to calibrate the AM 1.5 G 100 mW cm ⁻² equivalent irradiance. Explain why this information is not reported/not relevant.
6. Mask/aperture		
Size of the mask/aperture used during testing	☒ Yes ☐ No	Provided in Method section (0.07 cm ²). 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. This work provides an in-depth understanding of the Sn-rich surface state in Sn-Pb mixed perovskite fabricated by solution process and address the critical issue that has limiting the Jsc in all-perovskite tandem cells.
A copy of any certificate(s)	☐ Yes ☒ No	Certificate copies should be provided in the Supplementary information. Please state the supplementary item number. Not certified.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	12 individual cells for both the Sn-Pb single-junction and tandem cells. Explain why this information is not reported/not relevant.
Statistical analysis of the device performance	☒ Yes ☐ No	Provided in the figure 5a-b and Fig.S10, S11, S15. Explain why this information is not reported/not relevant.
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions	☒ Yes ☐ No	Provided in the Fig. 5g, Fig. S18, S19. Detailed testing conditions are given in the Method section. Explain why this information is not reported/not relevant.

