

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 The area of tested solar cells is 0.055 cm².
- Method used to determine the device area ☒ Yes ☐ No Metal aperture mask (black color)

2. Current-voltage characterization

- Current density-voltage (J-V) plots in both forward and backward direction ☐ Yes ☒ No Explain why this information is not reported/not relevant.
- Voltage scan conditions ☒ Yes ☐ No See details in Method.
For instance: scan direction, speed, dwell times
- Test environment ☒ Yes ☐ No See details in Method.
For instance: characterization temperature, in air or in glove box
- Protocol for preconditioning of the device before its characterization ☐ Yes ☒ No No preconditioning condition is used.
- Stability of the J-V characteristic ☐ Yes ☒ No Stability is not related to our band edge extending concept.
Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.

3. Hysteresis or any other unusual behaviour

- Description of the unusual behaviour observed during the characterization ☐ Yes ☒ No Negligible hysteresis was observed.
- Related experimental data ☐ Yes ☒ No Hysteresis is not relevant to our band edge extending concept.

4. Efficiency

- External quantum efficiency (EQE) or incident photons to current efficiency (IPCE) ☒ Yes ☐ No We provide EQE measurement in Fig. 3g and Supplementary Fig. 15.
- A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator ☒ Yes ☐ No We compare the integrated J_{sc} with one from JV scan. The difference between the integrated J_{sc} from EQE and J_{sc} from JV scan is within 2% difference, which is within accuracy confidence of the measurements.
- For tandem solar cells, the bias illumination and bias voltage used for each subcell ☐ Yes ☒ No We didn't fabricate tandem solar cell.

5. Calibration

- Light source and reference cell or sensor used for the characterization ☒ Yes ☐ No See details in Method.
- Confirmation that the reference cell was calibrated and certified ☒ Yes ☐ No Our solar simulator was calibrated by Si reference cell.(certificated by Newport.)

Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	A spectral mismatch calculation was performed based on the spectral intensity of the solar simulator and 3 typical EQEs of our cells. This resulted in 2 mismatch factors of $M = 0.9951$ and 0.9968.
6. Mask/aperture Size of the mask/aperture used during testing Variation of the measured short-circuit current density with the mask/aperture area	☒ Yes ☐ No ☐ Yes ☒ No	An optical aperture mask (0.055 cm^2) was used. No significant variations was observed.
7. Performance certification Identity of the independent certification laboratory that confirmed the photovoltaic performance A copy of any certificate(s) <i>Provide in Supplementary Information</i>	☐ Yes ☒ No ☐ Yes ☒ No	Our paper does not emphasize solar cell efficiency. Our paper does not emphasize solar cell efficiency.
8. Statistics Number of solar cells tested Statistical analysis of the device performance	☐ Yes ☒ No ☐ Yes ☒ No	Our paper does not emphasize solar cell efficiency. Our paper does not emphasize solar cell efficiency.
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	Stability was not related to our band extending concept.