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Solar Cells Reporting Summary

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ü Experimental design

Please check: are the following details reported in the manuscript?

1. Dimensions

   Area of the tested solar cells
   ☒ Yes
   ☐ No
   | For the single device area was 0.05 mm2, and for the multisection device area was 1.85 mm2. The information can be found in the Material and Device Characterization. |

   Method used to determine the device area
   ☒ Yes
   ☐ No
   | Defined by the area between anode and cathode. |

2. Current-voltage characterization

   Current density-voltage (J-V) plots in both forward and backward direction
   ☒ Yes
   ☐ No
   | Supplementary Figure 1 |

   Voltage scan conditions
   For instance: scan direction, speed, dwell times
   ☒ Yes
   ☐ No
   | Reverse scan, 0.03 V/s, Dwell time: 0.333 s |

   Test environment
   For instance: characterization temperature, in air or in glove box
   ☒ Yes
   ☐ No
   | Devices are measured in vacuum, air and glove box at room temperature. |

   Protocol for preconditioning of the device before its characterization
   ☐ Yes
   ☒ No
   | No preconditioning is required before characterization. |

   Stability of the J-V characteristic
   Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.
   ☒ Yes
   ☐ No
   | Photocurrent output are measured by tracking the maximum power point (Figure 6g). |

3. Hysteresis or any other unusual behaviour

   Description of the unusual behaviour observed during the characterization
   ☒ Yes
   ☐ No
   | There was weak hysterisis between backward scan and forward scan. |

   Related experimental data
   ☒ Yes
   ☐ No
   | Supplementary Figure 1 |

4. Efficiency

   External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)
   ☐ Yes
   ☒ No
   | The light intensity in EQE measurement is too low to generate stable photo current in microscale lateral structured device. |

   A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator
   ☐ Yes
   ☒ No
   | None liner photoresponse. |

   For tandem solar cells, the bias illumination and bias voltage used for each subcell
   ☐ Yes
   ☒ No
   | Single crystal perovskite solar cell is investigated in this work are not tandem solar cells. |

5. Calibration

   Light source and reference cell or sensor used for the characterization
   ☒ Yes
   ☐ No
   | Simulated AM 1.5 G irradiation was produced by a Xenon lamp solar simulator (SOLARBEAM-02-3A, CROWNTECH.INC.). The light intensity was calibrated by a reference solar cell (SRC-1000-TC-K-QZ-C, VLSI Standards). |

Confirmation that the reference cell was calibrated and certified — ☒ Yes ☐ No | The reference silicon detector (SRC-1000-TC-K-QZ-C, VLSI Standards) was calibrated and NREL traceable.

Calculation of spectral mismatch between the reference cell and the devices under test — ☐ Yes ☒ No | No calculation was used.

6. Mask/aperture

Size of the mask/aperture used during testing — ☒ Yes ☐ No | The information can be found in the Material and Device Characterization.

Variation of the measured short-circuit current density with the mask/aperture area — ☐ Yes ☒ No | The efficiency distribution is provided in Figure 6c, d, e, f.

7. Performance certification

Identity of the independent certification laboratory that confirmed the photovoltaic performance — ☐ Yes ☒ No | No certification

A copy of any certificate(s)
Provide in Supplementary Information — ☐ Yes ☒ No | No certification

8. Statistics

Number of solar cells tested — ☒ Yes ☐ No | A total of 20 single crystal perovskite solar cells were tested.

Statistical analysis of the device performance — ☒ Yes ☐ No | Figure 6e and 6f.

9. Long-term stability analysis

Type of analysis, bias conditions and environmental conditions
For instance: illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature — ☒ Yes ☐ No | in Figure 6g, the single crystal perovskite solar cell device was measured by tracking the photocurrent at its MPP condition under 1 Sun illumination