

## Solar Cells Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form is intended for publication with all accepted papers reporting the characterization of photovoltaic devices and provides structure for consistency and transparency in reporting. Some list items might not apply to an individual manuscript, but all fields must be completed for clarity.

For further information on Nature Research policies, including our [data availability policy](#), see [Authors & Referees](#).

### ü Experimental design

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

##### 1. Dimensions

- Area of the tested solar cells  Yes 0.04 cm<sup>2</sup>  
 No
- Method used to determine the device area  Yes The device area is calculated by multiplying the width of ITO electrode and metal electrode.  
 No

##### 2. Current-voltage characterization

- Current density-voltage (J-V) plots in both forward and backward direction  Yes Difference between forward and backward direction was not observed for organic solar cells, thus backward direction scan was not applied in this system.  
 No
- Voltage scan conditions  Yes From -0.10 V to 1.0 V with 0.01 interval, 10 ms delay.  
*For instance: scan direction, speed, dwell times*  
 No
- Test environment  Yes The test environment at home lab was in glove box and at room temperature. The device tested at NIM was encapsulated with epoxy. And the test condition at NIM comply to IEC 60904-1 2006, as indicted in the responding test report.  
*For instance: characterization temperature, in air or in glove box*  
 No
- Protocol for preconditioning of the device before its characterization  Yes There is no other protocol for preconditioning before characterization.  
 No
- Stability of the J-V characteristic  Yes This manuscript is mainly focused on the new materials and device performance, and the stability measurement will be considered in the following studies.  
*Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see [ref. 7](#) for details.*  
 No

##### 3. Hysteresis or any other unusual behaviour

- Description of the unusual behaviour observed during the characterization  Yes No. There is no hysteresis or any other unusual behaviour.  
 No
- Related experimental data  Yes *Explain why this information is not reported/not relevant.*  
 No

##### 4. Efficiency

- External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)  Yes EQE is provided.  
 No
- A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator  Yes The error is less than 5% between the measured J<sub>sc</sub> and calculated J<sub>sc</sub> from EQE.  
 No
- For tandem solar cells, the bias illumination and bias voltage used for each subcell  Yes This manuscript is not relevant to tandem solar cells.  
 No

##### 5. Calibration

- Light source and reference cell or sensor used for the characterization  Yes Yes, all of these information has been included in method.  
 No

Confirmation that the reference cell was calibrated and certified

 Yes

Yes, all of these information has been included in method.

 No

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

 Yes

Yes, all of these information has been included in method.

 No

## 6. Mask/aperture

Size of the mask/aperture used during testing

 Yes

2.636 mm<sup>2</sup>

 No

Variation of the measured short-circuit current density with the mask/aperture area

 Yes

When we use mask, the Voc and Jsc are a little lower, the FF is higher, the power conversion efficiency is equivalent compared with no mask.

 No

## 7. Performance certification

Identity of the independent certification laboratory that confirmed the photovoltaic performance

 Yes

Yes, we confirmed the photovoltaic performance from independent certification laboratory, and the copy of the certificate was included in the Supplementary Information.

 No

A copy of any certificate(s)

*Provide in Supplementary Information*

 Yes

See supplementary information

 No

## 8. Statistics

Number of solar cells tested

 Yes

At least 10 cells.

 No

Statistical analysis of the device performance

 Yes

We show the statistical analysis of the device performance in device performance part in manuscript.

 No

## 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. This manuscript is mainly focused on the new materials and device

 No

performance, and the stability measurement will be considered in the following studies.