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Manuscript Number: _____

Reporting Checklist For Solar Cell Manuscripts

In order to improve the reproducibility and transparency of manuscripts related to photovoltaic cells, we strongly recommend that authors consider the following points in the preparation of their manuscript. **Please supply a response to the checklist alongside your submitted manuscript, and ensure that the relevant responses are also provided in the main manuscript, methods section or supplementary information as appropriate.** The completed checklist will be shared with reviewers.

Solar Cell Data:	Response
1. Have current–voltage (J–V) plots in both forward and backward direction been supplied? Have the stabilization of photocurrent at maximum power point voltage or maximum power point data (see ref.7 for further details) been shown?	Yes, as shown in Figure 5b.
2. Has external quantum efficiency (EQE) or incident photons to current efficiency (IPCE) data for the devices been provided? Has the integrated response under the standard reference spectrum been compared to the response measured under the simulator? In case of tandem solar cells, have the following been stated: bias illumination intensity; bias voltage used for each subcell?	Yes, the EQE was provided in Figure 5c. The integrated response under the simulator was calibrated by that under the standard reference spectrum.
3. Please describe the voltage scan conditions (direction, speed, dwell times), and test environment for your devices (for example: temperature, in air or in glove box). If a preconditioning protocol has been used before the characterization, please describe it.	J-V characteristics of FAPbI3 PSCs (0.991 cm2) were taken using a Keithley 2400 source meter under a simulated AM 1.5G spectrum. All the devices were measured without pre-conditioning such as light-soaking and applied bias voltage. We used thinner masks on it. Typically, the devices were measured in scan (-1.3 V ~ 0.2 V, step 0.02 V, 100 mV/s)
4. Please state the light source and the reference cell or sensor used for the characterization. Was the reference cell calibrated and certified? Was a spectral mismatch calculation between the reference cell and the devices under test performed? What is the mismatch factor used?	Newport, Class A simulator is used for the measurements. The light intensity was calibrated by reference solar cell by Newport.
5. Please state the dimensions of the tested solar cells.	The area of the solar cell is 1.5*1.5 cm2. Functional area is 0.12 cm2. The mask area is 0.0991 cm2.
6. Please state whether a mask/aperture was used for measurements. If this is the case, please state the size of the mask/aperture and declare whether the measured short-circuit current density of the devices varies with the mask/aperture area. If a mask/aperture was not used, please explain why.	We used thinner masks (0.0991 cm2) on it.

(Continues on following page)

Solar Cell Data:

	Response
7. Have you observed hysteresis or any other unusual behaviour during the characterization of the solar cells? If this is the case, please include a description of the observed behaviour and the related experimental data.	No.
8. Please state whether the photovoltaic performance of your devices has been confirmed from independent certification laboratories. (If this is the case, please include a copy of the certificate in the Supplementary Information).	Yes, the certified results of the 4-CA based device are shown in Figure S16.
9. How many solar cells have been tested? Has a statistical analysis of the performance been included?	More than 20 cells under each strain condition were tested; A statistical analysis of the performance been included in Figure 5e.
10. Has a stability analysis been performed? If so, please clearly describe the type of analysis (for example: thermal stress, shelf-life, light-soaking test, UV stress) and the bias conditions used during this characterization.	Yes. Figure 5f shows the unencapsulated device degradation curves for the control device and the 4CA-based device stored in humid air (T=25-30 ℃, RH=30-40%) for over 3000 hours. Figure 5g and S18 shows the devices without encapsulation [illegible]

Further reading:

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. Luber, 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. Mater.* **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.