Supporting Information

**Light Intensity Dependence of Current Density–Voltage Characteristics of an Organic Solar Cell and Dominance Switching between Shockley-Read-Hall and Radiative Recombination Losses**

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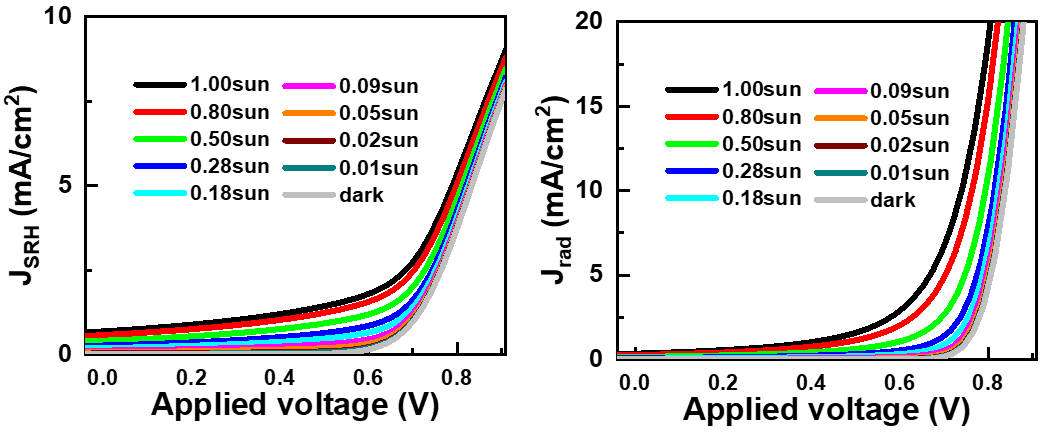
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Figure S1. Simulated Shockley-Read-Hall (*J*SRH) and radiative (*J*rad) recombination-loss currents with respect to bias voltages:

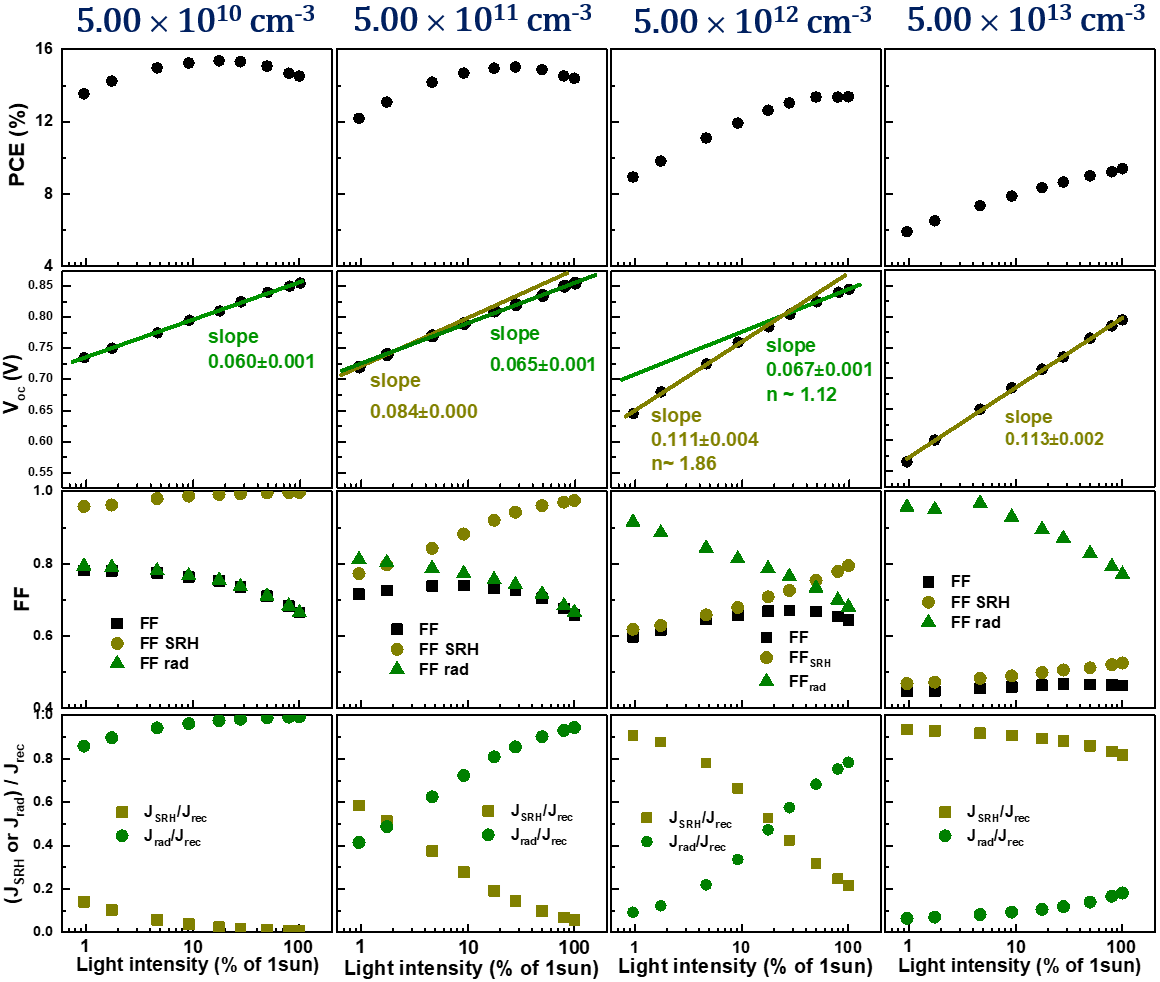


Figure S2. Comparison of light-intensity dependence of power conversion efficiency (PCE), open-circuit voltage (Voc), fill factor (FF), and fractions of SRH (*J*SRH/Jrec) and radiative recombination (*J*rad/Jrec) components in recombination-loss currents at defect densities of 5.00 × 1010, 5.00 × 1011, 5.00 × 1013, and 5.00 × 1013 cm-3.

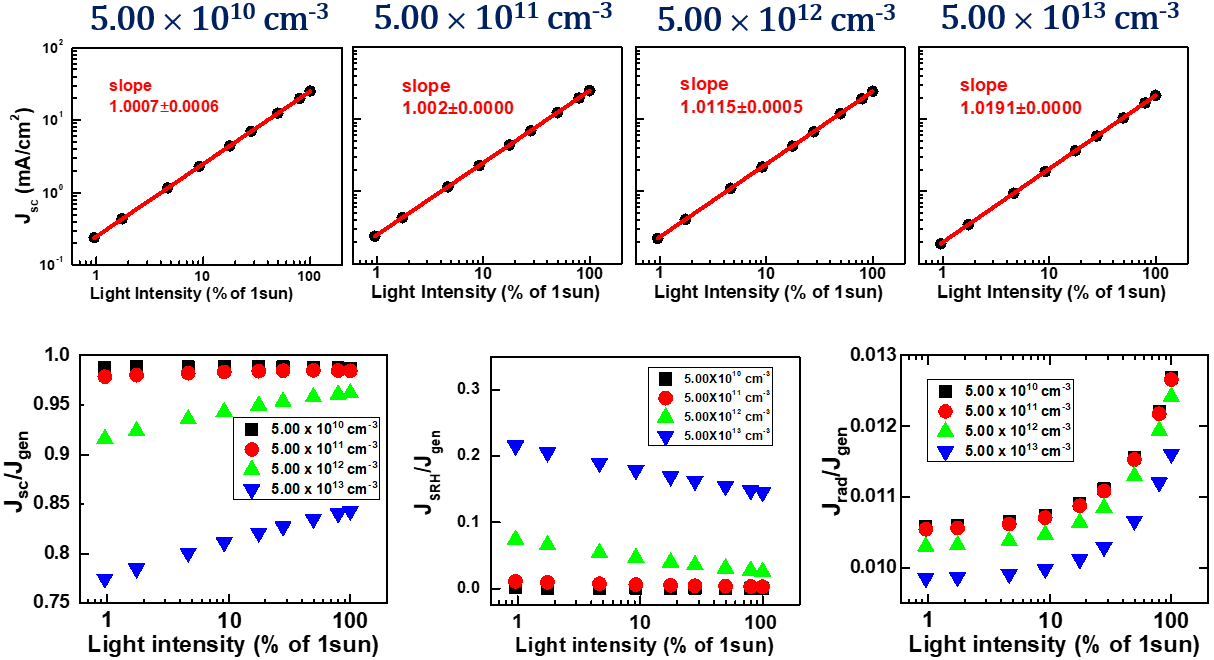


Figure S3. Upper row: Comparison of light-intensity dependence of short-circuit currents (*J*sc) at defect densities of 5.00 × 1010, 5.00 × 1011, 5.00 × 1012, and 5.00 × 1013 cm-3. Lower row: Comparison of light-intensity dependence of current components *J*sc, *J*SRH, and *J*rad normalized by generation currents *J*gen at the same four defect densities.

Table S1. Parameter values for electric simulations. We used the following parameter values for all OSC-operation simulations corresponding to different light-intensity conditions.

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***ETL*** | ***AL*** | ***HTL*** |
| Thickness (nm) | 40 | 90 | 10 |
| Band gap (eV) | 3.300 [1] | 1.290 [2] | 3.00 0[5] |
| Electron affinity (eV) | 4.000 [1] | 4.100[2] | 2.500 [5] |
| Conduction band effective density of states, Nc (cm-3) | 2.20×[4] | 1.0× [2] | 2.20× [5] |
| Valance band effective density of states, Nv (cm-3) | 1.80×[4] | 1.0× [2] | 1.80× [5] |
| Electron thermal velocity  (cm sec-1) | 1.00× [4] | 1.0× | 1.00× [5] |
| Hole thermal velocity  (cm sec-1) | 1.00× [4] | 1.0× | 1.00× [5] |
| Electron mobility  (cm V-1 sec-1) | 1.00× [4] | 3.2× [2] | 2.50× [5] |
| Hole mobility  (cm V-1 sec-1) | 2.50× [4] | 2.7× [2] | 1.00× [5] |
| Bimolecular recombination coefficient, ϒ (cm3sec-1) |  | 3.0× [2] |  |
| Defect density (cm-3) |  | 5.0× [3] |  |

**References**

1. Gutmann, S., Conrad, M., Wolak, M. A., Beerbom, M. M. & Schlaf, R. Work function measurements on nano-crystalline zinc oxide surfaces. *J. Appl. Phys.* **111**, (2012).

2. Tokmoldin, N. *et al.* Extraordinarily long diffusion length in PM6:Y6 organic solar cells. *J. Mater. Chem. A* **8**, 7854–7860 (2020).

3. Karki, A. *et al.* The role of bulk and interfacial morphology in charge generation, recombination, and extraction in non-fullerene acceptor organic solar cells. *Energy Environ. Sci.* **13**, 3679–3692 (2020).

4. Zapukhlyak, Z. R. *et al.* SCAPS simulation of ZnO/CdS/CdTe/CuO heterostructure for photovoltaic application. *Phys. Chem. Solid State* **21**, 660–668 (2020).

5. Li, W., Li, W., Feng, Y. & Yang, C. Numerical analysis of the back interface for high efficiency wide band gap chalcopyrite solar cells. *Sol. Energy* **180**, 207–215 (2019).