Supporting Information

# Characteristics of Perovskite Solar Cells under Low-illuminance Conditions

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**Device fabrication of c-Si and a-Si solar cells**

P-type Si wafer (resistivity=1-5 Ω·cm, thickness=200 μm) was used as substrate of c-Si solar cells. N-type emitter layer (Rs=50Ω/sq.) was formed by phosphorus diffusion using $POCl_3$ at 890°C. SiN layer was deposited on emitter layer by plasma enhanced chemical vapor deposition (PECVD). Then, Ag paste was applied on the SiN layer by screen printing. After the screen printing, the substrate was annealed at 800°C in rapid thermal annealing furnace (fire through process). After the fire through process, Al paste was screen printed on back surface of the substrate. Then, it was heated at 500°C for metalization.

Asahi-U substrate was used as substrate of a-Si solar cells. 10 nm of p-type amorphous SiC, 200 nm of intrinsic amorphous Si, and 20 nm of n-type amorphous Si were deposited on the substrate by PECVD. Here, a buffer layer inserted between the p-type a-SiC and the intrinsic a-Si was introduce to avoid abrupt change of bandgap of the interface by gradual controlling of the carbon concentration. Then, Al doped ZnO and Ag layer were formed on n-type amorphous Si layer. All deposition processes were carried out at less than 200°C.

Table S1. The *I–V* characteristics of mesostructured perovskite, c-Si, and a-Si solar cells under 1 sun illumination

| | $J_{SC}$ (mA/cm$^2$) | $V_{OC}$ (V) | FF | PCE (%) |
|---|---|---|---|---|
| Perovskite (Mesostructured) | 19.51 | 1.04 | 0.643 | 13.0 |
| c-Si | 20.82 | 0.520 | 0.676 | 7.31 |
| a-Si | 14.19 | 0.886 | 0.672 | 8.46 |

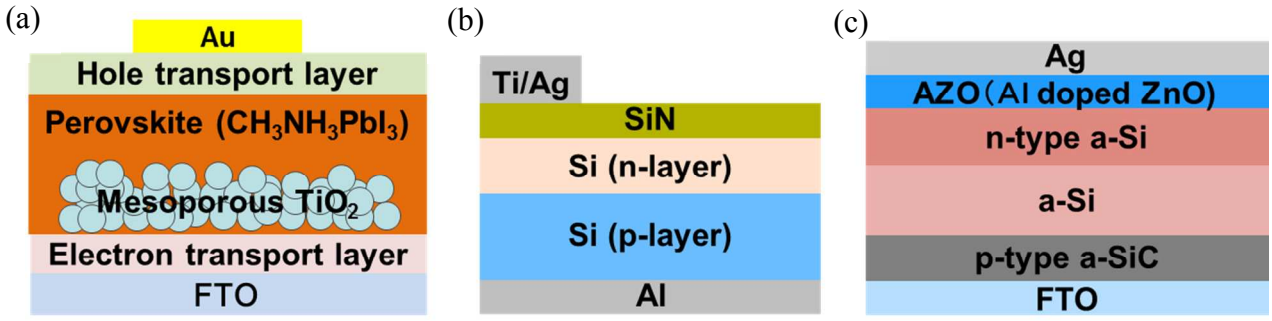


Figure S1. Device structures of (a) mesostructured perovskite, (b) c-Si, and (c) a-Si solar cells.

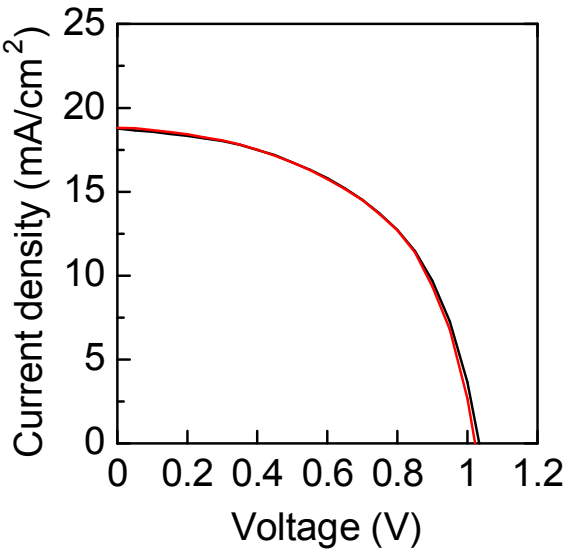


Figure S2. *I-V* curves of a perovskite solar cell under 1sun condition. The black line shows a pristine characteristic and the red line shows the *I-V* curve measured after the investigation of low-illuminance characteristics.

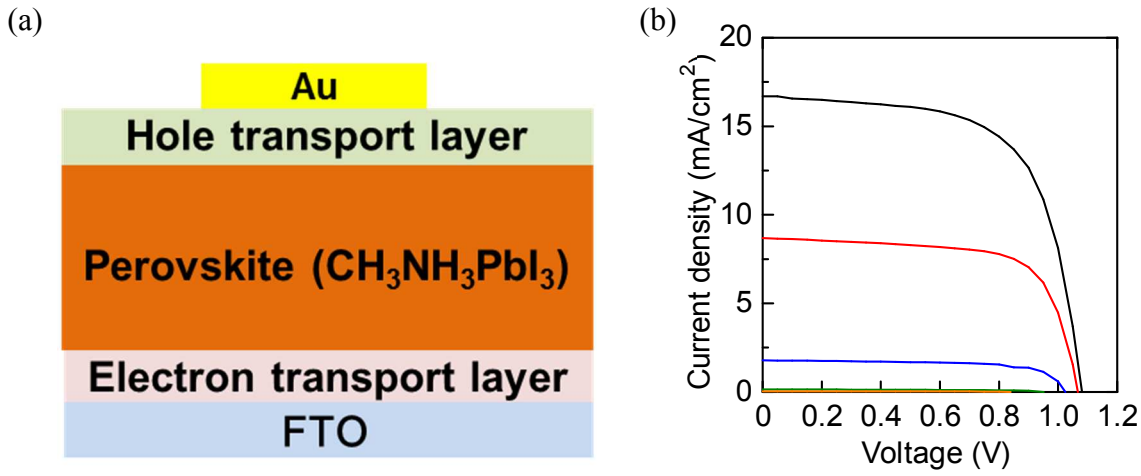


Figure S3. (a) Device structure of planar-type perovskite solar cells and (b) *I-V* curves of planar-type perovskite solar cell. The black, red, blue, green, and orange lines represent the *I-V* curves under 100, 50, 10, 1, and 0.1 mW/cm$^2$ illumination, respectively.

Table S2 The *I–V* characteristics of planar-type perovskite solar cell under 1 sun illumination

| | $J_{SC}$ (mA/cm$^2$) | $V_{OC}$ (V) | FF | PCE (%) |
|---|---|---|---|---|
| Perovskite (Planar) | 16.69 | 1.08 | 0.645 | 11.6 |

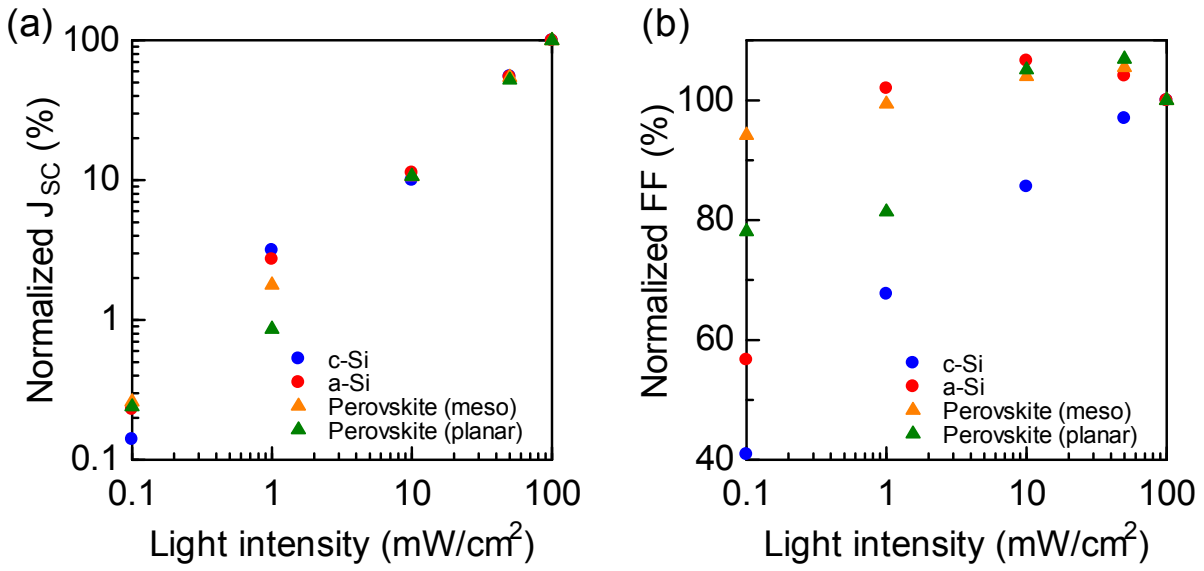


Figure S4. (a) Normalized $J_{SC}$ and (b) normalized FF of each solar cell under various illuminance conditions.

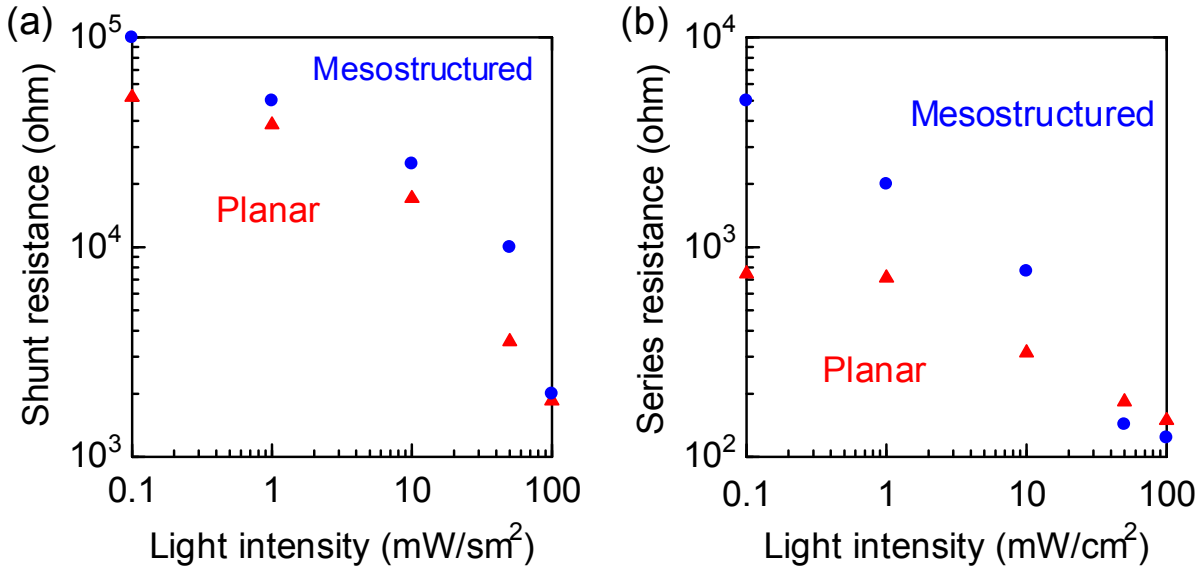


Figure S5. (a) Rsh and (b) Rs of planar-type and mesostructured perovskite solar cells under various illuminance conditions.