

Supporting Information

Single-Phase Brookite TiO₂ Nanoparticle Bridge Enhances the Stability of Perovskite Solar Cells

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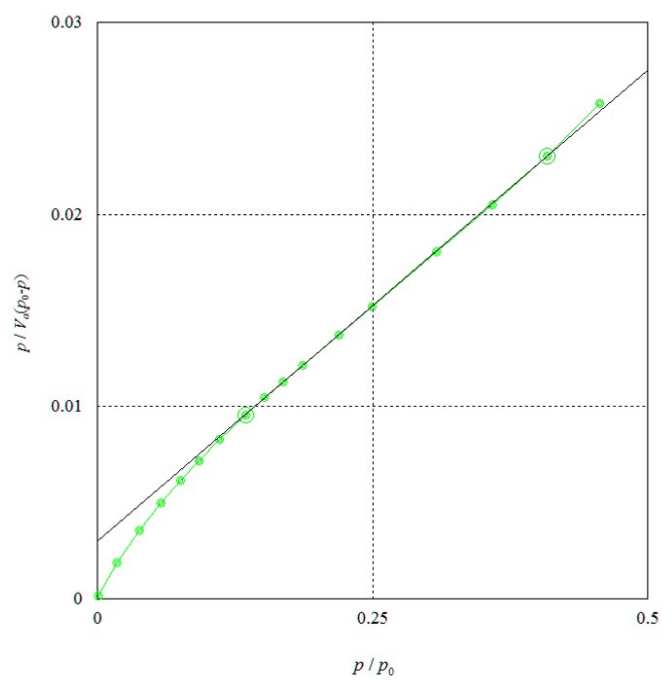
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Figure S1. BET analysis of BK TiO₂ NPs.

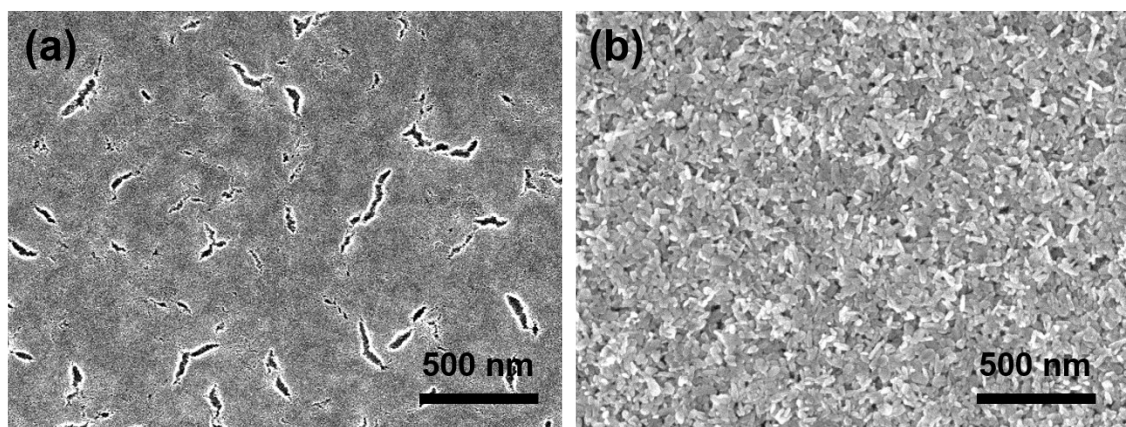
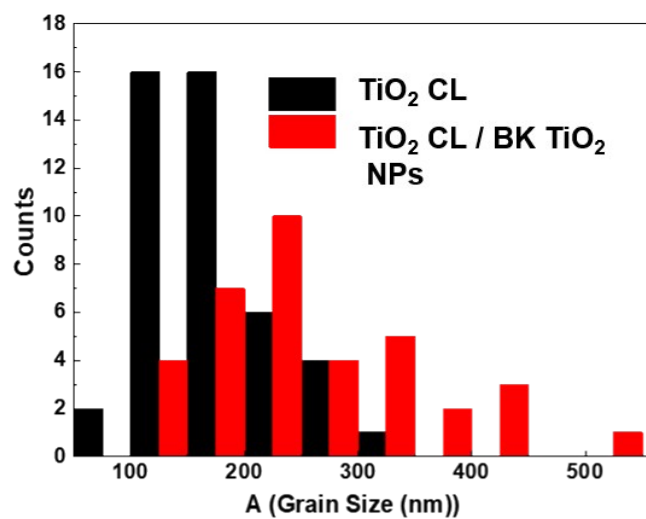


Figure S2. Top-view SEM images of (a) TiO_2 CL and (b) $\text{TiO}_2/\text{BK TiO}_2$ NPs.



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90 **Figure S3:** Domain size distribution of the perovskite without and with BK TiO₂ NPs.

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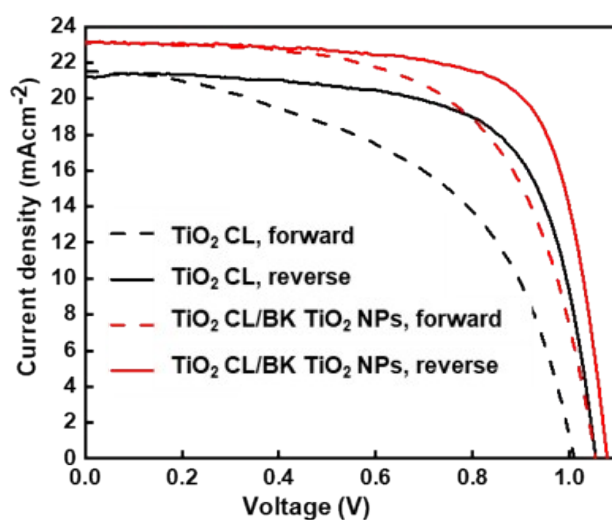
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111 **Figure S4.** FS and RS J - V characteristics of the devices with a TiO_2 layer only and with
112 TiO_2 CL/BK TiO_2 NPs layer.

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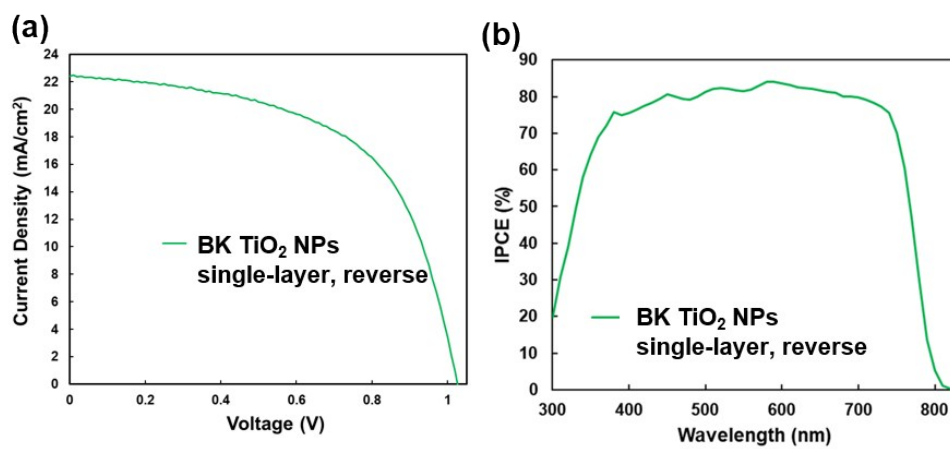
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130 **Figure S5.** (a) FS and RS J - V characteristics of the devices with a BK TiO₂ NPs single-
131 layer. (b) IPCE spectra of devices with a BK TiO₂ NPs single-layer.

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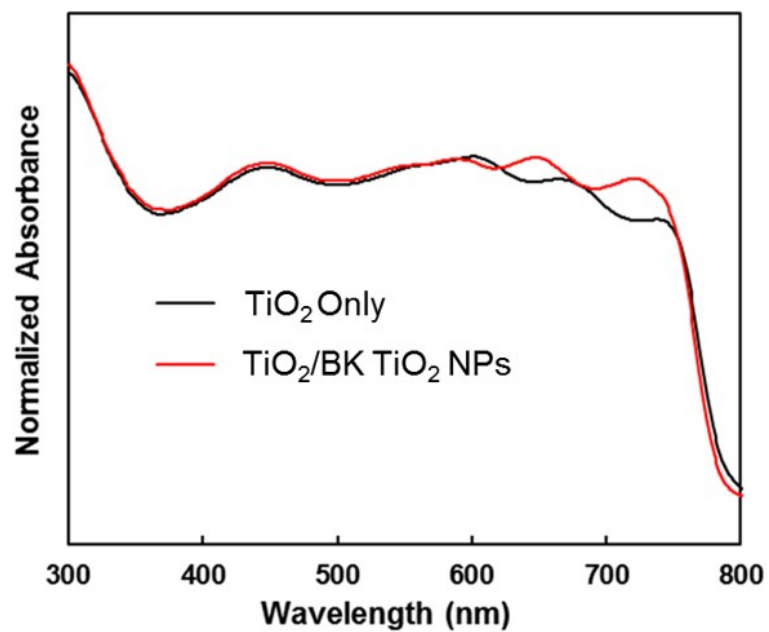
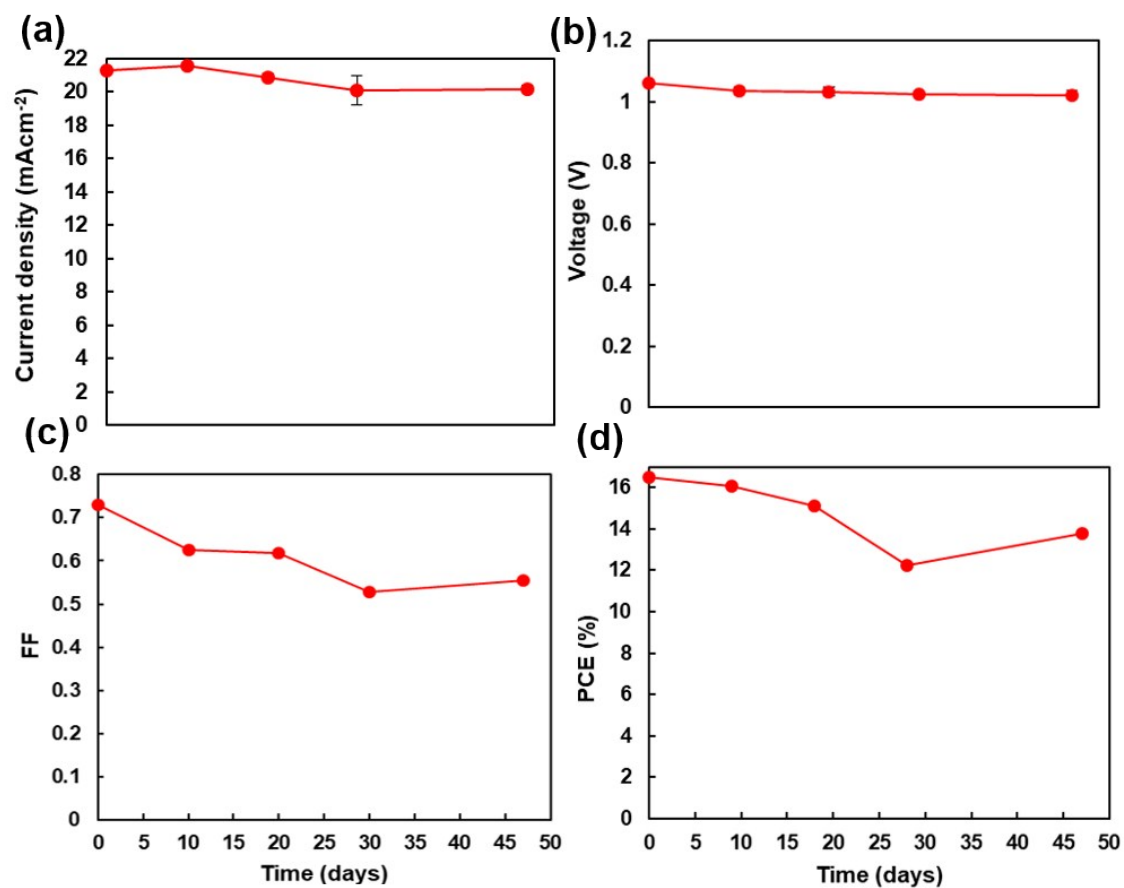


Figure S6. UV-vis characteristics of the perovskite with and without a BK TiO₂ NPs.



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165 **Figure S7.** Averaged photovoltaic parameters of PSCs fabricated with TiO₂/BK TiO₂ NPs: (a)
 166 J_{sc} , (b) V_{oc} , (c) FF, and (d) PCE, as functions of degradation period.

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Table S1. Peak parameters for calculating the mean crystalline size in perovskite thin films formed with and without a bilayer by the whole-pattern fitting method based on

Parameters	FTO/TiO ₂ CL/perovskite	FTO/TiO ₂ /BK TiO ₂ NPs/perovskite
Peak intensity	51.1	54.2
FWHM (B)	0.11	0.10
Bragg angle (θ) primary peak	14.12	14.12
X-ray wavelength (λ)	1.54	1.54
Constant (K)	0.9	0.9
Crystalline size (nm)	351	670

the Scherrer formula. (Instrument width FWHM = 0.139; Width = 0.150)

Devices	R_s (Ω)	R_{rec} (Ω)
TiO ₂ CL	54.27	5275
TiO ₂ CL/BK TiO ₂ NPs (bilayer CL)	23.65	18681

Table S2. The fitted Electrical impedance spectroscopy values of PSCs.

Table S3. Summary of cell performance characteristics of solar cells with different

Compact layer	Scan direction	J_{sc} (mA cm ⁻²)	V_{oc} (V)	FF	PCE (%)
TiO ₂ CL Only	Reverse	21.18	1.05	0.69	15.37
	Forward	21.50	1.01	0.52	11.25
BK TiO ₂ NPs Only	Reverse	22.41	1.02	0.58	13.25
	Forward	22.63	0.98	0.47	10.23
TiO ₂ CL/BK TiO ₂ NPs	Reverse	23.10	1.07	0.73	18.14
	Forward	23.10	1.05	0.62	15.07

types of ETLs.

