Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Reproducible 2D $Ti_3C_2T_x$ for Perovskite-based Photovoltaic Device

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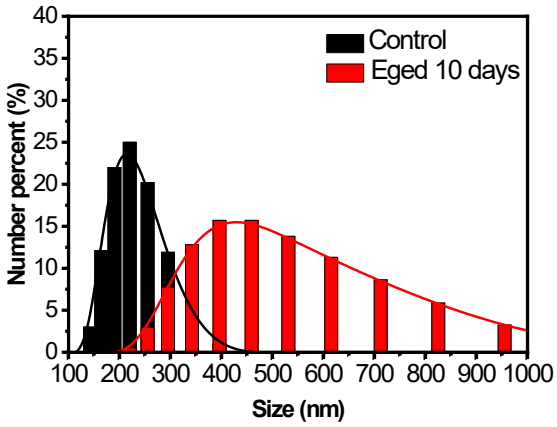

Figure S1. The shelf stability of $Ti_3C_2T_x$ suspension at room temperature.

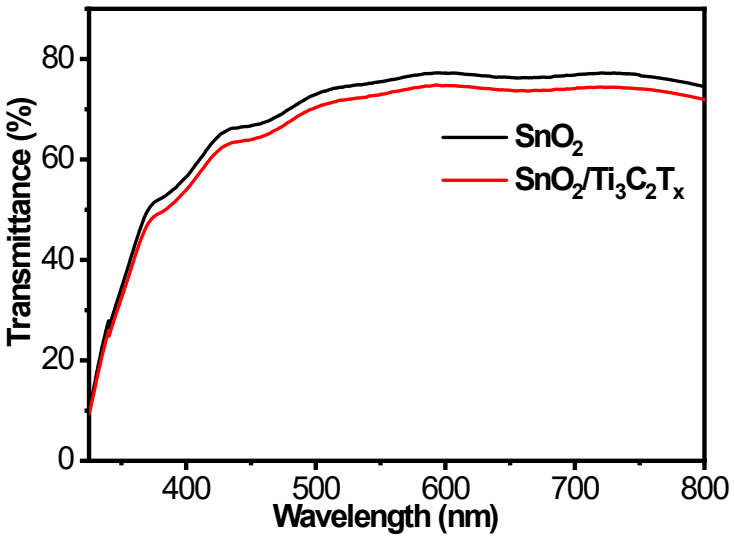

Figure S2. The UV-vis transmittance spectra of the electron transport layer with and without passivation.

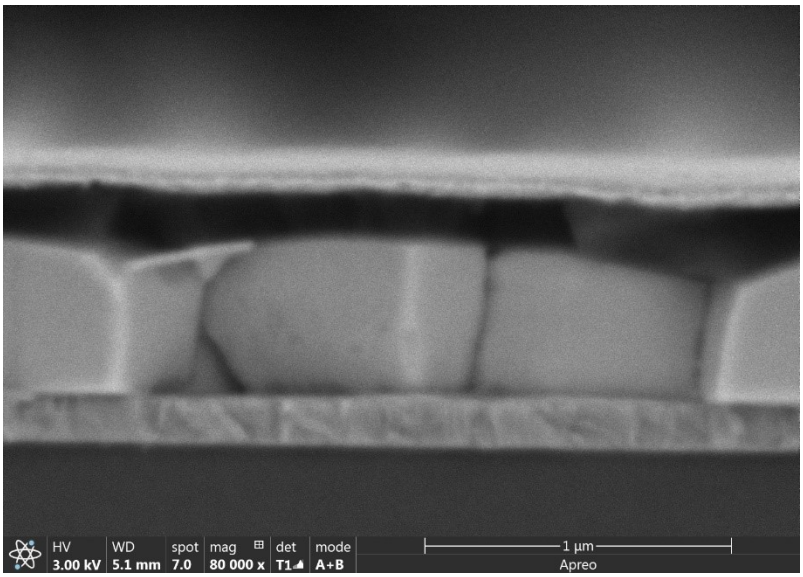

Figure S3. The cross-section images of optimal perovskite solar devices.

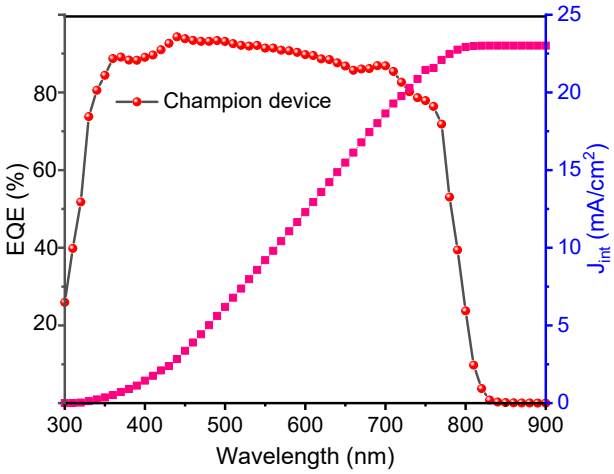

Figure S4. EQE spectrum of the optimal solar device.

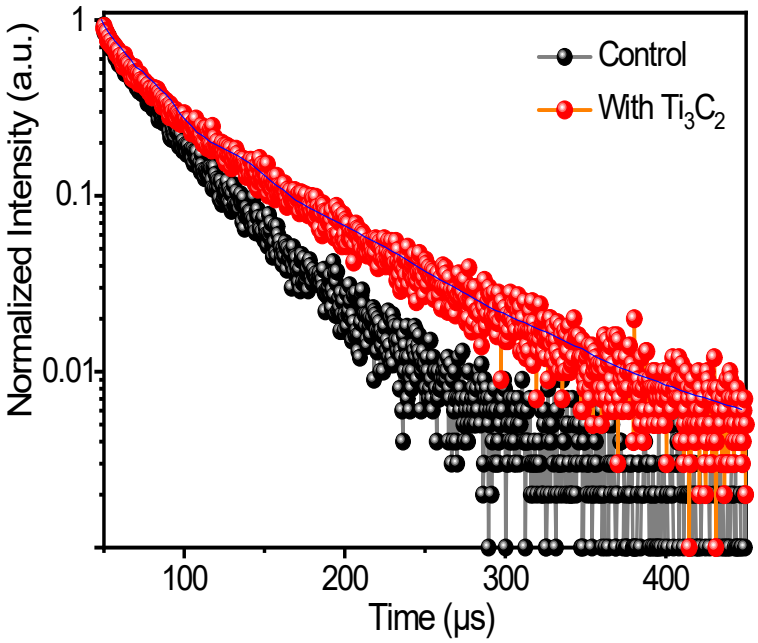

Figure S5. The TRPL of control and Ti_3C_2-modified perovskite films, respectively.

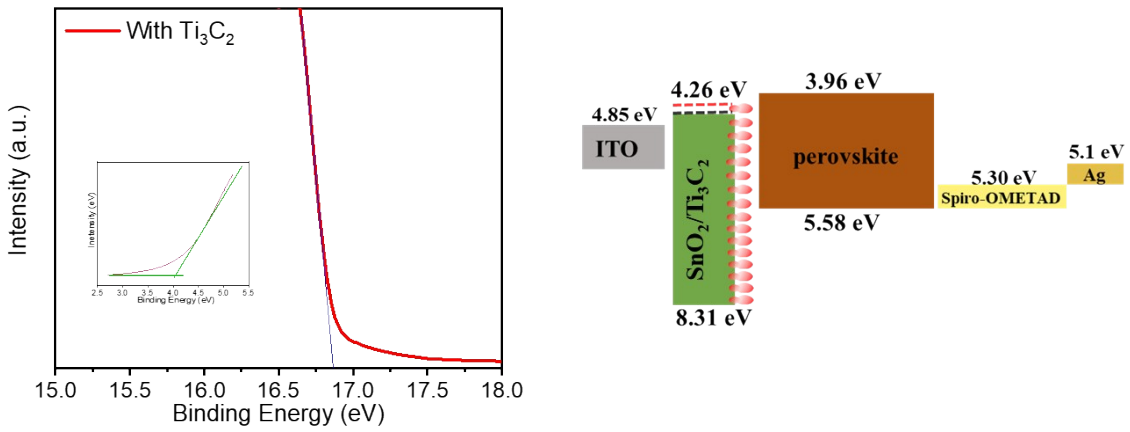

Figure S6. The UPS spectrum of Ti_3C_2-modified perovskite films and energy alignment in perovskite device, respectively.

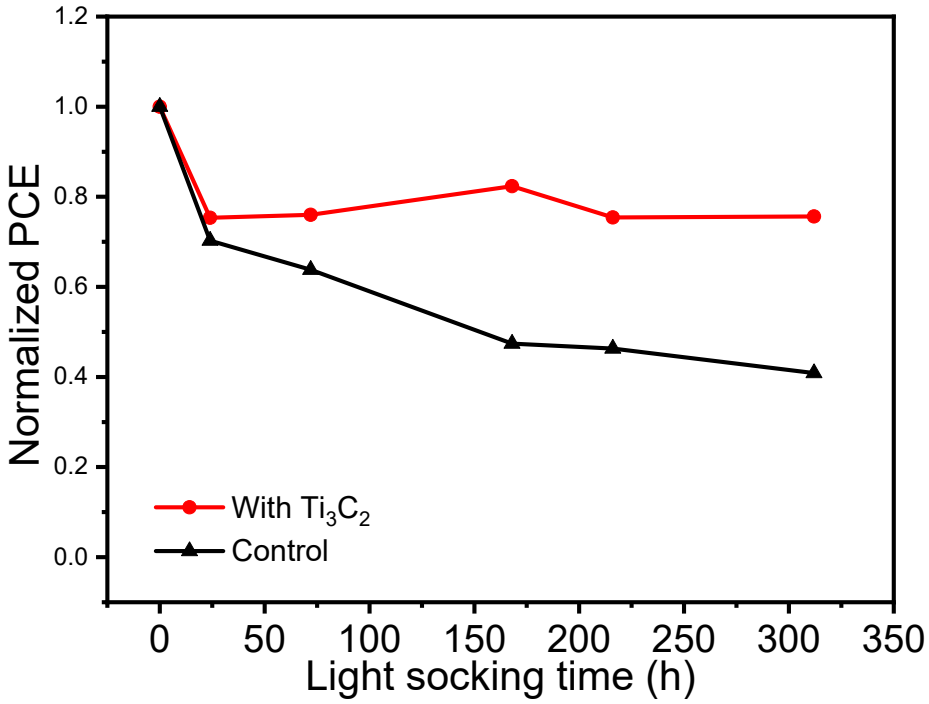

Figure S7. The operational stability of champion device under light socking with LED light source.

Table S1. The property of commercial Ti_3AlC_2 powder.

Name	Formula	Color	Formula weight	Density	-280 mesh	-325 mesh
Aluminum titanium carbide	Ti_3AlC_2	Black	197.6	1.87g/mL	87.56%	34.12%

Equation S1

Fabrication process:

$$3Ti\ (s) + 2C\ (graphite,\ s) \xrightarrow{1000\ ^\circ C} Ti_3C_2\ (s)$$

$$Ti_3C_2\ (s) + Al\ (s) \xrightarrow[Al\ intercalation]{1500\ ^\circ C} Ti_3AlC_2\ (s)$$

Etching process:

$$2Ti_3AlC_2\ (s) + 6HF\ (aq) \xrightarrow{Room\ temperature} 2Ti_3C_2T_x\ (s) + 2AlF_3\ (aq) + 3H_2\ (g)$$

Equation S2

The crystalline structures of the MXene membranes were

characterized by XRD; the d-spacing was calculated using Bragg's law:

$n\lambda = d\sin 2\theta$, (2)

where n is an integer (1, 2, 3…), λ is the wavelength of the X-ray, θ is the incident angle

and d is the spacing between the diffraction planes [1]

[1] Nair R. R., Wu H. A., Jayaram P. N., Grigorieva I. V., Geim A. K. Unimpeded permeation of water through helium-leak-tight graphene-based membranes. Science, 335, 442-444 (2012).