

Supporting Information

Decal Ni mesh to enhance the conductivity of carbon back contacts in dye sensitized and perovskite solar cells

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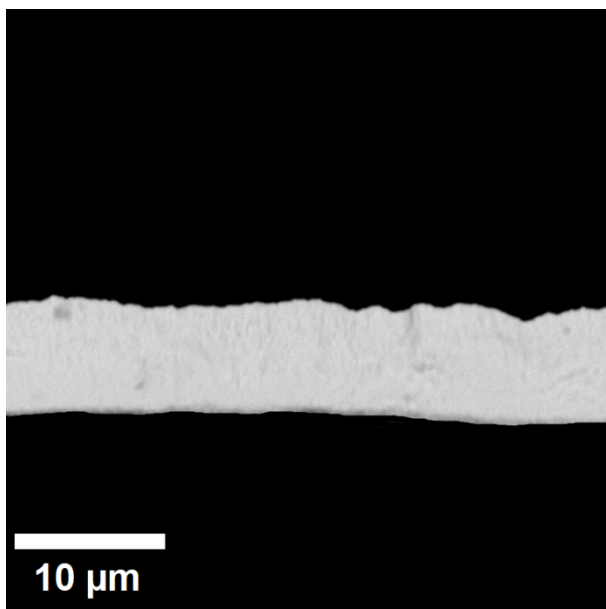


Figure S1 – Cross-sectional SEM image of electrodeposited Ni. Obtained using benchtop SEM Phenom XL.

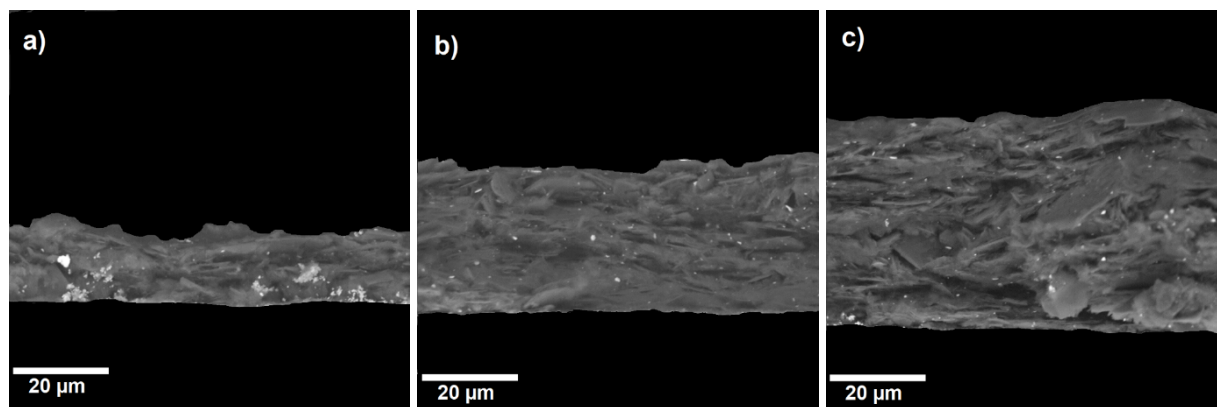


Figure S2 – Cross-sectional SEM images of the carbon layer after sequential screen-printing of one (a), two (b), and three (c) layers of carbon paste. The thickness of the carbon film is 13 μm (a), 32 μm (b), and 44 μm (c).

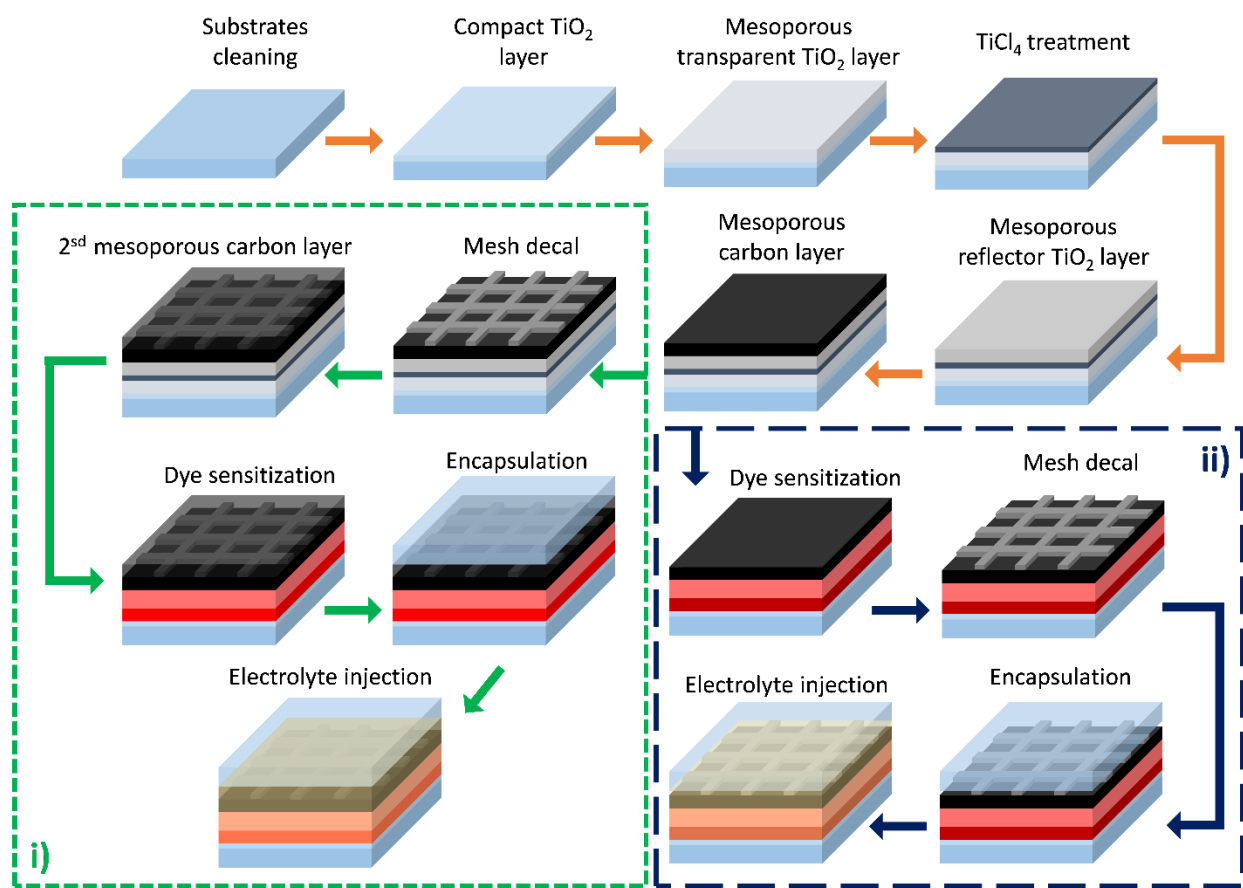


Figure S3 – Schematic illustration of the DSSCs preparation steps with the metallic mesh **i)** incorporated in the carbon layer or **ii)** applied on top of the monolithic DSSCs.

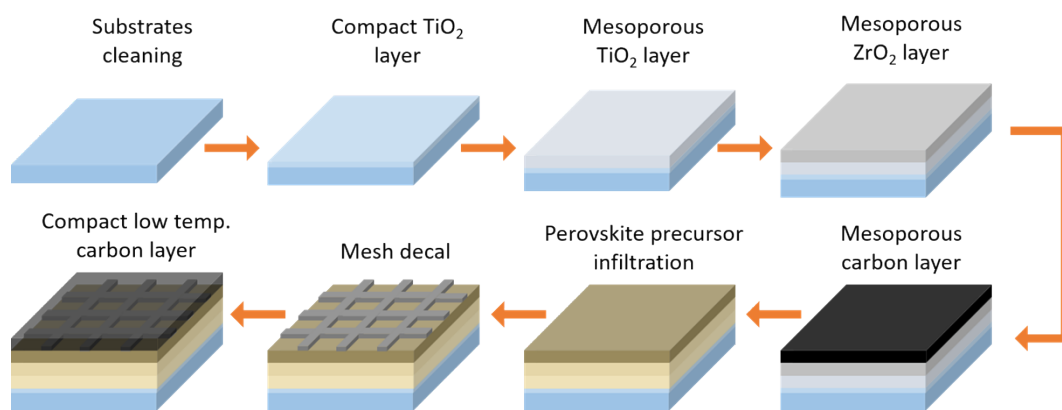


Figure S4 – Steps of production Ni mesh embedded PSCs.

Table S1 – Thickness and sheet resistance R_{sheet} of screen-printed carbon films.

Number of printed carbon layers	Thickness / μm	R_{sheet} / $\Omega\cdot\text{sq}^{-1}$
1	13.0 ± 0.5	11.5 ± 0.5
2	32.0 ± 0.8	6.0 ± 0.5
3	44.0 ± 1.0	4.0 ± 0.5

Table S2 – Average photovoltaic metrics of M-DSSCs with different thicknesses of carbon electrode.

Thickness / μm	13 μm	32 μm	44 μm
V_{oc} / V	0.86 ± 0.01	0.85 ± 0.00	0.82 ± 0.02
J_{sc} / $\text{mA}\cdot\text{cm}^{-2}$	11.1 ± 0.1	11.3 ± 0.2	7.0 ± 0.5
η_{FF}	0.75 ± 0.01	0.78 ± 0.01	0.78 ± 0.00
PCE / %	7.2 ± 0.1	7.4 ± 0.1	4.5 ± 0.4

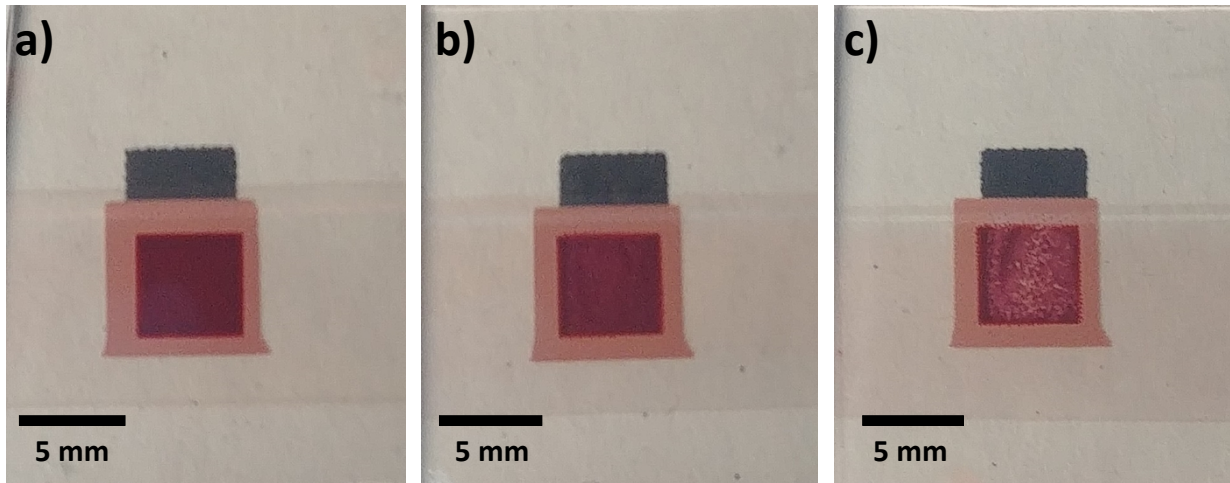


Figure S5– Photographs of DSSCs from the side of the photoanode; DSSCs differ with the thickness of the carbon counter electrode layer: 13 μm (a), 32 μm (b), and 44 μm (c).

Table S3 – Incident light intensity-dependent average and standard deviation photovoltaic parameters of large area DSSCs with 13 μm carbon electrode without and with Ni mesh applied on top (*t*) of the carbon layer.

Carbon thickness / μm	Light intensify / sun	V_{oc} / V	I_{sc} / $\text{mA}\cdot\text{cm}^{-2}$	η_{FF}	PCE / %
13 μm	2	0.91 ± 0.00	8.5 ± 0.3	0.27 ± 0.00	1.0 ± 0.0
	1.5	0.89 ± 0.00	8.1 ± 0.3	0.27 ± 0.00	1.3 ± 0.0
	1	0.89 ± 0.00	7.5 ± 0.2	0.28 ± 0.00	1.9 ± 0.1
	0.5	0.88 ± 0.00	5.7 ± 0.1	0.33 ± 0.01	3.2 ± 0.1
	0.3	0.87 ± 0.00	3.5 ± 0.1	0.44 ± 0.02	4.5 ± 0.1
	0.1	0.83 ± 0.01	1.1 ± 0.0	0.68 ± 0.00	6.4 ± 0.0
13 μm + Ni mesh on top	2	0.92 ± 0.00	15.1 ± 0.0	0.37 ± 0.03	2.6 ± 0.2
	1.5	0.92 ± 0.00	13.8 ± 0.2	0.39 ± 0.04	3.3 ± 0.3
	1	0.90 ± 0.01	10.7 ± 0.6	0.46 ± 0.05	4.4 ± 0.2
	0.5	0.89 ± 0.00	5.6 ± 0.3	0.60 ± 0.04	6.0 ± 0.1
	0.3	0.88 ± 0.00	3.4 ± 0.2	0.68 ± 0.02	6.8 ± 0.1
	0.1	0.84 ± 0.00	1.1 ± 0.0	0.77 ± 0.00	6.9 ± 0.3

Table S4 – Average and standard deviation photovoltaic parameters of large area DSSCs with 32 μm carbon film (32-*L*) without and with Ni mesh applied on top (*t*) or embedded (*e*) in the carbon layer at different light intensifies.

Carbon thickness / μm	Light intensify / sun	V_{oc} / V	I_{sc} / $\text{mA}\cdot\text{cm}^{-2}$	η_{FF}	PCE / %
32 μm	2	0.91 ± 0.00	13.0 ± 0.9	0.27 ± 0.00	1.6 ± 0.1
	1.5	0.91 ± 0.01	12.7 ± 0.7	0.27 ± 0.00	2.1 ± 0.1
	1	0.90 ± 0.01	10.8 ± 0.2	0.30 ± 0.01	2.9 ± 0.1
	0.5	0.88 ± 0.00	5.8 ± 0.0	0.47 ± 0.02	4.8 ± 0.2
	0.3	0.87 ± 0.00	3.5 ± 0.0	0.58 ± 0.01	6.0 ± 0.1
	0.1	0.84 ± 0.01	1.1 ± 0.0	0.73 ± 0.00	6.9 ± 0.0
32 μm + Ni mesh on top	2	0.92 ± 0.01	15.2 ± 0.9	0.28 ± 0.01	2.0 ± 0.1
	1.5	0.91 ± 0.01	14.2 ± 0.7	0.30 ± 0.01	2.6 ± 0.2
	1	0.91 ± 0.01	11.3 ± 0.5	0.36 ± 0.01	3.7 ± 0.2
	0.5	0.89 ± 0.01	6.0 ± 0.2	0.53 ± 0.02	5.6 ± 0.3
	0.3	0.88 ± 0.01	3.6 ± 0.1	0.64 ± 0.02	6.6 ± 0.2
	0.1	0.85 ± 0.01	1.1 ± 0.0	0.76 ± 0.01	7.2 ± 0.1
32 μm + Ni mesh	2	0.90 ± 0.02	15.4 ± 1.5	0.33 ± 0.02	2.2 ± 0.0

embedded	1.5	0.89 ± 0.02	14.1 ± 1.7	0.34 ± 0.03	2.8 ± 0.0
	1	0.87 ± 0.02	10.4 ± 0.6	0.41 ± 0.01	3.8 ± 0.0
	0.5	0.86 ± 0.03	5.6 ± 0.4	0.57 ± 0.01	5.4 ± 0.1
	0.3	0.84 ± 0.02	3.4 ± 0.2	0.66 ± 0.00	6.3 ± 0.2
	0.1	0.81 ± 0.03	1.1 ± 0.0	0.75 ± 0.01	6.6 ± 0.1

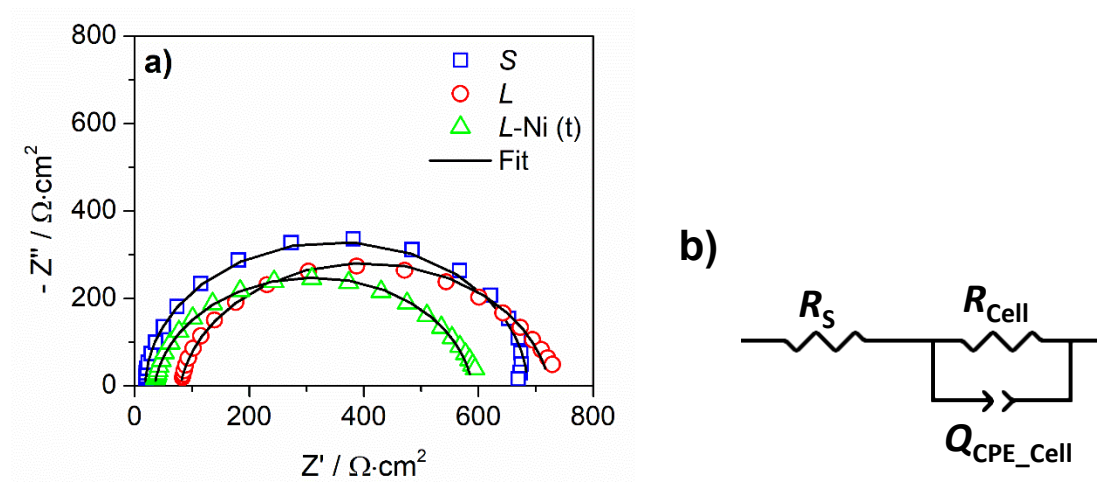


Figure S6 – Nyquist plots of PSCs (a) and equivalent circuit model used to fit the spectra (b).

Table S5 – Internal resistances of PSCs devices in $\Omega \cdot \text{cm}^2$ obtained by fitting the equivalent circuit model (Figure S6b) from EIS spectra.

Device	R_s	R_{cell}
<i>S</i>	18.9	613.8
<i>L</i>	73.5	598.9
<i>L-Ni</i>	36.5	538.4