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Nanocolumnar 1-dimesnional TiO_2 photoanodes deposited by PVD-OAD for perovskite solar cells fabrication

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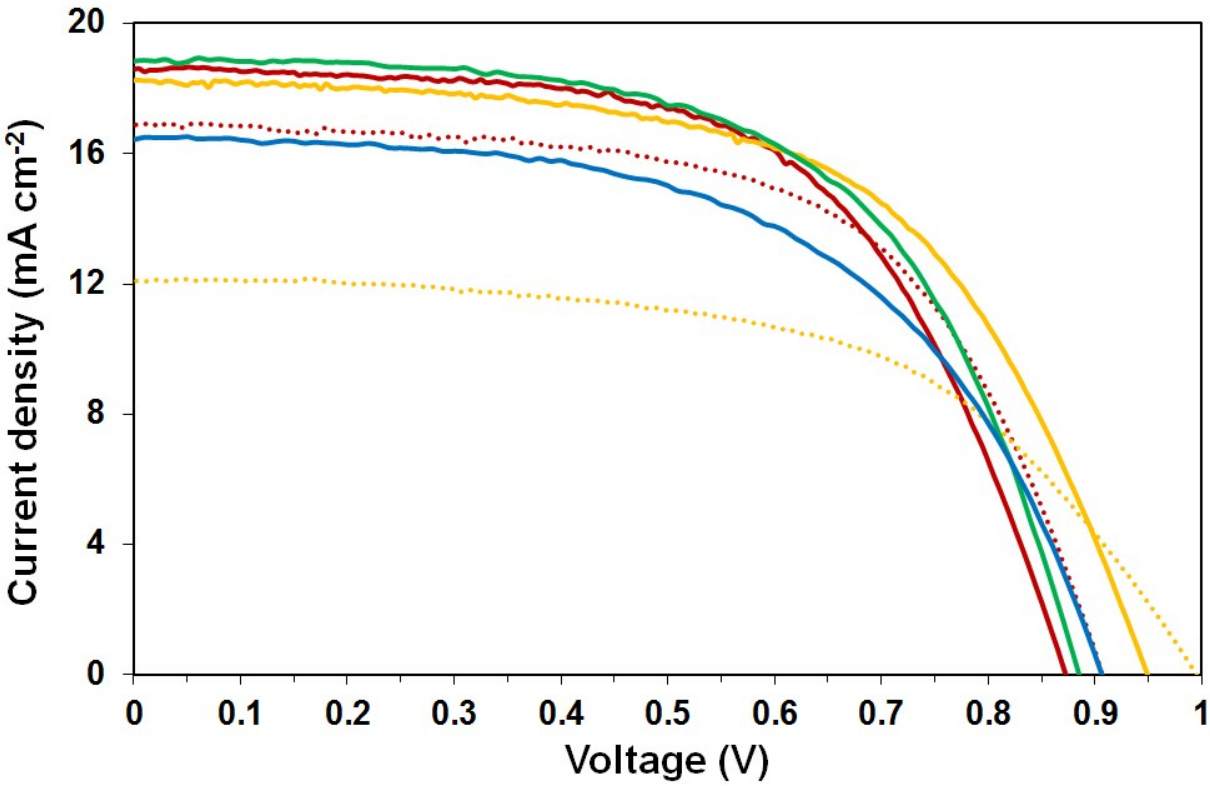


Figure S1. Current density-voltage performance of the PV devices employed in the study the different forming perovskite conditions over nanocolumnar 300nm thick TiO_2 photoanodes. $[PbI_2]$=1M, concentration of MAI = 10mg/mL at simulated AM1.5G solar irradiation of 99.3mW·cm^{-2} (red dotted line). $[PbI_2]$=1M, concentration of MAI = 8mg/mL at simulated AM1.5G solar irradiation of 98.1mW cm^{-2} (red solid line). $[PbI_2]$=1.25M, concentration of MAI = 10mg/mL at simulated AM1.5G solar irradiation of 99.3mW·cm^{-2} (yellow dotted line). $[PbI_2]$=1.25M, concentration of MAI = 8mg mL^{-1} at simulated AM1.5G solar irradiation of 99.6mW·cm^{-2} (yellow solid line). $[PbI_2]$=1.35M, concentration of MAI = 8mg mL^{-1} at simulated AM1.5G solar irradiation of 99.6mW cm^{-2} (green solid line). $[PbI_2]$=1.45M, concentration of MAI = 8mg/mL at simulated AM1.5G solar irradiation of 98.7mW cm^{-2} (blue solid line).

Table S1. Photovoltaic performance of the previous works published using 1-dimensional TiO_2 photoanode structures for perovskite-sensitized solar cells.

Ref.	Photoanode	Perovskite	HTM	TiO_2 photoanode thickness (nm)	J_{SC} (mA·cm^{-2})	V_{OC} (mV)	*FF*	*PCE* (%)
Qiu et al.[30]	TiO_2 nanowires	$CH_3NH_3PbI_3$	Spiro-OMeTAD	1500	10.67	740	0.54	4.29
		$CH_3NH_3PbI_{3-x}Br_x$		1500	10.12	820	0.59	4.87
Kim et al.[31]	TiO_2 nanorod (rutile)	$CH_3NH_3PbI_3$	Spiro-OMeTAD	560	15.6	955	0.63	9.4
				920	12.6	929	0.62	7.3
				1580	11.2	865	0.61	5.9
Dharani et al.[32]	TiO_2 nanofiber	$CH_3NH_3PbI_3$	Spiro-OMeTAD	413	15.88	980	0.63	9.82
				844	6.41	780	0.66	3.32
				1215	5.14	740	0.66	2.49
Jiang et al.[33]	TiO_2 nanowires (rutile)	$CH_3NH_3PbI_3$	Spiro-OMeTAD	400	18.6	850	0.62	9.7
				600	20.4	780	0.68	10.8
				900	22.3	770	0.68	11.7
				1200	9.3	720	0.71	4.8
Lee et al.[34]	TiO_2 nanohelix	$HC(NH_2)_2PbI_3$	Spiro-OMeTAD	400	19.88	912	0.66	12.03

Table S2. Optimization of the perovskite recipe employed over the 1-dimensional nanocolumnar TiO_2 films to obtain the optimum conditions. The concentration of the PbI_2 and the MAI solutions is tuned and the short-circuit current (J_{SC}), open-circuit voltage (V_{OC}), the fill factor and the power conversion efficiency were reported at 0.1 sun and 1 sun keeping constant the thickness and evaporation angle of the photoanodes on angle (α).

Thickness (nm)	α (º)	[PbI_2] (M)	MAI concentration (g mL^{-1})	Sun	J_{SC} (mA·cm^{-2})	V_{OC} (mV)	*FF*	Efficiency (%)
300	70	1	10	0.1	1.69	785.9	0.669	9.13
				1	16.89	907.2	0.604	9.31
300	70	1	8	0.1	1.87	754.4	0.690	9.95
				1	18.59	872.7	0.597	9.88
300	70	1.25	10	0.1	1.27	901.9	0.537	6.37
				1	12.10	994.9	0.569	6.89
300	70	1.25	8	0.1	1.81	830.4	0.671	10.39
				1	18.25	949.0	0.588	10.22
300	70	1.35	8	0.1	1.88	761.2	0.630	9.31
				1	18.84	885.0	0.594	9.95
300	70	1.45	8	0.1	1.68	791.3	0.568	7.77
				1	16.43	906.3	0.558	8.42

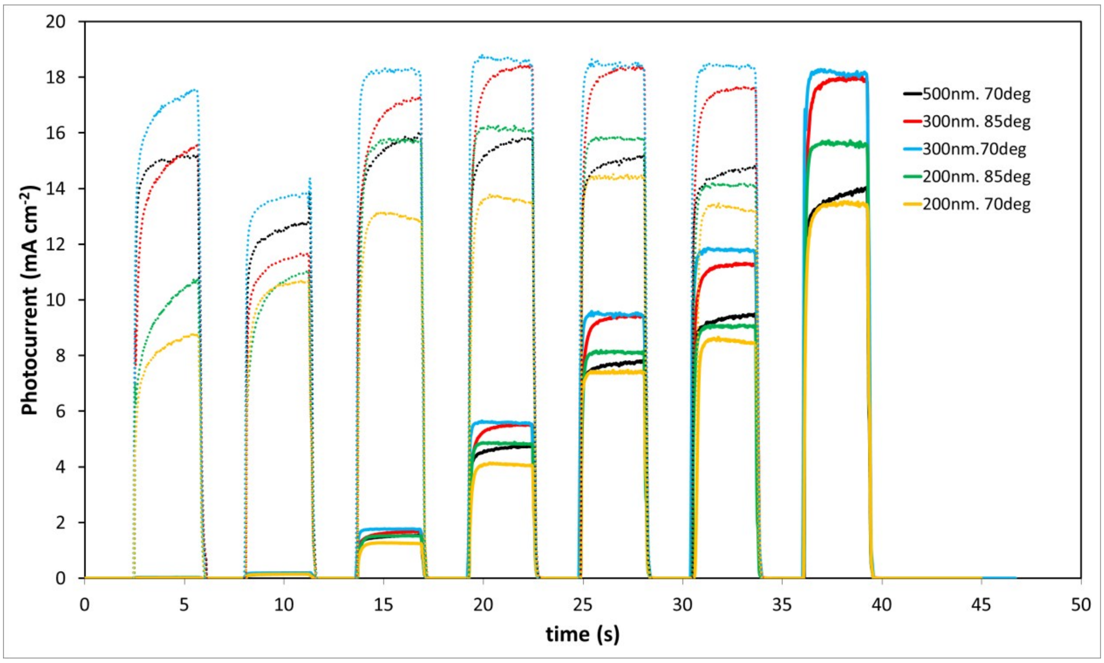
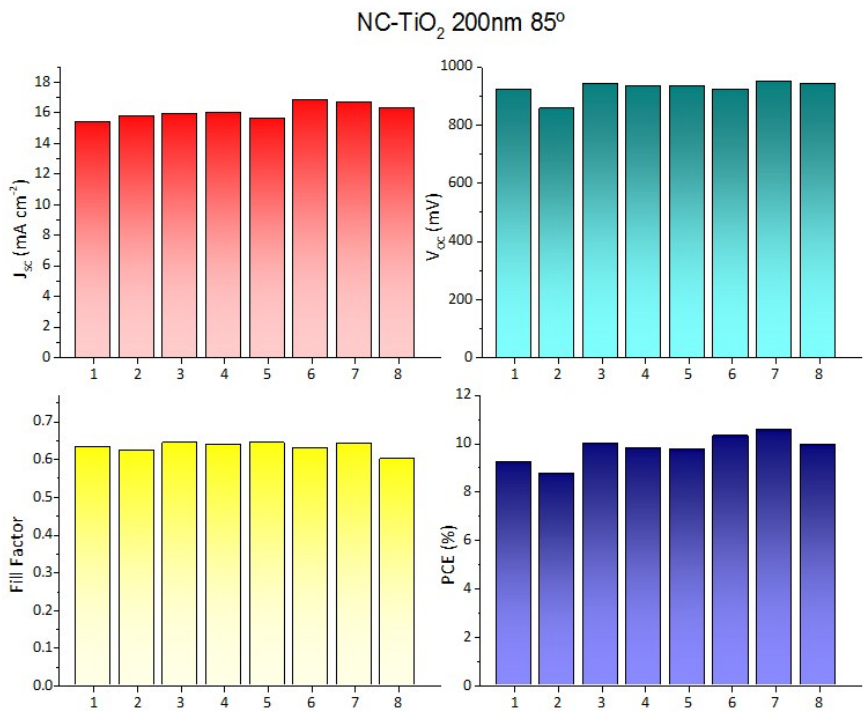
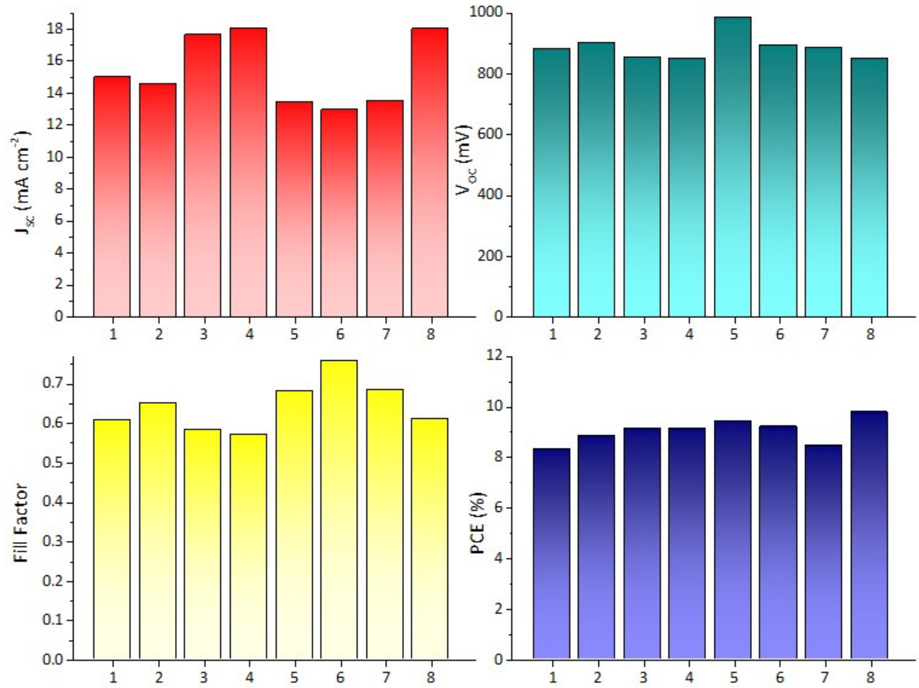


Figure S2: Transient photocurrent experiments for different thickness and porosity of nanocolumunar TiO_2. A linear behavior is observed, as the expected photocurrent at full sun (dashed lines) matches quite well with the observed photocurrent at 1 Sun. Here a relatively, slow response was observed in devices made from 500 nm thick NC-TiO_2 (black line) that is attributed due to the higher thickness of photoanode. Similarly for the 300nm (α=85^o) a marginally exponential increase was observed. Both for 300nm (α=70^o) and 200nm (α=85^o) the behavior was much more flat showing a better photo-transient response that is in agreement with the efficient devices reported elsewhere.

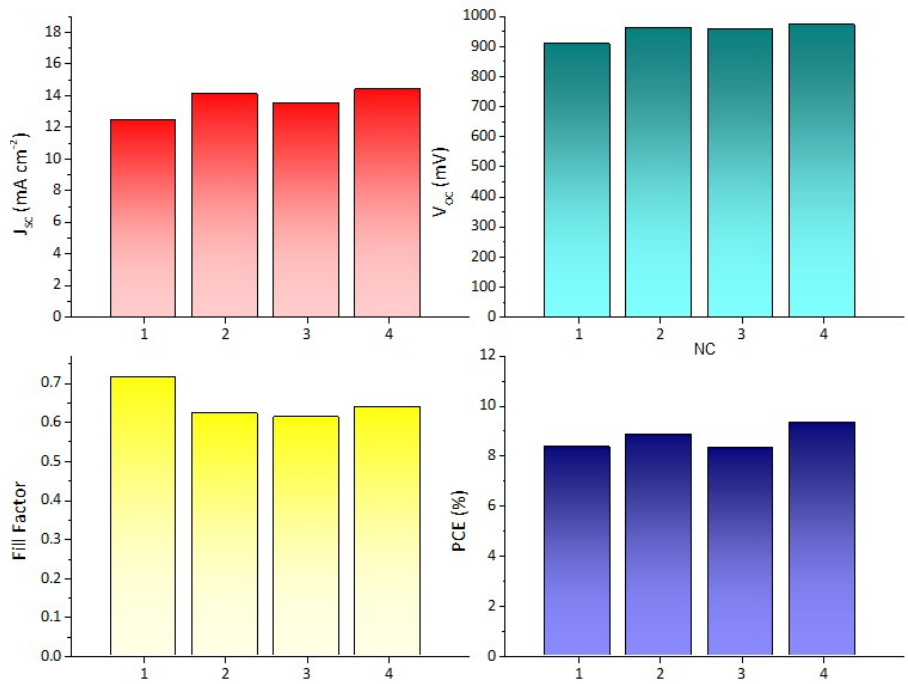
Histograms of the fabricated devices with different thickness and deposition angle (porosity).
The thickness was varied from 200-500 nm while the deposition angle was switched between 85^o and 70^o.



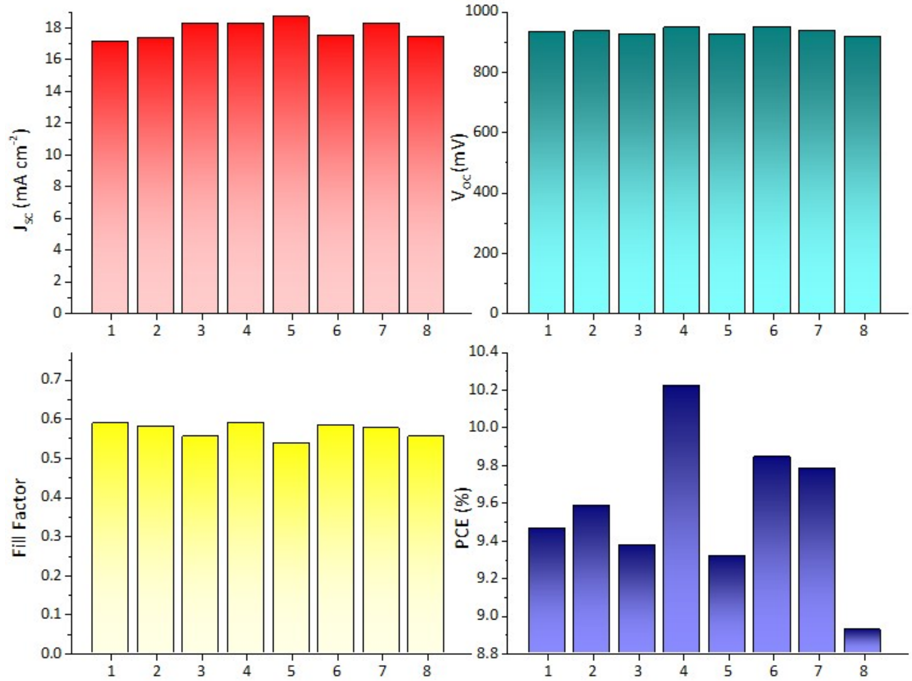
NC-TiO_2 300nm 85°



NC-TiO_2 200nm 70°



NC-TiO_2 300nm 70°



NC-TiO_2 500nm 70°