Electronic Supplementary Information

Enhanced efficacy of defect passivation and charge extraction for efficient perovskite photovoltaics with small open circuit voltage loss

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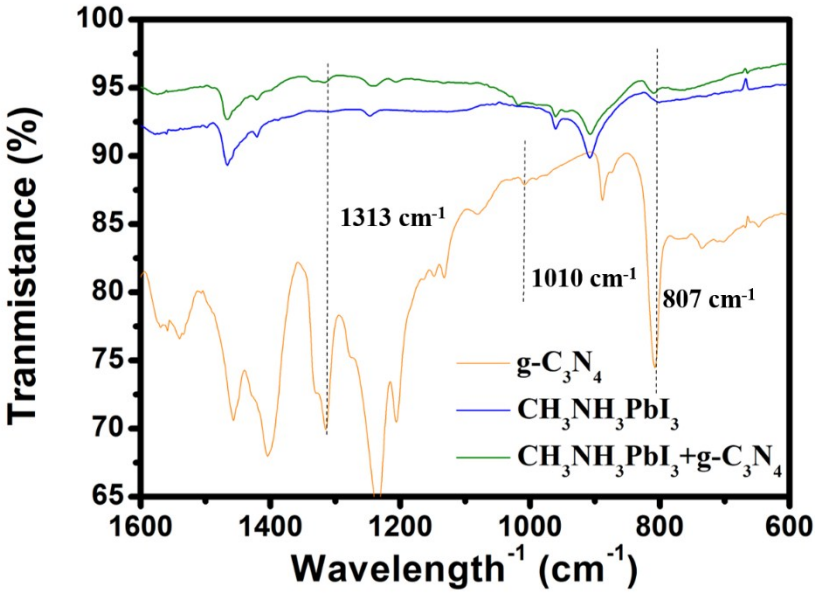

Fig. S1. The magnified FTIR spectra of pure g-C_3N_4, $CH_3NH_3PbI_3$ and g-C_3N_4 incorporated $CH_3NH_3PbI_3$ powder scraped from the films deposited on glass substrate.

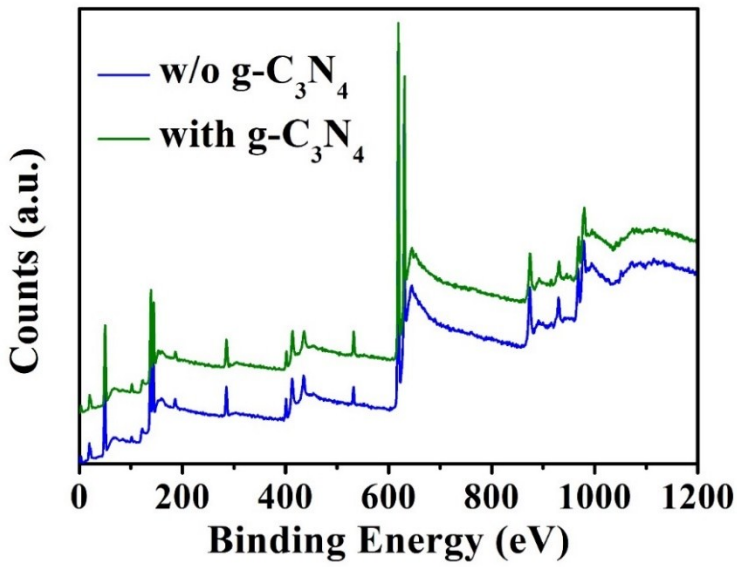

Fig. S2. XPS spectra of the control $CH_3NH_3PbI_3$ and *g*-C_3N_4 incorporated $CH_3NH_3PbI_3$ films deposited on glass substrate.

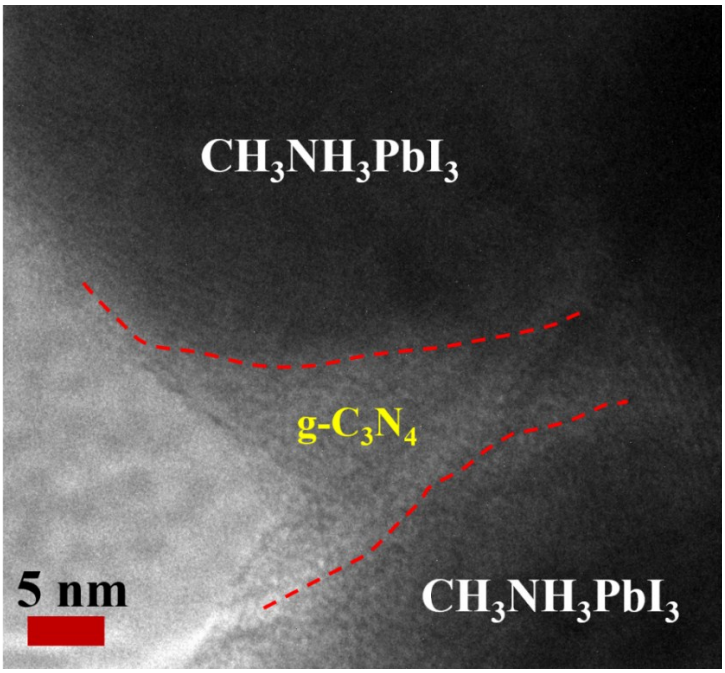

Fig. S3. High-resolution TEM image of g-C_3N_4 modified $CH_3NH_3PbI_3$ film, showing the heterogeneous anchoring of polymeric g-C_3N_4 around the GBs or surface of highly-crystalline perovskite grains.

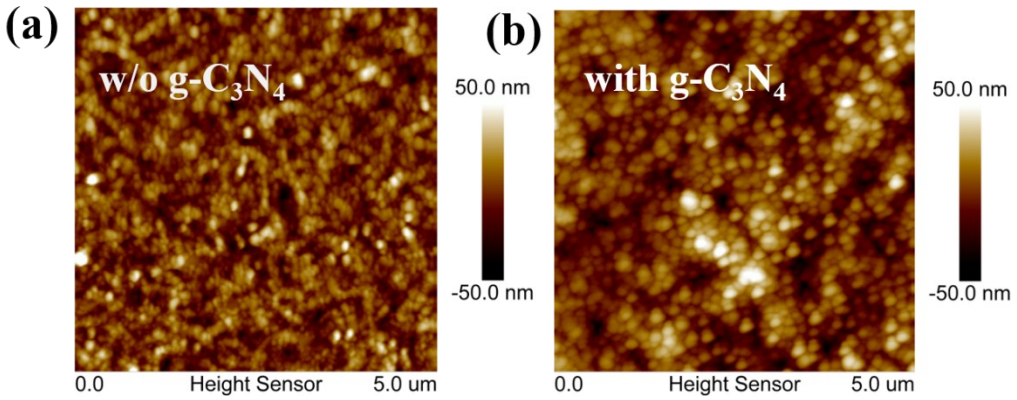

Fig. S4. Topographic AFM images showing the roughness of the control $CH_3NH_3PbI_3$ and g-C_3N_4 modified $CH_3NH_3PbI_3$ films.

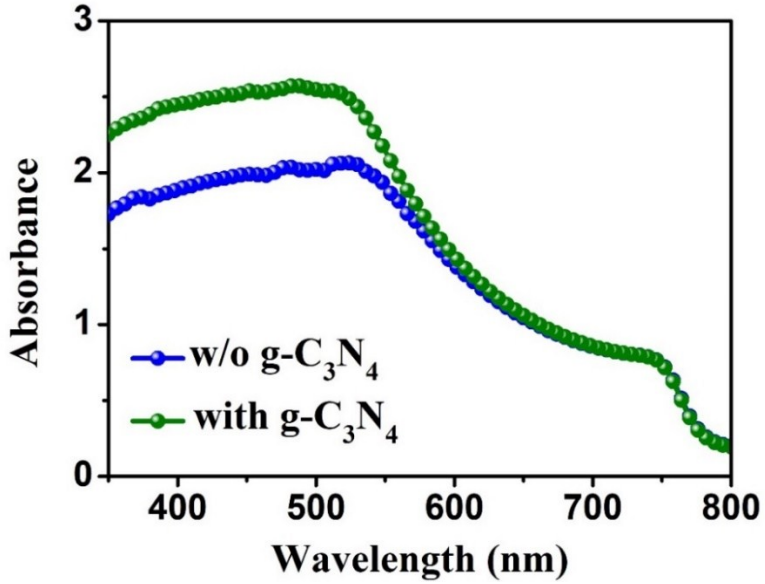

Fig. S5. UV-vis absorption spectra of the of control $CH_3NH_3PbI_3$ and g-C_3N_4 incorporated $CH_3NH_3PbI_3$ film deposited on FTO glass substrate.

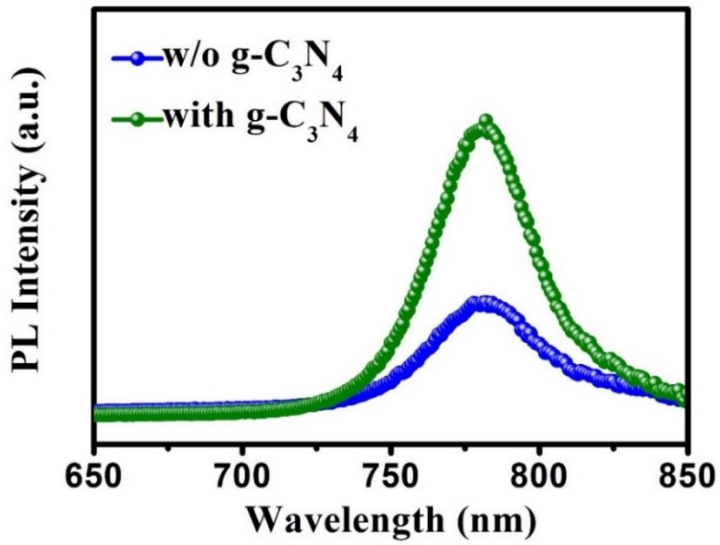

Fig. S6. PL emission spectra of control $CH_3NH_3PbI_3$ and g-C_3N_4 modified $CH_3NH_3PbI_3$ films coated on glass substrate.

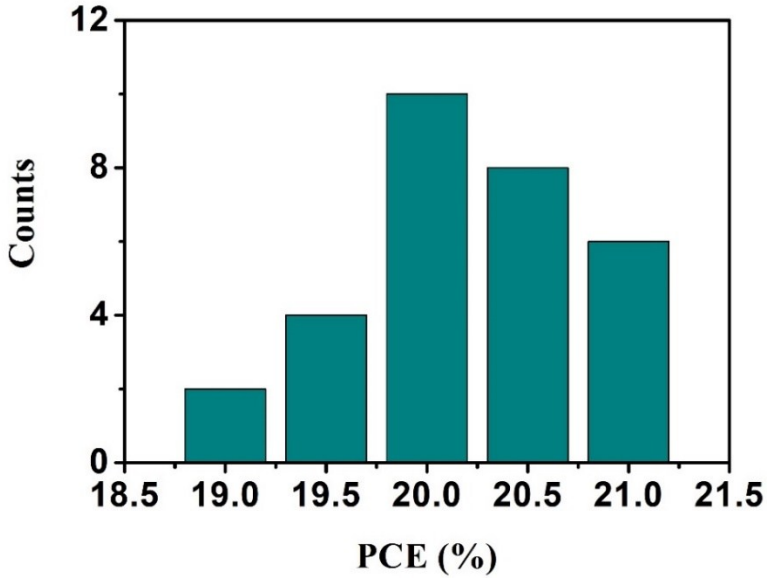

Fig. S7. PCEs histogram of a batch of 30 devices based on g-C_3N_4 modified $CH_3NH_3PbI_3$ films.

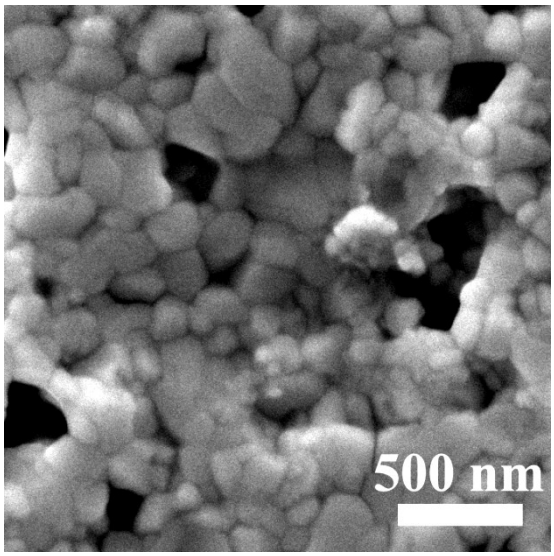

Fig. S8. Top-view SEM image of the $CH_3NH_3PbI_3$ perovskite film incorporated with 0.2 wt% g-C_3N_4.

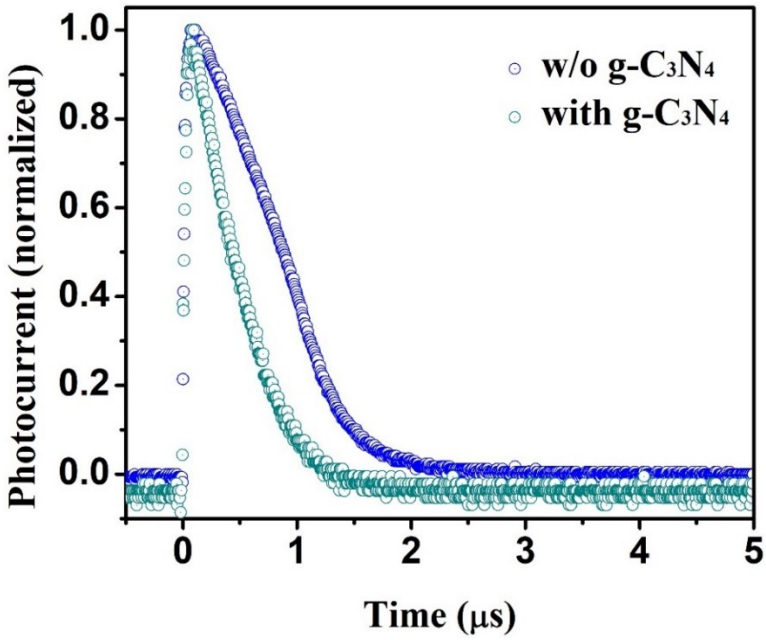

Fig. S9 Transient photocurrent decay of PSCs incorporated with or without g-C_3N_4.

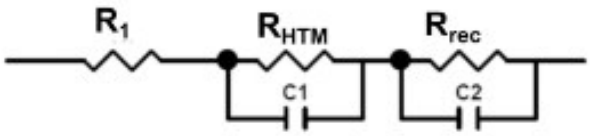

Fig. S10 The equivalent circuit model used for fitting the Nyquist plots.

Table S1. Summary of the photovoltaic parameters for the PSCs incorporated with different amounts of g-C_3N_4 additive.

g-C_3N_4 contents	J_{sc}/mA cm^{-2}	V_{oc}/V	η/%	*FF*
0.05 wt%	22.2	1.12	18.9	0.76
0.1 wt%	23.0	1.16	21.1	0.79
0.2 wt%	21.5	1.08	17.2	0.74

Table S2. The fitted recombination resistance (R_{rec}), capitance (C_2) and the claculated carrier lifetime (τ_e) of the PSCs based on control and g-C_3N_4 modified $CH_3NH_3PbI_3$ films according to the the Nyquist plots shown in Fig. 5a and 5b.

Bias (V)	R_{rec} (Ω cm^2)		C_2 (*E^{-8} F)		τ_e (*E^{-4} s)	
	w/o g-C_3N_4	with g-C_3N_4	w/o g-C_3N_4	with g-C_3N_4	w/o g-C_3N_4	with g-C_3N_4
-0.80	6092	6678	5.47	5.78	3.30	3.90
-0.85	4439	6162	4.72	4.63	2.10	2.90
-0.90	2419	4473	4.02	4.28	0.97	1.90
-0.95	1103	2468	2.93	3.50	0.32	0.86
-1.00	962	1736	2.74	2.85	0.26	0.49

*The carrier lifetime (τ_e) is calculated according to the following equation: $\tau_e = R_{rec} * C_2$.