Supporting Information

Tailored Au@TiO_2 Nanostructures for Plasmonic Effect in Planar Perovskite Solar Cells

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Experimental Section:

Preparation of Au@TiO_2 NPs: Briefly , 100 mL 0.4 mM $HAuCl_4 \cdot 4H_2O$ was heated to boiling. After the addition of 5mL 34 mM trisodium citrate dehydrate, the mixed solution was kept boiling for 15min. The as-prepared gold nano particles were centrifuged and redispersed into 500 μL ultrapure water. To coat the gold nano particles with titania, 0.55 mL $NaHCO_3$ was added into the solution of 100 μL $TiCl_3$ in 3 mL ultrapure water dropwise, after which the gold nano partilces solution was immediately injected under vigorous stirring and the resultant solution was kept stirring for half an hour. The obtained Au@TiO_2 NPs were washed several times by centrifuge and redispered into 500 μL ethanol for further use.

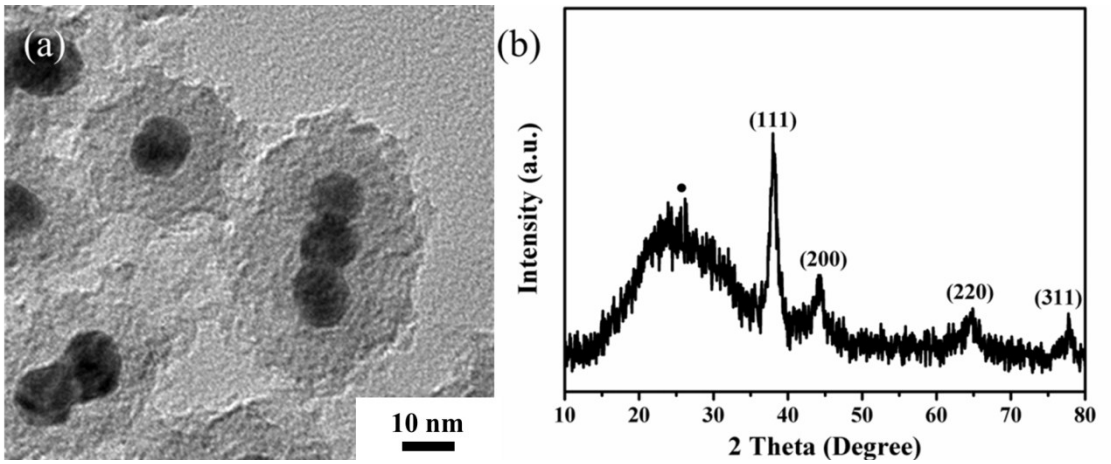

Figure S1. (a) TEM image of the Au@TiO_2 NPs (b) XRD pattern of Au@TiO_2 NPs

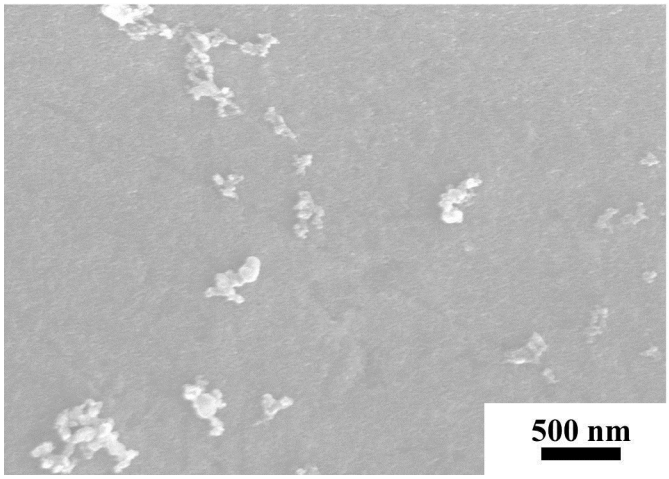

Figure S2. SEM image of plasmonic nanoparticles spin-coated on top of the ETL

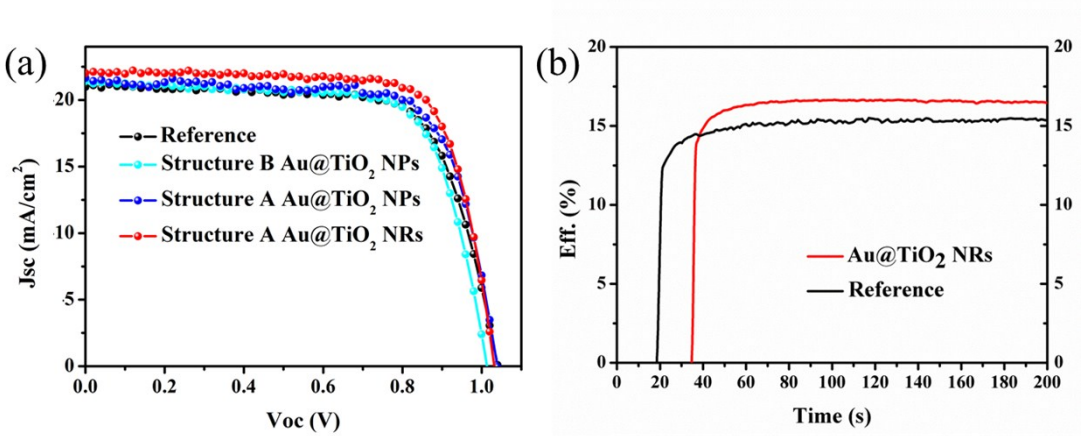

Figure S3. (a)The comparison of Au@TiO_2 NPs and Au@TiO_2 NRs assembled in different structures.

(b) Steady state output at 0.88V for the devices with/without Au@TiO_2 NRs

Table S1. The device performance comparison of Au@TiO_2 NPs and Au@TiO_2 NRs assembled in different structures

Device	Voc(V)	Jsc(mA/cm^2)	PCE(%)	FF.(%)
Reference	1.041	21.39	15.69	70.49
Structure B Au@TiO_2 NPs	1.014	20.86	15.80	74.69
Structure A Au@TiO_2 NPs	1.040	21.45	16.49	73.95
Structure A Au@TiO_2 NRs	1.032	22.42	17.38	75.12

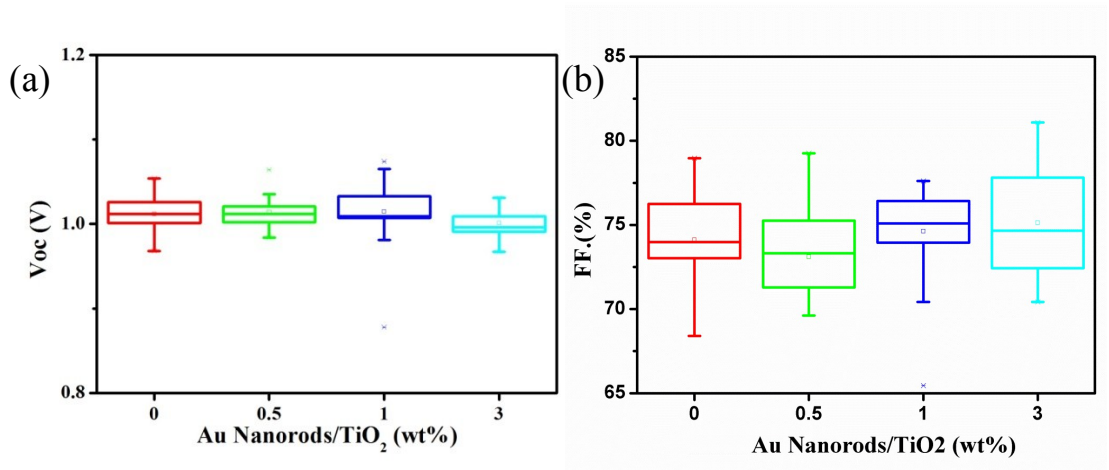

Figure S4. Statistical analysis of device characteristics by varying the concentration of Au nanorods/TiO_2 embedded into the ETL in perovskite solar cell. (a) Voc. (b) Fill Factor.

Table S2. The device performance of reference samples.

Number	Voc(V)	Jsc(mA/cm^2)	PCE(%)	FF.(%)
1	1.017	20.32	13.30	64.38
2	1.024	20.13	15.07	73.08
3	1.015	20.93	15.61	73.47
4	1.034	21.40	16.05	72.56
5	1.016	21.51	16.99	77.76
6	1.054	21.09	17.44	78.46
7	1.040	19.09	15.06	75.9
8	1.018	19.73	14.59	72.65
9	1.023	18.93	15.09	77.94
10	0.968	19.68	13.95	73.23
11	0.997	22.07	16.06	73.02
12	1.002	21.75	16.06	73.70
13	0.987	22.50	15.93	71.73
14	1.004	21.44	14.93	69.34
15	1.010	19.76	14.81	74.23
16	1.004	21.90	16.33	74.32
17	1.005	21.70	16.13	73.95
18	1.046	20.73	15.69	72.37
19	1.001	20.73	15.42	74.27

20	1.041	21.39	15.69	70.49
21	1.004	20.89	14.98	71.41
22	0.982	21.75	14.61	68.40
23	1.004	21.69	16.08	73.85
24	0.996	21.41	15.99	75.02
25	1.010	21.88	16.49	74.65
26	1.012	21.56	16.89	77.39
27	0.994	21.36	15.57	73.33
28	1.012	20.98	16.03	75.50
29	1.029	21.49	16.86	76.24
30	1.027	21.44	16.68	75.76
31	1.026	21.70	16.18	72.68
32	1.005	20.78	15.51	74.26
33	1.026	21.46	16.73	75.99
34	0.983	20.72	15.01	73.73
35	1.012	21.56	16.89	77.39
36	0.994	21.36	15.57	73.33
37	1.012	20.98	16.03	75.5
38	1.029	21.49	16.86	76.24
39	1.014	22.09	16.49	73.63
40	0.994	21.37	15.72	73.98

Table S3. The device performance of perovksite solar cells with 1% Au@TiO_2 NRs

Number	Voc(V)	Jsc(mA/cm^2)	PCE(%)	FF.(%)
1	1.008	21.51	15.95	73.57
2	1.033	20.74	15.10	70.43
3	1.035	20.51	16.16	76.19
4	1.074	21.91	18.13	77.01
5	1.005	21.42	16.01	74.38
6	1.013	21.04	16.43	77.14
7	1.018	21.16	15.99	74.23
8	1.065	22.19	17.61	74.52
9	1.008	20.57	14.53	70.08
10	1.031	21.83	14.73	65.45
11	1.033	21.80	16.72	74.27
12	1.037	21.67	18.20	80.98
13	1.008	21.82	15.61	70.96
14	1.022	21.99	17.16	76.37
15	1.002	20.88	15.71	75.09
16	1.007	21.98	16.71	75.49
17	1.008	21.72	16.73	76.42
18	1.008	21.40	16.70	77.40
19	1.009	22.27	16.78	74.67
20	1.010	21.60	16.74	76.71

21	1.018	21.76	17.19	77.62
22	1.037	19.83	15.54	75.59
23	1.044	19.76	15.36	74.49
24	1.057	20.31	16.56	77.13
25	1.060	21.86	17.01	73.43
26	0.986	21.75	16.17	75.41
27	0.993	22.31	16.66	75.25
28	1.032	22.42	17.38	75.12
29	0.981	22.25	15.97	73.17
30	0.985	22.54	15.80	71.20
31	0.998	21.76	16.20	74.55
32	1.002	21.83	15.99	73.06
33	0.995	21.43	15.75	73.90
34	1.016	22.30	17.40	76.8
35	1.012	22.61	17.22	75.25
36	1.007	20.95	15.59	73.89
37	1.008	21.57	15.96	73.38
38	1.000	21.35	15.91	74.53
39	1.004	21.18	16.38	77.05

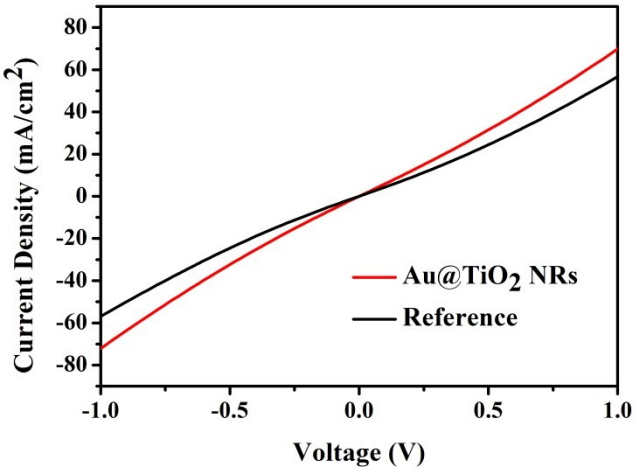

Figure S5. Linear sweep voltammetry curves of the device with a structure of ETL/Spiro-OMeTAD/ETL to compare the conductivity change in the presence of Au@TiO_2 NRs.