

Supplementary information

Effect of tantalum doping in TiO₂ compact layer on the performance of planar Spiro-OMeTAD free perovskite solar cells

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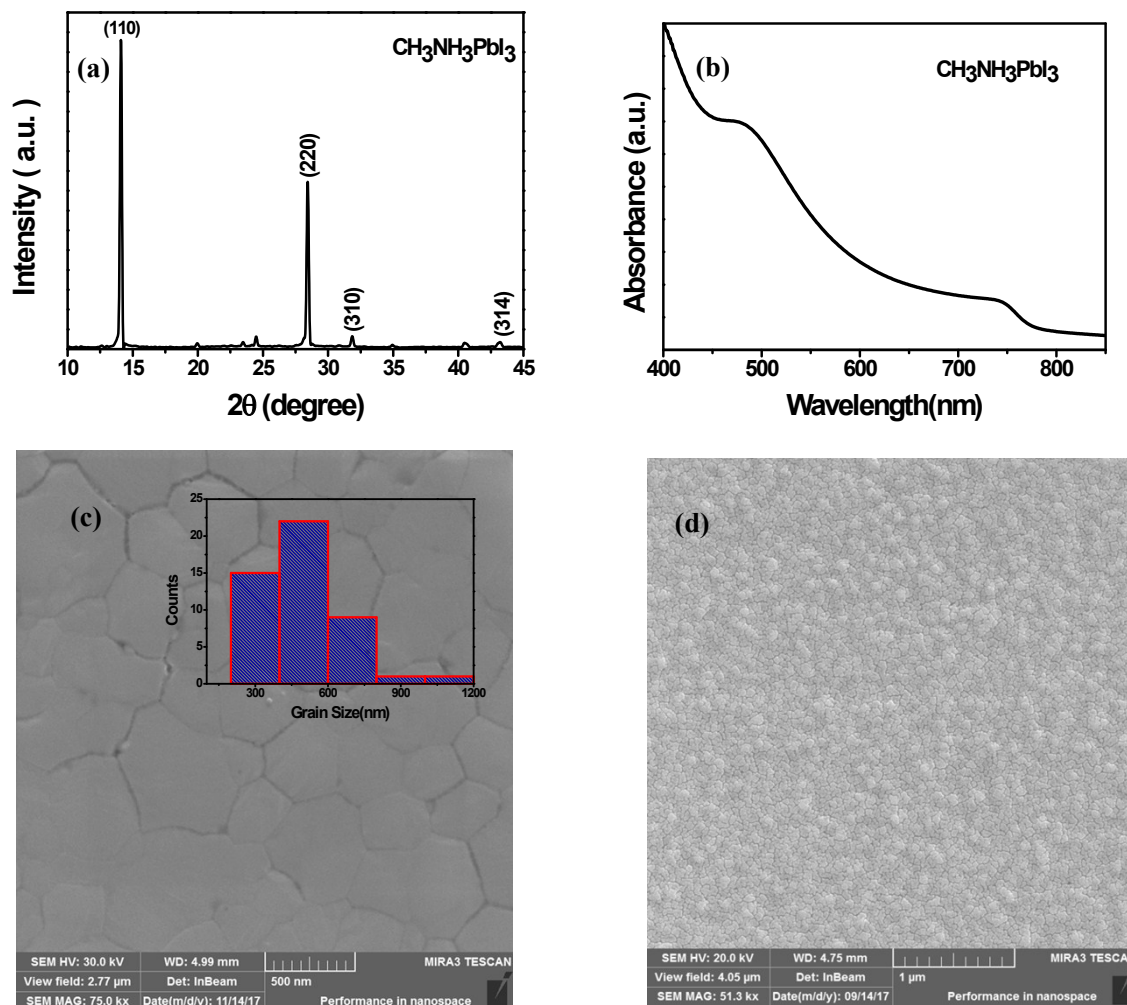


Fig. S1 (a) XRD, (b) absorbance, and (c) SEM image of $\text{CH}_3\text{NH}_3\text{PbI}_3$ perovskite film (inset shows grain size distribution); (d) SEM image of compact TiO_2 .

The XRD data shows the characteristic perovskite peak at 14.1° , 28.4° , 31.9° and 43.2° corresponding to diffraction planes of (110), (220), (310) and (314) which are in agreement with previous report.¹ The absorbance spectrum of $\text{CH}_3\text{NH}_3\text{PbI}_3$ film shows broad range of absorbance from 400 to 760 nm suggesting that perovskite film has good absorption in visible region. Further, SEM image shows the grain size of perovskite in the range of 200-1200 nm along with good surface coverage.

Table-S1 Atomic % of different elements for undoped TiO₂ and Ta-TiO₂ thin film samples from XPS data

Sample	O1s (atomic %)	Ti2p (atomic %)	Ta4f (atomic %)
Pure TiO ₂	67.1	32.9	0.0
3.0 mol.% Ta-TiO ₂	66.6	24.7	4.2
5.0 mol.% Ta-TiO ₂	68.2	23.8	7.2

Table-S2 Summary of planar perovskite solar cells having P3HT as HTL

Planar device Structure with P3HT as HTM	J_{sc} (mA/cm ²)	FF	V_{oc}	PCE (%)	Year	Reference
FTO/c-TiO ₂ /CH ₃ NH ₃ PbI _{3-x} Cl _x /P3HT/Ag	17.7	56.2	0.92	9.2	2014	2
<i>P3HT doped with Li salt and D-TBP</i>	19.1	66.3	0.98	12.4		
FTO/TiO ₂ /MAPbI ₃ /P3HT/Ag	16.22	45	1.007	7.42	2015	3
FTO/c-TiO ₂ /CH ₃ NH ₃ PbI _{3-x} Cl _x /P3HT/Ag	19.06	56.11	0.70	7.81	2015	4
<i>Au doped P3HT</i>	21.53	0.72	60.72	9.82		
FTO/c-TiO ₂ /CH ₃ NH ₃ PbI _{3-x} Cl _x /P3HT/Ag	18.2	44.6	0.626	5.1	2015	5
<i>P3HT doped with Li salt and D-TBP</i>	21.8	52	0.863	9.7		
FTO/c-TiO ₂ / CH ₃ NH ₃ PbI _{3-x} Cl _x /P3HT/Ag	14.7	55.2	0.56	4.57	2016	6
	14.4	57.1	0.60	5.26 (cesium doped TiO ₂)		
FTO/c-TiO ₂ / CH ₃ NH ₃ PbI _{3-x} Cl _x /P3HT/Ag	14.88 15.04	0.458 0.47	0.85 0.86	5.85- Forward 6.23- Backward	2017	7
<i>Cobalt doped P3HT</i>	21.7 21.8	0.68 0.7	1.05 1.06	15.87- Forward 16.28- Backward		
ITO/TiO ₂ /MAPbI ₃ /P3HT/Ag	16.97	61.32	0.87	9.05	2017	8

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