SUPPORT INFORMATION

Effects of alkali and transition metal-doped TiO_2 hole blocking layers on the perovskite solar cells obtained by two-steps sequential deposition method in air and vacuum

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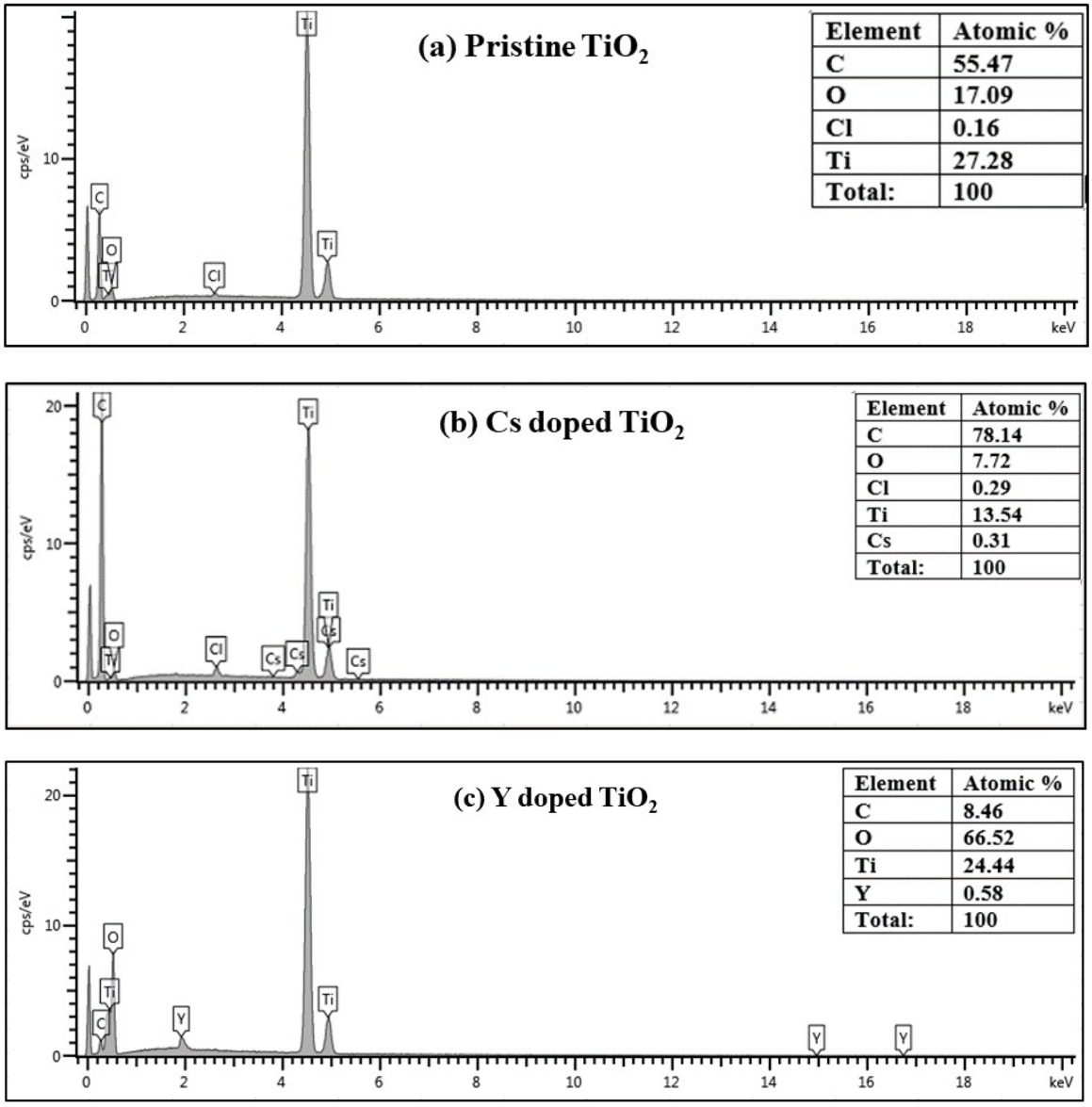


Figure S1: EDX Spectra of (a) Pristine TiO_2 (b) Cs-TiO_2 and (c) Y-TiO_2. The EDX measurements were performed along with the SEM imaging for the pristine, Cs- and Y-doped TiO_2 and the elemental composition of the dopant was confirmed in the material.

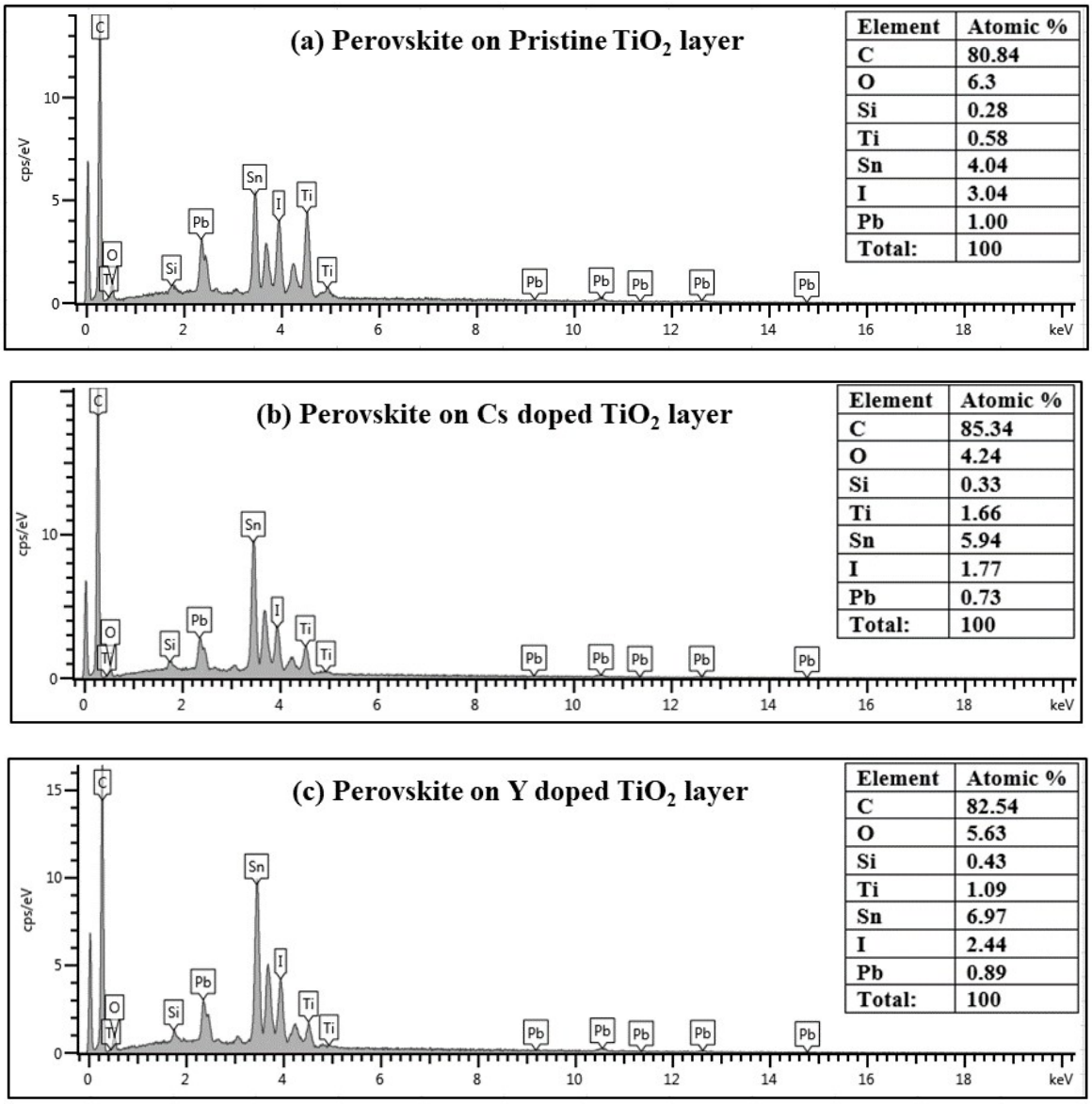


Figure S2: EDX Spectra of perovskite material on (a) Pristine TiO_2 (b) Cs-TiO_2 and (c) Y-TiO_2. The EDX measurement was performed along with the SEM imaging for the perovskite absorber layers grown on pristine, Cs- and Y-doped TiO_2 and the elemental composition of the dopant and perovskite material were confirmed in the spectrum.

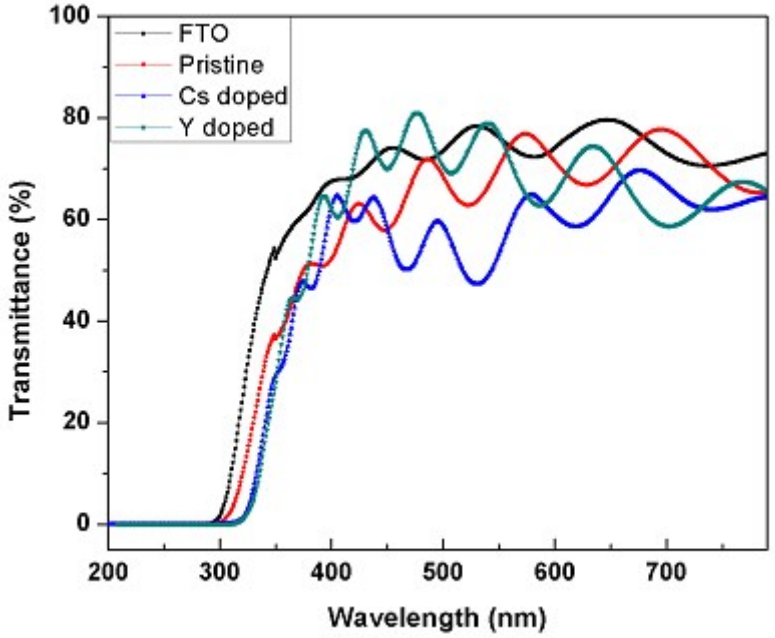


Figure S3: Optical transmittance spectra of the pristine, Cs-doped and Y-doped TiO_2. The optical transmittance spectra for Bare FTO substrate (black), Pristine TiO_2 (red), Cs-doped TiO_2 (blue) and Y-doped TiO_2 (green) measured in the UV-vis region of the electromagnetic spectrum prior to the deposition of the perovskite absorber layers.

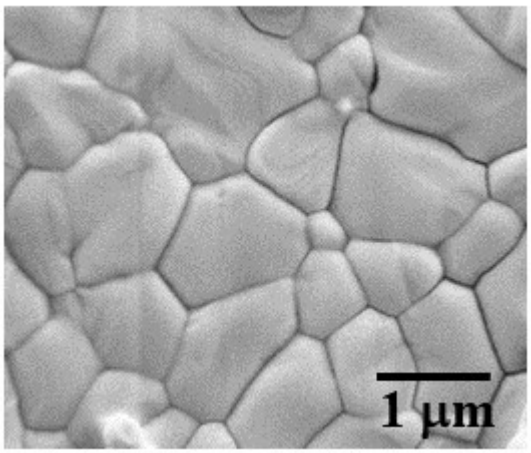
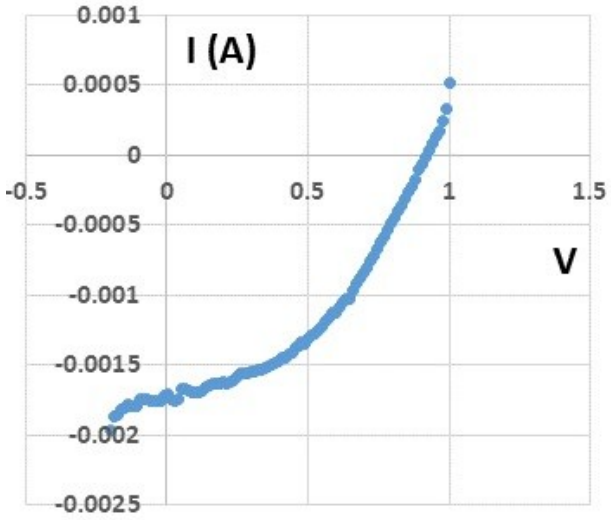


Figure S4: SEM image of Perovskite layer grown by CVD. The SEM image show a larger grain size compare to the perovskite layer grown by spin coating. The estimated average grain size of the perovskite layer grown by CVD is 0.857 ± 0.012 µm.



(a)

V_{oc} = 0.915V

I_{sc} = 0.0017A

I_{sc} = 1.7mA

Area of shadow mask = 0.0512 cm^2

J_{sc} = 33.20mA/cm^2

FF = 42%

(b)

Figure S5: (a) Current -voltage (I-V) curve for perovskite layer deposited on Y-doped TiO_2 for vacuum processed (b) Estimated perovskite solar cell photovoltaic parameters for perovskite absorber layer on Y-doped TiO_2 with high short-circuit current densities (J_{sc}) exceeding 25 mA/cm^2. This cell was measured along with the cell presented in the manuscript. The current-voltage (I-V) characteristics was measured with Keithley 2420 source meter under standard simulated solar irradiation of 100 mW/cm^2 and AM 1.5 at room temperature. The active area of the solar cell was 0.0512 cm^2 as defined by the shadow mask used for the solar testing.

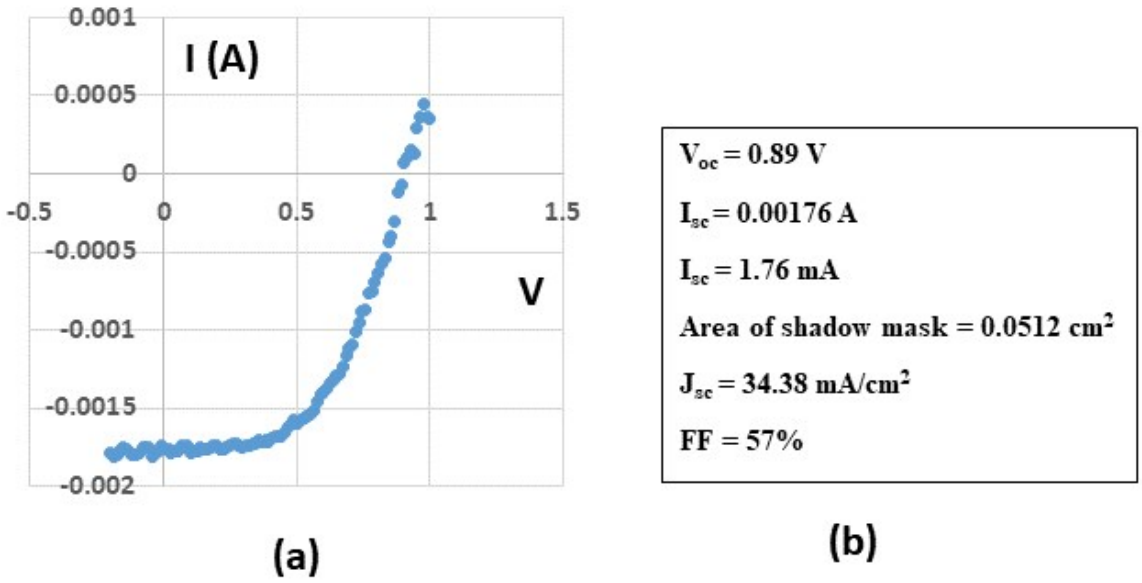
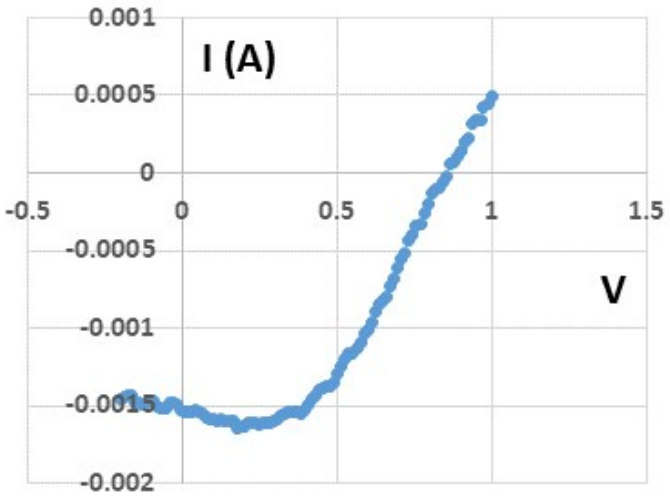


Figure S6: (a) Current -voltage (I-V) curve for perovskite layer deposited on Y-doped TiO_2 for vacuum processed (b) Estimated perovskite solar cell photovoltaic parameters of another perovskite absorber layer grown on Y-TiO_2 layer. Measurements repeated on another to perovskite solar cell grown with the growth condition to compare with the short-circuit current density (J_{sc}) value presented in the main manuscript.



(a)

V_{oc} = 0.85 V

I_{sc} = 0.0015 A

I_{sc} = 1.7 mA

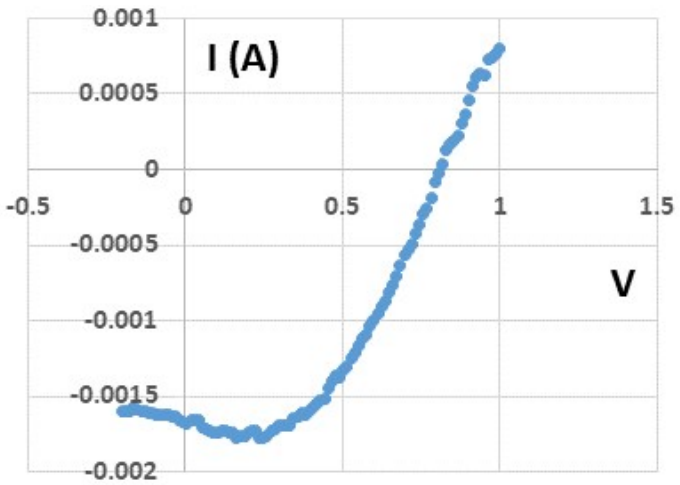
Area of shadow mask = 0.0512 cm^2

J_{sc} = 29.30 mA/cm^2

FF = 47%

(b)

Figure S7: (a) Current -voltage (I-V) curve for perovskite layer deposited on Y-doped TiO_2 for vacuum processed (b) Estimated perovskite solar cell photovoltaic parameters of another perovskite absorber layer grown on Y-TiO_2 layer.



(a)

V_{oc} = 0.80 V

I_{sc} = 0.00166 A

I_{sc} = 1.66 mA

Area of shadow mask = 0.0512 cm^2

J_{sc} = 32.42 mA/cm^2

FF = 54%

(b)

Figure S8: (a) Current -voltage (I-V) curve for perovskite layer deposited on Y-doped TiO_2 for vacuum processed (b) Estimated perovskite solar cell photovoltaic parameters of another perovskite absorber layer grown on Y-TiO_2 layer. Measurements repeated on another to perovskite solar cell grown with the growth condition to compare with the short-circuit current density (J_{sc}) value presented in the main manuscript. Fig. S4 - S7 show that the short-circuit current density for all the perovskite absorber layer used in this work are high than 25 mA/cm^2.