Electronic Supplementary Material (ESI) for Dalton Transactions.

Supporting Information

Non-equilibrium Ti^{4+} doping strategy for an efficient hematite electron transport layer in perovskite solar cells

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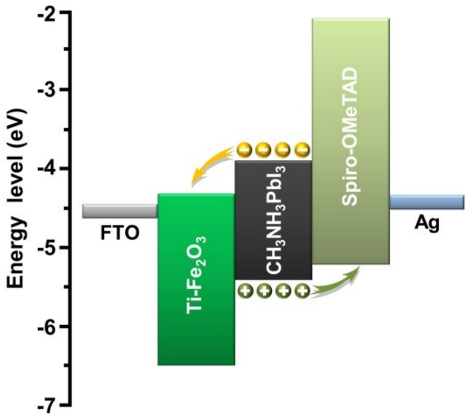

Fig. S1 Energy level diagram of planar perovskite solar cell with the configuration of FTO/Ti-Fe_2O_3/$CH_3NH_3PbI_3$/Spiro-OMeTAD/Ag.

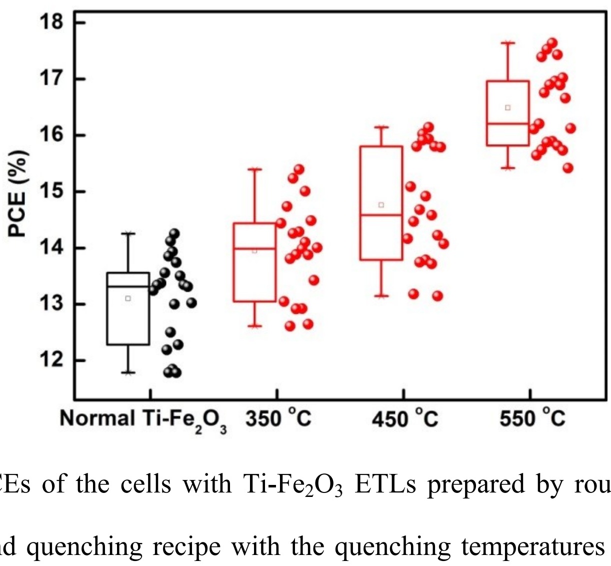

Fig. S2 Statistical PCEs of the cells with Ti-Fe_2O_3 ETLs prepared by routinely natural cooling (Normal Ti-Fe_2O_3) and quenching recipe with the quenching temperatures of 550, 450, and 350 °C, respectively. Each PCE were measured under 1.5 G simulated sunlight (100 mW cm^{-2}) in the reverse sweep (from 1.5 to -0.1 V) with the rate of 100 mV s^{-1}.

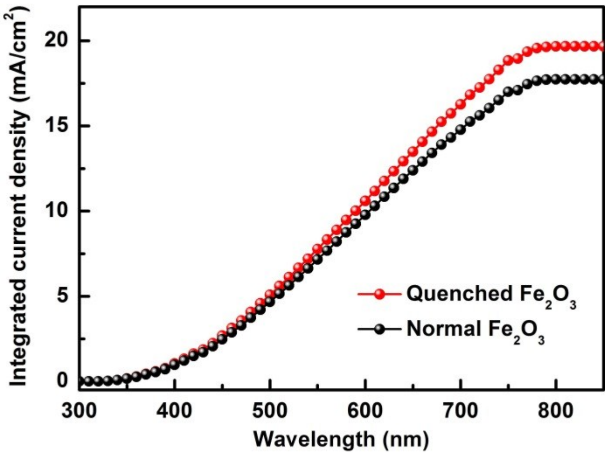

Fig. S3 Integrated current densities from the EQE spectra for the optimized cells fabricated with normal and quenched Ti-Fe_2O_3 ETLs.

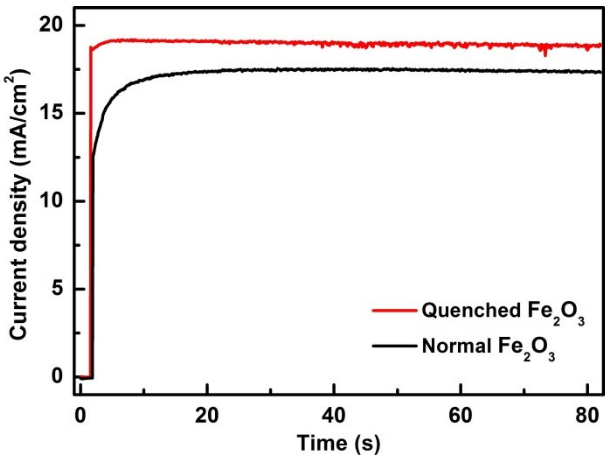

Fig. S4 Steady-state current output at the maximum power point for the optimized cells fabricated with normal and quenched Ti-Fe_2O_3 ETLs, repectively.

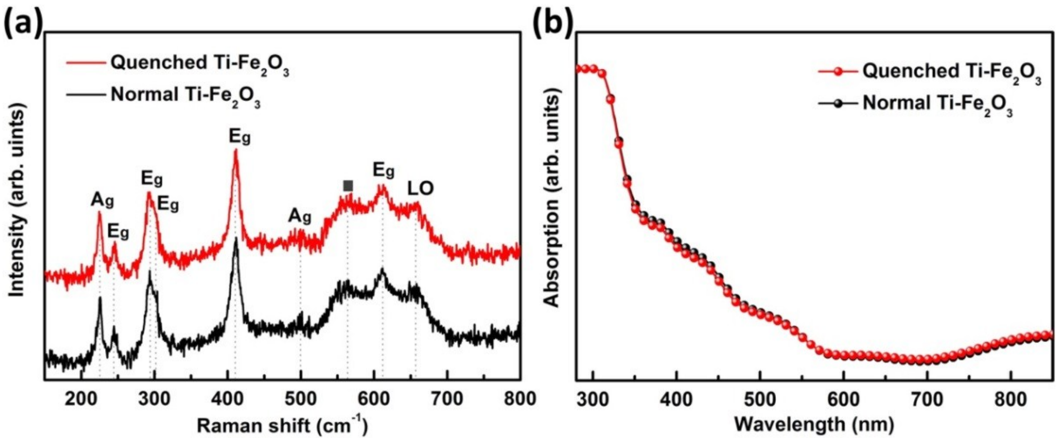

Fig. S5 (a) Raman spectra and UV-Vis spectra of normal and quenched Ti-Fe_2O_3 ETLs.

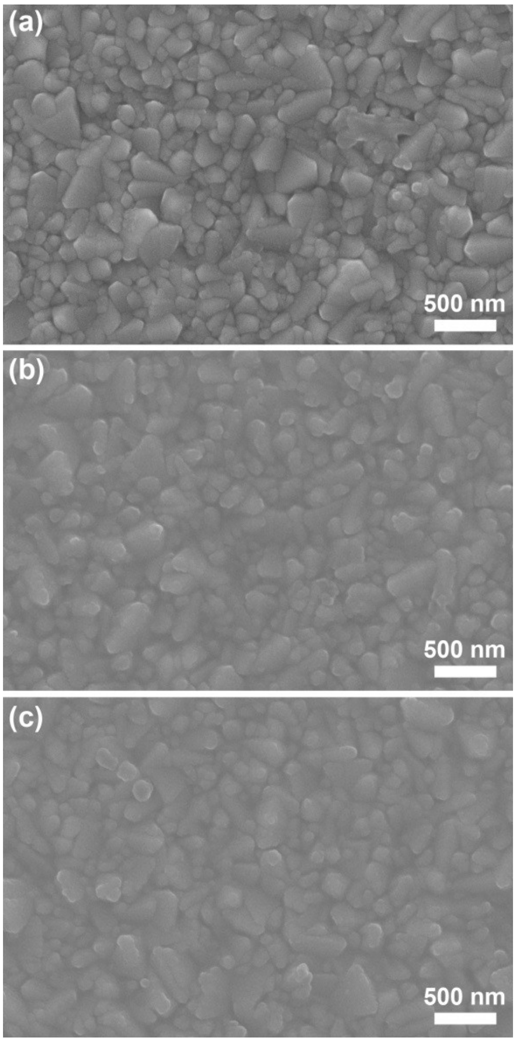

Fig. S6 SEM images of (a) bare FTO, (b) normal Ti-Fe_2O_3 ETL, and (c) quenched Ti-Fe_2O_3 ETL, respectively.

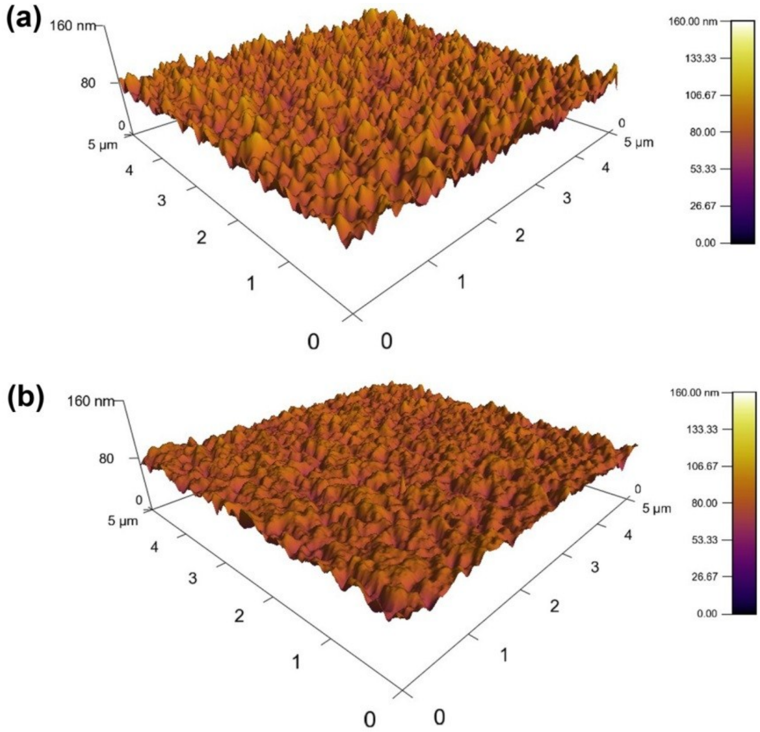

Fig. S7 AFM height images of (a) normal Ti-Fe_2O_3 ETL and (b) quenched Ti-Fe_2O_3 ETL.

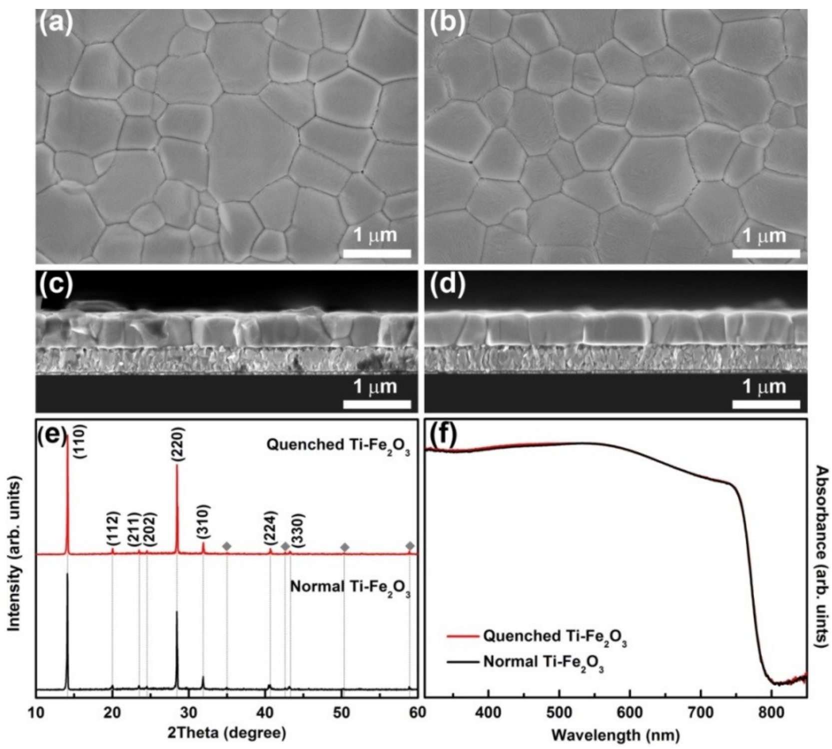

Fig. S8 Surficial and cross-sectional SEM images of (a and c) normal Ti-Fe_2O_3 ETL and (b and d) quenched Ti-Fe_2O_3 ETL. (e) XRD patterns and (f) UV-vis absorption spectra of the corresponding samples.

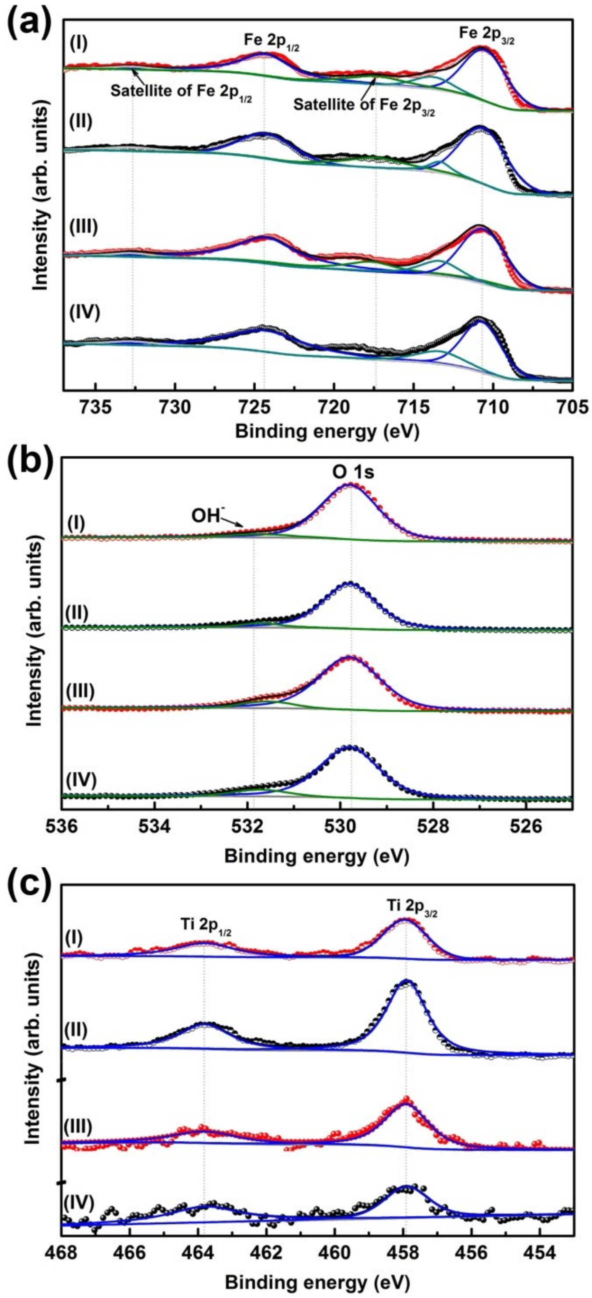

Fig. S9 Surface and bulk XPS spectra of (a) Fe 2p, (b) O 1s, and (c) Ti 2p for normal and quenched Ti-Fe_2O_3 ETLs. (I), (II), (III), and (IV) represent the surface of quenched Ti-Fe_2O_3 ETL, the surface of normal Ti-Fe_2O_3 ETL, the bulk of quenched Ti-Fe_2O_3 ETL, and the bulk of normal Ti-Fe_2O_3 ETL. Two satellite peaks at around 717.5 eV and 732.8 eV in panel (a) manifests that iron in the sample is at high oxidation state (Fe^{3+}) rather than low oxidation state (Fe^{2+}).[1,2]

Reference

[1] Z. Huang, J. Cheng, X. Ren, J. Zhuang, V. A. Roy, J. M. Burkhartsmeyer, K. S. Wong and

W. C. Choy, *Nano Energy*, 2018, DOI:10.1016/j.nanoen.2018.02.019.

[2] L. Wang, H. Yang, X. Liu, R. Zeng, M. Li, Y. Huang and X. Hu, *Angewandte Chemie*, 2017, **129**, 1125-1130.