Supporting Information

Interlayers Engineering for Flexible Large-Area Planar Perovskite Solar Cells

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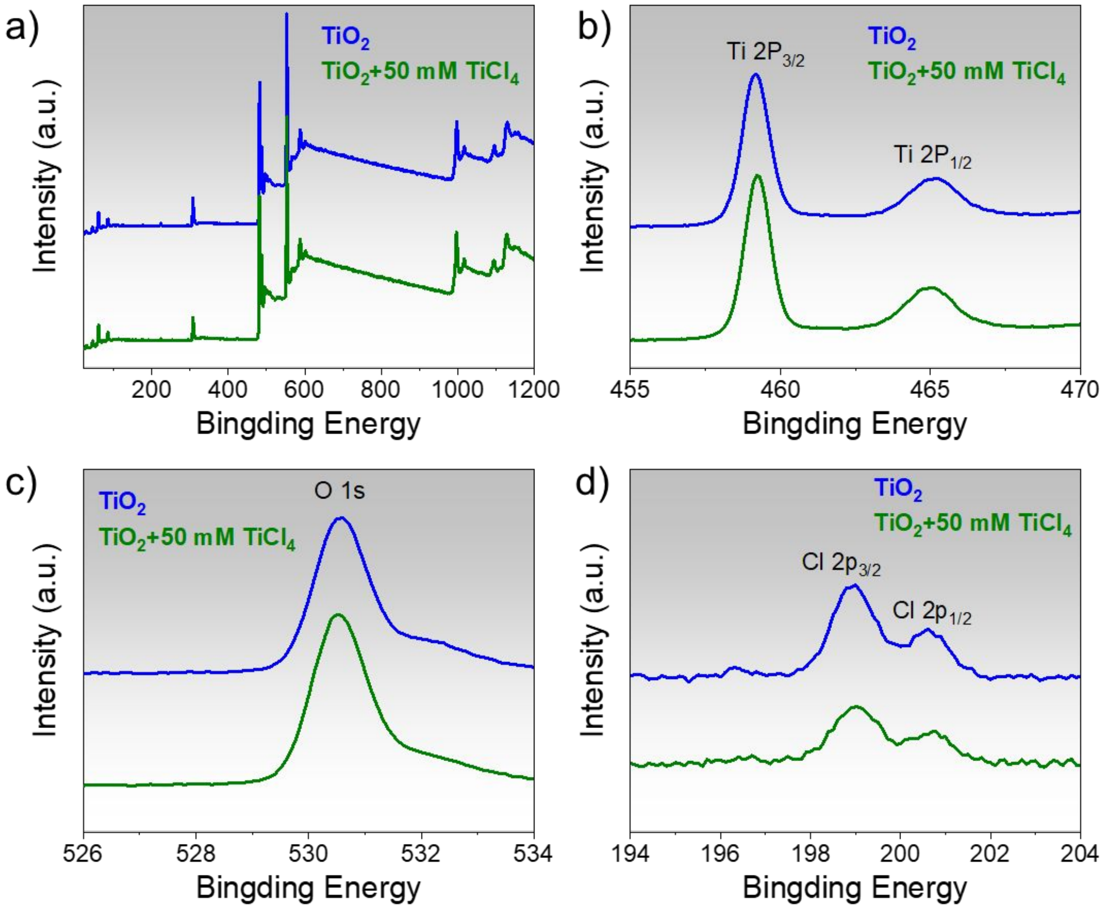

Figure S1. XPS spectra of TiO_2 and $TiCl_4$-terated TiO_2 films a) full spectra, b) Ti 2p, (c) O 1s, and (d) Cl 2p.

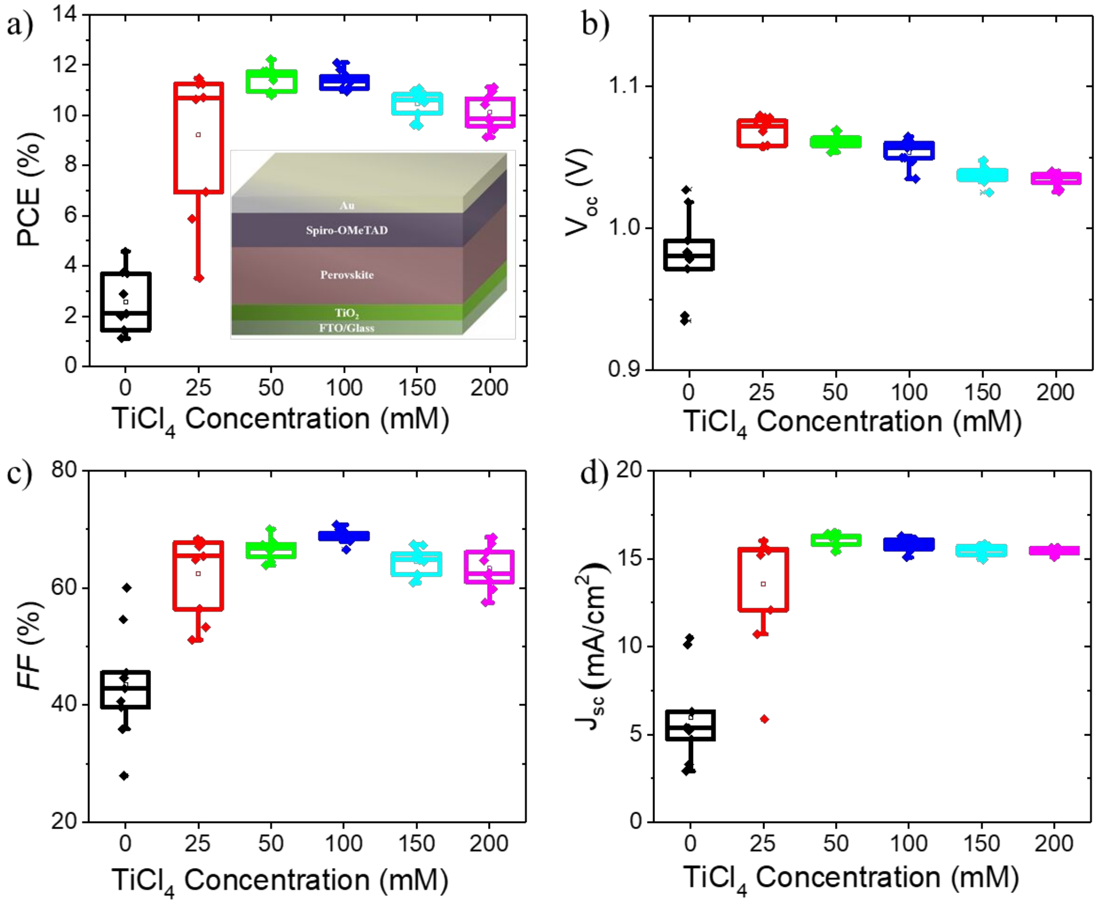

Figure S2. N-i-p planar 1.72 eV perovskite solar cells (PSCs) on glass with active area 0.16 cm^2, the compact TiO_2 layer quality was optimized to by varying $TiCl_4$ addition and so the $TiCl_4$ concentrations varied from 0 to 200 mM in the TiO_2 dispersion. The highest PCEs (~12%) were obtained for $TiCl_4$ concentrations 50 mM, while for higher ones the excess of Cl^- ligands leads to a reduction of film conductivity,Statistics data over 9 PSCs for each $TiCl_4$ concentration: a) PCEs, the PSCs layered structure is reported in the inset), b) V_{oc}, c) *FF* and d) J_{sc} distribution.

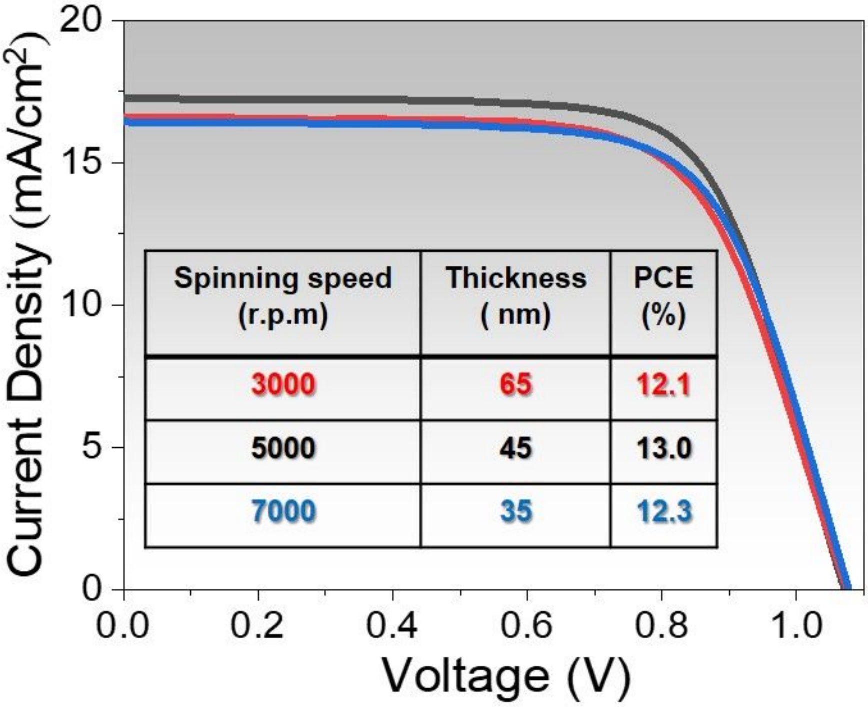

Figure S3. N-i-p planar 1.72 eV perovskite solar cells (PSCs) on glass with active area 0.16 cm^2, the compact TiO_2 layer thickness was tuned by varing spinning speed of TiO_2 suspension with 50 mM $TiCl_4$. J-V curves of PSCs based varing TiO_2 thickness, inset table show TiO_2 thickness and their coresponding PCE.

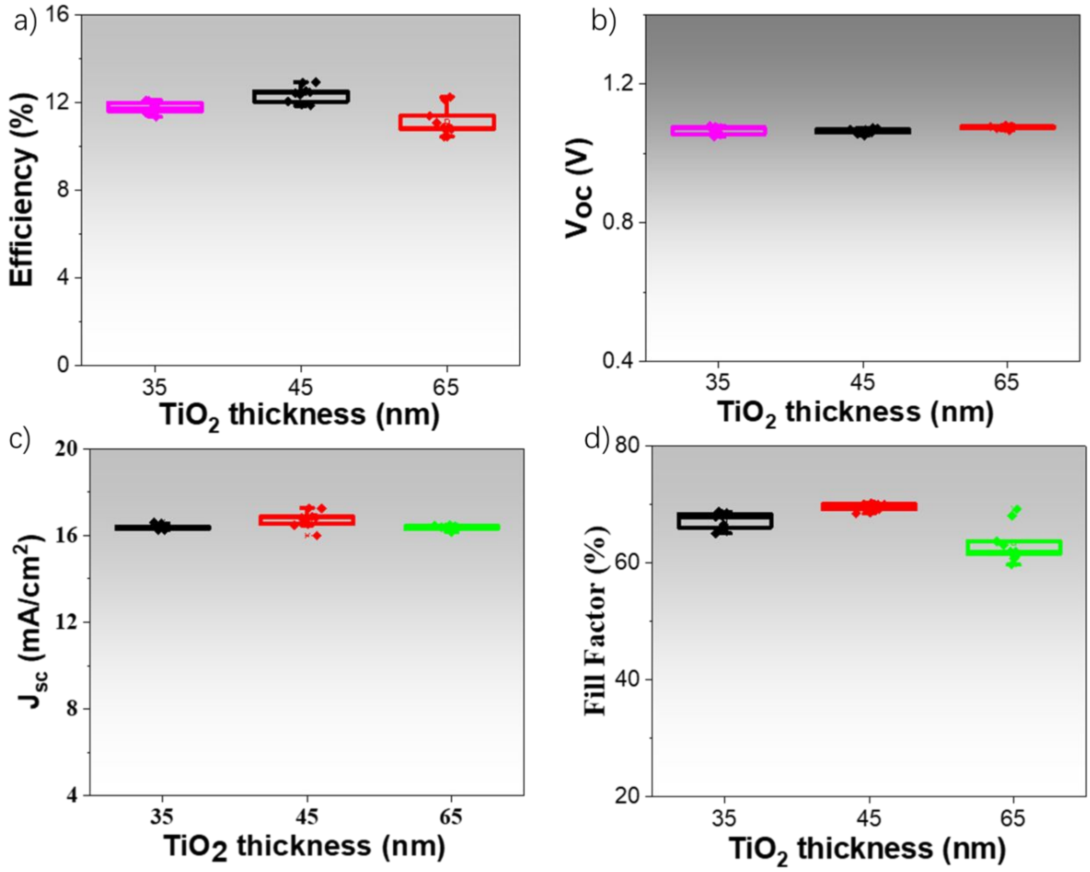

Figure S4. N-i-p planar ~1.72 eV perovskite solar cells (PSCs) on glass with active area 0.16 cm^2, the compact TiO_2 thickness was optimized to by varying spin-coating speed. The highest PCEs (~13%) were obtained for TiO_2 thickness of ~45 nm,Statistics data over 9 PSCs for each TiO_2 thickness: a) PCEs, the PSCs layered structure is reported in the inset), b) V_{oc}, c) J_{sc} and d) *FF* distribution.

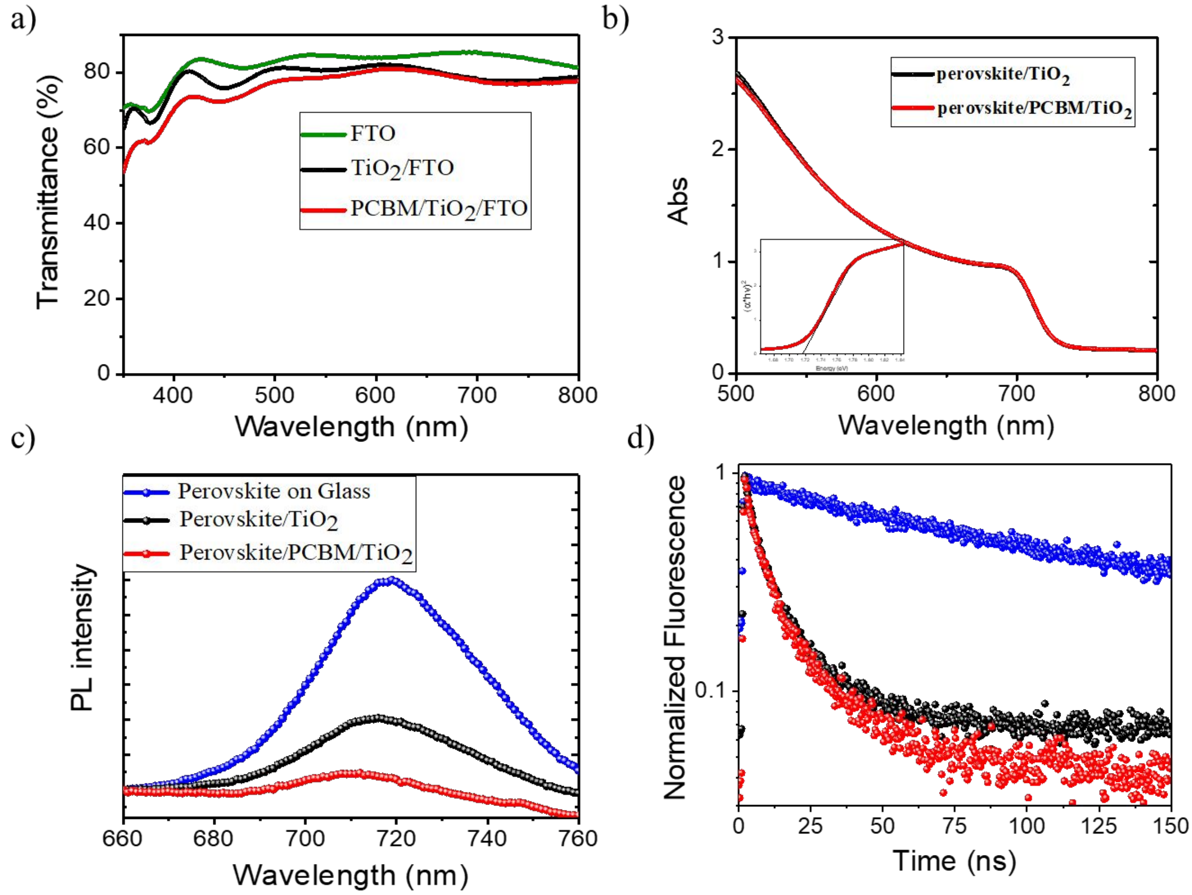

Figure S5. Characterization of $Cs_{0.15}FA_{0.85}Pb(I_{0.7}Br_{0.3})_3$ thin film on FTO, TiO_2 and $PCBM/TiO_2$. a) transmittance spectra of FTO, TiO_2/FTO and PCBM/TiO_2/FTO substrates, b) absorption spectra of perovskite layer deposited on TiO_2/FTO and PCBM/TiO_2/FTO, c) steady state and d) time-resolved PL spectra of perovskite on glass, TiO_2/FTO and PCBM/TiO_2/FTO substrates.

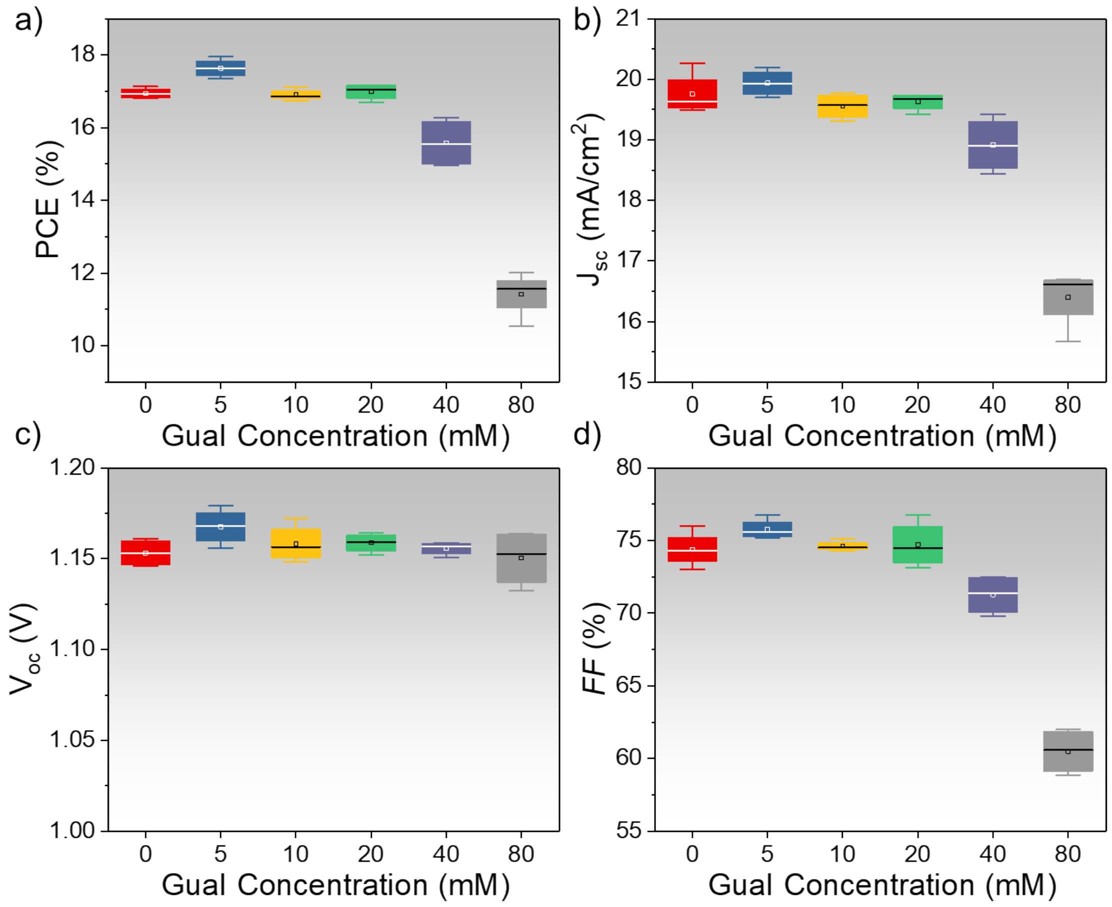

Figure S6. Photovoltaics performances of n-i-p planar 1.72 eV perovskite solar cells (PSCs) as function of guanidium iodide (GuaI) passivation concentration (from 0 to 80 mM): a) efficiency, b) J_{sc}, c) V_{oc} and d) Fill Factor. The highest effciencies (~18%) were obtained for GuaI concentrations 5 mM.

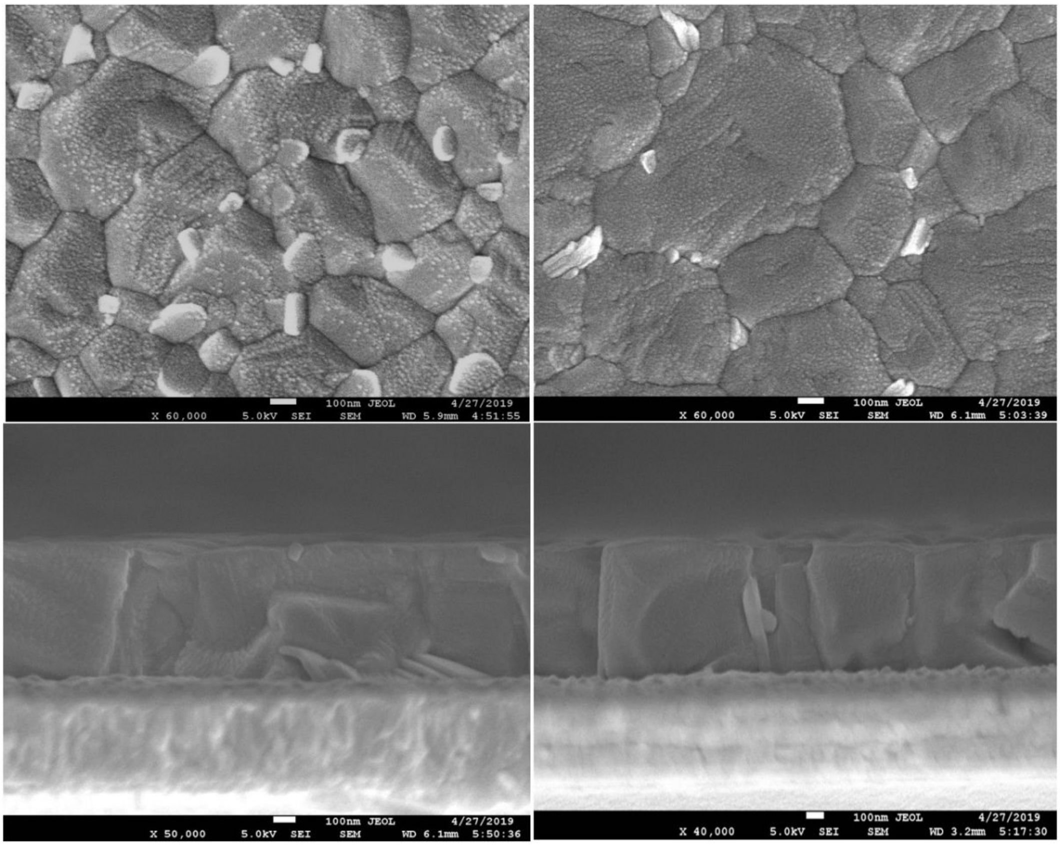

Figure S7. Top view and cross-sectional SEM images of 1.72 eV perovskite film before and after GuaI treatment.

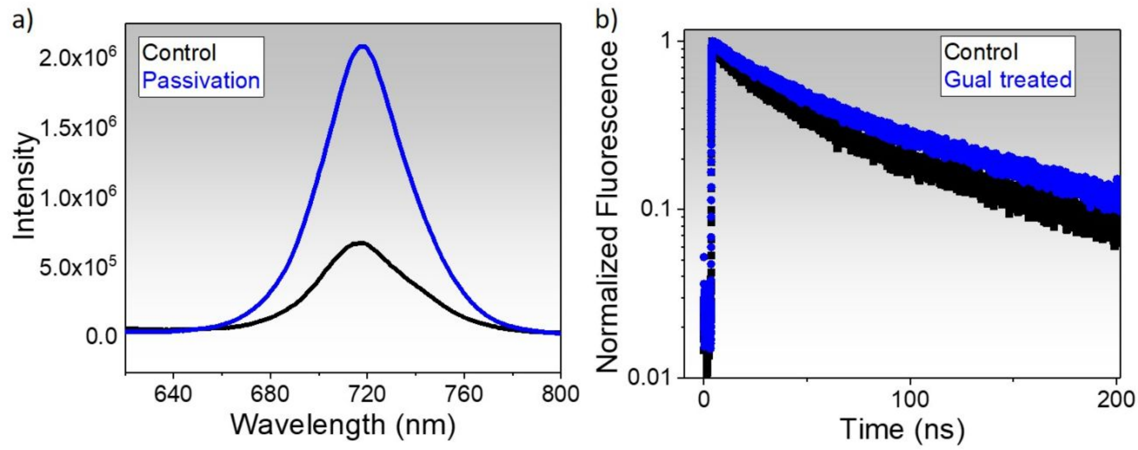

Figure S8. a) Steady-state spectra and b) time-resolved PL decays of untreated (control) and GuaI-treated 1.72 eV perovskite on glass.

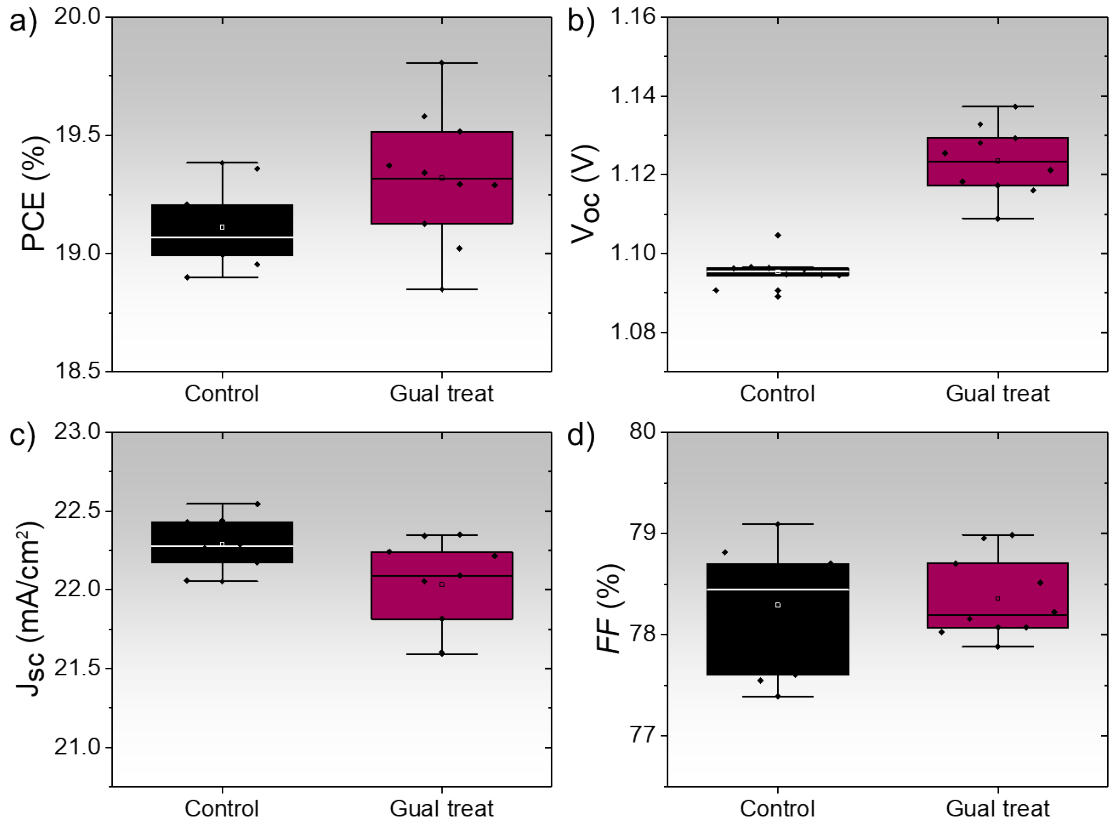

Figure S9. Photovoltaics performances of n-i-p planar untreated (control) and GuaI-treated 1.58 eV perovskite solar cells (PSCs) on glass with active area 0.16 cm^2: a) PCE, b) V_{oc} c) J_{sc} and d) Fill Factor. Statistics data over 20 PSCs for each condition.

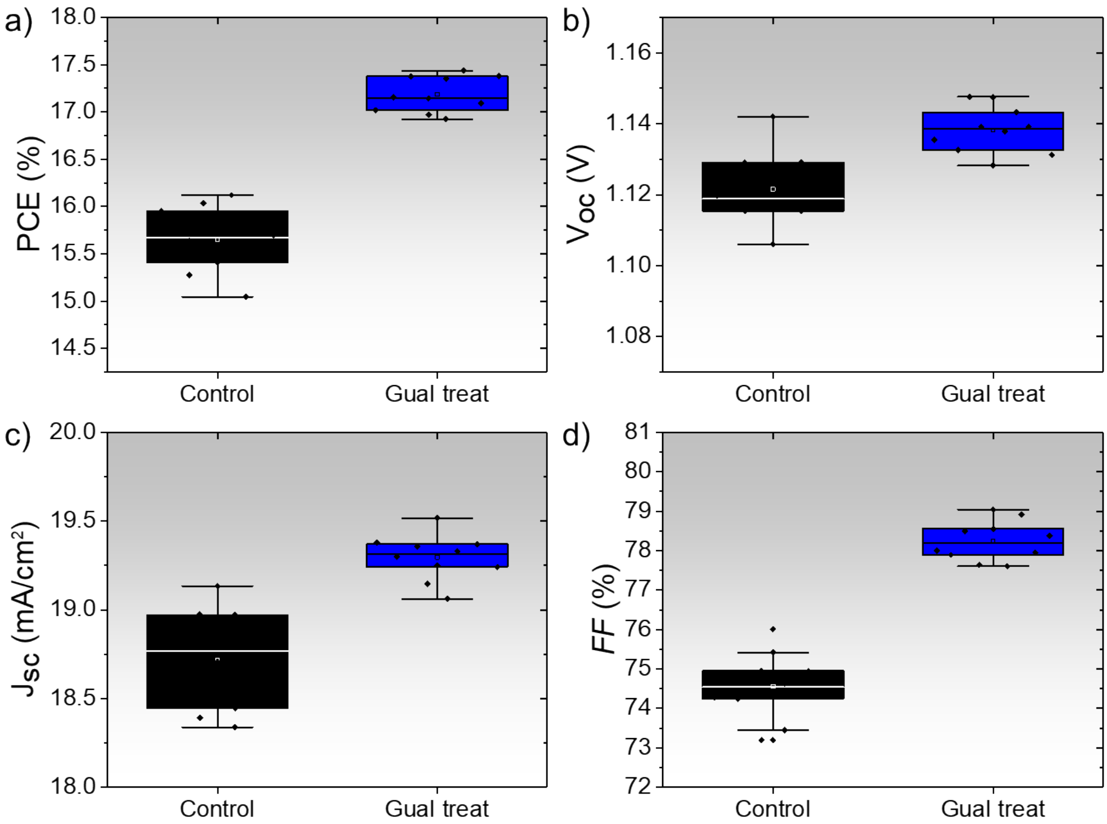

Figure S10. Photovoltaics performances of n-i-p planar untreated (control) and GuaI-treated 1.72 eV perovskite solar cells (PSCs) on glass with active area 0.16 cm^2: a) PCE, b) V_{oc} c) J_{sc} and d) Fill Factor Statistics data over 20 PSCs for each condition.

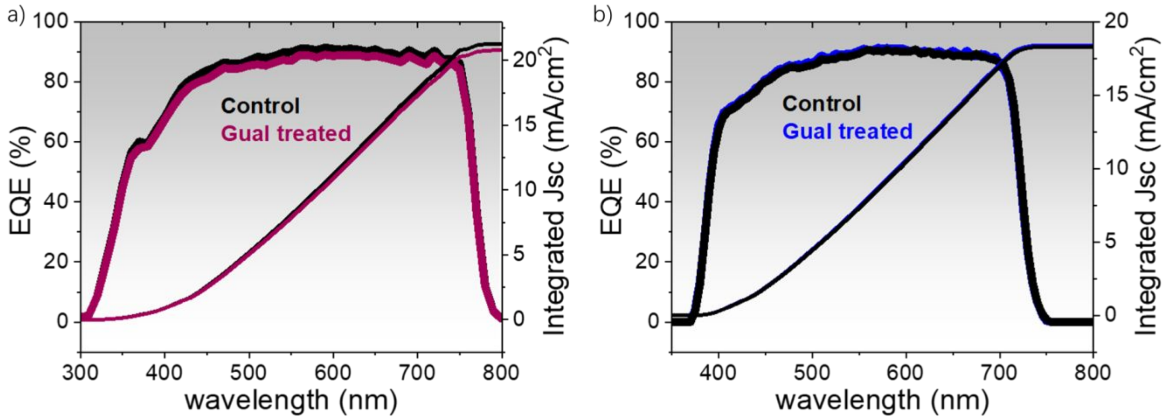

Figure S11. a) IPCE of untreated (control) and GuaI-treated 1.58 eV PSCs, b) IPCE of untreated (control) and GuaI-treated 1.72 eV PSCs.

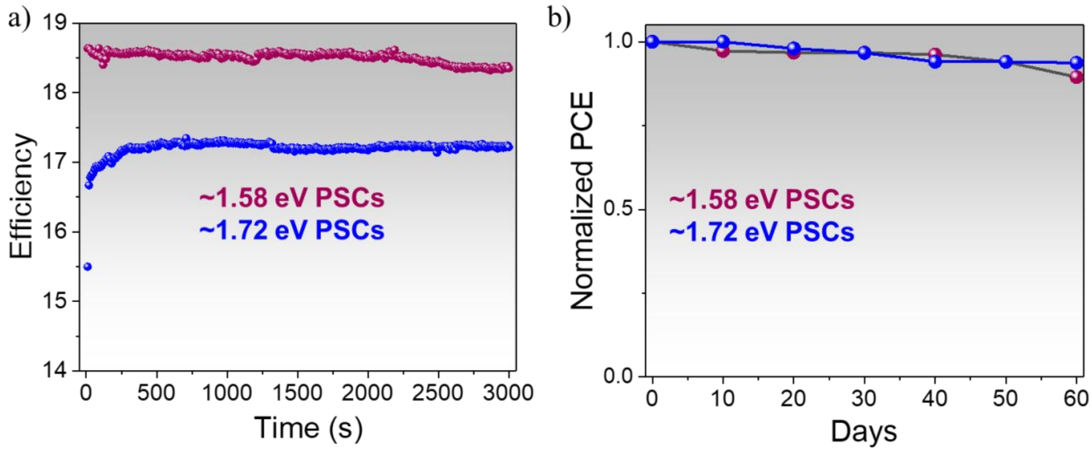

Figure S12. a) Maximum power point track over 3000 s under 1 sun condition (AM 1.5), b) shelf stability under around 35% humidity of both 1.58 and 1.72 eV PSCs.

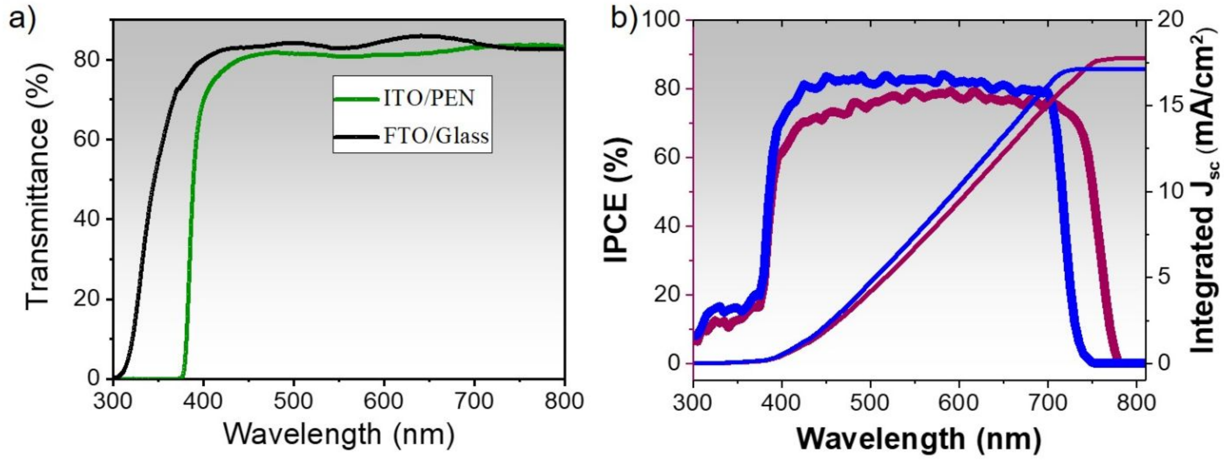

Figure S13. a) Transmittance of FTO/glass and ITO/PEN, b) IPCE of both GuaI-treated 1.58 eV and 1.72 eV PSCs on PEN substrates.