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Supplementary Information

Temperature dependence of hole conductor free formamidinium lead iodide perovskite based solar cells

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The FormAmidinium Iodide (FAI) was prepared by reacting FormAmidine Acetate (FAAc) with hydroidic acid (HI) (more details can be found in the experimental section). Figure S1A shows the Nuclear Magnetic Resonance (NMR) spectra of the synthesized FAI and FAAc, for the whole measured range while figure S1B shows a magnification of the scale between 7.77-7.88ppm. The molecular structures of FAAc and FAI are shown in figure 1B.

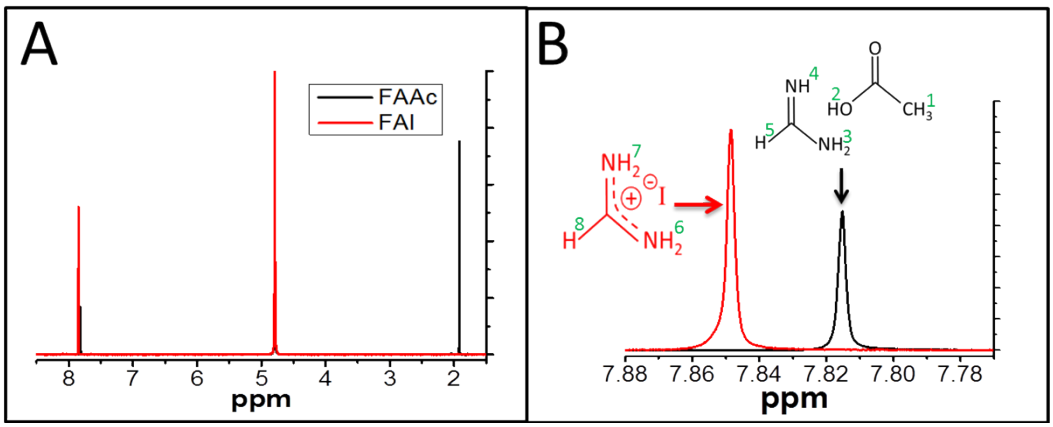

Figure S1: (A) NMR measurements of FormAmidine Acetate - FAAc (black) and FormAmidinium Iodide - FAI (red). (B) magnification of the ppm scale in the range of 7.78-7.88ppm, and the chemical structure of FAAc (black) and FAI (red). The green numbers (1-8) identify the different hydrogens in each of the two molecules.

It can be seen that the peak of FAAc (black line) at ~1.95ppm (figure S1A), representing H^1, doesn't appear in the FAI measurement (red line), as expected. The peak at ~4.80ppm, which corresponds to H_2O traces (D_2O is used as a solvent), is present in both samples, in the exact same chemical shift. The chemical shift of H^5 is located ~0.04ppm lower than that of H^8. The reason for this difference is that H^8 has a more electronegative close neighbor (i.e. I^-) than H^5 (i.e. OH). The iodide anion shields the magnetic field of the hydrogens more strongly than the OH group does, thus "pushes" the peak of H^8 towards higher ppm values. The peaks of $H^{3,4}$ and $H^{6,7}$ do not appear, probably due to

their deprotonation by the D_2O molecule (the replacement of $H^{3,4}$ and $H^{6,7}$ by deuterium). The NMR spectra provide confirmation for the high quality synthesized FAI.

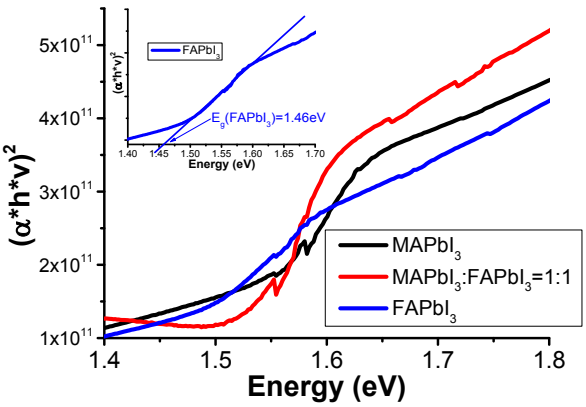

Figure S2: Tauc Plot of the different perovskite layers. Inset: Demonstration of E_g extraction for the $FAPbI_3$ sample.

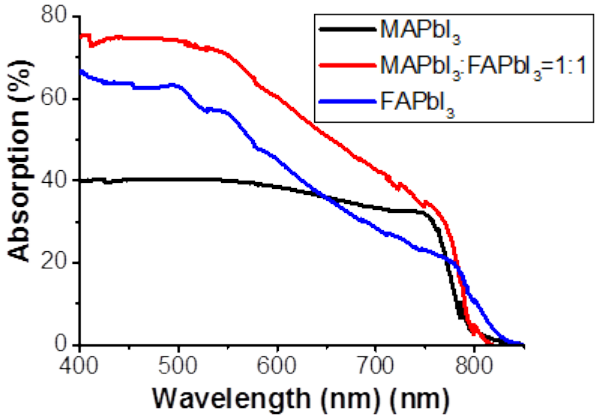

Figure S3: Absorption spectra of the studied samples.