

Detailed Investigation of Pyridine Passivation for Perovskite Solar Cells

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Organometal halide perovskite solar cells have recently shown the highest efficiency for a thin film device. This, combined with their tuneable adsorption spectrums make them ideal candidates for the top cells in tandem perovskite-silicon solar cells.¹ To create feasible tandems the efficiency and long wavelength transparency of the perovskite cell must be maximised. Surface defects such as ion vacancies on the perovskite layer will reduce efficiency by trapping charge carriers, creating a need to passivate these traps. The dominant vacancy is thought to be halide deficiencies², which will create positive traps leading to the use of electron donating Lewis bases to passivate perovskite surfaces.³ Pyridine was one of the first Lewis bases studied, generating a 3.5% boost in efficiency.³ Pyridine has since been the subject of further studies that have shown that it causes new structure to form.⁴

While the efficiency and photoluminescence enhancement from pyridine passivation has been shown, a detailed investigation on the effects of pyridine on the other properties of the perovskite is required to identify the new structures and the effects of passivation. In this work we use confocal fluorescence microscopy (CFM) combined with x-ray diffraction to identify the new structures as PbI_2 . By comparing the CFM images at different excitation wavelengths we will show this PbI_2 forms on and passivates the surface of the perovskite. As per previous work we will use bulk steady state and time resolved photoluminescence as an indicator of trap density and charge mobility. Atomic force microscopy (AFM) combined with scanning kelvin force probe (SKPM) imaging will show the changes in morphology and electronic potential. Cross-sectional SKPM will show how the pyridine changes the electronic interaction at the perovskite-hole transport material (spiro) interface. The combination of these measurements will provide a clearer picture as to the overall effects of pyridine passivation, which will enable a systematic approach to finding better performing passivation molecules.

Early work into passivation molecules focused on MAPbI_3 based perovskites, while newer research has moved onto mixed cation and anion perovskites. Currently there is no work comparing the effect of passivation on MAPbI_3 and mixed perovskites. We will address this by comparing MAPbI_3 and $(\text{FA}_{0.25}, \text{MA}_{0.7}, \text{Cs}_{0.05})\text{Pb}(\text{I}_{0.85}, \text{Br}_{0.15})_3$ (mixed) perovskites using the above techniques. Both the MAPbI_3 and mixed perovskites show a performance enhancement. However the relative enhancement for the mixed perovskite is much lower, indicating a lower initial trap density.

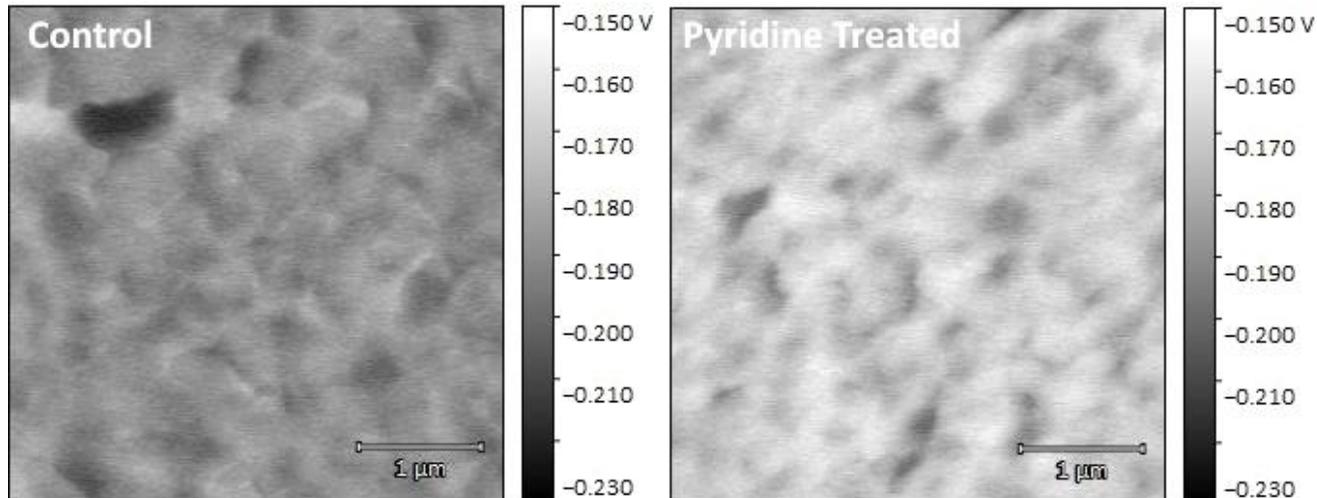


Figure 1. SKPM images of a MAPbI₃ films with pyridine treatment (right) and without (left). The pyridine treatment reduced the average contact potential difference from an average value of -0.19V (control) to -0.17V (treated). Pbl₂ grains are visible as the dark (low potential) regions on these images.

References

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