Very high humidity fabrication of planar perovskite solar cells and modules

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During the short time since their discovery, organic-inorganic halide perovskites have exploded in popularity as promising light harvesters for photovoltaic devices with certified power-conversion efficiencies (PCEs) now exceeding 22%. One of the most attractive aspects of perovskite solar cells is the ease of their fabrication, allowing relatively high efficiencies to be achieved using simple spin-coating and thermal annealing techniques. Currently, an ‘anti-solvent’ processing method has proven popular for the formation of highly uniform, pinhole-free perovskite films with large grains. Upon the deposition of this anti-solvent during perovskite precursor spin-coating, an intermediate precursor-solvent phase is formed which, upon annealing, allows a highly uniform perovskite film to form. Typical solvents used for this route include toluene, chlorobenzene and diethyl ether.

Due to the reported instability of the intermediate phase formed, this deposition process is typically performed inside a nitrogen glovebox to avoid any interactions with moisture in the air. This poses a potential issue for large-scale manufacture of such films, which would prove more expensive if performed under an inert atmosphere.

In this work, we demonstrate a modification to the anti-solvent perovskite deposition method which allows for highly crystalline, uniform and pinhole free perovskite films to be deposited despite processing relative humidity reaching over 80%. Using a variety of anti-solvents, we investigate the effect of processing humidity on perovskite layer crystallinity, absorption and solar cell performance. Using this method, we have achieved power conversion efficiencies in excess of 15% for an inverted, planar $CH_3NH_3PbI_3$ perovskite solar cell processed entirely in a 75%RH environment. This method is also demonstrated to work for larger area devices including series-connected modules with efficiencies in excess of 12% for a device with an active area of 13.5 cm^2. This work opens up the possibility of processing high quality perovskite films for research groups working in climates with high humidity, as well as increasing the process window for the technology’s eventual commercialisation.

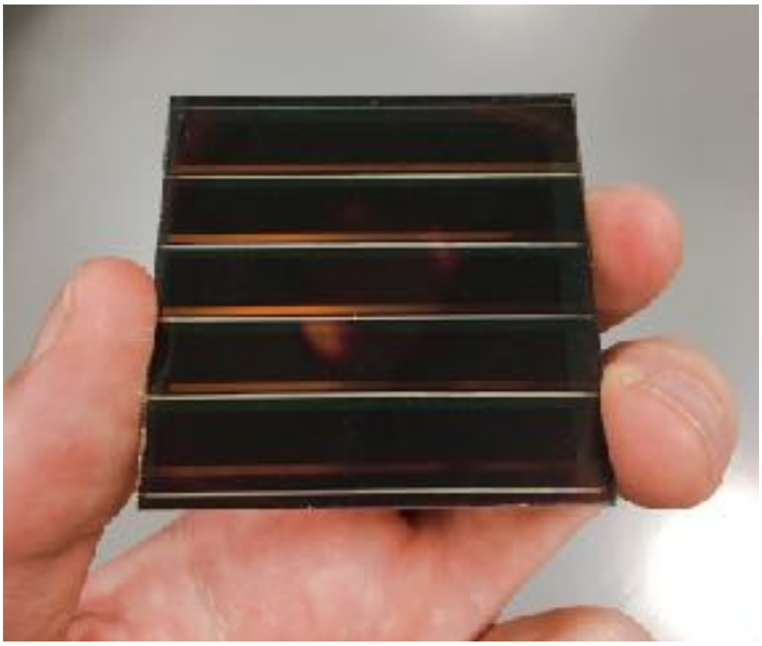

Figure 1. A series-connected perovskite sub module processed in a high humidity, ambient environment with a PCE of 11.8% over an active area of 13.5 cm^2