Highly efficient Hole conductor free perovskite based solar cells

Lioz Etgar

The Institute of chemistry Casalli center for applied chemistry, the Hebrew University of Jerusalem, Israel

Perovskite is a promising light harvester for use in photovoltaic solar cells. In recent years, the power conversion efficiency of perovskite solar cells has been dramatically increased, making them a competitive source of renewable energy.
This work will discuss several topics related to perovskite based solar cells:

Micron sized grains in planar hole conductor free perovskite based solar cells, In this work we demonstrate the planar configuration on HTM free perovskite based solar cells. The $CH_3NH_3PbI_3$ perovskite was deposited using the spray technique to achieve micron size perovskite crystals. The number of spray passes changes the $CH_3NH_3PbI_3$ film thickness; for example, 10 spray passes achieved a film thickness of 3.4mm of perovskite. Surprisingly, power conversion efficiency of 6.9% was demonstrated for this novel, simple solar cell structure with thick perovskite film that has no HTM. Capacitance-voltage measurements reveal charge accumulation at the $CH_3NH_3PbI_3$/Au interface while the compact TiO_2/$CH_3NH_3PbI_3$ junction showed a space charge region, which inhibits the recombination.

High Voltage hole conductor free perovksite solar cells.
In this work we demonstrate high open circuit voltage of 1.35V using Al_2O_3/$CH_3NH_3PbBr_3$ perovskite solar cells without a hole conductor. The contact potential difference under light measured by surface photovoltage spectroscopy for $CH_3NH_3PbBr_3$ was more than twice than that for $CH_3NH_3PbI_3$, which results with smaller surface potential for the Al_2O_3/$CH_3NH_3PbBr_3$ cells. Incident modulated photovoltage spectroscopy shows a longer recombination lifetime for the Al_2O_3/$CH_3NH_3PbBr_3$ cells than for the TiO_2/$CH_3NH_3PbI_3$ cells or for the TiO_2/$CH_3NH_3PbBr_3$ cells, further supporting the high open circuit voltage. The possibility to gain high open circuit voltage even without a hole transport material in perovskite solar cells shows that the perovskite/metal oxide interface has a major effect on the open circuit voltage in perovskite based solar cells.

Kelvin probe force microscopy is used to measure cross-sections of hole conductor free $CH_3NH_3PbI_3$ perovskite solar cells. A depletion region width of about 45 nm was determined from the measured potential profiles at the interface between $CH_3NH_3PbI_3$ and nanocrystalline TiO_2, whereas a negligible depletion was measured at the $CH_3NH_3PbI_3/Al_2O_3$ interface. A complete solar cell can be realized with the $CH_3NH_3PbI_3$ that functions both as light harvester and hole conductor in combination with a metal oxide. The band diagrams were estimated from the measured potential profile at the interfaces, and are critical findings for a better understanding and further improvement of perovskite based solar cells.