Degradation Pathways of Screen-Printed Mesoporous Carbon Perovskite Solar Cells

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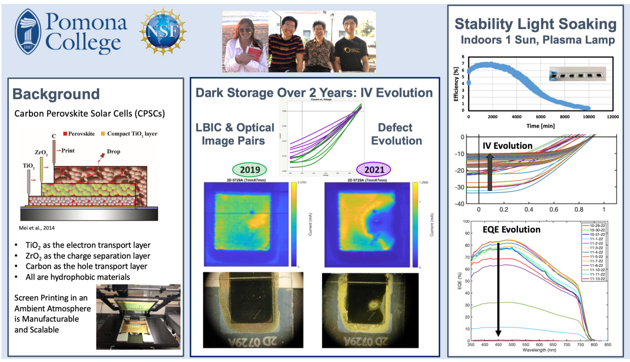

We fabricate and characterize carbon-based lead halide perovskite solar cells composed of a mesoscopic scaffold of metal oxides that is screen printed and infiltrated with a lead halide perovskite precursor solution with a methylammonium cation.(MAPbI3) We characterize the cells over time to investigate degradation pathways and improve fabrication methods. We measure the current produced by the cells under various illumination conditions as a function of applied bias voltage (IV curves) as well as spatially mapping both the structure and the photovoltaic performance of our cells to track and classify defects using both optical micrographs and Light Beam Induced Current (LBIC) imaging.   Observations of the spectral response of the cells enables us to determine the External Quantum Efficiency (EQE) of our devices as well.

In an undergraduate laboratory environment we fabricate and characterize Screen-Printed Mesoporous Carbon Perovskite Solar Cells (CPSCs). The fabrication is based on pioneering work by Hongwei Han's research group.[1] We adapt our methods from those developed by Trystan Watson's group [2]. We start with FTO coated glass substrates and laser engrave isolation lines. We spay coat a compact titania layer followed by screen printing a mesoporous layers of titania (for electron transport), zirconia (for a spacer), and Carbon (for hole transport and a back contact). A Methylammoina Lead Iodide (MAPbI) perovskite precursor is then inflitrated into the mesoporous layers crystalizing to form the perovskite semiconductor structure. Silver contact electrodes are added to complete the devices. The fabrication is performed in an ambient environment and no encapsulations are added to the devices. Each substrate has 36 devices each with an active area of 0.49 sq. cm. We have produced over a thousand devices with 4 generations of students in the lab.

We characterize our devices with a wide range of techniques. Current Voltage characteristics are measured for all devices. Hero cells have power conversion efficiencies over 12%. The devices show negligible hysteresis, and are limited in performance by moderate shunt and series resistances. New higher conductivity Carbon and Silver ink formualations have been tested with significantly better conductivities that have improved Fill Factors and reduced series resistance. We observe a variety of spatial defects by both LBIC and optical micrographs in the printing process and do statistical analysis of yields on every run to optimize our initial device performance. We measure EQEs with peaks approaching 80% for freshly made devcies.

We have performed dark storage shelf life measurements over two years. While devices still work after two years in dark storage, the performance decreases and defects clearly evolve as seen in our spatial imaging over time. We also perform light soaking studies of both individual cells and modules of cells in series. We record not only the IV characteristics and the IV curve evolution, but also the changes in EQE and spatial imaging as a function of light soaking under 1 sun conditions with no encapsulation or UV filtering. We will present these data and discuss what this says about the degradation of these CPSCs.

References:

[1] Ku, Z., Rong, Y.; Xu, M.; Liu, T.; Han, H. Full Printable Processed Mesoscopic CH3NH3PbI3/TiO2 Heterojunction Solar Cells with Carbon Counter Electrode. Sci. Rep. 3, 3132 (https://doi.org/10.1038/srep03132)

[2] Baker, J.; Hooper, K.; Meroni, S.; Pockett, A.; McGettrick, J.; Wei, Z.; Escalante, R.; Oskam, G.; Carnie, M.; Watson, T. High Throughput Fabrication of Mesoporous Carbon Perovskite Solar Cells. J. Mater. Chem. A, 2017,5, 18643-18650 (https://doi.org/10.1039/C7TA05674E)

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International Conference on Hybrid and Organic Photovoltaics

(/hybrid-and-organic-photovoltaics-international-conference)**International Conference on Hybrid and Organic Photovoltaics (/hybrid-and-organic-photovoltaics-international-conference)**

International Conference on Hybrid and Organic Photovoltaics (HOPV) is celebrated yearly in May. The main topics are the development, function and modeling of materials and devices for hybrid and organic solar cells. The field is now dominated by perovskite solar cells but also other hybrid technologies, as organic solar cells, quantum dot solar cells, and dye-sensitized solar cells and their integration into devices for photoelectrochemical solar fuel production.

(/international-perovskite-and-organic-photovoltaics-and-

optoelectronics-conferenc)**Asia-Pacific International Conference on Perovskite, Organic Photovoltaics and Optoelectronics (/international-perovskite-and-organic-photovoltaics-and-optoelectronics-conferenc)**

The main topics of the Asia-Pacific International Conference on Perovskite, Organic Photovoltaics and Optoelectronics (IPEROP) are discussed every year in Asia-Pacific for gathering the recent advances in the fields of material preparation, modeling and fabrication of perovskite and hybrid and organic materials. Photovoltaic devices are analyzed from fundamental physics and materials properties to a broad set of applications. The conference also covers the developments of perovskite optoelectronics, including light-emitting diodes, lasers, optical devices, nanophotonics, nonlinear optical properties, colloidal nanostructures, photophysics and light-matter coupling.

(/perovskite-thin-film-photovoltaics-perovskite-photonics-and-optoelectronics)**International Conference on Perovskite Thin Film Photovoltaics Perovskite Photonics and Optoelectronics (/perovskite-thin-film-photovoltaics-perovskite-photonics-and-optoelectronics)**

The International Conference on Perovskite Thin Film Photovoltaics Perovskite Photonics and Optoelectronics (NIPHO) is the best place to hear the latest developments in perovskite solar cells as well as on recent advances in the fields of perovskite light-emitting diodes, lasers, optical devices, nanophotonics, nonlinear optical properties, colloidal nanostructures, photophysics and light-matter coupling.