Thesis title: Fabrication and Characterization of Perovskite Solar Cells Under Air Ambient Conditions

Subrata Ghosh (18ES91R04)

Abstract:

Organic-inorganic lead halide perovskite-based solar cells (PSCs) have shown great promise in solar energy harvesting. The superior optoelectronic properties of halide perovskites and application of various engineering techniques, like composition engineering, additive engineering, interfacial engineering, and fabrication process modification, led the power conversion efficiency (PCE) up to 25.7%. However, the perovskite solar cell fabrications are mostly done inside the glove box/ or controlled atmosphere, which is not suitable for commercial production.

In this thesis, the process/protocols are developed to bridge this gap between lab-scale fabrication and commercial production. The devices are fabricated in air ambient conditions with controlled humidity (20% < RH < 35%). The electron transport layer (ETL), perovskite layer and interface between these two layers play a crucial role in device efficiency and stability. A successful synthesis of TiO_2 and SnO_2 ETL are optimized and materials are characterized using various techniques such as SEM, AFM, XRD, UV-VIS, PL, I-V etc. It is observed that both the ETLs can be used as effective compact layers for perovskite solar cells. Further, the interfacial engineering at ETL/perovskite interface by utilizing ionic liquid and antisolvents treatment produced homogeneous perovskite grains, reduced interfacial defects, improved electron transfer efficiency. The optimized devices showed PCE over 16% with high reproducibility (~ 90%). Furthermore, large area perovskite film (5 x 5 cm^2) fabrication is established using a multi-channel micropipette during antisolvent dripping which resulted in homogeneous and pinhole-free perovskite films over large substrate. The metal contact (back and front contact) recycling resulted in improved long-term stability with PCE retention of 85% after 3000 hr. of dark storage under ambient conditions. At last, the role of the work function of back contact materials is explored using SCAPS-1D software on HTL-free PSCs. It is found that a work function of 5.4 eV or more results in the best efficiency.

Keywords: Perovskite solar cells, Air ambient fabrication, Interface engineering, Ionic liquid, Antisolvent, Efficiency, Stability, Back contact work function