***Dissertation Title:*** Performance and Stability of Perovskite Solar Cells

***Advisor:*** Dr. Vikram Dalal

***Abstract:***

Perovskite solar cells have great potential not only as a high-efficiency and low-cost single junction solar cell, but also as a top cell (larger bandgap material) for tandem cells with either c-Si or CIGS solar cells. Perovskite as an active layer has a lot of fascinating photonic and electrical properties such a high absorption coefficient, low defect density, long diffusion lengths and low exciton binding energy. These properties have made perovskite an excellent choice for thin film solar cells. Given all exciting properties it also shows some very challenging characteristics such as hysteresis in light IV measurement, environmental instability, voltage evolution, self-degradation in dark and photon-induced degradation.

In the initial part of this work, we have optimized the power-conversion efficiency of a p-i-n structured solar cell and obtained an efficiency of about 18.5%, which is one of the best cells in the world on PTAA as hole transport layer using single-solution processed antisolvent technique.

For most part of this work, we have studied the detailed device physics to understand the photon-induced degradation of perovskite solar cells. We have developed a model based on generation and migration of ions. We have proposed a modified equivalent circuit model to understand the change in photovoltaic parameters during photon-induced degradation. The degradation in short-circuit current density can be modeled using a double-exponential model which explains both migration and generation of ions. The change in open-circuit voltage can be explained by two opposing components: open-circuit voltage increases due to migration from ions from perovskite-transport layers’ interfaces towards bulk perovskite and decreases with increase in non-radiative recombination. These factors can be considered with a dependent current source in parallel with the photo-generated current source and a dependent voltage source in series with the diode to have complete equivalent circuit for perovskite solar cells.

Finally, we have studied how different factors such as the transport layers, stoichiometry of perovskite ($PbI\_{2}$ to $MAI$ molar ratio), the biasing conditions at which the device is kept during photo-degradation, fabrication techniques of perovskite (Solution or Vapor) and perovskite grain size can affect the photon-induced degradation and dark-recovery. We have demonstrated that our model based on generation and migration of ions can explain these comparative studies completely.

For electrical characterization, we have calculated the dielectric constant of perovskite using capacitance spectroscopy and reported this value to be about 60, which suggests that perovskite has exciton binding energy of about 0.59 meV.