Title: Understanding electronic defects in organic solar cells: Defect identification, characterization & mitigation

Abstract: Among several thin-film based solar technologies, organic or hybrid organic- inorganic photovoltaic (PV) technology is envisioned as a foremost candidate towards the realization of ubiquitous and economical solar power. Organic PV (OPV) technology has the advantages of facile fabrication suitable for roll-to-roll processing on flexible substrates, high optical absorption coefficients, low- temperature processing, and easy tunability by chemical doping. Substantial progress has resulted from the optimization of materials processing parameters and the emergence of new materials. Recent works have achieved conversion efficiencies exceeding 13%, but with the Shockley-Queisser limit calculated at 21% for single-junction cells, there are many facets left for improvement. Recombination and mobility deficits are considered two of the largest bottlenecks in organic solar cells – accounting for 50-60% of losses. Electronic defect bands can significantly affect both these bottlenecks, introducing charged trap sites, Shockley-Read-Hall centers, or both. Thus, the identification, characterization and mitigation of these defects largely remain open and important areas of interest. This research work focuses on understanding defects in OPVs through systematic identification of defects, characterization of their nature and exploring approaches for defect mitigation. An understanding on the physical origin of electronic defects is developed using several organic materials. Different approaches have been explored to minimize these defects to optimized device performance. This work shows the distribution of defect states in the bandgap of organic semiconductors used in OPVs with accurate energetic location and interpret on their physical origin. Exploring ways to minimized electronic defects, this work demonstrates improvement of power-conversion-efficiency and stability of OPVs.