Deposition and Infiltration of Absorber Materials for Solution Processable Solar Cells using Electric Field-Assisted Spray Technique

Abstract

Solar photovoltaics play an important role in solar energy conversion technologies. The role of solution-processable solar cells and thin film solar cells in the development of cost-effective and sustainable energy generation is significant. The major component and the process of solution-processable solar cells, Dye-Sensitized (DS) and Perovskite (P) solar cells (SCs) are porous electrodes and accommodate active materials in these electrodes. In this thesis, the work is focused on the infiltration of dye and perovskite materials in their respective photoanodes/devices. Particularly, the electric field-assisted spray (e-spray) technique is proposed as a facile technique for this purpose.

The role of electric fields in the spray technique is established by studying the effectiveness of infiltration of the dye and its loading in DSSCs using e-spray and comparing the results to the conventional DSSCs. The concept of tandem photoanodes for DSSCs is discussed and existing techniques to fabricate them are evaluated. Facilitating a controlled and precise infiltration for the fabrication of tandem and gradient absorbers is demonstrated by fine-tuning the experimental parameters of e-spray and tandem DSSC devices are realized. Apart from the improvement in the dye loading, which resulted in the improvement of the device's current density, the e-spray technique accelerated the fabrication process from several hours to a few mins.

For the spray-deposited perovskite material, the effect of the electric field on the morphology and optoelectronic properties is investigated. The e-spray technique is extensively used in lead and non-lead perovskite material infiltration in Carbon-PSCs to address the issue of the poor and non-uniform infiltration and crystallization of perovskite into complex C-PSC architectures. The

prototyping and demonstration of the e-spray fabricated C-PSC are carried out using bismuth perovskite, followed by the ink development for spray technique and fabrication of lead-based C-PSC using e-spray.

This thesis tries to fill the research gap in the domain of infiltration of absorber materials into porous electrodes and device architectures with the complex hetero-porous structure to fabricate solution-processable solar cells with an emphasis on using the e-spray technique for the same. The work demonstrates the flexibility of e-spray deposition and serves as an important proof of concept for the infiltration of active material for energy storage and conversion application.