Laboratory for Thin Films and Photovoltaics
Überlandstraße 129
8600 Dübendorf
Switzerland

Empa
Materials Science and Technology

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Master Thesis

Scalable Coating of Perovskite films for All-Perovskite Tandem Solar Cells and Mini-modules

Research areas

Photovoltaics (PV)

Perovskite solar cells

Solar module

Tandem solar cells

Thin-film coating

Solution processing

Ink formulation

Focus

☒ Experimental
☒ Opto-electronic characterization
☒ Analytical
☒ Literature and research

Duration

4-6 months

Entry

As soon as possible

Contacts

Jonathan Austin, Postdoctoral Researcher
E-mail: jonathan.austin@empa.ch

Literature

Li, Jinzhao, et al. Advanced Energy Materials, 13, 33 (2023)

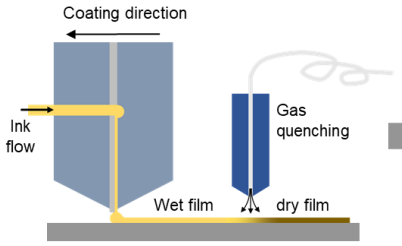
Pious, Johnpaul K. et al. ACS Applied Materials and interfaces, 16, 30 (2024)

Gao, Han, et al. Science, 368, 6685 (2024)

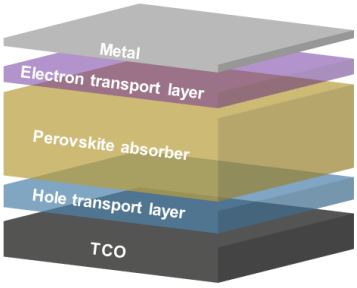
Motivation

Metal-halide perovskite solar cells are promising candidates for the next generation of photovoltaic devices, owing to their high power conversion efficiency (PCE), low cost, and light-weight. These perovskites display broad band-gap tunability, making them ideal for use in tandem solar cells, where multiple perovskite absorber layers with different band-gaps have been used to achieve efficiencies beyond the single-junction limit. However, despite the high performances displayed by all-perovskite tandem solar cell devices, they typically require bespoke fabrication techniques and are yet to reach commercial viability. Slot-die coating and doctor-blade coating offer promising routes for large scale industrial-style fabrication of these devices; it can be used to coat flexible substrates with high throughput roll-to-roll processing over large areas. However, formulation of new perovskite inks and optimisation of the coating parameters is needed to achieve the high-uniformity films required for solar cells.

This thesis will focus on the development of uniform perovskite layers on flexible substrates via scalable coating techniques, for the fabrication of solar cells with high efficiency and stability. This work will lay a solid foundation for the development of industrial scalable methods for upscaling of both perovskite single-junction and tandem solar cells.



Slot-die coating



Slot-die coated perovskite solar cell

Your task

You will learn to fabricate narrow-bandgap perovskite (~1.25 eV) solar cells on both glass and flexible polymer substrates. The focus will be on developing high-quality perovskite absorber films using slot-die coating, which requires precise control and understanding of the ink formulation. Additive and solvent engineering strategies, as well as process parameter optimisation will be explored to improve the uniformity and the optoelectronic properties of the perovskite absorber films. You will learn to characterise the rheological and chemical properties of the inks using drop-shape analysis, viscometry, NMR, etc. You will also learn to use SEM, XRD, PL&TRPL, etc., to study the structural and optoelectronic properties of the perovskite films and evaluate the photovoltaic performance and stability of the solar cells using JV, EQE, stress test chamber, etc. In addition, you will apply the coated perovskite absorber in mini-modules and all perovskite tandem solar cells.

Key tasks include:

- Development of high-quality perovskite absorber films using scalable coating techniques
- Optical and electrical characterisations, for enhanced understanding of how ink formulation and processing parameters affect the uniformity and optoelectronic quality of the perovskite films
- Fabrication of single-junction solar cells and testing of PV performance.
- Based on promising single junction results, apply the developed absorber to demonstrate mini-modules (10 cm x 10 cm) and perovskite-perovskite tandem applications.

Requirements

- Strong interest in solar cells
- Background in materials science, semiconductors, physics, chemistry etc.
- Master students in Switzerland is preferred

Notes

Please include a CV and a transcript of records with your application. The field of photovoltaic research requires a multidisciplinary knowledge. Hence, students with backgrounds in materials science, physics, chemistry etc. are welcome to apply. The project is highly flexible and can be tailored to student's expertise and interests. For further information, please contact Jonathan Austin.