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Empa
Materials Science and Technology

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Master thesis

Hybrid PVD/slot-die coating for wide bandgap perovskite solar cells/modules

Research area

Perovskite photovoltaics (PV)

Tandem solar cells and modules

Thin film processing

Thermal evaporation

Slot-die coating

Green solvents

Focus

☒ Experimental
☒ Optoelectronic characterization
☒ Analytical
☒ Literature and research

Duration

6 months (reduced workload possible)

Start

As soon as possible

Contacts

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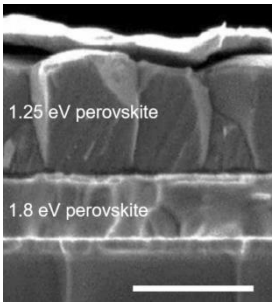
Literature

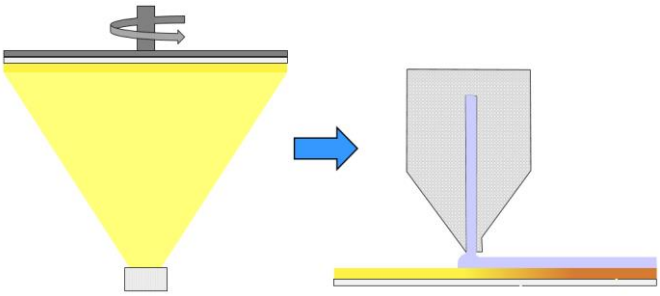
Nat Commun **6**, 8932 (2015)
J. Mater. Chem. A, 2021,**9**, 26680-26687

Motivation

Tandem solar cells outperform single junction solar cells by reducing thermalization losses. At Empa, we work on developing highly efficient perovskite-based thin-film tandem devices, which require a high-performance 1.8 eV wide bandgap perovskite with excellent uniformity on large-area substrates. To scale-up wide bandgap perovskites, either solution-based or vapour-based methods are used. However, each of these methods has its own pros and cons. For example, solution-based methods allows facile compositional engineering and passivation additives can directly be mixed into the solution, but toxic solvents (e.g. DMF) are normally used and coatings on rough substrates are challenging. On the other hand, vapour-based methods conformally coat rough substrates, but controlling the composition of the perovskite is very challenging.
In our lab, we have developed a scalable hybrid PVD/blade coating process to fabricate efficient 1.57 eV perovskite solar cells. This process combines the merits of both methods: facile compositional engineering, efficient passivation management with additives, conformal coatings and non-toxic solvents only, thus being very promising for all-perovskite tandem devices. Ultimately, the uniformity is further enhanced by replacing the solution-based blade coating step with slot-die coating.



All-perovskite tandem device consisting of a narrow and a wide bandgap perovskite [1]. Scale bar is 1 µm.



Sequential hybrid PVD/Slot-die coating process: An inorganic halide template is first deposited by thermal evaporation, followed by slot-die coating the organic halide precursors that initiates the perovskite conversion process.

Task

You will first fabricate your own 1.57 eV perovskite solar cells, using PVD/blade coating. After that, you adapt slot-die coating and increase the bandgap of the perovskite to 1.8 eV. You systematically vary the PVD step to screen the perovskite composition and characterize the optoelectronic properties as well as the photostability of the films by using photoluminescence measurements. Furthermore, you use advanced characterization methods (e.g. XRD, XPS, SEM) to investigate the morphology, crystallinity and uniformity of your perovskite films. Finally, you implement your optimized wide bandgap perovskite into single junction cells and modules. In the course of your thesis, you will further learn to use basic techniques to characterize your photovoltaic devices, such as current-voltage scan (JV), UV-Vis photospectroscopy, external quantum efficiency (EQE), etc.

Key tasks include

- Develop PVD/Slot-die coating process for wide bandgap perovskite solar modules.
- Investigate the uniformity, the stability and the performance of your solar cell devices and relate it to the perovskite composition and its deposition parameters.
- Fabricate high-performance wide bandgap perovskite solar cells and modules.

Requirements

- Hands-on student with strong interest in solar cells and thin film manufacturing.
- Background in material science, chemistry, physics, engineering.

Interested?

Please send your application including a curriculum vitae (CV) and a transcript of records to the contacts. Note, that the field of perovskite solar cell research requires a multidisciplinary knowledge. The project can be tailored according to the field of studies, your interests and time.

[1] Nature Energy volume 5, pages 870–880 (2020)