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Empa
Materials Science and Technology

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Eidgenössische Technische Hochschule Zürich
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Master Thesis

Upscaling of vapor-deposited perovskite solar cells towards highly efficient modules

Research area

Photovoltaics

Perovskite solar cells

Thin-film coating

Physical vapor deposition (PVD)

Focus

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

Duration

6 months

Starting Date

Anytime

Course of Study

☒ Mechanical and Process Engineering
☒ Materials Science
☒ Physics
☒ Chemistry and Applied Biosciences
☒ Information Technology and Electrical Engineering

Contacts

Ioanna Vareli, Postdoctoral Researcher
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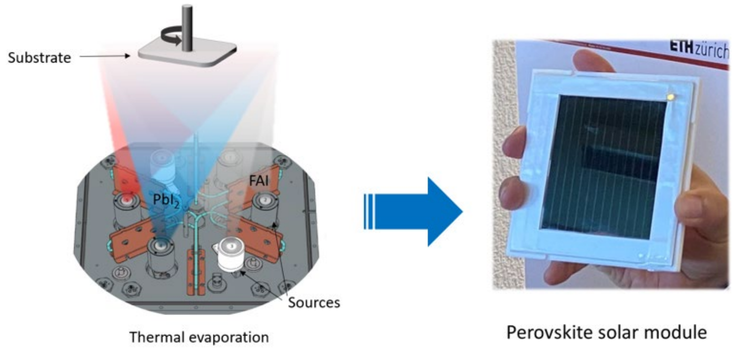
Literature

Abzieher, Tobias et al. Energy & Environmental Science 2024, 17,1645 DOI: 10.1039/d3ee03273f

Jiye, Han, et al. Nature Reviews Methods Primers, 2025, 5, 3 DOI: https://doi.org/10.1038/s43586-024-00373-9

Motivation

Perovskite-based solar cells (PSCs) are rapidly progressing toward commercialization due to their higher power conversion efficiency (PCE) potential and lower cost. However, ensuring uniform and high-quality deposition across large substrates has always been challenging, especially with solution-based techniques.
Thermal evaporation (vacuum-based process) is a solvent-free, industry-scalable method for upscaling well-controlled ambient perovskite thin-film photovoltaics that can achieve conformal coatings with minimal edge effects. This thesis will focus on upscaling high-performance solar cells and modules in large substrates based on thermal evaporation of perovskite solar cells.



Task

You will learn to fabricate vapor-deposited perovskite solar cells in a *p-i-n* architecture. The main focus of this thesis is to develop bifacial high-performance solar cells and modules based on the deposited perovskites combined with transparent electrodes.

This research will first focus on optimizing the deposition process of the vapor-deposited perovskite solar cells to achieve the desired performance and stability in 5 x 5 cm^2 and 10 x 10 cm^2 substrates. Moreover, the bifacial structure will be designed to achieve efficient light harvesting and charge carrier transport. This will involve optimizing the different electron transport layers and electrodes. Furthermore, the effect of the perovskite layer's thickness on the solar cell's overall performance will also be investigated.

Requirements

- Ideally, basic knowledge in the field of photovoltaic research
- Interest in solar cells
- Laboratory experience is desirable

Notes

Please include a curriculum vitae 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, etc. are welcome to apply. The project can be tailored to the field of study and interests. You should be able to work independently and be motivated to learn new topics. Initial programming experience is desirable. For further information, don't hesitate to get in touch with Ioanna Vareli.

Master Thesis

The role of passivation layers in upscaled vapor-deposited perovskite solar cells

Research area

Photovoltaics

Perovskite solar cells

Thin-film coating

Physical vapor deposition (PVD)

Focus

☒ Experimental
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6 months

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☒ Mechanical and Process Engineering
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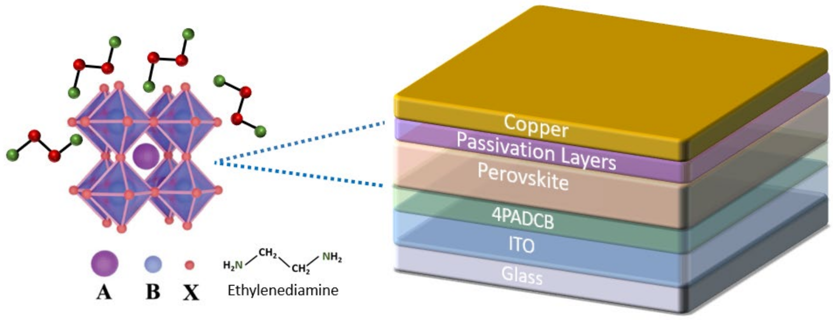
Literature

Hu, Shuaifeng et al., ACS Appl. Mater. Interfaces 2022, 14, 56290−56297 DOI:https://doi.org/10.1021/acsami.2c15989

Chiang, Yu-Hsien et al., *ACS Energy Lett.* 2023, 8, 2728−2737 DOI:https://doi.org/10.1021/acsenergylett.3c00564

Motivation

Perovskite-based solar cells (PSCs) are rapidly progressing toward commercialization due to their higher power conversion efficiency (PCE) potential and lower cost. However, ensuring uniform and high-quality deposition across large substrates has always been challenging, especially with solution-based techniques.
Unlike traditional solution-based processes, thermal evaporation (vacuum-based process) offers precise control over film thickness and composition, leading to superior device performance and stability. This method eliminates solvent-related issues and enables the deposition of uniform, high-quality layers, making it ideal for lab-scale experiments and industrial applications.



Task

You will learn to fabricate vapor-deposited perovskite solar cells in a *p-i-n* architecture. This thesis mainly focuses on developing fully vacuum-based high-performance solar cells and modules.

Firstly, this research study will focus on optimizing the deposition process of the vapor-deposited perovskite solar cells to achieve the desired performance and stability in 5 x 5 cm^2 and 10 x 10 cm^2 substrates. By integrating vacuum-deposited perovskite absorbers, hole transport layers (HTLs), electron transport layers (ETLs), and passivation layers, we aim to achieve efficient light harvesting and charge carrier transport. A key focus of our research is the role of passivation layers in enhancing device performance. This approach addresses surface defects and improves charge-carrier transport, significantly boosting the efficiency and stability of perovskite solar cells.

Requirements

- Ideally, basic knowledge in the field of photovoltaic research
- Interest in solar cells
- Laboratory experience is desirable

Notes

Please include a curriculum vitae and a transcript of records with your application. The field of photovoltaic research requires multidisciplinary knowledge. Hence, students with backgrounds in materials science, physics, etc. are welcome to apply. The project can be tailored in the field of study and interests. You should be able to work independently and be motivated to learn new topics. Initial programming experience is desirable. For further information, don't hesitate to get in touch with Ioanna Vareli.