Laboratory for Thin Films and Photovoltaics
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Empa
Materials Science and Technology

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Master thesis

Flash lamp annealing for rapid processing of perovskite solar modules

Research area

Photovoltaics (PV)

Perovskite solar cells and modules

Thin film processing

Photonic curing

Focus

☒ Experimental
☒ Optoelectronic characterization
☒ Analytical
☒ Literature and research

Duration

6 months (reduced workload possible)

Start

As soon as possible

Contacts

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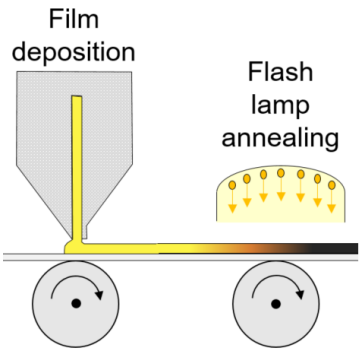
Literature

ACS Appl. Energy Mater. 2020, 3, 9, 8636–8645

Front. Energy Res., 9:640960

Motivation

Hybrid organic-inorganic perovskite solar cells have achieved certified efficiencies of 25.7 % within a decade. This quick development is partially attributed to facile fabrication of high quality, polycrystalline perovskite films by solution-based methods. However, to crystallize the as-deposited perovskite films, post-annealing treatment is required. This is normally done at elevated temperatures (up to 170 °C) for 10 – 30 min, which drastically prolongs the processing time and thus the fabrication cost. Moreover, thermal annealing exposes the underlying layers equally to heat, which potentially harms the heat-sensitive materials in the stack and also limits the choice of materials for perovskite solar cells.
Flash lamp annealing (FLA) is a promising approach to squeeze the annealing time of the as-deposited films to seconds, thus enabling a cost-effective production and further offers a new way to fabricate high quality perovskite films rapidly. FLA uses ultra-short pulses of intense broadband light flashes to selectively crystallize the as-deposited layer while keeping the bottom layers relatively intact, which allows using heat-sensitive, flexible substrates for perovskite solar cells fabrication.



Perovskite fabrication by slot-die coating and flash lamp annealing.

Flash lamp annealing machine PulseForge 1300 by Novacentrix at Empa.

Task

You will first learn to fabricate perovskite solar cells on glass and flexible substrates, using scalable solution-based coating methods, thermal evaporation, sputtering, etc. After that, you will use flash lamp annealing (FLA) to crystallize your solution-deposited perovskite films. By using advanced characterization methods (SEM, XRD, PL/TRPL, etc.), you will analyze your perovskite films and optimize your FLA process parameters accordingly. Furthermore, you will apply your FLA-knowledge to perovskite materials of different bandgaps (1.25 eV – 1.85 eV). Finally, you will use the developed FLA-perovskite layers and implement it into perovskite solar cells. 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 photo-spectroscopy, external quantum efficiency (EQE), etc.

Key tasks include

- Use simulation and experiments to develop of a comprehensive understanding of crystal nucleation and growth of the perovskite films with different compositions by FLA.
- Use optical and electrical characterizations to optimize FLA recipes for high quality perovskite films of different bandgaps and analyze the film quality and the photovoltaic performance.

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.