

Master Thesis

Reducing nonradiative recombination in perovskite solar cells

Research area

Photovoltaics
Perovskite solar cells
Thin-film coating
Physical vapor deposition (PVD)
Solar cell characterization

Focus

- Experimental fabrication
- Defect and interface passivation
- Opto-electronic characterization
- Literature and research

Course of Study

- Mechanical and Process Engineering
- Materials Science
- Physics
- Chemistry and Applied Biosciences

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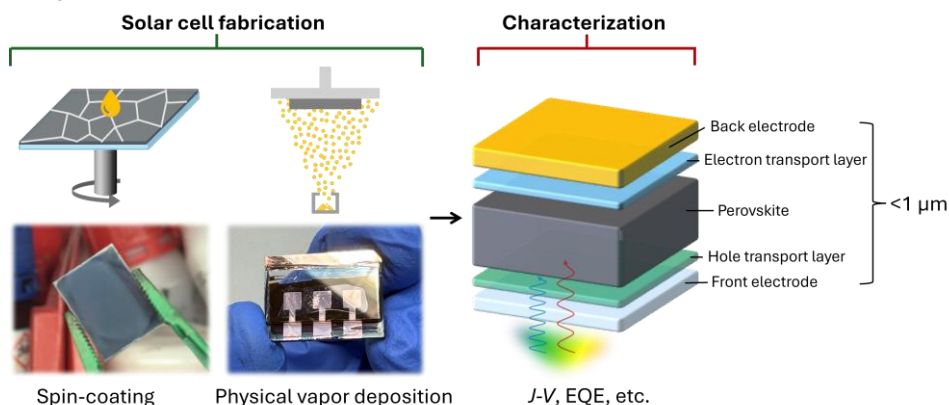
Literature

[High-Performance Flexible All-Perovskite Tandem Solar Cells with Reduced VOC-Deficit in Wide-Bandgap Subcell - Lai - 2022 - Advanced Energy Materials - Wiley Online Library](#)

[Reducing nonradiative recombination in perovskite solar cells with a porous insulator contact | Science](#)

Motivation

Nonradiative recombination remains a key limitation preventing perovskite solar cells from reaching their full efficiency potential. It lowers the open-circuit voltage and fill factor and can further accelerate device degradation under operation. Despite the excellent optoelectronic properties of perovskite absorbers, recombination losses frequently originate from defects at surfaces, buried interfaces, grain boundaries and charge-selective contacts. Understanding and suppressing these losses is therefore essential for improving both efficiency and stability. This thesis will focus on uncovering the dominant pathways of nonradiative recombination in perovskite solar cells and on developing practical approaches to reduce them through defect passivation and interface design.



Task

You will learn to fabricate perovskite solar cells starting from glass substrates, and to evaluate their optoelectronic performance. The central objective of this thesis is to reduce nonradiative recombination through the optimization of materials, interfaces and processing conditions.

The project will focus on linking device losses to thin-film quality and interfacial properties. Depending on the specific direction of the work, this may include tuning perovskite composition and deposition conditions, introducing surface or buried-interface passivation layers, and optimizing charge-selective contacts. You will learn to assess the device performance by current density–voltage measurements (J - V), external quantum efficiency (EQE), and steady-state and time-resolved photoluminescence, complemented by structural or spectroscopic characterization where available. The aim is to identify the dominant loss pathways and to establish practical design rules for reducing nonradiative recombination and overall improving power-conversion efficiency.

Requirement

- Ideally basic knowledge in the field of photovoltaic research
- Interest in solar cells and opto-electronic characterization
- 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 studies and interests. You should be able to work independently and be motivated to learn new topics. For further information, please contact Dr. Huagui Lai or Prof. Dr. Wolfgang Tress.

Master Thesis

Thermal/light cycling of perovskite solar cells for space photovoltaics

Research area

Photovoltaics
Perovskite solar cells
Solar cell characterization

Focus

- Opto-electronic characterization
- Literature and research
- Data analysis

Course of Study

- Mechanical and Process Engineering
- Materials Science
- Physics
- Chemistry and Applied Biosciences

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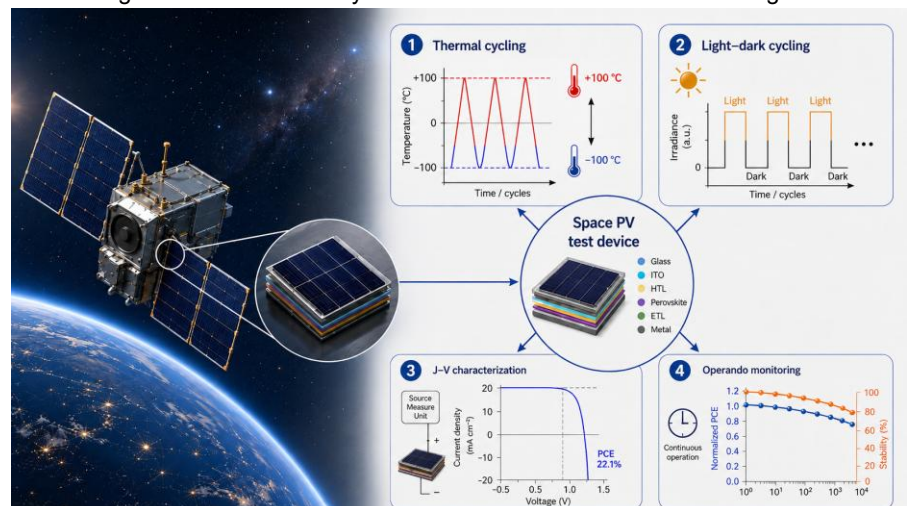
Literature

Wu, Luyan, et al. "Resilience pathways for halide perovskite photovoltaics under temperature cycling." *Nature Reviews Materials* 10.7 (2025): 536-549.

Yilmaz, Cem, et al. "Perovskite solar cells with enhanced thermal fatigue resistance under extreme temperature cycling." *Nature Communications* (2026).

Motivation

Perovskite solar cells are promising candidates for space photovoltaics because of their high specific power, low cost and compatibility with lightweight substrates. However, in low-Earth orbit the repeated transition between sunlit and shadowed conditions imposes severe thermal shocks that can accelerate ion migration, lattice contraction, interfacial fatigue and delamination. Recent space-oriented testing guidelines therefore highlight tiered thermal-cycling protocols and the need to quantify recovery or self-healing rather than relying on simple pass/fail metrics. This thesis will develop a ground-based thermal/light-cycling workflow for perovskite solar cells and will link the observed degradation and recovery behavior to materials and device design.



Task

You will get familiar with regular perovskite solar cells and learn to evaluate their stability under space-relevant thermal cycling. The central objective of this thesis is to establish a test platform based on liquid-helium circulation and a cold head, and to use it to quantify the effect of repeated temperature/light excursions on device performance.

The project will focus on defining cycling protocols inspired by space-photovoltaic guidelines, and measuring device response before, during and after cycling. You will assess the devices by current density-voltage measurements ($J-V$), external quantum efficiency (EQE), steady-state and time-resolved photoluminescence, and structural or spectroscopic characterization where available. Based on the degradation signatures, you will identify dominant failure pathways and feed the results back to the fabrication side to optimize composition, interfaces, encapsulation and processing conditions. The goal is to build a closed feedback loop between space-relevant reliability testing and solar-cell engineering.

Requirement

- Ideally basic knowledge in photovoltaics, semiconductors or thin-film materials
- Interest in solar cells, and opto-electronic characterization
- Laboratory experience is desirable

Notes

Please include a curriculum vitae and a transcript of records with your application. Students with backgrounds in materials science, physics, chemistry, process engineering or related disciplines are welcome to apply. The project can be tailored to the field of study and interests, and may combine device fabrication, cryogenic or vacuum experiments and data analysis. Independent working style and motivation to learn new topics are expected. For further information, please contact Dr. Huagui Lai or Prof. Dr. Wolfgang Tress.

Master Thesis:

Developing a 2D Photocurrent Mapping Technique to Investigate Degradation Phenomena on Solar Cells

Research area

Photovoltaics
Next generation solar cells
Optoelectronics instrumentation
Python coding
Solar cell characterization

Focus

- Laboratory automation
- Scientific programming
- Opto-electronic characterization
- Literature and research

Course of Study

- Physics
- Electronics
- Mechanics

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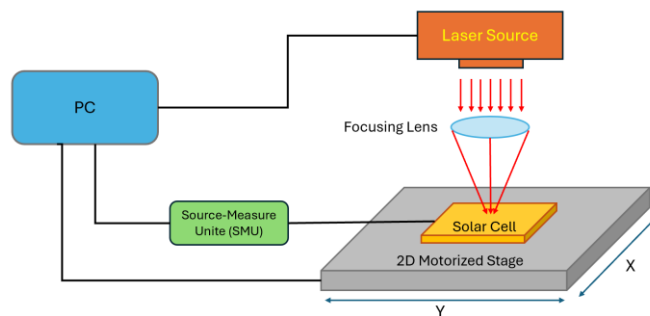
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Motivation

In laboratory-scale research, solar cells are typically fabricated on relatively small devices with limited active area. However, for large-scale production, these technologies must eventually be transferred to much larger-area devices and modules. One of the main challenges during this scale-up process is maintaining good uniformity across the entire device area. Small local defects, non-uniform coating, or inhomogeneous electrical properties can strongly affect the overall device performance and long-term stability.

One powerful method to investigate such issues is spatially resolved 2D photocurrent mapping. By measuring the local photocurrent response at different positions across a solar cell or module, it becomes possible to identify non-uniform regions, local defects, degradation spots, or variations in charge collection efficiency. Such measurements are important both for improving fabrication processes and for studying the stability and scalability of next-generation photovoltaic technologies.



Task

In this project, a 2D photocurrent mapping setup will be developed and automated. A focused laser beam will locally illuminate the sample surface while the generated photocurrent is measured at each position using a source-measure unit (SMU). The solar cell or module will be mounted on a motorized XY stage, allowing automated scanning across the device area and generation of a two-dimensional photocurrent map.

The required hardware components including the laser source, motorized stage, optical components, and SMU will be available in the laboratory. The main task of the project is to synchronize and automate these instruments through Python-based control software. Basic communication codes for the instruments are already available, and the student will mainly adapt and combine existing scripts into a functional automated measurement system. After commissioning the setup, the student will also perform initial measurements on solar-cell devices in order to investigate spatial non-uniformities and degradation effects in photovoltaic samples.

Notes

The project offers valuable hands-on experience with optoelectronic instrumentation, laboratory automation, optics, electronics, and scientific measurements. Such experience is beneficial for students planning to continue toward laboratory physics research or future careers in instrumentation development, and R&D environments. In addition, the developed setup may contribute directly to ongoing research and publications based on measurements performed with the system can include the student who developed the setup.

Depending on the student's interests, focus could be more on the technique itself or its application to study degradation, charge extraction and recombination phenomena in perovskite solar cells. The project is best suited for students who are motivated to work independently, are comfortable learning new concepts from different fields, and enjoy solving practical experimental problems in a research environment. For further information, please contact Kazem Meraji or Prof. Wolfgang Tress.

Master Thesis:

Development of an EQE Measurement Technique to Investigate Transient and Ionic Loss Effects on Perovskite Solar Cells

Research area

Photovoltaics
Next generation solar cells
Optoelectronics instrumentation
Python coding
Solar cell characterization

Focus

- Laboratory automation
- Scientific programing
- Opto-electronic characterization
- Literature and research

Course of Study

- Physics
- Electronics
- Mechanics

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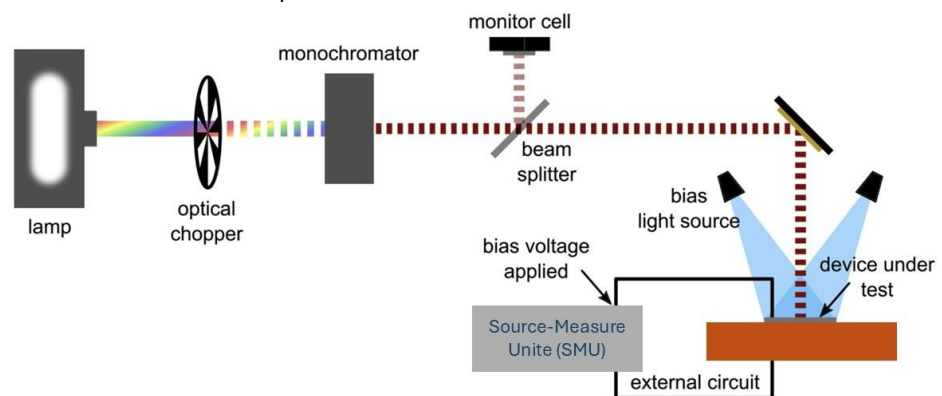
[Novel Semiconductor Devices Team | ZHAW Institute of Computational Physics ICP](#)

Reference Literature

[Subcell-Resolved EQE Method Using Reverse Voltage Biasing for Multijunction Photovoltaics With Overlapping Subcell Absorbance](#)

Motivation

External Quantum Efficiency (EQE) measurements are among the most important characterization techniques for solar cells. EQE provides the spectral response of a photovoltaic device, showing how efficiently photons of different wavelengths are converted into electrical current. This information is particularly important for modern multi-junction and tandem solar cells, where understanding the contribution of each sub-cell across the solar spectrum is essential for device optimization and current matching. In this project, an advanced EQE setup will be developed with capabilities beyond standard commercial systems. In addition to conventional EQE measurements with voltage and light bias, the system will allow programmable pre-bias conditions applied before the measurement. These features are especially relevant for emerging photovoltaic technologies such as perovskite solar cells where transient and ionic effects are important.



Task

The project mainly focuses on integrating and automating already available laboratory instruments into a unified measurement platform. The required hardware components — including the monochromatic light source, optical chopper, source-measure unit (SMU), lock-in amplifier, and bias illumination system — are already available in the laboratory. The student will work on synchronizing these instruments through Python-based control software in order to perform automated measurements. Importantly, the project does not require extensive software development experience. Basic communication codes for the different instruments are already available, and the main task will be adapting and combining existing scripts into a functional and user-friendly set-up. The project is therefore highly suitable for physics students interested in experimental research, instrumentation, optics, electronics, and scientific programming. After commissioning the setup, the student will also perform initial measurements on perovskite solar cells to study ionic effects.

Notes

The project offers valuable hands-on experience with optoelectronic instrumentation, laboratory automation, optics, electronics, and scientific measurements. Such experience is beneficial for students planning to continue toward laboratory physics research or future careers in instrumentation development, and R&D environments. In addition, the developed setup may contribute directly to ongoing research and publications based on measurements performed with the system can include the student who developed the setup.

Depending on the student's interests, focus could be more on the technique itself or its application to study transient and ionic losses phenomena in perovskite solar cells.

The project is best suited for students who are motivated to work independently, are comfortable learning new concepts from different fields, and enjoy solving practical experimental problems in a research environment. For further information, please contact Kazem Meraji or Prof. Wolfgang Tress.