Development of solution-processed kesterite absorbers for thin film solar cells

Summary

Photovoltaic (PV) is recognized as one of the main renewable energy solutions for fulfilling the targets defined by the EU Energy Roadmap 2050 and the SET Plan. To meet the rapidly increasing demand for solar power generation capacity, it is essential to develop technologies that are more ecologically sustainable, more efficient, and versatile enough for a wide range of applications. The main goal of the research group at the Photovoltaic Materials Laboratory of Tallinn University of Technology is to achieve a significant breakthrough in the technology of flexible solar panels based on kesterite (CZTSSe) materials. CZTSSe is one of the most promising light absorber material candidates for potential use in lower-cost thin-film solar cells. Recently, there have been significant breakthroughs in thin film kesterite technology resulting in several efficiency records in a very short time using a simple solution-based process. Although, there are still many challenges to reach closer to theoretical maximum efficiencies. The overall goal of the PhD project is to further develop and optimize non-toxic, earth-abundant kesterite absorbers for efficient thin-film solar cells using a solution-based technique.

Research field:	Chemical, materials and energy technology
Supervisors:	Dr. Marit Kauk-Kuusik Maris Pilvet
Availability:	This position is available.
Offered by:	School of Engineering Department of Materials and Environmental Technology
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

Developing large scale, cost-effective, and efficient PV devices is a major challenge for increasing the competitiveness and sustainability of the PV sector in the energy market. Enhancing the competitiveness of photovoltaics requires the development of new PV materials and technologies. A key priority is developing PV materials that are non-toxic and made from readily available elements rather than rare and precious metals. Multinary chalcogenide compounds, especially those containing the relatively common metals copper, tin and zinc – known as kesterites- have been proposed as solar cell absorber materials because they meet these essential criteria.

Recently, Meng's research group reported CZTSSe solar cells with efficiencies of ~15 % using a non-vacuum deposition process. The goal of this PhD project is to elaborate a robust non-vacuum process using non-toxic precursor solutions. Deposition methods should be simple and potentially scalable to large areas. One drawback of non-vacuum solution processing is poor crystallinity, very high surface roughness, high porosity, and the presence of microscopic voids in sintered layers. Different sintering approaches should be explored to circumvent this obstacle. The primary tasks for PhD candidate will be: i) to develop solution-based methods (e.g., spin coating, dip coating) to deposit kesterite absorber layers, ii) to investigate the effects of annealing in various atmospheres (e.g., sulfur, selenium) on film properties, iii) to explore new n-type buffer layers to optimize band alignment between absorber and buffer, which would additionally reduce recombination at the interface; and iii) to characterize the produced thin films and solar cells.

The results of this research will be published through at least three journal articles in high-impact journals and presented at international conferences. The infrastructure and trained operators at TalTech are available to support the implementation of the planned work.

Responsibilities and (foreseen) tasks

- The successful candidate will develop highly efficient kesterite thin films using solution-based methods, specifically tailored for flexible photovoltaic applications. Additionally, the PhD candidate will develop an alternative buffer layer to achieve improved band alignment while avoiding the use of toxic compounds.
- These thin films will be characterized in-depth using various techniques such as XRD, Raman, SEM, EDX and photoluminescence measurements.

- The successful candidate will also prepare the photovoltaic devices based on these materials. The PhD student will characterize the solar cell performances using J-V curve and EQE measurements.
- Co-supervision of undergraduate students
- The PhD student will work closely with the other colleagues in the Laboratory of Photovoltaic Materials, benefiting from the host group's strong expertise in material synthesis, as well as in the preparations and characterizations of related solar cells.

Applicants should fulfil the following requirements:

- A master's degree in physics, chemistry, materials science, or a related field;
- a clear interest in the topic of the position;
- Previous research experience in thin film solar cell technologies, with a strong focus on the fabrication and characterization of materials and devices. Knowledge of various physical and chemical deposition techniques, processing equipment and characterization tools is highly valued;
- A very high level of motivation and independent thinking abilities;
- Excellent communication and writing skills in English;
- Strong analytical skills and competencies in using data analysis & graphing software, including MS Office (Word, Excel, and PowerPoint) and Origin.
- capacity to work both as an independent researcher and as part of an international team;
- capacity and willingness to provide assistance in organizational tasks relevant to the project.

The candidate should submit a research plan for the topic, which should include a description demonstrating their understanding of the current state of the art of kesterite solar cells and a detailed proposal of possible research activities aimed at using kesterite thin films in flexible photovoltaics applications.

We offer:

- 4-year PhD position in an internationally recognized photovoltaic research group with a portfolio of ongoing European and national research and development projects;
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of photovoltaics.

(Additional information)

For further information, please contact Prof Marit Kauk-Kuusik marit.kauk-kuusik@taltech.ee and or visit https://taltech.ee/en/laboratory-photovoltaic-materials

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