Development of Kesterite-based Monograin Layer Technology for Indoor Photovoltaics

Summary

The indoor photovoltaic (IPV) has great market potential as the demand for constantly available energy sources grows, especially for small electronic devices and Internet of Things (IoT) devices. The project focuses on developing flexible kesterite-based monograin layer solar cells specifically designed for indoor photovoltaic applications. The aim is to customize the optical and electronic properties of the absorber material and the device architecture so that they better match indoor light sources such as cold and warm LEDs.

Research field:	Chemical, materials and energy technology
Supervisors:	Prof. Dr. Maarja Grossberg-Kuusk Dr. Marit Kauk-Kuusik
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

In our interconnected world, the escalating demand for sustainable and efficient energy sources has never been greater. With the projected exponential growth of Internet of Things (IoT) devices, estimated to reach 125 billion by 2030, the need for powering these devices sustainably becomes paramount. Traditional batteries are not a viable solution due to their limited lifespan. Replacing or recharging billions of batteries would lead to service interruptions and increased maintenance costs. Moreover, the disposal of toxic battery waste poses a substantial environmental problem. Grid-connected electricity is another option, but wiring numerous wireless sensors to the grid is impractical and requires building restructuring. Remarkably, the IoT devices operate on a µW to mW scale—requiring 1000 times less energy than charging a typical mobile phone. Fortunately, indoor energy harvesting emerges as a sustainable alternative.

The goal of this PhD project is to advance the development of sustainable, flexible kesterite-based monograin layer solar cells with enhanced configurations, specially designed for IPV applications. This will involve adjusting the bandgap of absorber material to align with indoor light sources, optimizing the charge carrier density to maximize power output under indoor lighting conditions. Additionally, the interface properties will be enhanced by restructuring the absorber surface layer and introducing a new buffer layer. The project will also assess device performance under both diffuse ambient and artificial light sources to determine their effectiveness for IPV applications.

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 wider bandgap kesterite materials using solid state and molten salt synthesis methods, focusing on optimizing bandgap properties to facilitate efficient energy harvesting under low ambient light conditions. Additionally, the PhD candidate will develop an alternative buffer layer to achieve improved band alignment while avoiding the use of toxic compounds.
- These materials 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.
- 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 molten salt 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 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 materials in indoor 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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