Development of Kesterite-based Technology for Indoor Photovoltaic Applications

Summary

Indoor photovoltaics (IPV) have significant 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 objective is to customize the optical and electronic properties of the absorber material, as well as the device architecture, to better align with indoor light sources such as cool 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, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

The research

In today's interconnected world, the demand for sustainable and efficient energy sources has never been greater. With the number of Internet of Things (IoT) devices projected to reach 125 billion by 2030, powering these devices sustainably has become a critical challenge. Traditional batteries are not a viable long-term solution due to their limited lifespan. Replacing or recharging billions of batteries would cause service interruptions, incur high maintenance costs, and generate substantial toxic waste. Grid-connected electricity is another option, but wiring large number of wireless sensors is impractical and would require extensive restructuring of existing infrastructure. Remarkably, IoT devices operate at power levels ranging from µW to mW—up to 1000 times less than required for charging a typical mobile phone. This makes indoor energy harvesting a promising and sustainable alternative.

The aim 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. The research will focus on tuning the absorber bandgap to match indoor light spectra and optimizing charge carrier density to maximize power output under low-light conditions. Additionally, the interface properties will be enhanced by restructuring the absorber surface layer and introducing a novel buffer layer. The project will also assess device performance under both diffuse ambient and artificial lighting to determine their effectiveness for IPV applications.

The results will be disseminated through at least three high-impact journal publications and presentations at international conferences. TalTech's advanced infrastructure and trained personnel are in place to support successful implementation of the project.

Responsibilities and (foreseen) tasks

- The successful candidate will develop wider bandgap kesterite materials using both solid state and molten salt synthesis methods, with a focus on optimizing the bandgap properties for efficient energy harvesting under low ambient light conditions. An additional objective is to develop an alternative, non-toxic buffer layer to achieve improved band alignment.
- The synthesized materials will be characterized in-depth using various techniques such as XRD, Raman, SEM, EDX and photoluminescence measurements.
- The candidate will fabricate photovoltaic devices based on these materials and evaluate their performance through J-V and EQE measurements.
- The PhD student will collaborate closely with colleagues in the Laboratory of Photovoltaic Materials and benefit from the group's extensive expertise in molten salt synthesis, as well as in the preparations and characterization of related solar cells technologies.

Applicants should fulfil the following requirements:

- A Master's degree in physics, chemistry, materials science, or a related discipline;
- A demonstrated interest in the topic of the position;
- Previous research experience in solar cell technologies, particulary in 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 academic writing skills in English;
- Strong analytical skills and competencies in using data analysis & graphing software, including MS Office (Word, Excel, and PowerPoint) and Origin.
- Ability to work both independently and as part of an international research team;
- Willingness and capacity to contribute to organizational tasks relevant to the project.

The candidate must submit a research plan that demonstrates a solid understanding of the current state of kesterite solar cell technology. The plan should also include a detailed proposal outlining proposed research activities aimed at utilizing kesterite materials for indoor photovoltaic applications.

We offer:

- A 4-year PhD position within an internationally recognized photovoltaic research group, engaged in a diverse portfolio of ongoing European and national research and development projects;
- Opportunities to attend international conferences, participate in research stays and network with leading universities and research centers worldwide 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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