Development of next-generation all-inorganic perovskite solar cells for residential green hydrogen production systems

Summary

Perovskites have revolutionized the emerging photovoltaic field achieving record-breaking efficiencies. The main objectives of PhD project are to apply the new method to synthesize emerging inorganic perovskites; to understand the potential of Pb-free inorganic perovskites for solar-to-hydrogen production technologies and design cost-effective high-performance fully inorganic perovskite PV device.

Research field:	Chemical, materials and energy technology
Supervisors:	Dr. Marit Kauk-Kuusik Dr. Katri Muska
Availability:	This position is available.
Offered by:	School of Engineering Department of Materials and Environmental Technology
Application deadline:	Applications are accepted between June 01, 2022 00:00 and June 30, 2022 23:59 (Europe/Zurich)

Description

The conversion of solar energy directly into fuels is a promising solution to the challenge of intermittency in renewable energy sources, addressing the issues of effective storage and transport. Hydrogen, which is the simplest form of energy carrier, can be generated renewably with solar energy by photovoltaic – driven electrolysis (PV-EC). The primary consideration to realize a large-scale and low-cost hydrogen production with PV–EC system is highly efficient and stable PV cells.

Perovskites have revolutionized the emerging photovoltaic field achieving record-breaking efficiencies. Hybrid organic–inorganic halide perovskite solar cells were improved rapidly over the past few years, possessing an increased output voltage (≈1.1 V) and their power conversion efficiency has increased rapidly from 3.8 % in 2009 to over 25.8 % in 2021, which provides a solid foundation for designing perovskite-driven EC systems towards green hydrogen production. Perovskites have also high light absorption coefficients; the precise tailoring of band gaps and band edges by varying the chemical compositions, which makes them thermodynamically favorable for solar hydrogen production reactions.

To ensure however economic feasibility and competitive levelized cost of electricity, the technology should offer long-term stability with high power conversion efficiency to match the or even exceed reliability of silicon-wafer-based modules. At present, the long-term stability of lead (Pb) halide perovskite cells does not meet this target. Fully inorganic tin-halide perovskites compounds with formula $ASnX_3$ (A- Cs; X- I, Br) as absorber materials might be good choice to avoid instabilities related to volatile organic components.

The expected outcome of this PhD project is implementation of unique synthesis method for low-cost, stable, inorganic halide perovskite materials, understanding of the potential of Sn-halide perovskites for solar-to-hydrogen production technologies and design cost-effective, high-performance fully inorganic perovskite PV device.

The results will be published in at least three journal articles in high impact journals. The results will be presented at international conferences. The infrastructure and trained operators are available in TalTech to implement the planned work.

Responsibilities and (foreseen) tasks

- The successful candidate will develop the preparation of the new perovskite materials by solid state and molten salt synthesis methods. Various parameters of synthesis will be optimized for getting high quality crystals.
- These materials will be in-depth characterized by various techniques such as XRD, Raman, SEM, EDX and photoluminescence measurements.
- The successful candidate will also prepare the photovoltaic solar cells based on these materials. The PhD student will characterize the solar cell performances by J-V curve and EQE measurements.

- The PhD student will work in close interaction with the other colleagues from the Laboratory of Photovoltaic Materials. This work will be underpinned by the strong expertise of the host group on molten salt synthesis, on the preparations and characterizations of the related solar cells.

Applicants should fulfil the following requirements:

- Master's degree in physics, chemistry, materials science or a related field;
- A very high level of motivation and independent thinking abilities;
- A clear interest in the topic of the position;
- Excellent English in communication and in writing;
- Strong analytical skills, competencies in using data analysis & graphing software: MS Office (Word, Excel, and PowerPoint), Origin.

We offer:

- 4-year PhD position in internationally known 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 Dr. Marit Kauk-Kuusik marit.kauk-kuusik@taltech.ee or visit https://taltech.ee/en/laboratory-photovoltaic-materials

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