Defect engineering in kesterite absorber for monograin layer solar cells

Summary

The research group hosting the proposed PhD project is developing an innovative, customized and efficient building integrated photovoltaic (BIPV) technology based on kesterite type materials Cu2ZnSn(S,Se)4 (CZTSSe) that among the environmentally friendly and abundant emerging thin film solar cell materials have shown the highest potential already reaching efficiencies above 12%. The PhD project focuses on the defect engineering in kesterite absorber via novel doping and alloying strategies in monograin powder technology aiming at reducing recombination losses in kesterite based monograin layer solar cells developed by the research group. The result of the PhD work would be improved performance of the CZTSSe based monograin layer solar cells for BIPV.

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, 2020 00:00 and July 03, 2020 23:59 (Europe/Zurich)

Description

The research group hosting the proposed PhD project is developing an innovative, customized and efficient building integrated photovoltaic (BIPV) technology based on kesterite type materials Cu2ZnSn(S,Se)4 (CZTSSe) that among the environmentally friendly and abundant emerging thin film (TF) solar cell (SC) materials have shown the highest potential. In addition to the sustainability, CZTSSe have many advantages for being efficient and sustainable absorber material for PV, namely its suitable band gap (in between 1 to 1.5 eV depending on the S/Se ratio) for solar energy conversion and high absorption coefficient (~ 104 cm-1) meaning that thin layers of material (around micrometer) are enough to absorb the sunlight unlike in the case of conventional Si PV available in the market. The latter fact makes the emerging TF SC technologies especially appealing for BIPV applications where the light weight and mechanical flexibility of the PV elements is needed. CZTSSe also have a crucial advantage of being free of non-abundant or toxic elements included in TF SC front-runners CdTe and Cu(In,Ga)Se2 (CIGSe), and in emerging mixed-halide perovskites. CZTSSe based SC have already demonstrated considerable power conversion efficiencies (PCE, 12.6%) and stability being in the leading position in emerging sustainable PV technologies, however, significant improvement in PCE is still needed for commercialization.

The aim of the PhD project is to bring the CZTSSe PCE to the next level by focusing on the currently shown key issue that is strong recombination of photogenerated charge carriers via various routes leading to short minority carrier lifetime (that is magnitude lower than in CIGSe, CdTe etc.) and diffusion length and resulting in large open circuit voltage deficit of CZTSSe SCs. The most crucial sources of strong recombination are identified as following: a) abundance of point defects and defect clusters with deep energy levels in the band gap, b) severe band tailing including potential and band gap fluctuations, and c) non-optimized interfaces in the CZTSSe SCs leading to interface recombination. The PhD project focuses on the defect engineering in kesterite absorber via novel doping and alloying strategies in monograin powder technology aiming at reducing recombination losses in kesterite based monograin layer solar cells developed by the research group. The result of the PhD work would be improved performance of the CZTSSe based monograin layer solar cells for BIPV.

Responsibilities and tasks

- development and implementation of new strategies for doping and alloying of kesterite monograins
- defect studies by using various electrical and optical characterization methods such as luminescence techniques, quantum efficiency of solar cells, capacitance spectroscopy methods, temperature dependent current-voltage analysis etc.

- writing research publications and presenting the results of PhD project at scientific conferences

Qualifications
Master degree in materials science, preferably in the field of semiconductor materials research.
The applicants should fulfill the following requirements:

- Excellent knowledge in semiconductor physics and/or chemistry.
- Experience with structural, optical and electrical materials characterization techniques.
- Excellent English in communication and in writing, team working attitude.

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