

Development of antimony chalcogenide semiconductor alloys for innovative photovoltaic and optoelectronic applications

Summary

The overall goal of the project is to develop and optimize the non-toxic and earth-abundant Sb- chalcogenide absorber alloys for efficient thin film solar cells by using cost-effective and mass production close-spaced sublimation (CSS) technique. The project addresses the following research questions: What will be the most suitable processing approaches for the synthesis of these materials using low temperature, low cost and highly scalable techniques? How a semiconductor alloy system would allow tailoring the bandgap (from 1.1 eV to 1.8 eV) and current-voltage tunability required to design efficient thin-film solar cell configurations? How systematic material and device characterization can provide understanding of the physico-chemistry of the processes, properties of the materials and solar cells, and deliver insights for further optimization? We offer an opportunity to be part of the COST action CA21148 - Research and International Networking on Emerging Inorganic Chalcogenides for Photovoltaics, RENEW-PV, <https://renewpv.eu/>

Research field:	Chemical, materials and energy technology
Supervisors:	Dr. Nicolae Spalatu Dr. Jon Major
Availability:	This position is available.
Offered by:	School of Engineering Department of Materials and Environmental Technology
Application deadline:	Applications are accepted between June 01, 2023 00:00 and June 30, 2023 23:59 (Europe/Zurich)

Description

The PhD candidate's doctoral study and research work will be a joint collaboration and supervision at Tallinn University of Technology – TalTech, Tallinn, Estonia and University of Liverpool – UOL, Liverpool, UK. The applicant will have a unique opportunity to carry out research work at TalTech and UOL. The candidate will carry out a multidisciplinary scientific activity in the framework of the projects PSG689 and PRG627 and European Union's H2020 programme under the ERA Chair project 5GSOLAR grant agreement No 952509, on the development and characterization of thin films and solar cell devices based on emerging antimony chalcogenides $\text{Sb}_2(\text{S},\text{Se})_3$ PV absorber materials. The PhD student will be involved in all the solar cells processing stages. This will include the fabrication of absorber layers by physical techniques such as CSS, vapor transport deposition (VTD) and vacuum thermal evaporation (VTE) on different substrates: glass, glass/TCOs, glass/Mo, glass/TCOs/window layer. Various CSS deposition parameters (substrate and source temperature, growth pressure) and post-deposition treatments (in tube-furnaces, hot- plates) will be optimized for obtaining single-phase, high-crystallinity, dense, and homogeneous absorber layers with suitable optoelectronic properties and proper thicknesses for thin film solar cell applications. The PhD student will also fabricate different window layers such as CdS, by CSS and chemical bath deposition methods (CBD), and TiO_2 by chemical spray pyrolysis (CSP) and will identify the optimal window/buffer partner in solar cells. The student will prepare the photovoltaic solar cells based on these materials, define the ad hoc selective contacts for efficient charge extraction and characterize the materials properties and solar cells output parameters.

The proposed research project will help the student to acquire a vast range of competences and skills in developing and design thin film solar cells, will strengthen the researcher's ability to publish in international journals, as well as broadening the network of international contacts with companies and other research groups in the PV field from EU and the world at large through the participation at different international conferences.

Supervisors:

Main supervisor: Dr. Nicolae Spalatu
Co-supervisor: Dr. Jon Major

Responsibilities and (foreseen) tasks:

- Screening and optimization of deposition processes of antimony chalcogenide-based absorbers, to create well-oriented, continuous, uniform films on appropriate substrates
- Optimization of deposition processes for $\text{Sb}_2(\text{S,Se})_3$ and related alloys ($\text{Sb}_2(\text{S,Se})_3$ - $\text{Bi}_2(\text{S,Se})_3$ alloys) with controlled tuned bandgap for efficient thin film solar cells
- Map the key technological parameters of the used experimental approaches
- Identification of optimal buffer layers and electron/hole selective transport layers for efficient cell device architectures.
- Development and optimization of thin film solar cells based on antimony chalcogenide-based absorbers
- Characterization of materials and solar cell devices using various dedicated characterization techniques.
- Analysis of the research data, preparing reports, presentation at conferences (poster, oral talk), write research papers
- Contribute to the organization and dissemination of research and practitioner workshops where project findings are presented

Applicants should fulfil the following requirements:

- Bachelor and Master degree in Physics, Chemistry, Electronic Engineering, Materials Engineering or a related field
- Previous research experience in thin film solar cell technologies, with a strong focus on the fabrication/characterization of films and solar devices, and knowledge on the use of different physical and chemical deposition techniques (CSS, VTE, sputtering, CBD, CSP), processing equipment (PDTs, furnaces) and characterization tools (XRD, SEM, Van-der-Pauw, solar simulator, spectral response) will be well evaluated
- Previous experience on the development of chalcogenide solar cells (including CdTe, SnS, CIGS based devices) on different kinds of substrates suitable for device integration in different kinds of elements and systems will be well evaluated
- Excellent communication skills in English (both written and oral) are an essential requirement
- 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
- Competences in using data analysis and graphing software: Microsoft Office (Word, Excel and PowerPoint), Origin

The candidate should submit a research plan for the topic, describing the understanding of the current state of the art of $\text{Sb}_2(\text{S,Se})_3$ - $\text{Bi}_2(\text{S,Se})_3$ thin film alloys and solar cells development and propose possible research activities.

We offer:

- 4-year PhD position in one of the most internationalized and leading research groups in Estonia and UK
- The chance to do high-level research in one of the most booming emerging photovoltaic field
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of material science
- Opportunity to be part of the COST action CA21148 - Research and International Networking on Emerging Inorganic Chalcogenides for Photovoltaics, RENEW-PV, <https://renewpv.eu/>

Additional information



For further information, please contact Dr. Nicolae Spalatu, nicolae.spalatu@taltech.ee and Dr. Jon Major, jonmajor@liverpool.ac.uk.



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