Laboratoire de l'Intégration du Matériau au Système CNRS UMR 5218

PhD Position 2023

Fabrication, Characterization and Modeling of Organic/Silicon Tandem Solar Cells

Location : Laboratoire de l'Intégration du Matériau au Système (IMS, www.ims-bordeaux.fr), Team ELORGA (Organic Electronics, https://oembordeaux.cnrs.fr/), Univ. Bordeaux, France

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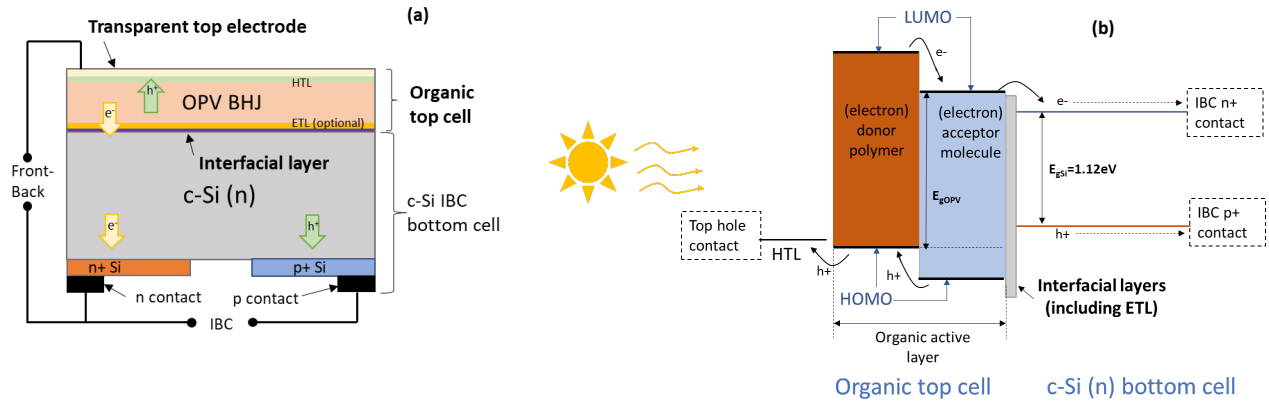
Description :

Context : Photovoltaics (PV) has today become a mature industry, dominated by silicon technology (more than 90% of the PV market). Solar cell efficiency is getting closer and closer to the single-junction theoretical Shockley-Queisser (SQ)[1] efficiency limit, specifically the Auger limit of 29.4% for crystalline silicon (c-Si)[2]. A record efficiency of 26.7% has been reached for the silicon single junction solar cell[3] and only marginal improvements in performance remain possible. The development of new concepts to surpass the SQ limit is therefore a hot topic in PV research and multijunction devices are the most promising solution. The dominant multijunction design today is the tandem solar cell which is achieved by combining two different bandgap materials, allowing a reduction of thermalization losses in comparison with a single junction solar cell. Silicon is an appropriate low bandgap (1.12 eV) bottom cell in a tandem configuration and there is great research activity investigating on larger bandgap semiconductors for the top cell. In this context, organic materials are very promising regarding the large choice of materials to develop either low or high band gap devices, their high absorption and the recent impressive progress in the power conversion efficiently of organic solar cells[4].

Scientific work: The thesis will take place in the framework of the ORGANIST research project (ORGANIc/Si 3-terminal Tandem solar cells) supported by the National Research Agency (ANR) in partnership with two other French laboratories (GeePs and LPICM). The main goal of the thesis is to fabricate a proof of concept of an organic/Si tandem solar cell in a 3-terminal configuration based on an interdigitated back contact (IBC) silicon bottom cell and to demonstrate an improvement for the tandem cell efficiency with respect to that of either organic solar cell (OSC) or Si cell working alone. The figures below show a schematic of the final 3-terminal hybrid tandem cell Organic/Silicon with a n-type c-Si bottom cell (a) and the energy diagram of both organic top cell and Si bottom cell in the 3T design (b).



The main steps of the thesis project will consist in (1) selecting and optimising the organic top cell partner of the c-Si bottom cell; (2) actively studying the organic/silicon interface to design and implement a suitable interface layer. Dry processes will be developed by the LPICM partner whereas wet processes will be investigated by the PhD student to modify the c-Si interface with the goal of providing suitable surfaces (concerning roughness and wettability) for the fabrication of the organic top-cell as well as efficient collection of the electrons photogenerated in the organic top-cell (considering band alignment); (3) developing the 3T organic/Si tandem using commercial IBC Si cells. The close collaboration with the GeePs partner, in charge of numerical modeling, will help to analyse and optimise component IBC and OSC elements and the full 3T tandem solar cell.

This thesis will give the PhD student the opportunity to expand their knowledge in solar photovoltaics and to work in a highly multidisciplinary environment involving device physics, materials science, organic electronics, and physico-chemistry. They will develop complementary technical skills ranging from emerging semiconductor technologies, to the characterization of optical and electronic transport phenomena in these materials and associated heterojunction devices.

Applicant profile:

For this study, the IMS is looking for a candidate holding a Master Degree (MSc or equivalent) in physics, electronics or materials science. Knowledge in the physics of semi-conductors is mandatory. One or several experiences in organic electronics and/or micro-/nano-technology would be strongly appreciated.

Duration/Funding:

- Duration: 3 years
- Starting date: September/October 2023
- Gross monthly salary: 2000€
- Net monthly salary: 1600€, social insurance included
- Information on studies, daily life and campus life: https://www.u-bordeaux.fr/application/files/5916/5830/6502/2022_Guide-etudiant_Student-guide.pdf

Application:

The application will include a CV and a motivation letter. Recommendation letters from two references would be a plus. Application sould be sent to marie.gueunier-farret@u-bordeaux.fr and sylvain.chambon@u-bordeaux.fr.
Application deadline: 31st May 2023.

[1] W. Shockley, H.J. Queisser, "Detailed Balance Limit of Efficiency of p-n Junction Solar Cells", J. Appl. Phys. 32 (1961) 510–519; DOI: 10.1063/1.1736034

[2] A. Richter, M. Hermle, S. W. Glunz, "Reassessment of the Limiting Efficiency for Crystalline Silicon Solar Cells", IEEE Journal of Photovoltaics 3 (2013); DOI: 10.1109/JPHOTOV.2013.2270351

[3] M.A. Green, et al. "Solar Cell Efficiency Tables (version 58)", DOI: 10.1002/pip.3444

[4] Y. Cui, Y. Xu, H. Yao, et al., Single-Junction Organic Photovoltaic Cell with 19% Efficiency; Adv. Mater. (2021) 2102420; DOI: 10.1002/adma.202102420