High Efficiency CIGS-Perovskite thin film tandem solar cells

Proposal for two PhD positions at CNRS,
Institut Photovoltaïque d'Île de France (IPVF), Paris area

Thesis one: **Optimization of fabrication processes and device realization**
Thesis two: **Characterization and modelling for device optimization**

Context: The research will be carried out within the PERCISTAND (Perovskite CIS tandems) European H2020 Project which has been recently granted. The project is coordinated by IMEC and involves reputed research and industrial partners in Europe:ZSW, KIT, EMPA, CNRS, TNO, VITO, Solaronix, Nice solar with links with USA and Australia (NREL, ANU). It will be held at CNRS in Paris with strong links with the other partners within the research program.

Research group at CNRS and supervisers : Daniel Lincot (CIGS), **Philip Schulz** (Perovskite and interfaces), Jean François Guillemoles (Theory and physics), Nathanaelle Schneider (Chemistry and ALD), **Jean Paul Kleider** (Electrical transport properties and modelling), Stéphane Collin (Optics), Emmanuelle Deleporte (2D perovskite), Muriel Bouttemy (Analytics)

Dates : 3 years from beginning of 2020

Location : IPVF, 18 Boulevard Thomas Gobert, 91120 Palaiseau, France. www.ipvf.fr

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Context: Tandem solar cells are attracting considerable attention as they bring a unique opportunity to cross the absolute conversion efficiency limit of single junction solar cells from about 33% to a new limit of about 45%. Tandem solar cells consist of two superimposed single junction solar cells working in specific regions of the solar spectrum, in the infrared one for the bottom cell and in the UV-visible one for the top cell. The top cell must be transparent for the IR light for it to reach the bottom cell and being converted into electricity more efficiently. Ideal band gaps should thus be about 1 eV and 1.6-1.7 eV for the two cells, respectively. Presently, major research activities are devoted to tandem cells based on silicon and perovskite combinations. This project presents an alternative approach which is to use thin film solar cells based on copper indium gallium diselenide (CIGS) as bottom cells instead of silicon. This leads to unique advantages since CIGS is already an established thin film technology with high power conversion efficiencies (23.3 %) using thin film deposition processes on simple glass or metallic or plastic foils substrates. The perovskite solar cell being also based on thin film technologies, with outstanding promising cell efficiency of 24.2%. **CIGS-perovskite tandem solar cells will thus open a new avenue for all thin film high efficiency tandem solar cells and modules**. **This area is still in its infancy and the PERCISTAND project aims to become a major player in this domain internationally.**

Aim of the theses: The aim of the offered thesis projects is to translate the development of the tandem CIGS-perovskite technology in a unique positioning along the value chain, from fundamental studies of fabrication processes, materials and interfaces to the proof of concept device fabrication, characterization and optimization. The ambitious target is to demonstrate tandem cells with 30% efficiency within three years, on the basis of fully integrated two terminal devices. Focus will be on the optimization of the interface, including highly efficient tunnel recombination junctions and electronically matched contacts, while concomitantly exploring innovative approaches such as 2D or lead free perovskite materials. The projects are embedded in a unique European Research Network in the frame of the PERCISTAND (PERovskite CIS TANDems) project which is conducted in the H2020 program framework of the European Commission. The studies will be carried within the task of the French CNRS team affiliated with the Institut Photovoltaïque Ile de France (IPVF) in Paris. The two PhD theses will also work in close collaboration.

Details on IPVF: The thesis project will be conducted at IPVF in the south of Paris (www.ipvf.fr), on the new Paris Saclay campus. The IPVF facility comprises about 8000 m^2 with 4000 m^2 of clean room laboratory space, allowing to carry out forefront studies in fabrication, characterization and modelling of advanced solar cell materials, interfaces and devices from wafer based silicon technologies to thin film technologies based on CIGS, III-V or perovskites towards ultra-high efficiency solar cells based on multijunction approaches and new concepts.

Staff: IPVF hosts about 150 researchers from different origins, either academic from CNRS, universities and Grandes Ecoles (Ecole Polytechnique, Chimie Paristech, CentraleSupelec…) or industrial from EDF, Total, Air Liquide, who specialize in physics, chemistry, material sciences, optics, nanosciences, etc., creating a stimulating research environment.

Methods

-Thin film deposition methods (ALD, MBE, Sputtering, printing, spin coating, electrodeposition, solution deposition…)
-Characterization methods: structural, composition, local probe, electrical, optical.
-Modeling: *ab initio*, electrical and optical properties of devices

Key words : Solid state physics, materials chemistry, semiconductors, advanced fabrication techniques, thin films, device integration, photovoltaics