Environmentally friendly colloidal quantum dots for high performance solar cells

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Long-Term Joint EU-AU Research
and Innovation Partnership on Renewable Energy

The LEAP-RE project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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Consortium

Project coordinator:

- Raphaël Schneider, Université de Lorraine, **France**

Project partners:

- University of Liege (**Belgium**),
- Université de Lorraine (**France**),
- Mohammed V University in Rabat (**Morocco**),
- Mohammed VI Polytechnic University (**Morocco**)
- University of the Witwatersrand (**South Africa**)

Aim of the project

- Develop new QDSSCs using heavy metal-free QDs as absorbing material in the visible and infrared regions for optimal use of the solar spectrum.
- Optimize the interface between Ag-In-Zn-Se or $CsSnX_{3-x}Y_x$ QDs and the TiO_2 photoelectrode using wet and vacuum deposition processes.

Relevance vs MARs

- Find new materials and better design PV cells to **make more efficient solar panels and decrease their cost for generating clean and renewable electricity**.
- Develop devices that will **allow not only autonomous but also decarbonated production of electricity and thus ensure energy independence.**

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Key challenges addressed by the project

1. Develop new syntheses of Ag-In-Zn-Se and $CsSnX_{3-x}Y_x$ QDs with optimal electronic and optical properties for use in QDSSCs.
2. Optimize the structure and the electronic properties of the dense TiO_2 layer via magnetron sputtering and of the porous TiO_2 layer by wet-based templating strategies.
3. Control the microstructure of the TiO_2 porous network, in order to form continuous and highly condensed interpenetrating nanochannels allowing to maximize QDs to TiO_2 charge injection and minimize recombination.
4. Establish the excited state and charge transfer properties of Ag-In-Zn-Se and $CsSnX_{3-x}Y_x$, as well as their interaction with TiO_2 to further boost the QDSSCs efficiency.

Expected results

- Achieve **power conversion efficiencies (PCEs) above 15%,** which constitutes a ground-breaking challenge for heavy metal-free PV cells.
- **Place Africa and Europe at the forefront of renewable energy technologies worldwide** and **enable market breakthrough**, notably through the development of tailored materials exhibiting high efficiency in the solar spectrum region and their optimized integration with the other solar cell components to assemble highly efficient QDSSCs.
- **Develop reliable stand-alone system architecture that can be easily and widely deployed in off-grid African rural and remote areas.**

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Expected outcomes in case of success of the project (2030)

1. Develop new materials, better design PV cells to make more efficient solar panels and lower the cost of generating clean and renewable electricity.
2. Enable the development of devices that will allow both autonomous and decarbonated production of electricity and thus ensure energy independence.
3. Engineering of reliable stand-alone system architecture that can be easily and widely deployed in off-grid African rural and remote areas.
4. This collaborative research will sustain significant progress towards a highly efficient, large scale, low-cost and flexible PV cells solution.

Which main risks of failure during project implementation ?

1. Problems to engineer adequate TiO_2/QDs interfaces (deterioration of morphological and/or optolectronic properties).
2. 15% PCE is not reached for the solid-state QDSSCs.
3. Optoelectronic properties changes over the cell area, risks related to the assembly of the full QDSSCs stack.
4. Drop of the PCE when increasing the device size from <2 cm^2 to 25 cm^2.

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Contribution of the project to AU – EU R&D cooperation

- *Solar-powered electricity production will become a major industry worldwide. Thus, it is important for Europe and Africa to develop their R&D capacity in this field and position their academic research as world leading to ensure that companies choose Europe and Africa as a location for R&D and manufacturing for the future clean electricity production.*
- *The project involves young researchers allowing them to develop future leadership (3 PhD students recruited by the French, Moroccan and South African partners and also Master students).*
- *Search for other financial support (Hubert Curien program (France, Morocco, South Africa, Belgium), CNRS PEPS program (France), WBI (Belgium), FNRS (Belgium) to promote the mobility of researchers between the different teams and develop new collaborations.*

Interest of Consortium members in participating in LEAP-RE clustering activities

QDSOC is focused on the synthesis of nanocrystals and on the architectural design of TiO_2 layers for the development of QDSSCs.

All consortium members are open to sharing knowledge and developing new projects.