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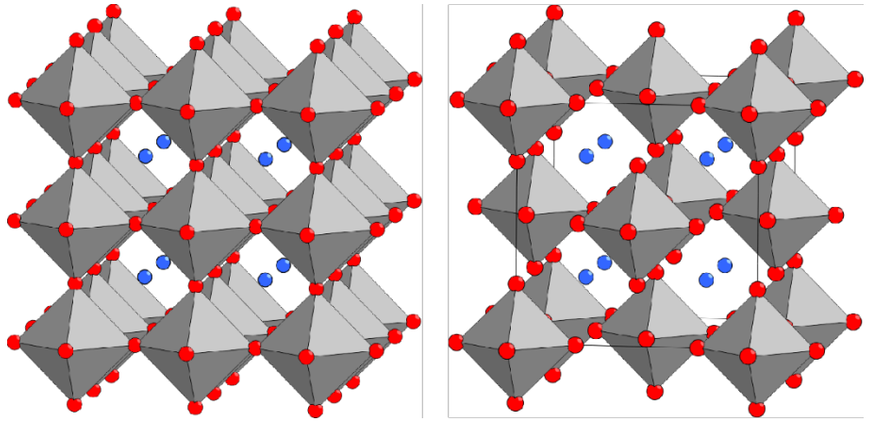
Description of the funded research project

2nd Call for H.F.R.I. Research Projects to Support Post-Doctoral Researchers

Title of the research project:
Advanced Materials for Perovskite Solar Cells (AMPERCEL)



Principal Investigator:
Dr. Andreas Kaltzoglou

Reader-friendly title:
Advanced Materials for Third-Generation Solar Cells

Scientific Area:
Physical Sciences

Institution and Country:
Theoretical and Physical Chemistry Institute, National Hellenic Research Foundation, Greece

Host Institution:
National Hellenic Research Foundation

Collaborating Institutions:
1. National Centre for Scientific Research "DEMOKRITOS"
2. Chemistry Department, Aristotle University of Thessaloniki
3. School of Electrical and Computer Engineering, National Technical University of Athens

Budget: 164.000 euros

Duration: 36 months

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Research Project Synopsis

The challenges in solar energy sources that need to be overcome concern mainly the replacement of expensive silicon-based solar cells with cheaper and more efficient materials. In this context, third generation solar cells have good potential for commercial use but so far lack applicability in warm weather conditions due to the accelerated heat degradation of the light absorbers and hole conductors. The AMPERCEL project aims to develop perovskite solar cells with high performance and stability in ambient conditions. This includes the synthesis of hybrid organic-inorganic chemical compounds based on lead and tin as metal cations, organic cations, such as formamidinium and methylammonium, and halogen atoms as anions. The assembly will consist of a photovoltaic unit as well as a thermoelectric unit, underneath the photovoltaic unit, that operates as Peltier cooler in order to reduce the temperature of the photovoltaic device. The optimum chemical composition of the new photovoltaic materials will be determined along with the electrical and mechanical characteristics of the novel photovoltaic-thermoelectric device.

Project Originality

The originality of the project is that: 1) novel organic cations, apart from formamidinium and methylammonium, will be used in the $A(Pb/Sn)X_3$ (X = Cl, Br, I) crystal structure which operates as light absorber in order to withstand ambient conditions without degradation, 2) low-cost tin perovskites will be used as hole transporters which will increase the power conversion efficiency to values over 20%, and 3) the hybrid device design will follow a bottom-up approach with operation of a commercially available thermoelectric unit in Peltier mode to cool down the photovoltaic unit. Such case of a thermoelectric element that serves as a cooling system on perovskite solar cells has not been reported so far. This will minimize the undesired solar heating that not only decreases the cell efficiency but also accelerates the irreversible chemical degradation rate of the light-harvesting material. The interdisciplinary project will include computational screening of the new materials, theoretical simulations for the assembly operation as well as extensive stress tests on the fabricated devices.

Expected results & Research Project Impact

The AMPERCEL Impact is to offer a robust photovoltaic-thermoelectric functionality with high potential for large-scale exploitation such as building-integrated renewable energy systems. This will allow the project to reach Technology Readiness Level 6, namely 'System Adequacy Validated in Simulated Environment'. In addition, new models for technical characteristics of multilayer devices combined with machine-learning techniques will be established to broaden the know-how of the scientific community. As the simultaneous use of perovskite absorber and perovskite hole transporter on a semiconducting substrate is a novel approach in solar cells, the aim is to improve the charge-transport phenomena on the materials interface owing to the chemical affinity of the two compounds and ultimately to reach power conversion efficiency values above 20% and long-term stability for the solar cell. In terms of real-life applications, the project is expected to boost hybrid photovoltaic-thermoelectric technologies.

The importance of this funding

It is very encouraging for young researchers to develop and implement their own scientific ideas. The H.F.R.I. provided me exactly this opportunity by funding my proposed project, which also helps me in building up my own research group at the Theoretical and Physical Chemistry Institute of the National Hellenic Research Foundation.

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