



HAL
open science

Hybrid Photovoltaic-thermoelectric systems for solar energy harvesting

Guilhem Almuneau, Léopold Boudier, Jean Baptiste Doucet, Sébastien Hanauer, Adnen Mlayah, Christophe Candolfi, Soufiane El Oualid, F. Kosior, Bertrand Lenoir, Philippe Masschelein, et al.

► To cite this version:

Guilhem Almuneau, Léopold Boudier, Jean Baptiste Doucet, Sébastien Hanauer, Adnen Mlayah, et al.. Hybrid Photovoltaic-thermoelectric systems for solar energy harvesting. Journées Nationales du Photovoltaïque, Nov 2022, Dourdan, France. 2022. hal-04251298

HAL Id: hal-04251298

<https://laas.hal.science/hal-04251298>

Submitted on 24 Oct 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Intrinsic losses in solar cells

Mono-junction photovoltaic cells have **two major sources of intrinsic losses**:

- Non-absorption of low energy photons ($E < E_g$);
- Thermalization of high energy photons ($E > E_g$).

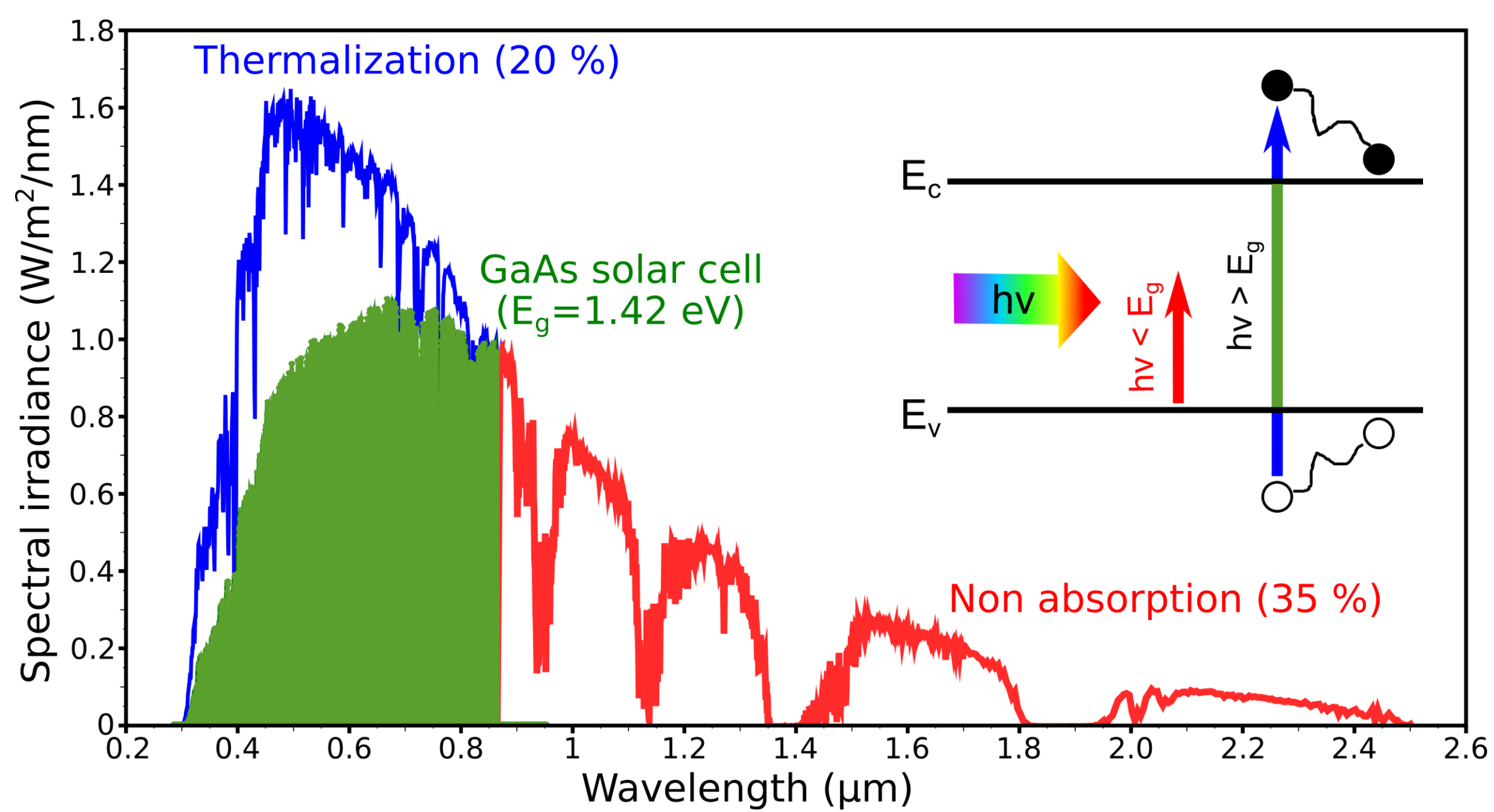


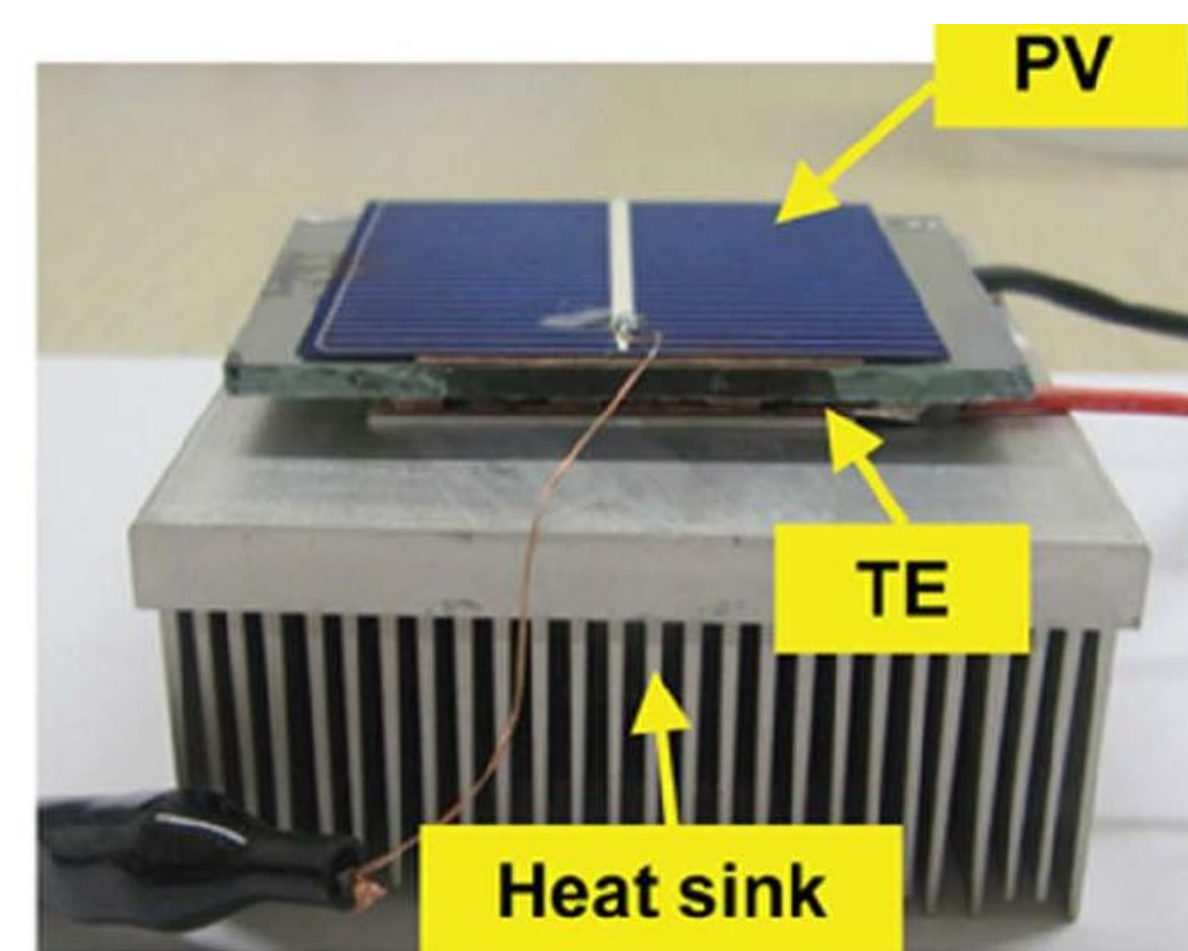
Figure 1. Intrinsic losses in a single-junction solar cell: schematic of the different processes and spectral distribution of the losses for a GaAs cell.

How can we harvest the energy lost in the solar cell ?

Our approach: hybrid PV-TE systems

An emerging strategy: hybrid photovoltaic-thermoelectric (PV-TE) systems

- Direct thermal coupling of the photovoltaic (PV) cell with a thermoelectric generator (TE);



Gain in conversion efficiency: + 4 % absolute gain with respect to the cSi cell alone [1]

- Solar energy conversion through **photovoltaic and Seebeck effects**;
- **Generic strategy**: demonstrations with cSi [1], OPV, DSSC, GaAs, CIGS [2], perovskite [3], multijunction,...

[1] K.-T. Park et al., *Sci. Rep.* 3, 2123, 2013.

[2] T.-J. Hsueh et al., *Progress in Photovoltaics* 23, 507-512, 2015.

[3] B. Lorenzi et al., *Applied Energy*, Vol. 300, 117343, 2021.

Objectives of the project HYDRES

Limitations of current hybrid PV-TE systems:

- Use of **commercial PV and TE components** thus not optimal for hybridization;
- **Low efficiency of the TE** (below 8% at room temperature);
- **Thermal losses** at the PV-TE interface;
- **No specific electronic interface** to ensure maximum power point tracking.

Ultimate goal of the project HYDRES:

Experimental demonstration of an optimal PV-TE system.

Our target: + 8-10% absolute gain with respect to the PV cell alone at ambient T

Methodology of the project HYDRES



Project funded by the ANR: Hybrid photovoltaic-thermoelectric for solar energy harvesting (2022-2025).

More info on the project website:



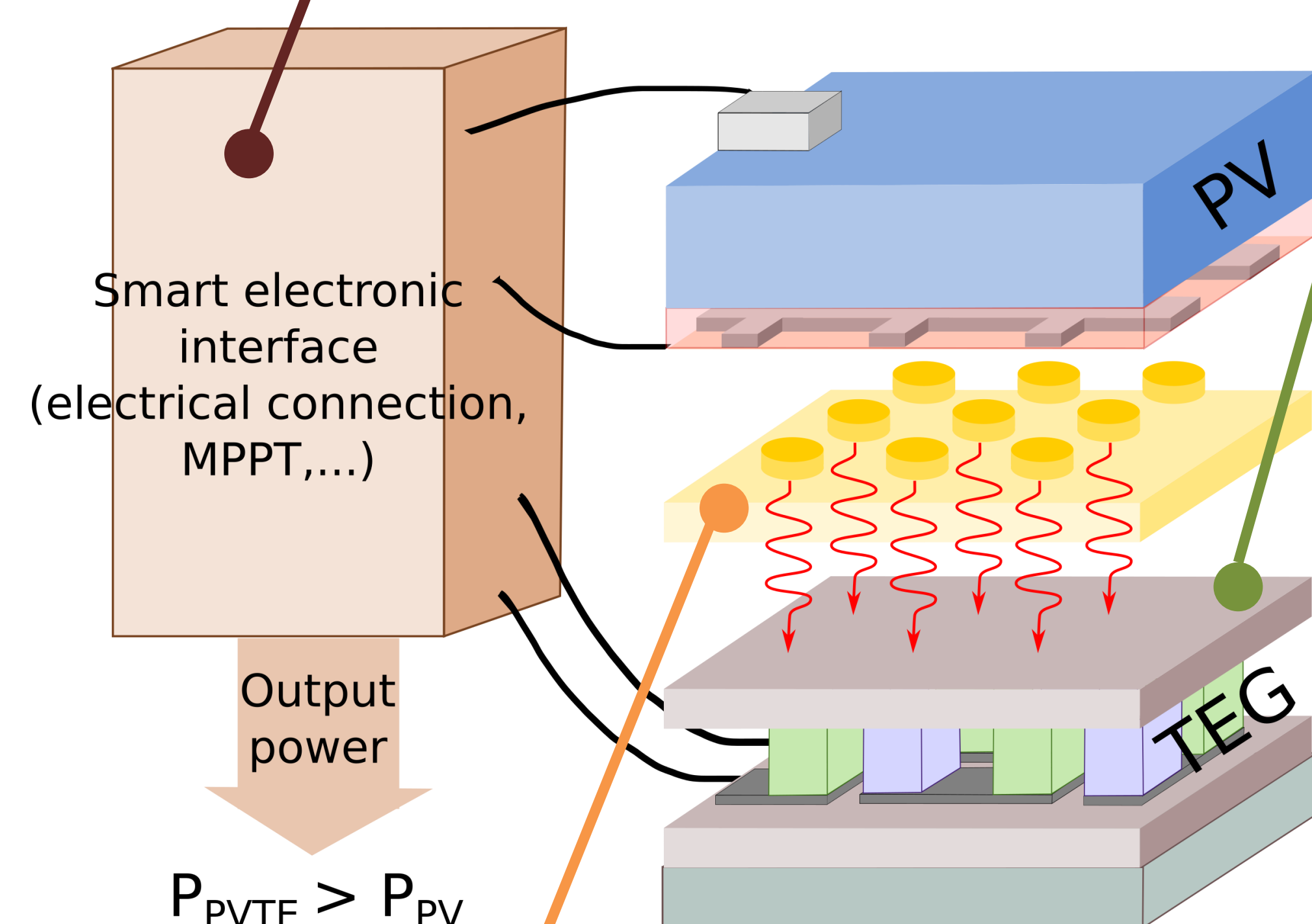
In order to reach our objectives, four key issues will be addressed in HYDRES:

1) Model of the complete system

Including

- the functionalized PV-TE interface
- the electronic interface

2) Design & fabrication of custom TEGs



- ### 3) Functionalization of the physical PV-TE interface with plasmonic photothermal antennas in order to boost the TEG conversion efficiency

[Talk of Sébastien Hanauer]

- ### 4) Technological fabrication process for high thermal coupling at all interfaces

Consortium

Three partners:

- The Photonics team at Laboratory for Analysis and Architecture of Systems (LAAS-CNRS), Toulouse;
- The "Materials with Thermoelectric Properties" team at Institut Jean Lamour, Nancy;
- The "Electronic Measures and Architectures" team at Institut Jean Lamour, Nancy.

→ Complementary expertise in photonics for photovoltaics, thermoelectricity and electronics.

Acknowledgement

The authors acknowledge the support of the French Agence Nationale de la Recherche (ANR), under grant ANR-21-CE50-0003 (project HYDRES). This work is also partly supported by LAAS-CNRS micro and nanotechnologies platform, member of the French RENATECH network.