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### ► 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

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# Hybrid photovoltaic-thermoelectric systems for solar energy harvesting

G. ALMUNEAU<sup>1</sup>, L. BOUDIER<sup>1</sup>, J-B. DOUCET<sup>1</sup>, S. HANAUER<sup>1</sup>, A. MLAYAH<sup>1</sup>, C. CANDOLFI<sup>2</sup>, S. EL OUALID<sup>2</sup>, F. KOSIOR<sup>2</sup>, B. LENOIR<sup>2</sup>, P. MASSCHELEIN<sup>2</sup>, M. HUQ<sup>2</sup>, S. JOVANOVIC<sup>2</sup>, P. POURE<sup>2</sup>, E. TISSERAND<sup>2</sup>, I. MASSIOT<sup>1</sup>

<sup>1</sup> LAAS-CNRS, Laboratoire d'analyse et d'architecture des systèmes, 31400 Toulouse, France

<sup>2</sup>Institut Jean Lamour, CNRS/Université de Lorraine, Nancy, France

Contact: Inès Massiot, LAAS-CNRS, [imassiot@laas.fr](mailto:imassiot@laas.fr)

## 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 ( $E > E_g$ ).

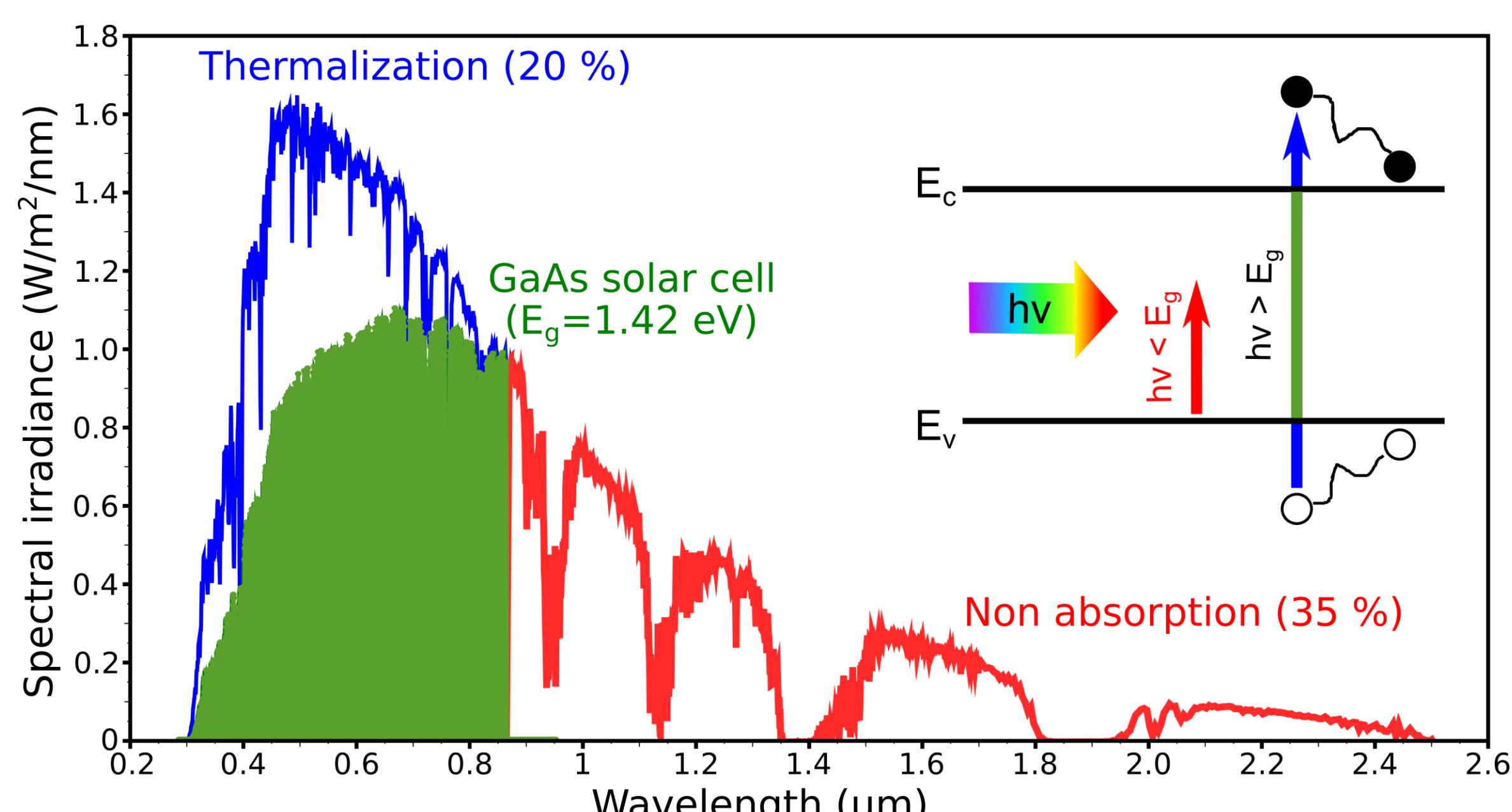


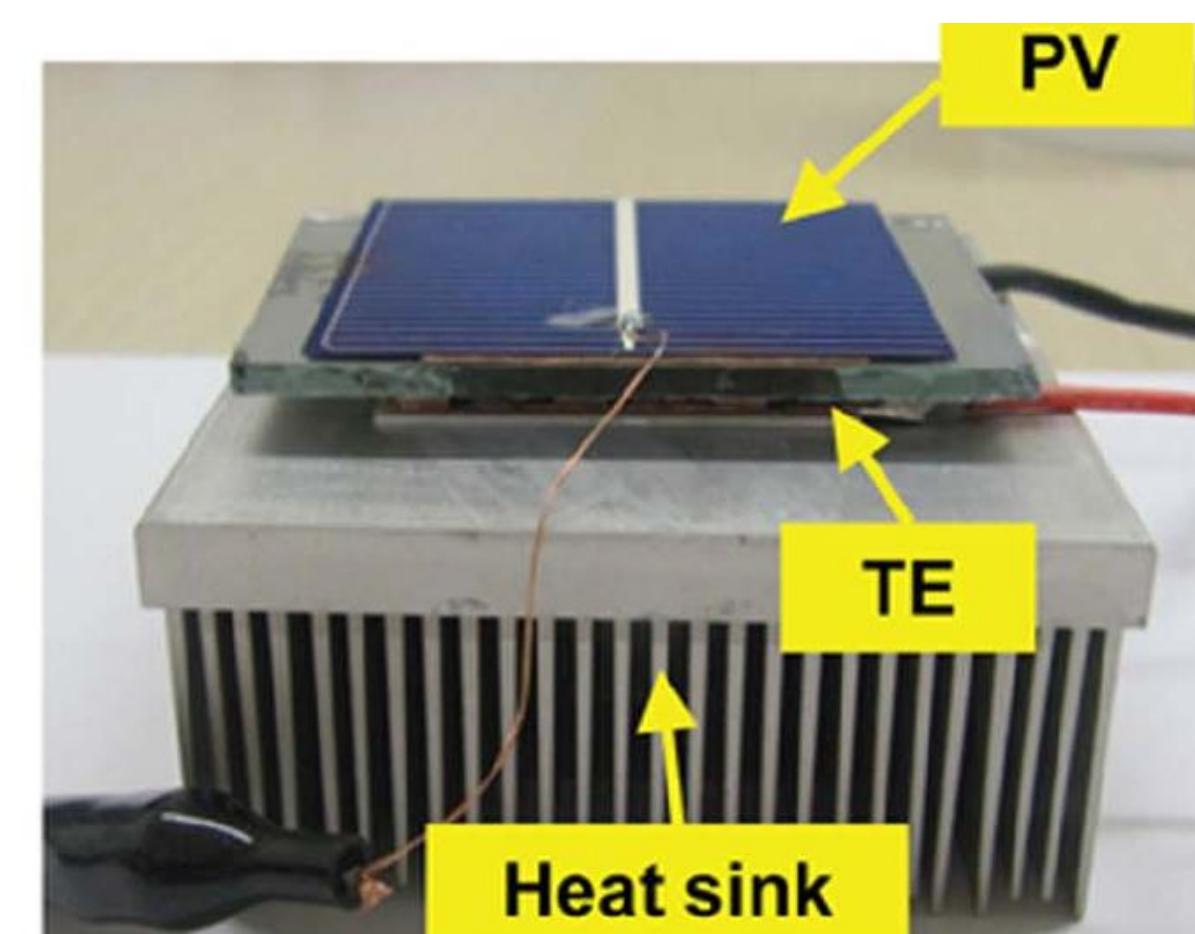
Figure 1. Intrinsic losses in a single-junction solar cell: schematic of the different processes and spectral distribution of the losses for a GaAs cell.

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

## 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.

## Methodology of the project HYDRES



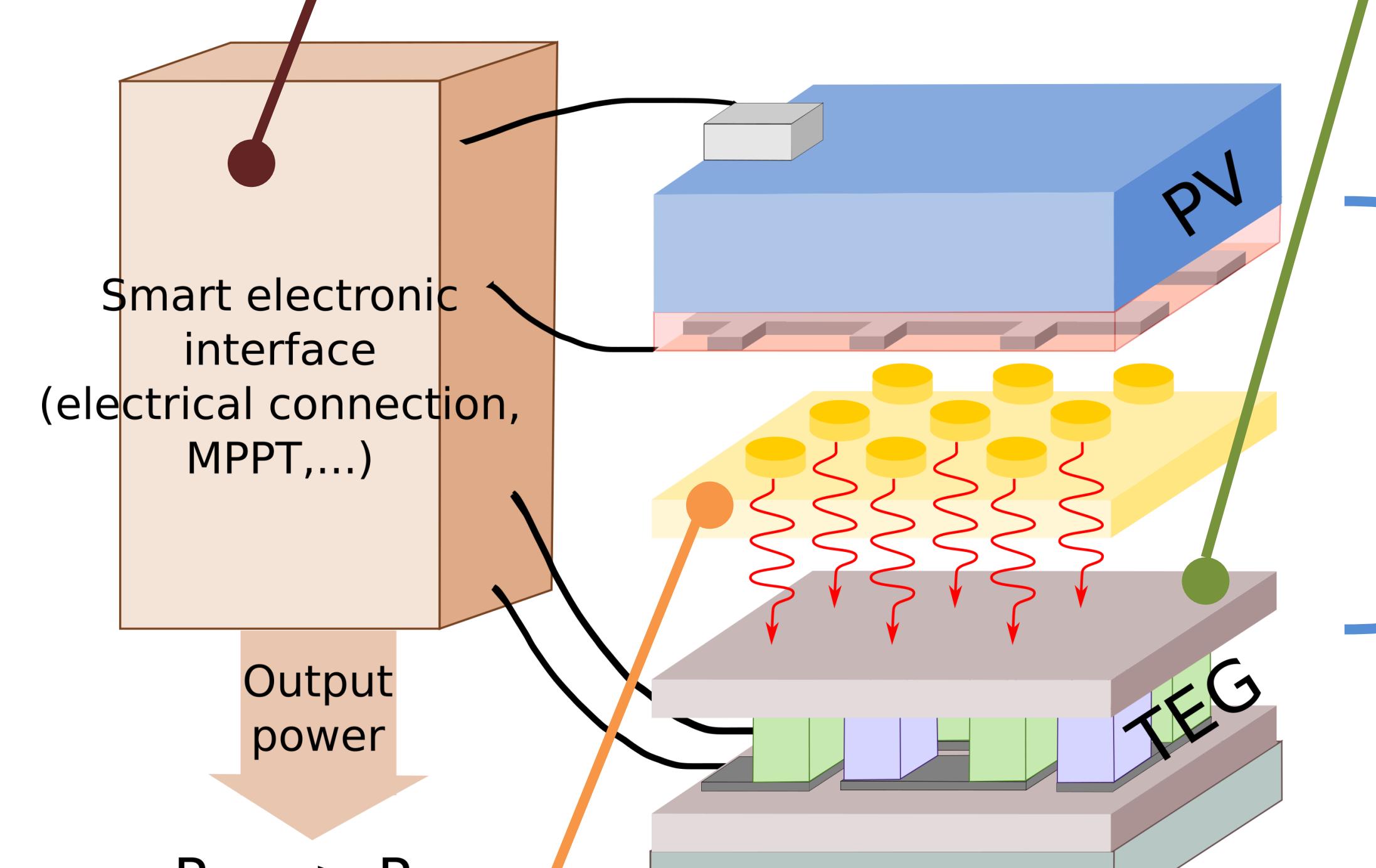
Project funded by the ANR: **Hybrid photovoltaic-thermoelectric for solar energy harvesting (2022-2025)**.

More info on the project website:



**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**