Hybrid Photovoltaic-thermoelectric systems for solar energy harvesting

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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 ($E > E_g$).

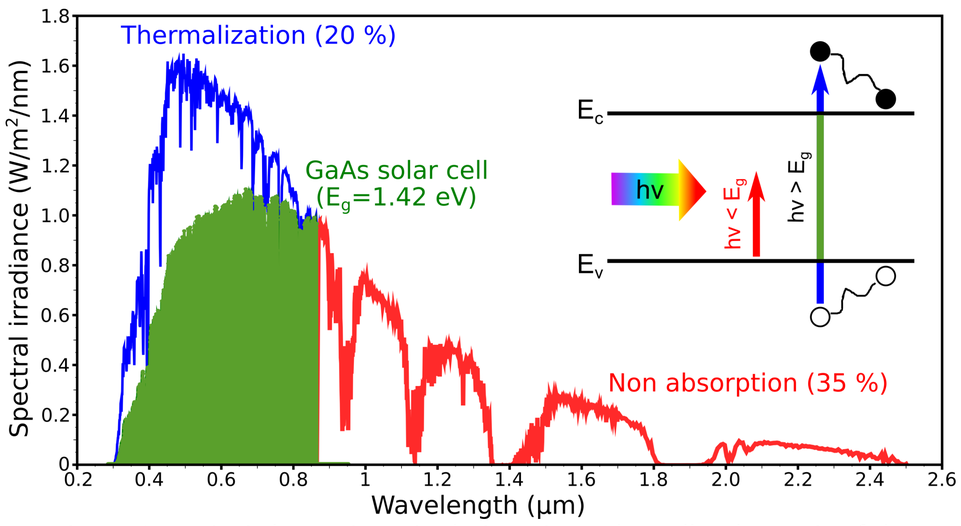


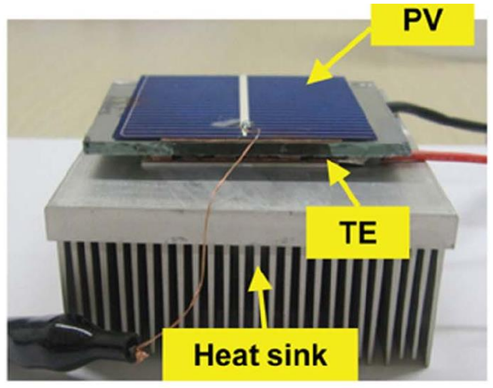
Figure 1. Intrinsic losses in a single-junction solar cell: schematic of the different processes and spectral distribution of the losses for a GaAs cell.

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 Phovoltaics 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.**

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The authors acknowledge the support of the French Agence Nationale de la Recherche (ANR), under grant ANR-21-CE50-0003 (project HYDRES).
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Methodology of the project HYDRES

Project funded by the ANR: **Hy**bri**d** photovoltaic-ther**m**oelectric for solar **e**nergy harves**s**ting (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