



HAL
open science

Current limitations of near-field thermophotovoltaic devices and some solutions to overcome them

Basile Roux, Oriol Teixidó, Christophe Lucchesi, Jean-Philippe Perez, Daniel Chemisana, Pierre-Olivier Chapuis, Rodolphe Vaillon

► **To cite this version:**

Basile Roux, Oriol Teixidó, Christophe Lucchesi, Jean-Philippe Perez, Daniel Chemisana, et al.. Current limitations of near-field thermophotovoltaic devices and some solutions to overcome them. 5th International Workshop on Nano-Micro Thermal Radiation (Nanorad 2024), Jul 2024, Sapporo, Japan. hal-04665694

HAL Id: hal-04665694

<https://hal.science/hal-04665694v1>

Submitted on 31 Jul 2024

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.

Public Domain

Current limitations of near-field thermophotovoltaic devices and some solutions to overcome them

Basile Roux¹, Oriol Teixidó², Christophe Lucchesi³, Jean-Philippe Perez¹, Daniel Chemisana², Pierre-Olivier Chapuis³, and Rodolphe Vaillon^{4*}

¹IES, Univ Montpellier, CNRS, Montpellier, France

²Applied Physics Section of the Environmental Science Department, University of Lleida, Lleida, Spain

³CNRS, INSA-Lyon, CETHIL, UMR 5008, Villeurbanne, France

⁴LAAS-CNRS, Université de Toulouse, CNRS, Toulouse, France

*Corresponding Author: rodolphe.vaillon@cnrs.fr

Several experiments have demonstrated the enhancement of thermophotovoltaic (TPV) power generation in the near field (see the review articles [1, 2]). However, a closer analysis of the generated electrical power density shows that only one experimental data item exceeds the far-field detailed balance limit [3]. However, this experiment uses a very low bandgap cell which needs to be cooled to cryogenic temperatures [4].

Based on this preliminary observation, the objective is to review several current known limitations of near-field thermophotovoltaic devices and examine some solutions for overcoming them. The first point to consider, often overlooked, is the selection of the optimum bandgap for the cell, which depends on the emitter temperature. Narrow bandgap cells (< 0.5 eV) are the best choice in terms of electrical power density, but their operation at room temperature remains very challenging [5]. Some other points to consider are the Joule losses [6], the impact of front metallic contact grids on near-field radiation transfer [7], and out-of-band absorption caused by phonon-polaritons [8]. There are several ways of dealing with these issues, including: hybrid thermionic-thermophotovoltaic devices [9], cells with back contacts, standard multi-junction cells [10] and vertical multi-junction cells [11]. By combining the advantages of these options, which are still under development, it might be possible to demonstrate experimentally that near-field TPV devices can effectively exceed the far-field detailed balance limit under application-relevant conditions.

[1] J. Song, J. Han, M. Choi, and B.J. Lee, *Sol. Energy Mater. Sol. Cells* **238**, (2022).

[2] R. Mittapally, A. Majumder, P. Reddy, and E. Meyhofer, *Phys. Rev. Applied* **19**, (2023).

[3] B. Roux, C. Lucchesi, J.-P. Perez, P.-O. Chapuis, and R. Vaillon, *J. Photonics Energy* **14**, (2024).

[4] C. Lucchesi, D. Cakiroglu, J.-P. Perez, T. Taliercio, E. Tournié, P.-O. Chapuis, and R. Vaillon, *Nano Lett.* **21**, (2021).

[5] R.Q. Yang, W. Huang, and M.B. Santos, *Sol. Energy Mater. Sol. Cells* **238**, (2022).

[6] D. Milovich, J. Villa, E. Antolin, A. Datas, A. Marti, R. Vaillon, and M. Francoeur, *J. Photonics Energy* **10**, (2020).

[7] K. Austry, Y. Jeyar, M. Luo, B. Guizal, R. Messina, R. Vaillon, and M. Antezza, in preparation, (2024).

[8] K. Chen, P. Santhanam, and S. Fan, *Appl. Phys. Lett.* **107**, (2015).

[9] A. Datas, and R. Vaillon, *Nano Energy* **61**, (2022).

[10] J. Song, M. Choi, M. Lim, J. Lee, and B.J. Lee, *Sol. Energy Mater. Sol. Cells* **236**, (2022).

[11] D. Chemisana, O. Teixidó, and R. Vaillon, *ACS Energy Lett.* **8**, (2023).

Acknowledgments: Financial supports by the French National Research Agency (ANR) under grants No. ANR-16-CE05-0013 (DEMO-NFR-TPV) and ANR-21-CE50-0018 (LOW-GAP-TPV), by the European Commission under grant 2020-EIC-FETPROACT-2019/GA951976 (TPX-Power), and by CNRS INSIS (project-team TREE) are acknowledged. D. Chemisana thanks Institució Catalana de Recerca i Estudis Avançats (ICREA) for the ICREA Acadèmia award.