Master internship (M2)

Experimental study of near-field thermophotovoltaic and thermophotonic conversion
(Approche expérimentale de la conversion thermophotovoltaïque et thermophotonique en champ proche)

Advisor: P-Olivier Chapuis (CNRS researcher)
Centre for Energy and Thermal Sciences of Lyon (CETHIL), INSA Lyon, Villeurbanne

Context: The recovery of waste heat and its conversion into electrical energy is a means of limiting greenhouse gas emissions. Different possibilities allow this conversion, depending on the temperature of the hot source and the dimensions of the planned installations. One of them is thermophotovoltaic conversion, where thermal energy is harvested by harnessing thermal radiation from the hot source and the conversion is done by photovoltaics, with dedicated cells in the infrared.
The Micro and Nanoscale Heat Transfer (MiNT) group at CETHIL has shown theoretically and has experimentally demonstrated that the performance of thermophotovoltaic devices is greatly improved when the distance between the radiative source and the photovoltaic cell is reduced to reach the so-called "near field" regime. One of the key points is to match the spectrum of thermal radiation emitted by the source to that which can be converted by the cell.

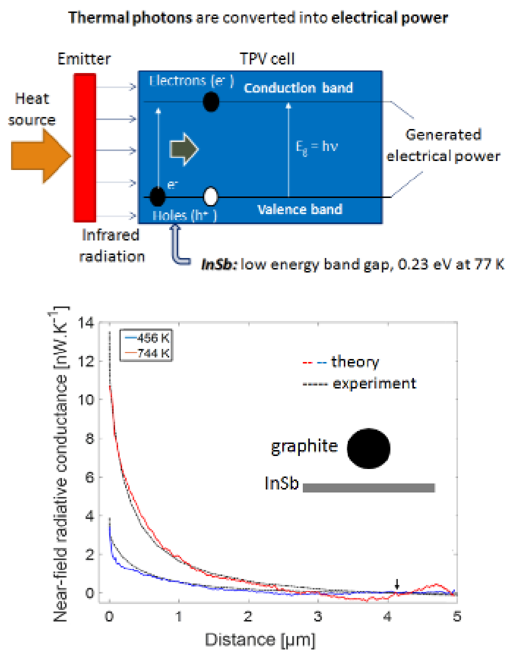

Figure: (a) Principle of a thermophotovoltaic energy-harvesting device (b) Large power increase when a hot body (here a graphite sphere) is brought close to a cold body (here an InSb plate).

References :
- *Harnessing near-field thermal photons with efficient photovoltaic conversion*, C. Lucchesi *et al.*, submitted to high-impact journal and already available online on ArXiV website
- *Indium antimonide photovoltaic cells for near-field thermophotovoltaics*, Dilek Cakiroglu, Jean-Philippe Perez, Axel Evirgen, Christophe Lucchesi, Pierre-Olivier Chapuis, Thierry Taliercio, Eric Tournié, Rodolphe Vaillon, Solar Energy Materials and Solar Cells 203, 110190 (2019)
- PhD student prize for C. Lucchesi at the French National Days on Solar Energy (JNES) in 2018. See News section in June 2018 on the CETHIL website.

Goal of the project: This master internship, which is essentially experimental in nature, will consist in modifying the current experiment, based on AFM microscopy, to perform local near-field radiative heat transfer measurements of nanostructures samples. This aims at pointing to the capabilities of the technique (i) to perform spectroscopy of materials and (ii) to observe if some surface shapes are of interest for thermophotovoltaics. Some near-field thermophotovoltaic experiments will also be performed, and an analysis of the possibility to modify the experiment to measure "thermophotonic" conversion will be conducted, where the spectrum of the radiation emitted is controlled electrically like in a light-emitting diode (LED) and is no longer fixed, unlike the thermophotovoltaic case.

Work to be performed
- Understanding the project goals; bibliography
- Experimental measurements with the setup of already-existing samples

- Design of few novel samples
- Analysis of the implementation of thermophotonic experiments
- Final report/oral defense

Framework: Collaboration with other laboratories in the frame of the TPX-Power EU project starting in January 2021 (Aalto Univ and VTT Technical Research Centre of Finland, both in Helsinki area, Finland; Raadboud Univ. and tf2 devices, both in Nijmegen, Netherlands). Collaboration with IES Montpellier is also possible.

Required background: Knowledge of thermal physics is mandatory. Electromagnetism, solid-state physics and electronics will also be applied. English is mandatory.

Possibility of PhD thesis after the internship: Yes. A funded PhD thesis offer is available from September 2021 in the frame of the TPX-Power EU project..

Contact: olivier.chapuis@insa-lyon.fr (webpage, office in Carnot building third floor: 304A)