## Subject of the thesis

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**Laboratory :** Charles Fabry (France) and Laboratoire Nanotechnologies Nanosystèmes (Canada)

**THESIS TITLE :**

# Solar near-field thermophotovoltaic conversion system

ABSTRACT :

Low cost and efficient clean energy production is one of the most challenging problems of our time. With emphasis on environmental concerns, energy harvesting from renewable sources have become more crucial than ever. Among them thermophotovoltaic (TPV) devices have attracted the imagination of scientists and engineers over the past decades as they can allow the conversion of energy radiated by hot bodies into electricity. TPV devices work in a similar way to solar photovoltaïc cells. PV cells rely on sun for energy whereas TPV cells exploit other high temperature radiators (such as flames and the walls of combustion chambers) as emitters of radiation. The increase in radiative energy is a key requirement to improve the power extracted from TPV devices and therefore to reduce the cost per Watt. However, theoretically, the power transferred from the emitter to the PV cell is limited by the Stefan-Boltzmann's law (i.e. blackbody limit). Yet, if the distance between the emitter and the receiver is reduced to values smaller than the thermal wavelength, the radiative flux can be enhanced by several orders of magnitude.

Indeed, at this scale, evanescent photons which are confined near the surface of some materials are the main contributors to transfer and they participate via tunneling through the separation gap. A significant heat flux increase results from this transport. When illuminated by a far field emitter, the major limitation on the efficiency of energy conversion device is the mismatch between the incident spectrum (broadband) and the absorption spectrum (narrow) of the cell so that only photons of energy corresponding to the bandgap of the cell can create electron - hole pairs and therefore produce electricity. This intrinsic limitation of the far field technology can be overcome in near-field. Indeed, at subwavelength scale, the radiation spectrum is no longer broadband and can be even quasi monochromatic in the near field in the presence of resonant surface modes such as surface plasmons or surface phonon polaritons. This remarkable property has the potential to overcome one of the most severe limitations of photovoltaic cells.

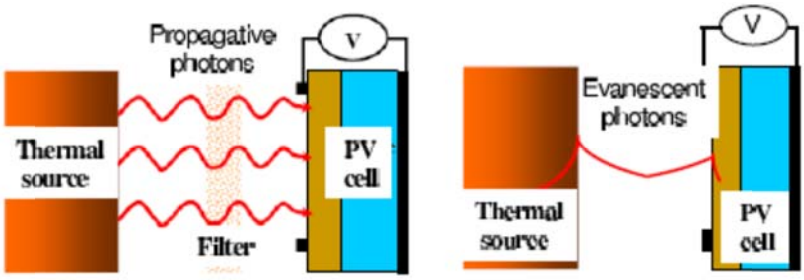


*Fig.1: Principle of thermophotovoltaic energy conversion devices. (a) In far field, the photovoltaic (PV) cell is located at long distance (compared to the thermal wavelength) from a thermal source. Propagative photons only reach the cell. A filter can eventually select the photons with energy higher than the energy gap of the cell. (b) In near-field TPV the cell is located at subwavelength distance from the source. Evanescent photons are the main contributors to the radiative power transferred from the source to the cell.*

In this thesis work we propose to develop a new generation of solar thermophotovoltaic devices that operate in near-field regime after having heated by the sun light. This work will be done in a close partnership between the Charles Fabry laboratory at Institut d'Optique (Palaiseau, France) for ttheoretical developments in plasmonic and near-field heat transfers and the Nanotechnology and Nanosystems Laboratory at Sherbrooke University (Sherbrooke, Canada) for nanofabrication and experimental characterizations.

Candidate requirements:

-A master in physics or mechanical engineering is required.
-Experience in optics will be greatly appreciated.
-The candidate must speak English and/or French but French language is not necessary.

Salary: half time (18 months) of the thesis salary will be supported by the French minister of research (salary of about 1500 euros/month) and the rest will be supported by the Canadian partner

Starting date is September 1st 2014.