# Very-low bandgap thermophotovoltaic cell based on type-II InAs/InAsSb superlattice MWIR photodetector

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A thermophotovoltaic (TPV) cell aims at harvesting thermal radiations from a nearby hot emitter to convert it into electrical power. The temperature of the source induces some constraints, such as its thermal degradation/resistance, undesired heat transfer to the cell (which often needs cooling [1]), or its spectral-matching with the cell. Many research work in this domain have chosen high temperature emitters and relatively high bandgaps cells able to reach higher efficiencies [2] [3]. These strategies rely on very performant reflectors sending back sub-bandgap photons to the emitter. However, this leads to only a small part of the spectrum contributing to the photovoltaic conversion, which greatly reduces the electrical power generated by the cell.

In this context, our work focuses on the design of a very-low bandgap TPV cell (0.25 eV) intended for the conversion of mid-infrared radiation coming from medium-grade heat sources (700-1000°C). This choice is meant to maximize the power output while lessening the thermal stress on the emitter and the cell (figure 1). The main challenge deals with the operational temperature of the cell, which is wanted to be as close as possible to room temperature along with acceptable performances. TPV cells achieving comparable objectives have already been demonstrated with similar Ga-containing structures [4].

In the present work, the cell is based on a Ga-free barrier structure infrared photodetector, with a type-II InAs/InAsSb superlattice absorber [5]. The devices are fabricated using Molecular Beam Epitaxy and standard clean-room processes. Some photovoltaic effects were measured for photodetectors illuminated by a 300°C globar source (figure 2), giving good expectations for future optimized devices. TCAD 1D simulations [6] were thus performed to adapt the photodetector design for photovoltaic conversion.

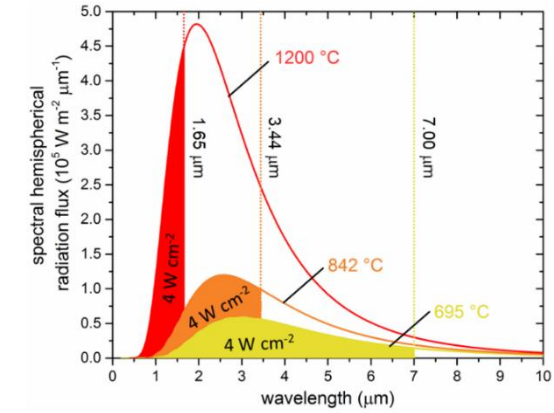


*Figure 1: Spectrum power fraction of 4W/cm2 accessible for conversion at different cutoff wavelengths and emitter temperatures.*

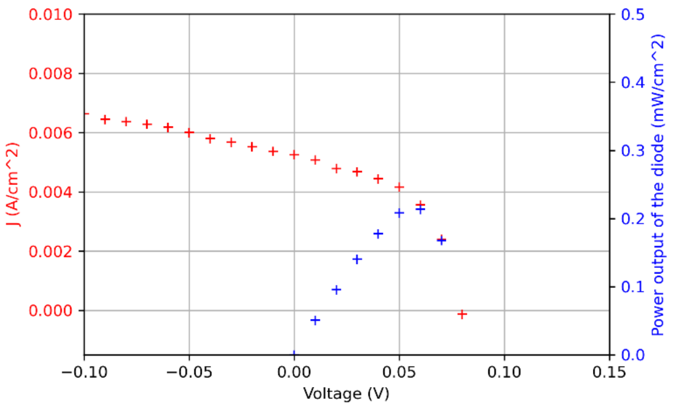


*Figure 2: Current-voltage and power output of a photodetector with a type-II InAs/InAsSb superlattice absober illuminated by a 300°C source.*

[1] Lucchesi, Christophe, et al. "Near-field thermophotovoltaic conversion with high electrical power density and cell efficiency above 14%." *Nano Letters* 21.11 (2021): 4524-4529.
[2 Fan, Dejiu, et al. "Near-perfect photon utilization in an air-bridge thermophotovoltaic cell." *Nature* 586.7828 (2020): 237-241.
[3] Omair, Zunaid, et al. "Ultraefficient thermophotovoltaic power conversion by band-edge spectral filtering." *Proceedings of the National Academy of Sciences* 116.31 (2019): 15356-15361.
[4] Huang, Wenxiang, and Rui Q. Yang. "Limiting factors and efficiencies of narrow bandgap single-absorber and multi-stage interband cascade thermophotovoltaic cells under monochromatic light illumination." *Journal of Applied Physics* 126.4 (2019): 045714.
[5] Zavala-Moran, Ulises, et al. "Structural, optical and electrical characterizations of midwave infrared Ga-free type-II InAs/InAsSb superlattice barrier photodetector." *Photonics*. Vol. 7. No. 3. MDPI, 2020.
[6 Parola, Stéphanie, et al. "Improved efficiency of GaSb solar cells using an Al0. 50Ga0. 50As0. 04Sb0. 96 window layer." *Solar Energy Materials and Solar Cells* 200 (2019): 110042.

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