Assessment of a silicon vertical multijunction cell for thermophotovoltaic conversion

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Thermophotovoltaics refers to the conversion of thermal radiation power from a hot body into electrical power. When the thermal radiation emitter is at high temperature (>1800 °C), the photovoltaic cell is subjected to high illumination conditions. Typically, a photovoltaic cell illuminated by a blackbody emitter at 2100 °C with a unit view factor receives 179.8 W/cm^2. In solar photovoltaics, this would correspond to a concentration factor of 1798. Under these conditions, series resistance losses are critical, due to the squared dependence of the electrical current. One solution is to use (standard) horizontally-stacked multijunction cells in order to reduce the current. This pathway is currently successfully pursued in thermophotovoltaics [1-3], with limitations of performances caused by series resistance losses.

Another solution is to use vertical multijunction cells (figure 1), proposed in the seventies as a new type of solar cell [4], and envisaged for TPV conversion in the nineties [5] but without experimental testing. In our work, performances of a ~1 cm^2 silicon vertical multijunction solar cell are experimentally assessed in solar and thermophotovoltaic conditions [6]. Operation at low short-circuit current density (< 6 mA) and high open-circuit voltage (> 25 V, see figure 2) and a low series resistance (~2.5 mΩ) lead to negligible series resistance losses. The pairwise efficiency of 10.4% could be improved to 52.9% by designing a perfect reflector of the out-of-band photons. Analysis of experiments and simulations as a function of multiple factors, such as the temperature of the thermal emitter and the cell, reveals the advantages and limitations of using vertical multijunction cells for thermophotovoltaic conversion, as well as pathways for future research.

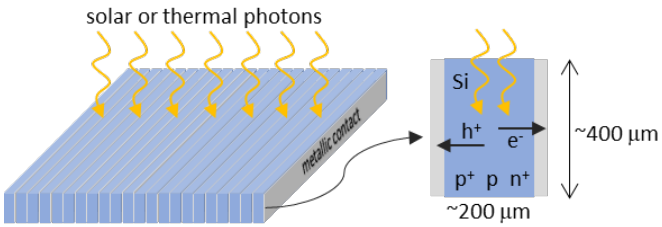

Figure 1: Schematic of a Si vertical multijunction cell (from [6]).

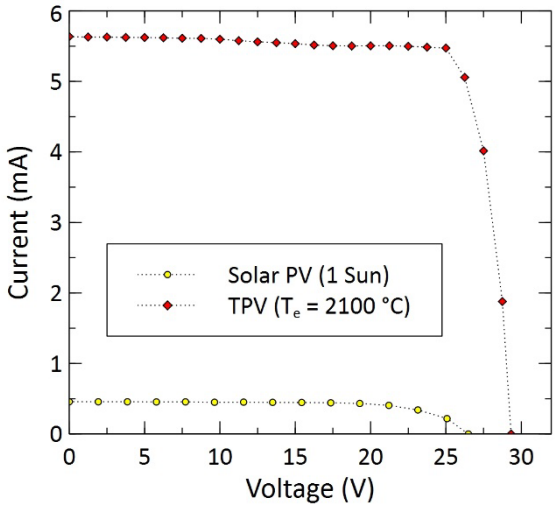

Figure 2: Current vs voltage for the tested Si VMJ cell at 25 °C under 1-Sun illumination or that of a thermal radiation emitter at 2100 °C (from [6]).

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