Hot-Carrier Multi-Junction Solar Cells: a resilient approach to high efficiency

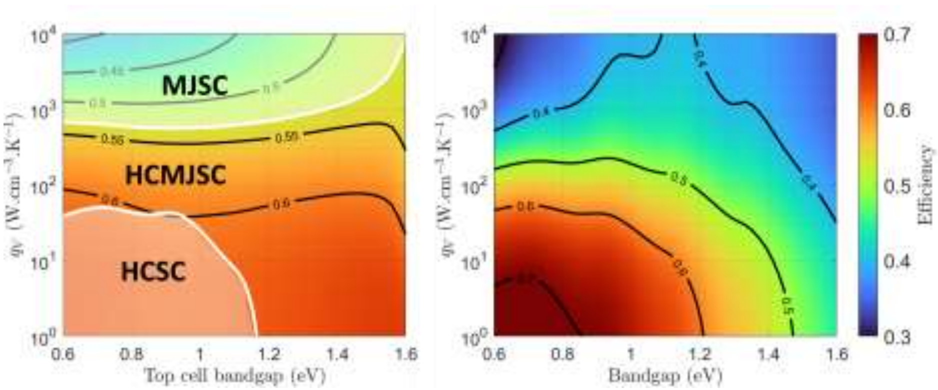
Maxime Giteau[a,b], Samy Almosni[a,c], Jean-François Guillemoles[a,d], Daniel Suchet[a,d]

[a]NextPV, CNRS, The University of Tokyo, Tokyo, Japan.
[b] ICFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels, Barcelona, Spain
[c]Saule Technologies, Wroclaw Technology Park, 11 Dunska, 54-130 Wroclaw, Poland.
[d] CNRS, Ecole Polytechnique, Institut Photovoltaique d'Ile de France (IPVF), UMR 9006, 91120 Palaiseau, France.

Over the last decades, several ideas have been suggested to circumvent the 30% power conversion efficiency limit set by the detailed balance of a single junction (Shockley-Queisser limit). Among them, Hot Carriers Solar Cells (HCSC) offer a promising route, by harvesting the energy of photogenerated carriers before they dissipate their excess of kinetic energy. However, most of advanced proposals have not yet allowed exceeding the Shockley-Queisser limit in practice.

A possible key to understand the difficulties met by advanced concepts resides in their vulnerability to non-idealities. It appears indeed that, while ideal systems are expected to reach ultra-high efficiencies, the introduction of even very small imperfections can reduce the yield significantly. Such deviations from ideal conditions can occur from non-optimal design (material bandgap, layer thickness...), from internal imperfections of the device (non-radiative recombination, limited absorptivity, finite thermalization coefficient…), or from non-standard operating conditions (ambient temperature, illumination spectrum…). In this perspective, it is important to aim not only at high efficiency devices, but also at structures exhibiting resilience against non-idealities.

To achieve such features, we propose a novel architecture which consists in a multi-junction solar cell (MJSC) using a thin hot carrier absorber as top cell (HCMJSC). We show that this device offers an efficiency gain as compared to a standard tandem cell. But more importantly, we show that this structure maintains a high efficiency over a larger range of gaps than a usual MJSC, and does not require a thermalization coefficient as low as a standard HCSCs to show excellent performances.



Efficiency of a HCMJSC (left) and HCSC (right) as a function of the absorber bandgap and thermalization coefficient.

Giteau et al, "Hot-carrier multi-junction solar cells: A synergistic approach," *Applied Physics Letters* (2022).
Giteau et al, "Hot-carrier multijunction solar cells: sensitivity and resilience to nonidealities," *J. Photon. Energy* 12(3), 032208 (2022)
Giteau et al, Patent application pending