Practical Limits of Multijunction Solar Cells

Ian Marius Peters[1], Carlos Rodríguez Gallegos[2], Larry Lüer[3], Jens Hauch[1], and Christoph Brabec[1]

[1]Helmholtz-Institut Erlangen-Nurnberg fur Erneuerbare Energien
[2]National University of Singapore Solar Energy Research Institute of Singapore
[3]Friedrich-Alexander-Universitat Erlangen-Nurnberg

December 6, 2022

Abstract

Multijunction solar cells offer a path to very high conversion efficiency, exceeding 60% in theory. Under ideal conditions, efficiency increases monotonically with the number of junctions. In this study, we explore technical and economic mechanisms acting on tandem solar cells. We find that these mechanisms produce limitations that are the more pronounced the greater the number of junction is and, hence, limit the ideal number of junctions, as well as the corresponding efficiencies. Spectral variations induce current losses in series-connected tandem solar cells. For Denver, we find that these losses reduce achievable harvesting efficiencies to 51% for non-concentrated light, and that they restrict the ideal number of junctions to less than nine. Independently operated solar cells suffer from optical losses with similar consequences. Optical efficiencies of 99% restrict the ideal number of junctions to below ten, and reduce achievable efficiencies by more than 10%. Only architectures with a sequential cell illumination are more resilient to these losses. Restricting available materials reveals that a sufficiently low band gap for the bottom cell of 0.9 eV or below is expedient to realize high efficiencies. Economic considerations show that five junctions or less are economically ideal for most conceivable applications.

Hosted file

pip-22-458-File001.docx available at https://authorea.com/users/563094/articles/610294-practical-limits-of-multijunction-solar-cells