# IBSC with an electronic ratchet : achieving the best of both worlds !


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The concept of intermediate band solar cell (IBSC) was introduced 20 years ago as an innovative way to overcome the celebrated Shockley Queisser limit by harvesting low energy photons. Since then, IBSC have received much attention both from a theoretical and experimental perspective. Yet, despite these efforts, no working proof of concept could be achieved, notably due to the important voltage loss induced by recombination.

It was recently suggested that a slight energy shift in the intermediate transition – the so called *electronic ratchet* – could increase the efficiency of IBSC [1]. Within the detailed balance model, we have shown that this feature is not a mere improvement of the IBSC concept, but is actually mandatory to outmatch the Shockley Queisser limit [2]. Indeed, in all IBSC candidates considered so far, the intermediate transition occurs within the same band (intra-band transition), which limits the width of the absorptivity and allows strong non-radiative recombination. Moreover, in nanostructure-based IBSC, the fact that electrons are excited in confined states brings further limitations [3]. We demonstrated numerically that the simultaneous influence of these flaws severely inhibit the ability of IBSC to reach very high efficiency (fig 1). By contrast, the introduction of an electronic ratchet mitigates these effects to the point where the 33% threshold can always be surpassed, regardless how stringent the defects are.

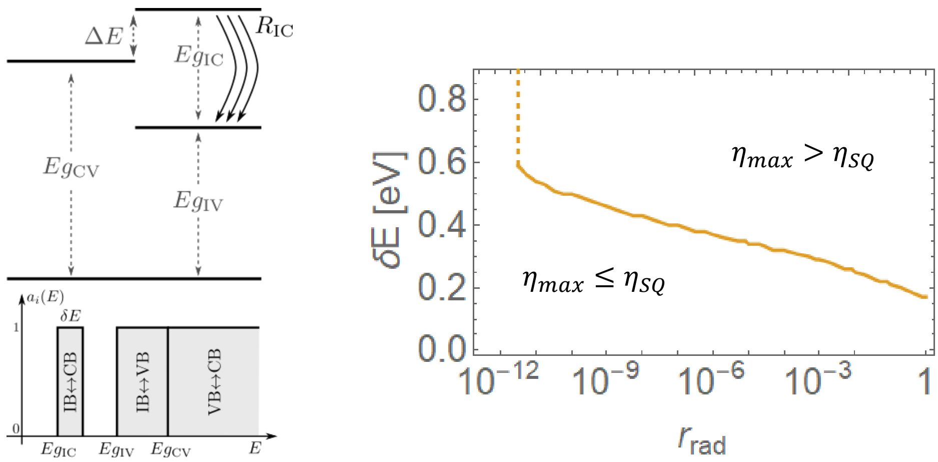


*Fig 1 : We study an intermediate band system with an electronic ratchet ΔE. As the intermediate transition is intraband, we consider it narrow and subject to non radiative recombination. These non-idealities strongly impact the power conversion efficiency of a standard IBSC.*

Furthermore, we offer a physical explanation of the influence of the ratchet by performing an analytical optimization [4]. Using Lagrange multipliers, we show that the ratchet allows the system to match photo-currents to- and from the intermediate band while preventing voltage degradation. By lifting a constraint set on the energy gaps, the ratchet thus allows the system to take the best of both worlds: the open circuit voltage and fill factor from a single junction, but the current increase of an IBSC.


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[2] A. Delamarre, D. Suchet, N. Cavassilas *et al.*, accepted in JPV (2018, available in early access)
[3] N. Cavassilas, D. Suchet, A. Delamarre *et al.*, submitted in EPJ PV (2018), ArXiV 1802.04212
[4] D. Suchet, A. Delamarre, N. Cavassilas *et al.*, Prog. in PV, **26**, 10, pp. 800 (2018)