# Influence of hot carrier effects on electrical performance of a quantum well solar cell

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# Abstract

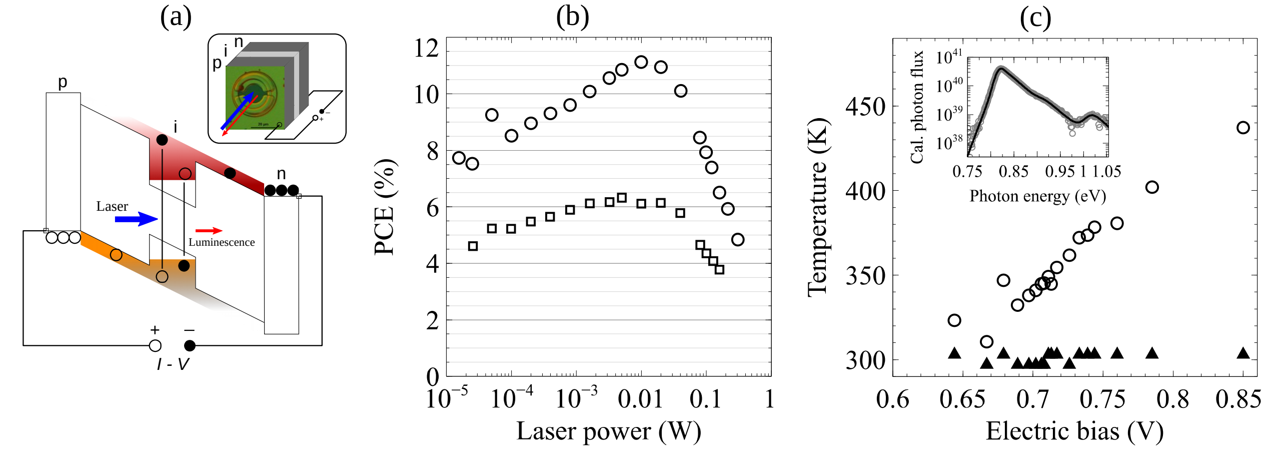


*Figure : (a) Schematic drawing of energy bands in the studied quantum well solar cell. (b) Dependence of power conversion efficiency on laser illumination power, for two microcells with diameters 11 µm (circles) and 21 µm (squares). (c) Temperature of charge carriers in the quantum well (circles) and barriers (triangles) as a function of electric bias. The inset shows a fit of photoluminescence spectrum.*

In the concept of hot carrier solar cells, photo-generated charge carriers are captured at energies higher than the band edges, thus maximizing the light-to-electricity power conversion efficiency [1]. Until now, most published works reported either on purely optical or electrical characterization of such devices.

We report opto-electrical measurements and discuss the influence of the hot carrier effect on electrical performance. A quantum-well/barriers structure is used as absorber/semi-selective contacts (figure a) [2]. The multilayer structure is grown by molecular beam epitaxy and the optoelectrical device is obtained by lithography, etching and metal coating. An original setup allows electrical characterization and spectral analysis of luminescence for each microcell under laser excitation. Thermodynamic properties of photo-generated charge carriers are investigated by fitting the luminescence spectra (inset of figure c), using the generalized Planck's law [3,4]. The absorptivity, whose spectral profile must be identified to obtain good fit accuracy [5], takes into account the absorption of excitons and free carriers in the quantum well [6], as well as free carriers in the barriers. The amplitude of absorption is determined from quantum well absorption theory and experiments [7].

Electrically, our first-version devices present a maximal power conversion efficiency of 11% under laser illumination equivalent to 15 000 Suns (figure b). Temperature and electrochemical potential of the carriers in the quantum well (i.e. absorber) are tunable with either laser power or electric bias (figure c). Variation of electrochemical potentials of carriers in the quantum-well and in the barriers, and also the dependence of open circuit voltage on laser illumination power, hint at a detectable contribution of the hot carrier effect. Our studies shed light on the photo-generation and electrical transport in a hot carrier solar cell and our prototype analysis can help to design advanced devices. In addition, studies on tunnelling diodes or colloidal quantum dots as candidates for energy selective contacts are being carried out by our partner teams.


# Reference

[1] Ross and Nozik, J. App. Phys. 53, 1982
[2] Rodière et al, App. Phys. Lett. 106, 2015
[3] Würfel, J. Phys. C, 15, 3967, 1982
[4] Gibelli and Guillemoles, IEEE-PVSC, 2016
[5] Tedeschi et al - Nano letters 16-3085, 2016
[6] Colocci et al, J. App. Phys. 68, 2809, 1990
[7] Fang et al, PNAS 110, 2013.