Direct Hot Carrier Impact on the Operation of a Solar Cell

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The Shockley-Queisser theory takes hot carriers into consideration only via their thermalization and resulting lattice heating. Our communication evidences direct negative impact of hot carriers on the total photoresponse signal before they cool down. The hot carrier photovoltage across a p-n junction has polarity opposite to the classical electron-hole generation-caused photovoltage. It can be induced by light photons having energy both higher and lower than the bandgap of a semiconductor[1]. Also, we propose a model that allows revealing the individual input of three components – rising due to generation, hot carrier effect and semiconductor lattice heating after their thermalization – to the total photovoltage signal[2].

As for application, the minimized hot carrier photovoltage will give rise to the efficiency of a single-junction solar cell. On the other hand, may be still experimentally unattainable Shockley–Queisser limit will be lowered if the theory were revised by taking into account the direct negative impact of hot carriers.

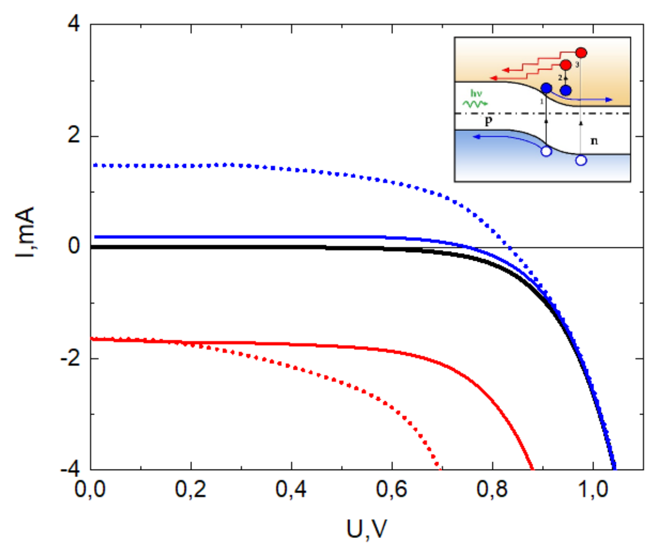

Figure 1. I-V curves of GaAs p-n junction in the dark (black line) and under pulsed 1.06 µm laser illumination: blue lines stand for photocurrent caused by carrier pair generation, and red ones represent the hot carrier photocurrent at different laser intensities (0.4 MW/cm^2, solid lines; and 0.7 MW/cm^2, dotted lines). In inset: schematic description of hot carrier photovoltage (red arrows) and generation-caused (blue arrows) photovoltage rise across a p-n junction.

References

1) Ašmontas, S., et al. *Appl. Phys. Lett.*, 113, 071103, (2018).
2) Gradauskas, J., et al. *Appl. Sci.*, 10, 7483, (2020).