# Tyrinėjimas neišvengiamo karštų nešiotojų efekto GaAs p-n jungtyje

# Exploring the unavoidable hot carrier effect in GaAs p-n junction

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The realm of solar cell technology is evolving, and as we delve deeper into harnessing the power of sunlight, we often find ourselves pushing against the boundaries of established theory. The Shockley-Queisser limit [1] that is about 33% for single junction solar cells, is a theoretical base that puts maximum possible efficiency for the solar cells and it is the desired limit in the way for solar cell efficiency boosting. However, there exists an aspect that this limit does not encompass – the phenomenon of hot carriers [2]. These high-energy carriers, existing well above the average energy, possess the potential to wield a profound influence on the net output signal of a solar cell.

In this presentation, we unveil the negative influence of hot carrier photocurrent in the formation of photoresponse across GaAs p-n junction – an influence that introduces a polarity opposite to that of classical electron-hole pairs generation-caused photocurrent [3]. Our exploration uncovers a substantial portion, more than 36% [3], of the incident solar radiation that has the capacity to heat the carriers. Equally significant is the revelation that even absorption of below-bandgap solar photons exerts a considerable influence that further complicates the pursuit of higher efficiency cells [4].

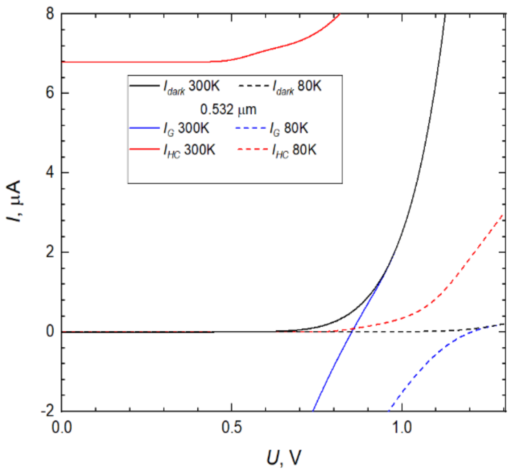


Fig. 1. Current-voltage characteristics in the dark (black lines) and under pulsed 0.532 μm laser illumination at room (solid lines) and liquid nitrogen (dashed lines) temperature. The red lines represent the hot carrier photocurrent, while the blue lines represent the generation photocurrent

The presence of the hot carrier component in the photocurrent remains consistent regardless of the wavelength of the incident radiation. It is dominant when the excitation is below the bandgap, and it is initiated by the surplus energy from the incident photons that is not utilized for electron-hole pair generation. Typically, the short-circuit photocurrent resulting from the hot carriers decreases as the cell's temperature decreases (see Fig. 1). This feature creates favorable conditions for the operation of a solar cell.

Furthermore, we introduce insights that shed the light a specific aspect of our research: the hot carriers can be heated up to 454 K under standard room conditions and up to 262 K under liquid nitrogen conditions in p-n junction that is exposed by laser light of 1.064 μm wavelength and 0.7 $MW/cm^2$ power. As a result of carriers' heating the hot carrier photocurrent has a recombinative nature.

In conclusion, our findings suggest that minimizing the hot carrier effect holds the potential to enhance solar cell efficiency. Furthermore, we propose that the revision of the venerable Shockley-Queisser theory by incorporating the direct influence of hot carriers will redefine our understanding of the theoretical limits of solar cell efficiency.

*Keywords: hot carriers, p-n junction, GaAs, single junction solar cell, Shockley-Queisser theory.*

## References

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