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Peculiarities of hot carrier transport across GaAs p-n junction

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The role of hot carriers in photovoltaics remains ambiguous. On the one hand, classical calculations of the possible efficiency of a solar cell [1] ignore intraband absorption, which is treated as an intrinsic “below bandgap loss” [2]. The indirect harmful impact of hot carriers on the operation of a cell is considered via a “thermalisation loss”; that is, their excess energy heats the crystal lattice and hence leads to the loss of efficiency. On the other hand, hot carriers are directly observed in solar cells, and, despite their extremely short lifetime, they offer both disadvantages and advantages. The hot carrier photocurrent flows across a *p-n* junction with a polarity opposite to that caused by electron-hole pair generation, thereby reducing the efficiency of a single junction solar cell [3]. The concept of the hot carrier solar cell supposes its efficiency as high as 60 % [4]. Therefore, knowledge of the hot carrier temperature in photovoltaic devices remains an important issue.

In this study, we proceed analysis of hot carrier photocurrent across GaAs *p-n* junction. The samples were illuminated with pulsed laser light at photon energies below the band gap. The *I-V* curves were recorded at 300 K and 80 K. The observed shift in the *I-V* characteristics with temperature can be described by the temperature coefficient, a material-specific parameter, indicating the voltage drop per temperature degree. The developed model for evaluating carrier temperature, based on the temperature coefficient of the *I-V* characteristics, provides the value of hot carrier temperature. In addition, we define the hot carrier distribution in the GaAs *p-n* junction which reveals the most possible mechanisms of the hot carrier transport across the junction.

In conclusion, the findings enhance the understanding of the hot carrier phenomenon in photovoltaic devices and may call for the necessity of a reevaluation of intrinsic loss types in solar cells. Also, the results suggest recalculation of the Shockley-Queisser limit [1] for a single-junction solar cell by accounting for the unavoidable presence of the hot carrier effect.

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