S4-P3

Low and high photon energy induced photoresponse in single junction solar cells

Jonas Gradauskas[1,2], Steponas Ašmontas[1], Ihor Zharchenko[1], Oleksandr Masalskyi[1,2], Algirdas Sužiedelis[1], Aldis Šilenas[1], Aurimas Cerškus[1,2], Aleksej Rodin[1] and Petrulėnas Augustinas[1]

[1]*Lab. of Electronic Processes, Center for Physical Sciences and Technology, Saulėtekio av. 3, LT-10257 Vilnius, Lithuania*

[2]*Dept. of Physics, Vilnius Gediminas Technical University, Saulėtekio av. 11, LT-10223 Vilnius, Lithuania*

Email: ihor.zharchenko@ftmc.lt

The practically achieved record level of 26.1% efficiency is still far below the theoretical 32% Shockley-Queisser limit of a silicon cell. The theory implies that photons with energy lower than a semiconductor band gap (E_g) are not absorbed at all, while the residual energy of the high energy photons is accounted only via the process of lattice heating after the hot carrier thermalization.

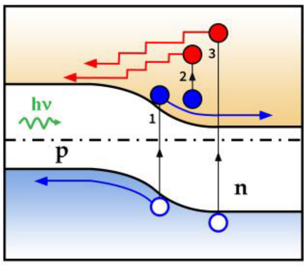

Fig. 1 Schematic formation of generation-induced photovoltage (blue arrows) and hot carrier photovoltage (red arrows) across a p–n

In this communication we demonstrate that 33.6% of the incident AM 1.5 G solar radiation high energy photons ($h\upsilon > E_g$) and 19.3% of the low energy ones have a potential to heat the free carriers in silicon. In the case of GaAs, the values are 21.7% and 33.0% respectively [1].

The present work gives experimental evidence that low and high energy photons participate in the formation of hot carrier photovoltage (HCPV). Fig. 1 shows that HCPV demonstrates polarity opposite to the generation induced PV, and this way has a harmful influence on the effective operation of solar cell.

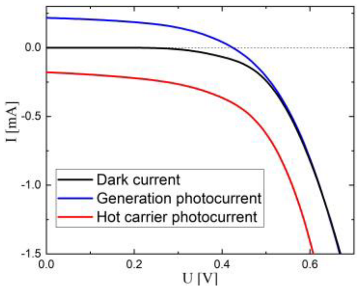

Fig. 2 I-V characteristic of Si solar cell exposed to 1.34 m laser light ($h\upsilon$ = 0.93 eV < E_g): black – in dark, blue – generation, red – hot carrier photocurrent.

When Si and GaAs p-n junctions were illuminated by 1.06 μm, 1.34 μm and 2 μm-long laser light pulses, the photoresponse composed of opposite polarity components was observed under certain experimental conditions. Analysis of the components' properties with regard to their polarity, response speed, dependence on bias voltage and spectral excitation gives proof that before cooling down the hot carriers give rise to the HCPV.

To conclude, conditions minimizing the HCPV will support rise of the efficiency of a single-junction solar cell. If the S-Q theory were revised by taking into account the direct negative impact of the hot carriers, the theoretical limit will come down closer to the practically achieved solar cell efficiency.

REFERENCES

[1] O. Masalskyi and J. Gradauskas; *Ukr. J. Phys. Opt.* 23 (2022) pp. 117–125.