CM&LTP 2021 | Kharkiv, Ukraine

Abstracts book

II International Advanced Study Conference

CONDENSED MATTER & LOW TEMPERATURE PHYSICS

6 – 12 June 2021

Kharkiv, Ukraine

B. Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine

II International Advanced Study Conference
Condensed Matter and Low Temperature Physics

CM&LTP 2021

6 - 12 June 2021 | Kharkiv, Ukraine

Conference Program

Book of Abstracts

Kharkiv 2021

Estimation of iron concentration in silicon solar cell by kinetics of light-induced change in short-circuit current

O. Olikh[1], **V. Kostylyov**[2], **V. Vlasiuk**[2], **R. Korkishko**[2]

[1] *Taras Shevchenko National University of Kyiv, 64/13, Volodymyrska Str., Kyiv, 03028, Ukraine*
[2] *V. Lashkaryov Institute of Semiconductor Physic Institute of NAS of Ukraine, 41 Nauky Ave., Kyiv, 03028, Ukraine*
olegolikh@knu.ua

The iron is a major contaminant as well as one of the most detrimental metal impurities in silicon photovoltaic devices. Therefore non-destructive methods of iron concentration (N_{Fe}) estimation in solar cells (SCs) are important from an applied point of view. To date, a not little collection of both direct and indirect methods has been developed to solve this problem. But almost all of them require special sample preparing or/and specialized equipment. At the same time, the current-voltage curve (IVC) measurement is a common method of SC characterization. Short-circuit current (I_{SC}) is among the fundamental SC parameters, which easy determined from IVC as well as depend on N_{Fe}. The proposed method is based on ability of pair FeB to dissociate under carriers injection and to associate in the dark [1] and involves for the measurement of I_{SC} kinetics after intense illumination.

During the kinetic fit it was assumed, that I_{SC} under monochromatic light described by

$$I_{SC} = \frac{W_{ph}(1-R)q\beta\lambda}{hc}\frac{\alpha\sqrt{D\tau}}{1+\alpha\sqrt{D\tau}}, \qquad (1)$$

where W_{ph} is the irradiance, D is the diffusion coefficient, τ is minority carrier lifetime in SC base:

$$\tau^{-1} = \tau_i^{-1} + \tau_{Fei}^{-1} + \tau_{FeB}^{-1} + \tau_{rest}^{-1}, \qquad (2)$$

where τ_i describes intrinsic recombination, τ_{Fei} and τ_{FeB} concern to Shockley-Read-Hall recombination on interstitial iron $\mathrm{Fe_i}$ and FeB pair; τ_{rest} deals with other processes. The time dependence of the $\mathrm{Fe_i}$ concentration was used from [2] and it was believed that associate characteristic time can be written as

$$t_{ass} = 1.3\cdot 10^3\, N_A^{-2/3}\exp(E_m / kT), \qquad (3)$$

where E_m is the $\mathrm{Fe_i}$ migration energy, N_A is the doping level.

The n+-p-p+-Si diffusion-field type SCs were used in experiments. SCs were fabricated by using single-crystal *p*-silicon wafer with a resistivity of 10 Ω· cm. Some examples of I_{SC} kinetic curve are presented on Fig. We use Eqs. (1)-(3) by taking W_{ph}, E_m and N_{Fe} as fitting parameters to fit the experimental data. The obtained values were following: $W_{\mathrm{ph}} \approx 0.3$ mW; this value is in according with data, obtained by Power Meter Rk-5720 for used light source; $E_m \approx 0.679$ meV; this value is in according to known [2] $\mathrm{Fe_i}$ migration energy; $N_{\mathrm{Fe}} \approx 2\cdot 10^{13}$ cm^{-3}; this value is close to one, obtained by long-wavelength spectrum of internal quantum efficiency.

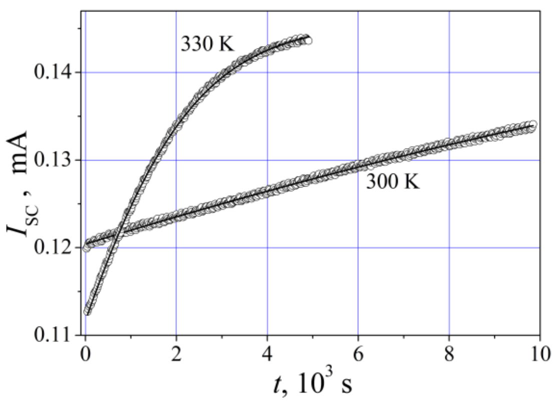

Fig. I_{SC} vs time after halogen lamp illumination (0.25 W/cm^2, 15 s). The marks are the experimental results, and the solid lines are the fitted curves. I_{SC} corresponds to the LED illumination (940 nm, 0.3 mW).

Thus, the proposed method allows to estimate the iron concentration in silicon solar cell. The work was supported by NRFU (project 2020.02/0036)

[1] L. J. Geerligs and D. Macdonald, Appl. Phys. Lett.85, 5227 (2004).
[2] W. Wijaranakula, J. Electrochem. Soc. 140, 275 (1993).