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INFLUENCE OF THE NON-IDEALITY COEFFICIENT ON THE EFFECTIVE POWER OF SOLAR CELLS

Abstract: *The article theoretically investigates the dependence of the effective power on the imperfection coefficient of the photovoltage-ampere characteristics of solar cells, based on the formula obtained for the temperature dependence of the saturation current density, open circuit voltage, short-circuit current density, effective voltage, effective current density.*

Key words: *solar element, current density short circuit, coefficient photovoltaic non-ideality, semi empirical method, temperature, open circuit voltage, height of the potential barrier, saturation current, photovoltaic.*

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Introduction

It is shown from the calculations that the dependence of the effective power on the nonideality factor of the current-voltage characteristic set at the point where the short-circuit current is determined is exponential, and at the point where the effective power is determined is linear.

In recent years, all over the world, one of the main and urgent problems of the physics of semiconductor devices is the search for ways to improve the efficiency of semiconductor solar cells (SC). To increase the efficiency of the SC, it is first of all necessary to study the quality of the pn junction, which is the basis of the structure, and the relationship of the photovoltage-ampere characteristic (photovoltage characteristic) of physical indicators of quality assessment under the indicated conditions with the coefficient of imperfection of the photovacc

As you know, the coefficient of imperfection of SCs made on the basis of semiconductors is determined by the type of current passing through them [1-10], namely the coefficient of the curvature angle of the photoVAC curve, which shows the quality of the pn junction that is the basis of the pn junction. Therefore, the coefficient of non-ideality of the solar cell, depending on the type of current, can be equivalent at different points of the photoVAC. The current generated in the solar cell can be divided into two types: generated as a result of the generation of current carriers, then the nonideality coefficient will change in the interval n = 1-1.5; the main current is formed as a result of the recombination of current carriers, then the coefficient of imperfection of the photoVAC will change in the interval n = 2-2.5; if the type of current is formed as a result of both generation and recombination of current carriers simultaneously, then the coefficient of imperfection of the photoVAC will change in the interval n = 2.5-5 [1-10].

Based on the research we made in our early works [1-10], we obtained expressions for the determining effect of temperature on the effective voltage and current density of the solar cell:

$$U_{эф} = \frac{kT}{q} \ln \frac{j_{кз}}{j_0} \frac{kT}{qU_{xx}} \qquad (1)$$

$$j_{эф} = j_{кз}\left(\frac{n'_2 \, kT}{qU_{xx}} - 1 - \frac{j_0}{j_{кз}} \right) \qquad (2)$$

where U_{xx} - open-circuit voltage, j_{sc}- short-circuit current density, j_0 - saturation current density, k- Boltzmann constant, q-electron charge, n_2 - nonideality coefficient of photoVAC where effective power is determined.

In work [1-10] for the temperature dependence of open circuit voltage, saturation current density, short-circuit current density, the following expressions were obtained:

$$U_{xx} = (U_{xx0} - \varphi)\frac{T}{T_0} + \varphi \qquad (3)$$

$$j_0 = j_{00} \exp\left(\frac{q\varphi}{k}\left(\frac{1}{T_0} - \frac{1}{T} \right) \right) \qquad (4)$$

$$j_{кз} = j_{00} \exp\left[\frac{q(\varphi_0 - \gamma T)}{k}\left(\frac{1}{T_0} - \frac{1}{T} \right) \right]\left[\exp\left[\frac{q(\varphi_0 - \gamma T)}{n'_1 \, kT_0}\left(\frac{U_{xx0}}{(\varphi_0 - \gamma T)} - 1 + \frac{T_0}{T} \right) \right] - 1 \right] \qquad (5)$$

where U_{xx0} is the open-circuit voltage, j_{00} is the saturation current at T_0 – room temperature, φ is the height of the potential barrier, φ_0 is the height of the potential barrier at absolute zero, γ is the temperature coefficient of the potential barrier, n'_1 is the coefficient of imperfection of the photoPC at the point where short-circuit current density.

As you know, the effective power density of the solar cell, that is, the maximum possible reproducible power by them is determined by the product of the effective voltage and the effective value of the current density emanating from the solar cell.

$$P_{эф} = j_{эф}U_{эф}. \qquad (6)$$

Now it can be seen that to bring the formula that determines the effective power density of the solar cell. Therefore, in expression (6) supplying expressions (1) and (2), we get the following equation

$$P_{эф} = j_{эф}U_{эф} = j_{кз}\left(\frac{n'_2 \, kT}{qU_{xx}} - 1 - \frac{j_0}{j_{кз}} \right)\frac{kT}{q} \ln \frac{j_{кз}}{j_0} \frac{kT}{qU_{xx}} \qquad (7)$$

If we take into account that the values of the short-circuit current density (j_{sc}) and saturation current density (j_0) are negative, then formula (7) will look like this:

$$P_{эф} = \frac{kTj_{кз}}{q}\left(1 + \frac{j_0}{j_{кз}} - \frac{n'_2 \, kT}{qU_{xx}} \right)\ln \frac{j_{кз}}{j_0} \frac{kT}{qU_{xx}} . \qquad (8)$$

Using this expression, one can determine the effective power density of the solar cell. It can be seen that formula (8) is clearly independent of n_1, but this expression contains a short-circuit current density, so the effective power will also depend on this coefficient.
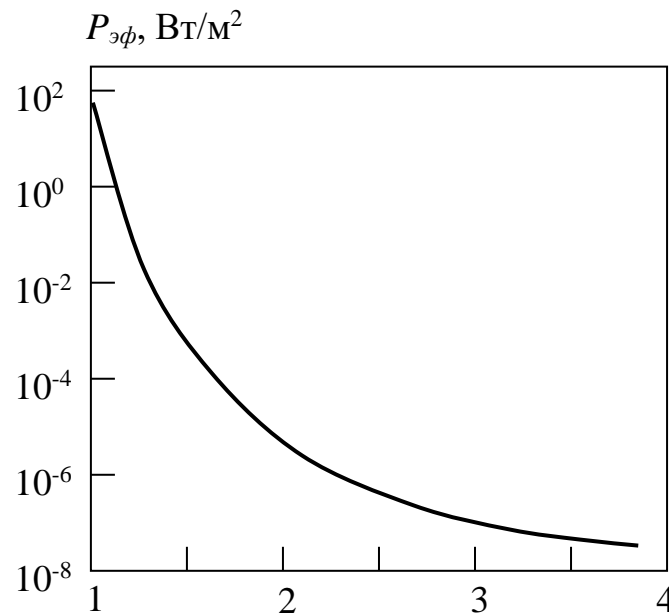
Figure 1 shows the results of calculating the dependence of the effective power on the coefficient of non-ideality of the ESS at the point where, the short-circuit current density is determined, according to the formula (8). Calculations were made for the values: $T_0 = 273K$, $T = 300 K$, $j_0 = 3.5 * 10{-10}A / cm^2$, $U_{si} = 0.63 V$, $\varphi_0 = 1.23 V$ and $\gamma = 2 * 10{-4} V / K$ and $n_2 '= 2.5$. It can be seen that as the nonideality coefficient increases, the effective power decreases exponentially. With changes in the value of the nonideality coefficient from 1 and 3.8, the effective power changes in the range from 75.9 mW / cm^2 to $2.94 * 10{-8}$ mW / cm^2

Figure 2 shows the calculation of the dependence of the effective power on the coefficient of non-ideality of the ESS at the point where the effective power is determined by formula (8). Calculations are performed for the values: $T_0 = 273 K$, $T = 300 K$, $j_0 = 3.5 * 10{-10}$ A / cm^2, $U_{si} = 0.63 V$, $\varphi_0 = 1.23 V$ and $\gamma =$

$2 * 10{-4}$ V / K and $n_1 '= 1.0028$. As can be seen from the figure, this dependence is linear; with an increase in the nonideality coefficient from 1 to 3.8, the effective power of the solar cell decreases in the interval $P_{eff} = (74.5 - 66.4)$ mW / cm^2.

This study presents a formula for determining the effective power of the solar cell. This formula theoretically investigated the dependence of the effective power on the coefficient of nonideality of the solar cell. From these calculations it can be seen that the growth of the nonideality coefficient, at the point where, the short-circuit current density is determined, lead to a very strong decrease in the effective power of the solar cell. And this leads to a general decrease in the efficiency of the solar cell.

It has been determined that the dependence of the effective power on the non-ideality factor, which is set at the point where the effective power is determined, is linear and does not so strongly affect the efficiency of the solar cell. The following conclusions can be drawn from the results obtained. With any increase in the coefficient of non-ideality of the solar cell, this will lead to a decrease in the values of the effective power, which will contribute to a decrease in the efficiency of the solar cell.
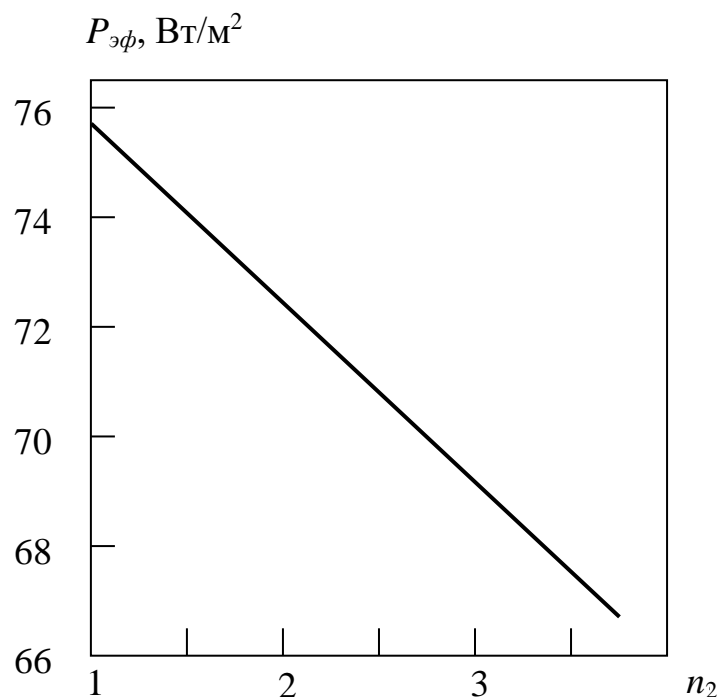

Fig. 1. The calculation results obtained by the formula (8), for the dependence of the effective power on the coefficient of nonideality of the ESS at the point where, the short-circuit current density is determined. Calculations were made for the values:: *T_0=273K, *T*=300 K, *j_0*=3,5*10^{-10}A/см^2, *U_{cu}*=0,63 B, *φ_0*=1,23V andγ=2*10^{-4}V/K*and *n_2'*=2,5.

Fig. 2. The results of calculating the dependence of the effective power of the solar cell on the coefficient of nonideality of the solar cell at the point where the effective power is determined, obtained by the formula (8). Calculations are performed for the values:T_0=273K, T=300 K, j_0=3,5*10^{-10}A/см², U_{cu}=0,63 B, φ_0=1,23 Vandγ=2*10^{-4}V/Kandn_1'=1,0028.

References:

1. (1982). *Amorphous semiconductors:* Per. from English / Ed. M. Brodsky. (p.418). Moscow: Mir.
2. Farenbruch, A., & Bube, R. (1987). *Solar cells* (theory and experiment), (p.278). Moscow: Energoatomizdat.
3. Aliev, R., Ikramov, R.G., Alinazarova, M.A., & Ismanova, O.T. (2013). Influence of the temperature on efficient importance photogalvanic characteristics of solar elements .. *International Scientifik Journal for Alternativ Energy and Ekologi*, Scientifik Technical Center TATA, No. 15, (137), pp. 36-40.
4. Aliev, R., Ikramov, R.G., Alinazarova, M.A., & Ismanova, O.T. (2009). Influence of temperature on photocurrent of amorphous semiconductor-based solar element. *Applied Solar Energy*, Vol. 45, No.3, pp.148-150.
5. Aliev, R., Ikramov, R.G., Ismanova, O.T., & Alinazarova, M.A. (2011). The semi-empirical equation for the temperature dependences of the photoelectric parameters of a-Si: *H solar cells. Solar engineering*, No. 1, pp. 61-64.
6. Zhu, L., et al. (2010). An effective heat dissipation method for densely packed solar cells under highconcentrations. *Solar Energy Mater Solar Cells*, 94: 133–40.
7. Wronski, C. R., Pearce, J. M., Koval, R. J., Ferlauto, A. S., & Collins, R. W. (2002). Progress in amorphous silicon basd solar cell technology. *RIO 02-Worid Climate & Energy Event*, N1, pp. 67-72.
8. Meftah, A.F., Meftah, A.M., & Belgachi, A. (2007). *Computer modeling of the photodegradation effect in a-Si* :H p-i-n solar cell, ICEEDT 2007. Hammamet Tunisia.

9. Meftah, A.M., Meftah, A.F., & Merazga, A. (2006). Numerical simulation and analysis of the dark and illuminated J –V characteristics of a-SiH p–i–n diodes. *J Phys: Condens Matter,* 18: 54-59.

10. Dutta, U., et al. (2005). Metastable defect migration under high carrier injection in hydrogenated amorphous silicon p–i–n solar cells. *J Appl Phys*, 98: 044511.