RELATION OF THE EFFECTIVE PHOTOVOLTAIC CHARACTERISTICS OF SOLAR CELLS TO THE COEFFICIENT OF NON-IDEALITY OF THE VOLT-AMPERE CHARACTERISTIC.

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Abstract: In this work, the relation of short-circuit current density, effective voltage, effective current density and effective power volt-ampere characteristics of QE to the non-ideality coefficient was theoretically investigated.

Key words: solar cell, short-circuit current density, effective voltage, effective current density, effective power, volt-ampere characteristic, nonideality coefficient, temperature.

One of the most important scientific problems to be solved in the field of physics of semiconductor devices in the world in recent years is to increase the efficiency of semiconductor QE. To increase the efficiency of QE, first of all, it is necessary to study the quality of the r-p-transition, which is the basis of the structures, and the dependence of the physical parameters evaluating this quality on the non-ideality coefficient of the volt-ampere characteristic (VAX) in the illuminated conditions. Studying the main output parameters of semiconductor photocells and their expressions of dependence on various factors, taking into account the non-ideality coefficient of VAX and relying on experimental data, is one of the urgent tasks. Today, in the world, to create highly efficient energy sources based on semiconductor materials, to develop specific scientific research, including simple and accurate expressions of the main output characteristics of semiconductor photocells; to determine the laws of their dependence on the coefficient of non-ideality; optimization of the process of efficient separation of photogenerated charge carriers in p-n-transition based on theoretical and practical data is one of the important tasks.

Hydrogenated amorphous silicon (*a-Si:H*) as the main properties of QE based on: they can be prepared on large surfaces, and it can be shown that the working layer of this material has a large optical absorption coefficient and photosensitivity compared to that of monocrystalline semiconductors. *a-Si:H* The magnitude of the optical absorption coefficient and photosensitivity of this material is determined by the irregularity of the material structure and the presence of hydrogen in it. Implementation of targeted scientific research in this regard, including hydrogenated amorphous silicon-based QE;

analysis of temperature dependence of photovoltaic characteristics and their optimization;

determine the temperature range of their effective operation;

is one of the urgent problems of this field.

[1; 14-16 б.] at work U_{cu}, $j_{қт}$ and n' It is shown that they are not related to each other and therefore their interrelation can be studied separately.

Non-ideality coefficient of Schottky barrier QE based on semiconductors $n' \approx 1{,}0\text{-}2{,}5$ in between, *p-n* and *p-i-n* and that of justified QE $n' \approx 1{,}0\text{-}3{,}5$ lies in between.

[2; 36-40 p.] in the work, we obtained the expressions that can be used to determine the effective values of the photovoltaic characteristics of QE. Our goal now is to investigate the relationship of these parameters to the non-ideality coefficient of the volt-ampere characteristic. [3; 19-22 p.] at work QE j_0 – saturation and $j_{кт}$– short circuit current density, U_{cu}- we obtained the expressions that determine the dependence of both the operating voltage and the temperature [4; pp. 41-44]. Based on the previous conclusions, we write these parameters in the following forms:

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

$$U_{cu} = (U_{cu0}-\varphi)\frac{T}{T_0}+\varphi, \tag{2}$$

$$j_{\kappa m} = j_0\left[\exp\left[\frac{q\varphi}{n'_1 kT_0}\left(\frac{U_{cu0}}{\varphi}-1+\frac{T_0}{T}\right)\right]-1\right]. \tag{3}$$

In these expressions n'_1- QE ini VAX sini is the coefficient of non-ideality VAX at the point where the short circuit current is determined, the value of this quantity is the temperature 100K<T<500K almost unchanged in the interval [5; 19-25 p.] is indicated in the work. φ- QE is the potential barrier height, which for not too low temperatures can be written as:

$$\varphi = \varphi_0 - \gamma T. \tag{4}$$

Here, φ_0 - QE is the height of the potential barrier at temperature T=0, which shows that only the operating voltage depends on the temperature ($U_{cu}(T)$), T=0K can be determined by extrapolating to [6; pp. 31-35] γ- The temperature coefficient of the potential barrier height is its value for semiconductors 10^{-3}-10^{-4} V/K lies in the interval. [7; pp. 405-410]

Based on the conclusions drawn in our previous works, we write the expressions defining QE effective voltage, effective current density, and effective power density dependence on temperature in the following form:

$$U_{\text{эф}} = \frac{kT}{q}\ln\frac{j_{\kappa m}}{j_0}\frac{kT}{qU_{cu}} \tag{5}$$

$$j_{\text{эф}} = j_{\kappa m}\left(\frac{n'_2 kT}{qU_{cu}}-1-\frac{j_0}{j_{\kappa m}}\right) \tag{6}$$

$$P_{\text{эф}} = \frac{kTj_{\kappa m}}{q}\left(1+\frac{j_0}{j_{\kappa m}}-\frac{n'_2 kT}{qU_{cu}}\right)\ln\frac{j_{\kappa m}}{j_0}\frac{kT}{qU_{cu}}. \tag{7}$$

Figure 1 shows the calculation results obtained from the formula (3) for determining the effect of the non-ideality coefficient of VAX on the short-circuit current density of QE. U_{0cu}=0.31 B, φ=1.16

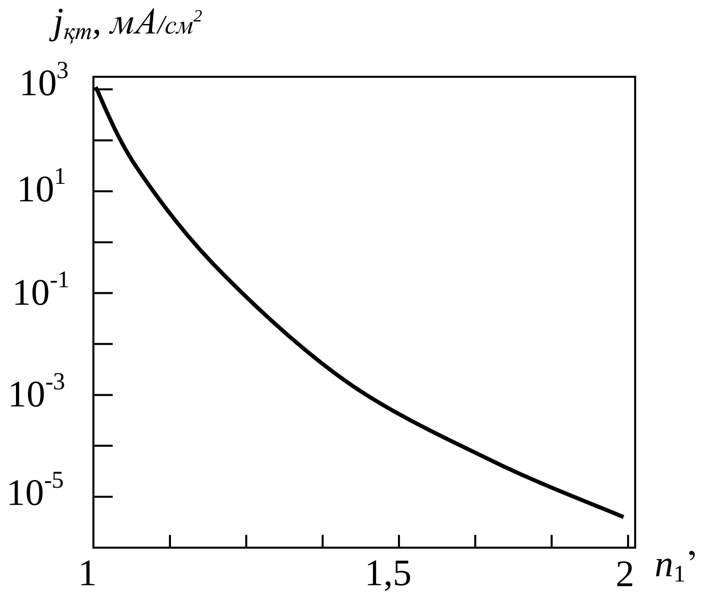


Figure 1 shows the calculation results obtained from the formula (3) for determining the effect of the non-ideality coefficient of VAX on the short-circuit current of QE. U_{0cu}=0.31B, φ=1.16B, j_{00}=1.28*10^{-4}мА done for

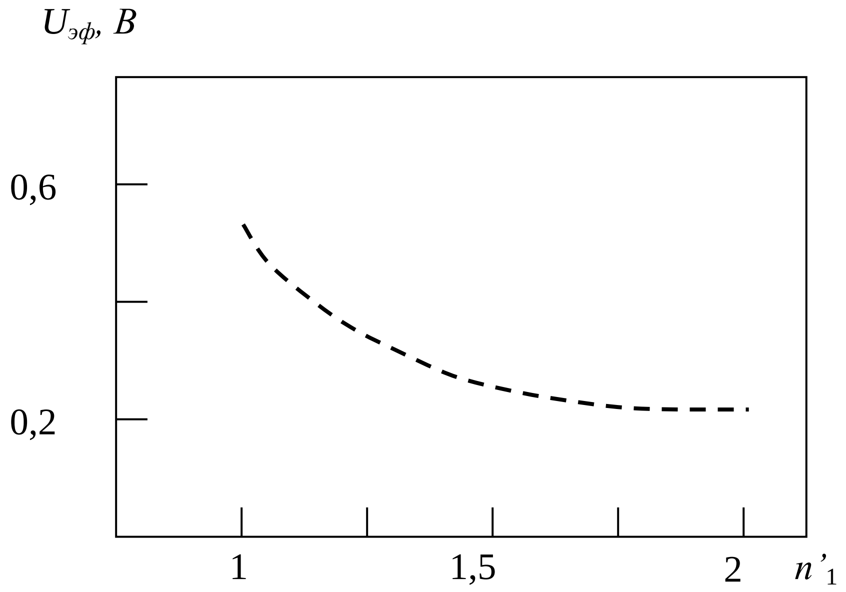
B, j_{00}=1.28*10^{-4} мА done for Calculations showed that the short-circuit current density decreases with the increase of non-ideality coefficient of VAX coupling, and this coupling becomes very strong.

We have seen in the previous chapter that the operating voltage of QE does not depend on the non-ideality coefficient of VAX at all. The effective voltage does not depend on the non-ideality coefficient of VAX at the point where the effective power of VAX of QE is determined, but since the short-circuit current density is present in the formula (5) derived for this parameter, this parameter also depends on the non-ideality coefficient of VAX at the point where the short-circuit current density is determined. depends. The effective values of the current density and power depend on the non-ideality coefficient of VAX at the point where the effective power of the QE is determined, and the non-ideality coefficient of VAX at the point where the short-circuit current is determined.

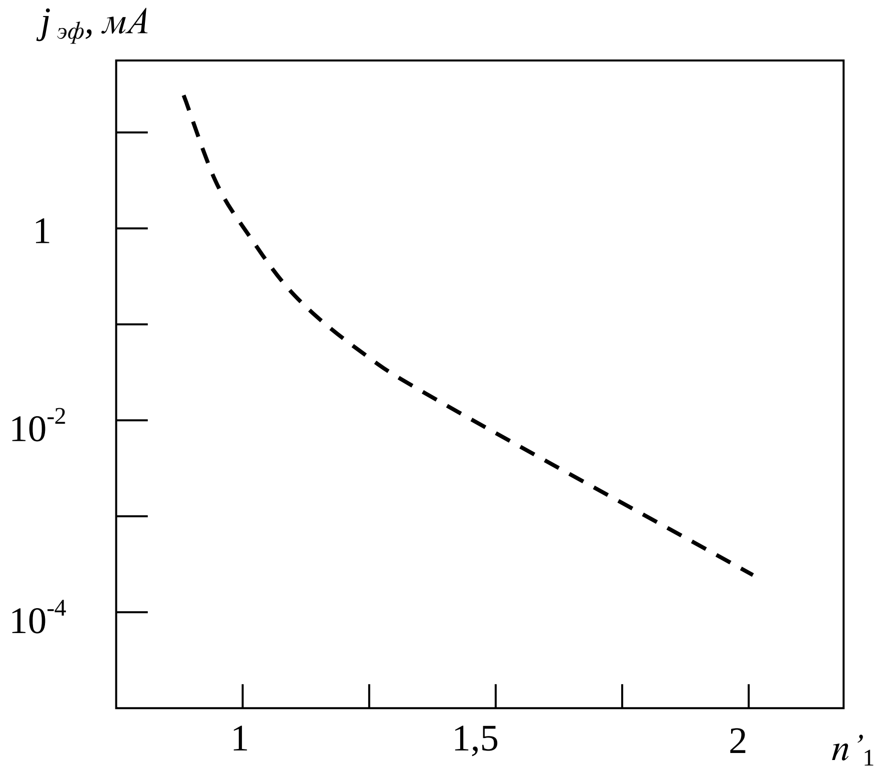
2 - picture. The connection of the effective voltage of QE to the coefficient of non-ideality of VAX at the point where the short-circuit current of VAX calculated from the formula (5) is given. Calculations T_0=273K,T=300 K, j_0=1,5$*$10^{-10}A, U_{cu}=0,65B, φ_0=1,12B ва γ=5$*$10^{-4}B/K It can be seen from the picture that the non-ideality coefficient of VAX at the point where the short-circuit current of VAX is determined increases, while the effective voltage decreases.

Figure 3 shows that the effective current of QE is related to the coefficient of non-ideality of VAX at the point where the short-circuit current of VAX is calculated from formula (6). Calculations T_0=273 K, T=300 K, j_0=1,5$*$10^{-10}A, U_{cu}=0,65B, φ_0=1,12B and γ=5$*$10^{-4}B/K done for values. It can be seen from the figure that the effective current of QE is very strongly related to the non-ideality coefficient of VAX at the point where the short-circuit current of VAX is determined. As the coefficient of non-ideality increases, the effective current decreases exponentially, when the value of the coefficient of non-ideality changes between 1 and 2, the value of the current is from 140.1 mA 9,05$*$10^{-4} мA as it changes in the interval.

Figure 4 shows the calculation results obtained from the formula (7) for connecting the effective power of QE to the non-ideality coefficient of VAX at the point where the short-circuit current of VAX is determined. This connection is also very strong, as the coefficient of non-ideality increases, the effective current decreases exponentially, when the value of the coefficient of non-ideality changes between 1 and 2, the value of the effective current is from 75.1 мВт 2,08$*$10^{-4} мВт as it changes in the interval.

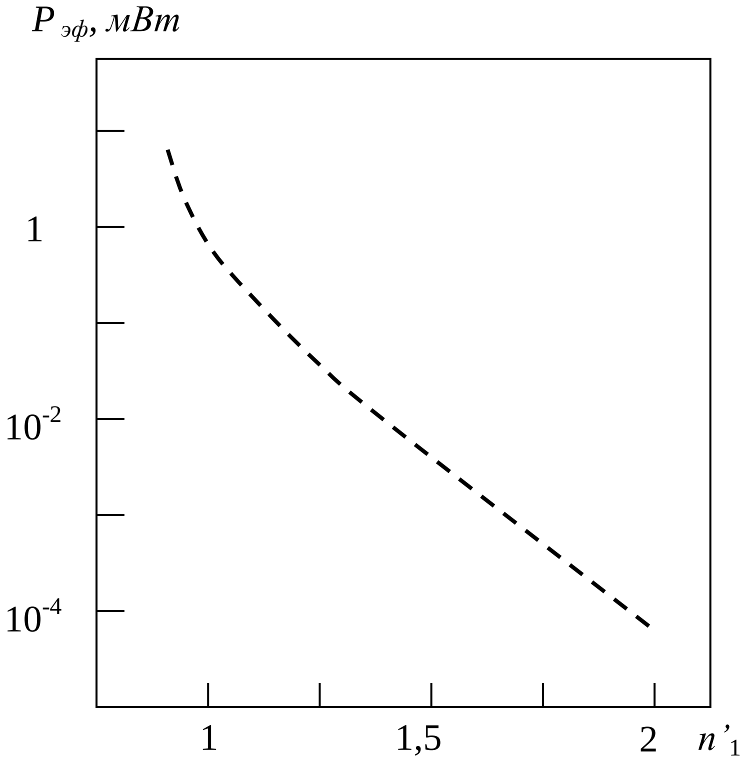


Picture 2. Short circuit of VAX of effective voltage of QE connection to the non-ideality coefficient of VAX at the moment determination point. Calculations T_0=273K, T=300K, j_0=1,5$*$$10^{-10}$$A$, U_{cu}=0,65B, φ_0=1,12B ва γ=5$*$$10^{-4}$$B/K$ done for values.



3 - picture. Relation of the effective current of QE to the coefficient of non-ideality of VAX at the point where the short-circuit current of VAX is determined. Calculations T_0=273K, T=300 K, j_0=1,5$*$$10^{-10}$$A$, U_{cu}=0,65B, φ_0=1,12B and γ=5$*$$10^{-4}$$B/K$ done for values.

Calculations T_0=273 K, T=300 K, j_0=1,5$*$10^{-10}A, U_{cu}=0,65B, φ_0=1,12B and γ=5$*$10^{-4}B/K done for values. It can be seen from these calculations that when the coefficient of non-ideality of VAX increases, the effective values of the photovoltaic characteristics of QE decrease. This leads to a decrease in FIK of KEs.



4 - picture. Relating the effective power of QEs to the point of non-ideality of VAX at the point where the short-circuit current of VAX is determined. Calculations T_0=273 K, T=300K, j_0=1,5$*$10^{-10}A, U_{cu}=0,65B, φ_0=1,12B and γ=5$*$10^{-4}B/K done for values.

The following conclusion can be drawn from these results. The relationship of these parameters to the non-ideality coefficient of VAX was theoretically studied on the basis of the new expressions derived for the dependence of short-circuit current density, effective voltage, effective current density and effective power of QE on temperature. Calculations showed that the short-circuit current density, effective voltage, effective current density, and effective power decrease strongly with increasing nonideality factor of photoVAX from these connections.

The following conclusion can be drawn from these results. Any increase of non-ideality coefficient of VAX of QE leads to a decrease in the values of photovoltaic characteristics. This causes QE to reduce FIK.

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