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OPTIMIZATION OF EFFICIENCY OF SOLAR CELLS BY ACCELERATED ELECTRON RAY TO HAVE AN OPTIMAL AND CONSTANT ENERGY

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Abstract- In this paper we want to show the influence of radiation electron ray with different dose on layers of hetero-junction AlGaAs-GaAs. The *V-I* characteristics and the parameters of J_{sc}, V_{oc} and η of solar cell will be evaluated under different dose of electron radiations on hetero-junction layers. The final aim of this research is to have constant radiation and energy of solar cell.

Keywords: Solar Cells, Hetero-Junction, Electron Rays.

I. INTRODUCTION

In Volt-ampere characteristics of solar cell with increasing irradiation dose current and voltage will decrease [1]. The J_{sc}, V_{oc} and η parameters will decrease proportional increasing electron radiation dose, but the variation of Voc is done slightly [4]. The solar cell after a long term , operating in radiation zone the life of their power operating parameters are reduced and that causes their life reduction [4]. The hetero-junction has been prepared on the base of n-GaAs-p-GaAs-p-$Al_{0.75}Ga_{0.25}As$ is operated as a solar cell. Its structure has been checked with different kinds of *V-I* characteristics by electron rays [1].

In this solar cell the photo current as a function of light intensity shows that changes of photo current $I(\lambda)$ will be done, for short wave radiation region [4]. Comparison of theoretical and practical operations shows that the hetero-junction, which is researching about it, has the most part of solar radiation on p-GaAs-p-AlGaAs layer [7]. High dose radiations (10^{16}-10^{17} elec/cm^2) causes changes of *V-I* characteristics, especially appears for voltage $V<V_d$. The history of β and J_0 shows that the mechanism of current transfer depends on generation recombination processes progressing in volumetric charging region.

II. GENERAL EXPLANATIONS ABOUT SOLAR CELLS PROPERTIES

Solar photovoltaic energy conversion is a one-step conversion process which generates electrical energy from light energy [8-15]. The explanation relies on ideas from quantum theory. Light is made up of packets of energy, called photons, whose energy depends only upon the frequency, or color, of the light. The energy of visible photons is sufficient to excite electrons, bound into solids, up to higher energy levels were they are more free to move. An extreme example of this is the photo electric effect, the celebrated experiment which was explained by Einstein in 1905, where blue or ultra violet light provides enough energy for electrons to completely from the surface of a metal.

Normally, when light is absorbed by matter, photons are given up to excited electrons to higher energy states within the material, but the exited quickly relax back to their ground state. In photovoltaic device, however, there is some built-in asymmetry, which poses the exited electrons away before they can relax, and feeds them to an external circuit. The extra energy of exited electrons generates a potential difference, or electromotive force. (emf). This force drives the electrons through a load in the external circuit to do electrical work. The effectiveness of a photovoltaic device depends upon the choice of light absorbing materials and the way in which they are connected to the external circuit.

The photocurrent generated by a solar cell under illumination at short circuit is dependent on the incident light. To relate the photocurrent density, J_{sc}, to the incident spectrum we need the cell's quantum efficiency, (*QE*). The *QE*(*E*) is the probability that an incident photon of energy *E* will deliver one electron to the external circuit.

$$J_{sc} = q\int b_s(E)QE(E)dE \tag{1}$$

where $\int b_s(E)$ is the incident spectral photon flux density.

The number of photons of energy in the range E to $E+dE$ which are incident on unit area in unit time and q is the electronic charge. The *QE* depends upon the absorption coefficient of the solar cell material, the efficiency of charge separation and the efficiency of charge collection in the device but does not depend on the incident spectrum. It is therefore a key quantity in describing solar cell performance under different conditions. The *QE* and spectrum can be given as functions of either photon energy or wavelength, λ.

Energy is a more convenient parameter for the physics of solar cells and it will be used in this paper. The relationship between E and λ is defined by

$$E = \frac{hc}{\lambda} \tag{2}$$

where h is Planck's constant and c the speed of light in vacuum. A convenient rule for converting between photon energies, in electron-volts, and wavelengths, in nm, is $\frac{E}{\text{ev}} = 1240 / (\frac{\lambda}{\text{nm}})$.

III. STRUCTURE OF HETERO-JUNCTION AND ELECTRON RADIATION RAY RESULT

Usage of different techniques of producing solar cells of A^3B^5 complex, and their solid solution are used in different fields of technology and the problem to have a constant radiation of them remains still as an unsolved problem. It has been determined that, solar cells after a long term, operation in radiation zone the life of their power operating parameters are reduced and this will reduce their life. Because of reduction of inner activity, production process, recombination and velocity of recombination will increase in the junction.

In Lux-Ampere characteristic, V_{oc} and J_{sc} will vary at different irradiation dose. The V_{oc} and J_{sc} will increase with increase of electron radiation dose at the constant amount Lux. On the other hand, degradation of quality of structural parameters (β, R, J_0), which modified the structure and depends on the nature of structure defects and probability of being complex layers and impact of them should be considered. Merely to increase the radiation of this material, several principles have been used, but the solution for this problem hasn't found yet. To solve this problem we review influence of accelerated electron ray on properties of photo electric for AlGa-GaAs.

The hetero-junction has been prepared on the base of n-GaAs-p-GaAs-p-$Al_{0.75}Ga_{0.25}As$ is appeared as a solar cell [4]. The n-GaAs layer with the density of 3×10^{17} cm^{-3} is on the layer of Zinc, with the thickness 15-20 μm as a solid solution. The thickness of p-GaAs layer is 1μm. During construction zinc metal powder is poured on its surface. Zinc layer is placed to reduce thickness of p-layer, with high concentration and improved state and with low contact resistance. The case study surface is 2 cm^2. At the firm of measurement, the curve of electrical characteristics of solar radiation spectrum (AM-1, 5) is used to determining the Volt-Ampere characteristics of solar cells, they will be under the uniformly radiation. This solar cell is uniformly under radiation with the power of P_g=91 mW/cm^2, the J_{sc}=20-25 mA/cm^2, V_{oc}=0.92-0.95 V and efficiency η=16-20%. This sample was under radiation with electric energy 4.5 Mev by electron ray of ELIT-6 equipment.

The n-GaAs-p-GaAs-P-$Al_{0.75}Ga_{0.25}As$ solar cell structure has been checked with different kinds of V-I characteristics by electron rays.

IV. RADIATION WITH DIFFERENT DOSE AND OBTAINED RESULTS

In Figure 1 we can see that, J_{sc} and V_{oc} are decreasing with increase of electron ray dose and V_{oc} is changing slightly.

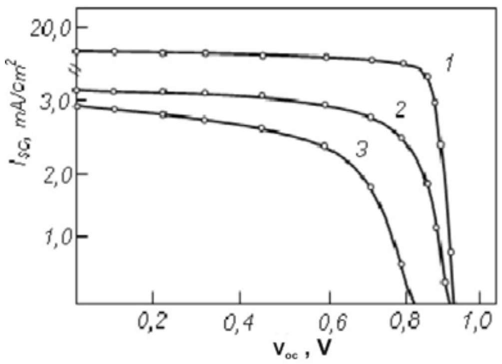

Figure 1. Volt-Ampere characteristics of solar cell before and after irradiation: 1: 0, 2: 10^{15}, 3: 10^{16} el/cm^2

In Figure 2, it is shown that the parameters are calculated according to the curves 1-3 shown in Figure 1and depend on radiation dose.

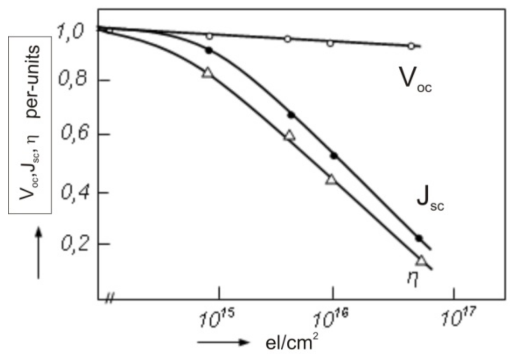

Figure 2. Dependence of J_{SC}, V_{OC} and η on the different radiation dose

It is known that, influence of electron rays on solar cells cause more variation on η and J_{sc} parameters, while V_{oc} is changing slightly. The $J_{sc}(p)$, $V_{oc}(p)$ are functions of electron ray radiation and because of the electron ray, the photo current variation (curves 1-3 in Figure 4) is observed.

In Figure 3, it can be seen that the change of $V_{oc}(p)$, depending on the radiation dose is about 20% in comparison with $J_{sc}(p)$. As in the irradiated samples at the results of an isochronous sealing (T=4000 C, t=30 min) J_{sc} is not completely recovered it justifies that the radiation defects formed in p-$Al_{0.75}Ga_{0.25}$ layer is much more resistant. Comparing of theoretical and practical results shows that defects caused by electron ray radiation have been existed on p-$Al_{0.75}Ga_{0.25}$ region with wide band gap. To explain this fact, the influence of electron radiation on the spectral characteristic of these elements has been investigated.

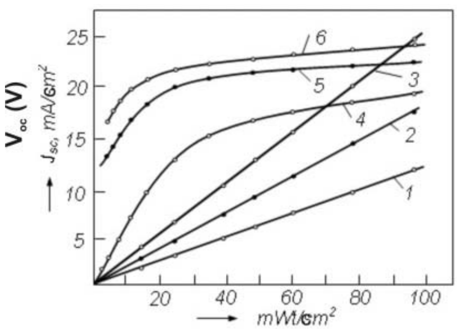

Figure 3. Lux-Ampere characteristics at different irradiation dose: J_{sc} - 1: 0, 2: 10^{15}, 3: 10^{16} el/cm^2; V_{OC} - 4: 0, 5: 10^{15}, 6: 10^{16} el/cm^2

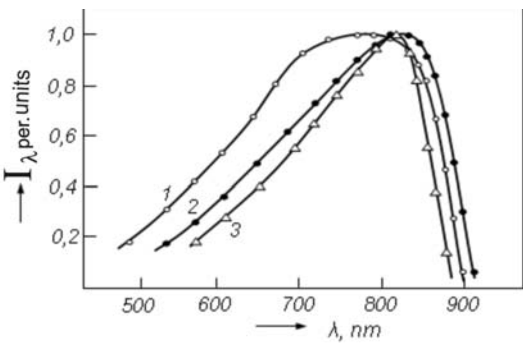

Figure 4. Spectral characteristics at different irradiation doses: 1: 0; 2: 10^{15} el/cm^2, 3: 10^{16} el/cm^2

In Figure 4, photo current ($I_f(\lambda)$) as the curves 1 to 3 and as a function of light intensity are compared, shows that changes of photo current ($I_f(\lambda)$) will be done, for short - wave radiation region). The obtained results conforms to the theoretical and experimental results obtained in the hetero-junctions which is radiated by electrons with 1 MeV energy [5].

Comparison of theoretical and practical operations shows that the hetero-junction, which is researching about it, has the most part of solar radiation on p-GaAs-p-AlGaAs layer. Diffusion path (L_n) is decreasing due to radiation and loss of recombination in p-layer, (after radiation L_n decrease from 7.5 to 5 μm).

$$L_n = \sqrt{\frac{kT\mu\tau}{q}} = \sqrt{D\tau} \tag{3}$$

$$D = \frac{kT\mu}{q} \tag{4}$$

where L_n is Diffusion path and D is Diffusion Coefficient. It is obvious that , the amount of influence within the quantum of light depends on its energy level and the GaAs strip make up attract a maximum depth of 4-6 μm. we must consider that , to provide maximum efficiency of solar cells we have to choose 10-16 μm thickness for p-$Al_{0.75}Ga_{0.25}As$ layer [6] .

The comparison of these facts and the obtained results proves once more that the electron radiation ray generates defects on p-$Al_{0.75}Ga_{0.25}As$ layer. The difference of the obtained result from the one obtained during the irradiation during the irradiation of the corresponding structure [3] by protons verifies our result too. To determine the effect of electron radiation ray on structural parameters, and the characteristics of solar cells, *V-I* curve characteristics of them in the presence of surface temperature, before and after radiation of electron radius in the temperature of 300 °C have been studied.

In Figure 5, we can see that, $I(V)$ depends on radiation ray for little dose (2×10^{14} elec/cm^2) and will not be unusual for $V \geq V_d$ (V_d is threshold voltage, curves 1 and 2). It means that, at first amount of electron ray irradiation is considered to be error [6-7] and it will be record in operations. High dose radiations (10^{16}-10^{17} elec/cm^2) causes changes of *V-I* characteristics, especially appears for voltage $V < V_d$. To clarify the facts which log ($I(V)$) and $C(V)$ are based on their dependence on the maximum flow to be determined

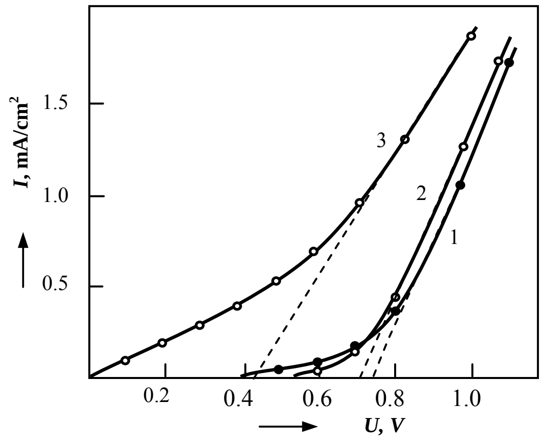

Figure 5. Volt-Ampere characteristics of Solar cell before and after irradiation: 1: 10^{16} el/cm^2, 2: 10^{15} el/cm^2, 3: 0

It's determined for little voltage in the straight direction; changes will follow of exponential low. For voltages upper than 0.6 V, difference of original material and result, linearity of characteristics is lost. The values (β, J_0) of diode coefficients calculated on the base of curves vary in the range of 1.35-2 and 10^{-10} to 10^{-9} A/cm^2.

The time history of β and J_0 shows that the mechanism of current transfer depends on generation recombination processes progressing in volumetric charging region. During the radiation of electron ray, (10^{12}-10^{16} elec/cm^2), β and J_0, have amount 1.5-2.6 and 10^{-8}-10^{-7} A/cm^2, respectively.

During the radiation of electron ray on hetero-junction, recombination centers will be produced in the divider layer [7]. In order to determine photoactive concentration centers, the linear part of $\frac{1}{C^2} \sim f(V_0)$ dependence has been used and it has been revealed that before and after radiation, the concentration of the centers is equal respectively 4.5×10^{15} cm^{-3} and 1.1×10^{15} ($\Phi = 10^{16}$ el/cm^2) .

The thickness of potential barrier in the concentration level of impurity (V_D, N_A, N_D) is calculated (0.9 V, 1.5×10^{9} cm^{-3} and 2×10^{17} cm^{-3}). The analyses of the optioned valves shows that the result of electron irradiation the doping profile in the volumetric charging region charges slightly. The relation $N_A - N_D < N_f$

shows that recombination concentration centers are generated on p-GaAs layer. Experimental considerations and practical results are the same in this research. Increasing of concentration of recombination centers to increase at hetero-boundary and in surficial region under the influence of radiation is observed.

V. CONCLUSIONS

An unsolved problem for solar cells is to have a constant radiation yet. The solar cells after a long-term operation in radiation zone the life of their operating parameters are reduced and this will reduced their life. Because of reduction of inner activity, production process, recombination and velocity of recombination will increase in the junction. To solve this problem we review influence of accelerated electron ray on properties of photo electric for AlGa-GaAs. In this search we choose a case study surface about 2 cm^2. We use electron ray of ELIT-6 equipment. We can see in this research J_{sc} and η are decreasing with increase of electron ray dose and VOC is changing slightly. Changes of photo current $[I(\lambda)]$ will be done, for short-wave radiation region. Diffusion path (L_n) is decreasing due to radiation and loss of recombination in p-layer. This process will be done in the temperature of 300 $^{\circ}$C. During the radiation of electron ray on hetero-junction, recombination centers will be produced in the divider layer. Increasing of concentration of recombination centers to increase at hetero-boundary an in surficial region under the influence of radiation is observed our researching is concentration about mater.

REFERENCES

[1] V.M. Andreyev, V.R. Larinov, V.D. Rumyancev, "Highly Effective Solar Photocells with 19% Efficiency Coefficient", Letters in JTF, Vol. 9, No. 20, pp. 1251-1254, 1983 (in Russian).
[2] R. Sahai, D.D. Edivall, J.S. Harris, "High Efficiency AlGaAs/GaAs Concentrator Solar Cells", Apll. Phys. Lett, Vol. 34, pp. 147-149, 1979 (in Russian).
[3] A.M. Allahverdiyev, V.M. Andreyev, B.V. Egorov, Sh.Sh. Shahmohammadov, JTF, Vol. 53, pp. 1658-1660, 1983 (in Russian).
[4] V.M. Andreyev, B.V. Egorov, V.M. Lantratov, "Solar Photo Cells with Increased Depth of Occurrence of p-n Transition", JTF, Vol. 53, No. 8, pp. 1658-1660, 1983, (in Russian).
[5] G.H Walker, E.J. Conway, "Short Circuit Current Changer in Electron Irradiated GaAlAs/GaAs Solar Cells", International Solar Energy Soc. Cong., N.Y., Pergamon Press, pp. 575-579, 1978 (in Russian).
[6] V.M. Andrev, A.A. Alaev, G.M. Gusinskiy, M.B. Kagan, "Influence of Radiating Irradiation on the Characteristics of AlGaAs/GaAs Solar Cells", Solar Engineering, No. 3, pp. 3-6, 1989 (in Russian).
[7] B.V Egorov, V.M. Lantratov, S.I. Troshkov, "Analysis of Dark Characteristics of Solar Cells on the Basis of Hetero-Junction AlGaAs/GaAs", USSR Conf. on Physical Processes in Semiconductor Hetero-Junctions, Odessa, Vol. 1, pp. 200-202, 1982 (in Russian).
[8] D. Anderson, "Clean Electricity from Photovoltaics", Eds. M.D. Archer and R.D. Hill, Imperial College Press, London, 2001.
[9] M.A. Green, "Photovoltaic: Coming of Age", Conf. Record, 21st IEEE Photovoltaic Specialists Conf., pp. 1-7, 1990.
[10] E. Lorenzo, "Solar Electricity: Engineering of Photovoltaic Systems", Progensa, 1994.
[11] T. Markvart, "Solar Electricity", Wiley, 2000.
[12] J.N. Shive, "Semiconductor Devices", Van Nostrand, 1959.
[13] C.A. Vincent, "Modern Batteries", Arnold, 1997.
[14] G.Sh. Mammadov, U.F. Samadova, F.F. Mammadov, "Economical Estimation of Solar and Wind Energies Application as Alternative of Fire Wood", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 3, Vol. 2, No. 2, pp. 8-12, June 2010.
[15] A. Rostami, K. Abbasian, N. Gorji, "Efficiency Optimization in a Rainbow Quantum Dot Solar Cell", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 7, Vol. 3, No. 2, pp. 106-109, June 2011.

BIOGRAPHIES

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