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Review Article

RESTORATION OF CHARACTERISTICS OF SILICON SOLAR CELLS MADE OF AN AMORPHOUS METAL ALLOY, ULTRASONIC PROCESSING UPSET BY THE IRRADIATION γ- QUANTA

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Abstract:
The experimental results demonstrating the ability to influence and control ¬ leniya parameters of silicon solar cells by sonication (RCD). The possibility of partial recovery of photovoltaic properties of solar cells that disturbed -γirradiation with ultrasonic treatment. C to investigate the impact of RCD on the change in the mechanism of charge transport, after each step of ultrasonic treatment, we measured the photovoltaic characteristics and temperature dependence of current-voltage characteristics of silicon solar cells [SC] in the forward and reverse current. The temperature was varied from 80K to 350K.

Keywords: ultrasonic waves, photo-electric properties, solar cells, amorphous, γ- irradiations, ultrasonic processings,

1. Introduction

It is known that the irradiation of semiconductor devices of high-energy charged particles accumulate in the bulk of radiation defects, which leads to significant deterioration of the electrophysical and photoelectric characteristics of devices [1,2,3]. Controlled impact on the defect structure of a semiconductor device in the p-n junction and the base region can specifically adjust its characteristics.

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Traditionally, to restore the damaged properties of irradiated materials used heat treatment, utilization, which leads to some negative consequences. Therefore, as an alternative, more and more attention is paid to thermal methods of processing, one of which is ultrasonic machining (RCD). In this paper we investigate the possibility of recovery by means of ultrasonic treatment of the initial properties of the investigated silicon solar cells, whose properties are worsened by exposure to radiation.

Experimental Process:-

The standard diffusive technology of obtaining was applied to manufacturing of silicon *TiAu/Si-n* +-p-p + SC on the basis of an amorphous metal alloy *αTiAu* p-n transition p-n transition in a silicon plate [4.8] Capability of obtaining the films of this alloy with amorphous structure was informed in paper [7]. Speed of evaporation of components got out so that the film structure corresponded to alloy $Ti_{60}Au_{40}$ as in paper [7] was informed that such alloy is inclined to amortization.

The investigated silicon solar cells were irradiated with γ- quanta 60Co with a dose of 10^6 Rad at room temperature. Then the samples were sequentially in two stages, subject to the RCD, the longitudinal wave was introduced into the back of the sample perpendicular to its surface. At the first stage RCD-1 (frequency F_{rcd} ≈9MGts, intensity W_{rcd} $^{\approx 0,5Vt/sm^2}$, duration t ≈120min); on the second, RCD-2, (F_{rcd}≈27MGts,W_{rcd} $^{\approx 1W/sm2}$ and t ≈200min). After each stage of the RCD was measured current-voltage characteristics of solar cells a wide temperature range (100 ÷ 350K).). It is shown that γ- the irradiation negatively affects both reverse and to direct current-voltage characteristics , worsening the last in comparison with initial (increase in reverse current $_{Irev}$ fig. 1, a curve 2 and current reduction in forward direction. The subsequent RCD-1 and, especially, RCD-2 restore dark current-voltage characteristics SE, approaching them to the initial.

Results and Their Discussions:-

The structure of a film of an alloy was supervised by the radiographic analysis, as shown in drawings-1. Alloy $Ti_{60}Au_{40}$ has amorphous structure. In amorphous film $Ti_{60}Au_{40}$ also, as well as in crystals the first maximum is completely resolved, i.e. the first minimum concerns a shaft of abscissas. It means that on certain distance firmness of absent-minded electrons is almost equal to zero [3].

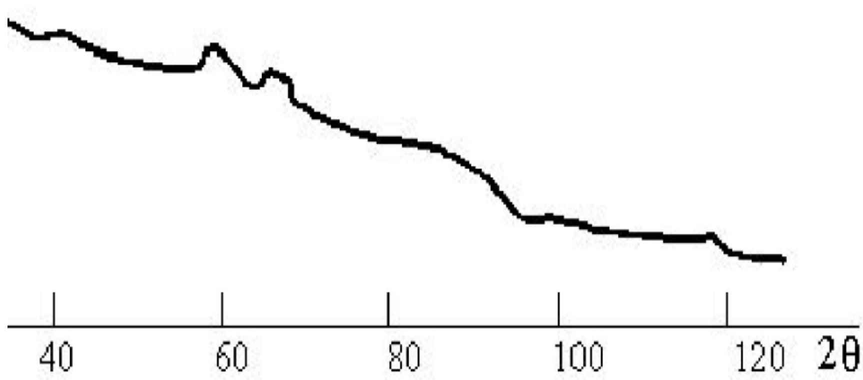

Fig. 1. The X-ray analysis of amorphous metal films $Ti_{60}Au_{40}$

Effect of γ- irradiations and RCD directly on the photoelectric characteristics of the investigated solar cells can be seen from Figure 1, which shows the load current-voltage characteristics of investigated solar cell. As might be expected, γ- irradiations leads to a deterioration of the load VAC SC, resulting in a decrease in short-circuit current $_{Isc}$ and open-circuit voltage $_{Uhv}$ and as consequence, in drop of maximum output power $_{Pmax}$, and γ- space factor. Follow the RCD-1, and particularly the RCD-2 reduced load VAC SC, bringing them closer to the original figure 2 (curves 3 and 4).

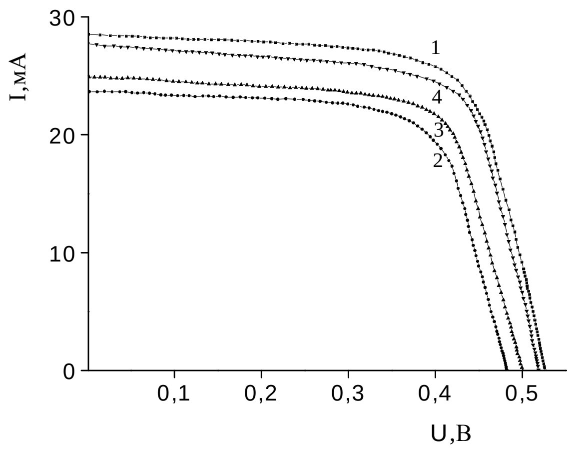

Fig 2. Loading VAC *TiAu/Si-n* +-p-p + the sample subjected to an irradiation γ- quanta both RCD at =100mW/sm2 and T=300К.

Curves: 1 - initial;

2 - after γ- irradiations at a dose of 10^6 Rad;

3 - after RCD-1 (W_{rcd} ≈0,5W/sm2, t ≈120 minutes, F_{uz} ≈9 MHz);

4 - after RCD-2 (W_{rcd} ≈1W/sm2, t ≈200min., F_{rcd} ≈27 MHz).

Let us analyze the possible mechanisms for the observed changes. It is known that the magnitude of the photocurrent is determined from the expression [5]:

$$I_f = qSN\Phi Q, \qquad (1)$$

Here, q - electron charge, and SNf - total number of photogenerated electron-hole pairs at the site S, Q - collection coefficient of charge carriers. Since the value of SNf remains practically constant in this experiment, it is happening as a result of γ-irradiation drop in photocurrent SE is obviously due to a decrease in Q. When the diffusion length of minority carriers in the base Ln <<dp, the value of Q is defined in [12]:

$$Q = \frac{\alpha L_n}{\alpha L_n + 1}, \qquad (2)$$

Here α - light absorption coefficient.

It is known that $L_n = \sqrt{D_n \tau_n}$, where D_n and τ_n - factor of diffusion and time of life of non-basic carriers in base accordingly.

Considering (2) for a photocurrent the following expression is obtained:

$$I_\Phi = qSN_\Phi \frac{\alpha\sqrt{D_n\tau_n}}{\alpha\sqrt{D_n\tau_n} + 1} \qquad (3)$$

Open-circuit voltage U_{xx} is determined as (5)

$$U_{xx} \approx \frac{AkT}{q} \ln \frac{I_{кз}}{I_o}, \qquad (4)$$

where k - Boltzmann constant, T - temperature, k - dimensionless coefficient characterizing the rate of recombination in the space-charge layer, Io - the reverse saturation current flowing through the p-n junction, Isc - short-circuit current. According to our estimates, the irradiation of γ-rays does not lead to significant change and the effect of γ-irradiation and RCD directly on the photoelectric characteristics of the investigated solar cells can be seen from Table 1, which represent the photovoltaic (where Isc-short-circuit current, Uh.h - voltage idling, .., a dimensionless ratio, Pmax - the maximum output power, and -ξ fill factor), the parameters of the sample SE, resulting in a decrease in short-circuit current Isc and open-circuit voltage Uhh, and as a consequence, to reduce the maximum power Pmax Follow the RCD-1, and particularly the RCD-2 restore options SE, bringing them closer to the source.

Table 1. Photo-electric parameters of *TiAu/Si-n* +-p-p + sample SE before and after γ- irradiations and after RCD at $_{Rizl}$ $^{=120мV/sм2}$ and T=300K.

. Parameteres / Condition of the sample	A	U_{xx},V	$I_{кз}$,mA	P,mW	ξ
Before irradiation	2,32	0,542	26,82	12,54	0,7232
after γ-irradiation	2,66	0,498	21,14	9,53	0,7214
After RCD-1	2,56	0,528	22,61	10,52	0,7235
after RCD-2	2,42	0,536	26,65	12,41	0,7263

It is known that exposure to γ-rays with energies of 60Co ~ 1.2 MeV, which is equivalent to the external irradiation by fast electrons SE resulting from Compton scattering and photoabsorption, which leads mainly to the formation of defects of the point type. In this case the interaction of radiation defects with those already in the crystal defects in the p-n junction and the base are more electrically and optically active centers, which play the role of recombination centers, resulting in a decrease in the lifetime of minority carriers tn and parameters Q and IF-dependent tn. In the initial state (Fig. 3, curve 1) the slope of the temperature dependence of Irev amounts 0,71~ eV, which indicates the presence of a diffusion mechanism of charge transport and generation.

Conclusion

The received results allow to make a conclusion that, at structure $Ti_{60}Au_{40}$ the sample is amorphous**.** Laws of influence of ultrasonic processing on photo-electric properties investigated silicon SE are revealed and it is established that interaction of ultrasonic waves with heterogeneous semiconductor structure of silicon SE affects the generation-recombination mechanism of conducting the current. The photo-electric measurement has proved that recovery of photo-electric properties of silicon SE by means of the ultrasonic processing, upset by γ- an irradiation, occurs at the expense of a regrouping and thermal annealing of radiation defects formed by gamma in quanta.

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