NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 10, Oct. -2020

IMPROVEMENT OF OPTICAL CHARACTERISTICS OF GLASSES OF PHOTOELECTRIC BATTERY

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ABSTRACT

Applying an antireflection coating on the glass base of a photovoltaic battery can increase its efficiency by 6-8%. The refractive index and the thickness of the antireflection coating weakly depend on the value of the refractive index of the glass. Based on this, it is concluded that the application of an antireflection coating to glass does not require strict technological regulations.

KEYWORDS: antireflection coating, solar cell, efficiency, refractive index.

INTRODUCTION:

The efficiency of solar energy is increased by optimizing its design and reducing non-fundamental energy losses, i.e. energy losses due to the technology of their production. Non-fundamental energy losses also include optical losses, the methods of reducing which are known: structuring the surface of solar energy, applying an antireflection coating to the front and metal layers on the back surface of solar energy, reducing the contact area and the depth of the p-n junction [2-5].

MAIN PART

A common structural element (mechanical basis) of various types of photovoltaic batteries (PB) is a glass sheet, the optical properties and thickness of which strongly affect the amount of generated electric current. It is possible to increase the flow of solar radiation through the glass both by reducing the thickness of the glass and by applying an antireflection coating (AC) on it. With a decrease in thickness and an increase in the glass area, its mechanical strength decreases, and thermal hardening of the glass in some cases leads to a deterioration in its optical characteristics [6]. The glass surface reflects ~ 5% of the incident solar radiation. Therefore, to reduce the reflection of solar radiation in the production of photovoltaic batteries (PB), corrugated glass is used on one side. However, in countries with hot climates, the troughs quickly fill up with dust, and the efficiency of the PB is significantly reduced.

Antireflective coatings for glass were not used in the production of PBs because they require materials with a refractive index of ~ 1.18 - 1.24 to apply them, and besides Na3AlF6 and MgF2, there are no other dielectric materials with such a refractive index [7.8]. The application of multilayer coatings is unprofitable.

Currently, EISA (evaporation-induced self-assembly) technology allows the application of single-layer transparent coatings with low refractive index on glass [9-11]. In this case, the sol-gel process, which is based on the EISA technology, can be used for the production of photovoltaic batteries on an industrial scale [11].

This work is devoted to optimizing the optical characteristics of the mechanical basis of the PB in order to increase its efficiency.

We choose as a criterion for increasing the efficiency of solar energy (PB) the relative change in the coefficient of performance of solar cells:

$$\gamma = \left|1 - \frac{\eta_1}{\eta_2}\right| \quad (1)$$

η_1, η_2 - coefficients of efficiency of the same SE (PB) before and after optimization. If you use the expression for the coefficient of performance SE

$$\eta = ff\,\frac{j_{sc} U_{oc}}{W} \quad (2)$$

then (1) can be written as

$$\gamma = \left|1 - \frac{j_{sc,1}}{j_{sc,2}}\right| \quad (3)$$

j_{sc} is short circuit current density, Uoc is the open circuit voltage, ff is the filling factor (coefficient) of the current – voltage characteristic, and W is the energy flux density of solar radiation. The dependence of the short circuit current density on the optical properties of glass, AP, and SE has the form:

$$j_{sc} = \frac{q}{hc}\int_{\lambda_1}^{\lambda_2} \lambda \cdot T(\lambda) \cdot E(\lambda) \cdot Q(\lambda) \cdot (1 - R(\lambda))\, d\lambda$$

(4)

q- electron charge, h- Planck constant, c- speed of light, λ - wavelength of solar radiation, E(λ) – spectral distribution of the energy flux of solar radiation, T(λ) – glass transmittance, Q(λ) – collection rate, R(λ) - glass reflection coefficient- AC – SE, λ_1, λ_2 – boundaries of the region of spectral sensitivity of SE.

Since the dispersion of the refractive index of glasses is insignificant in the solar region of the spectrum, the transmission coefficient in (4) can be replaced by the average value and taken out of the integral sign, then (3) can be written as

$$\gamma = \left|1 - \frac{T_1}{T_2}\right| \quad (5)$$

To reduce to zero the light reflection coefficient at a wavelength of λ, need to be applied to the surface of the glass AC with a refractive index $n_a = \sqrt{n}$ and optical thickness of 0.25λ. If as a result of optimization T2 ~ 1, then the increment in the efficiency of SE will be the largest:

$$\gamma_{\max} = 1 - T_1 \quad (6)$$

The transmittance (Fig. 1) of glasses of different thicknesses and different manufacturers were measured on a Lambda EZ 150 spectrophotometer. As expected, the transmission of transparent glasses (curves 2, 3) is almost independent of their thickness. Using the results of measurements of the transmittance, it is possible to calculate the refractive index of a transparent or weakly absorbing glass:

$$n = \xi + \sqrt{\xi^2 - 1} \quad (7)$$

Where $\xi = \frac{2}{\sqrt{T}} - 1$. The calculated values of the refractive index of KI glass (spectra 1.2) and photographic plates (spectrum 4) correspond to the published data [7.8].

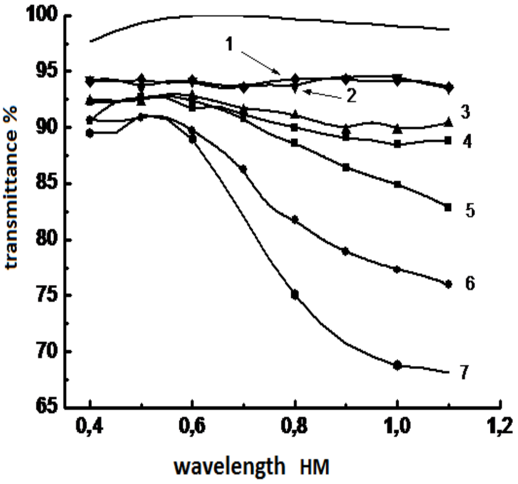

Fig. 1 Glass transmission spectra: without number - AC system - glass; 1 - KI glass (4 mm);

2 - KI glass (2 mm); 4 - photographic plate, (1.4 mm); 4 - glass made in South Korea, (2 mm); 5 - glass made in China, (6 mm); 6 - glass made in Russia (5.3 mm).

For spectra 4–6, overestimated refractive indices (1.63 and 1.81) were obtained due to the fact that formula (7) is not applicable for absorbing and weakly absorbing thick glasses. Table 1 shows the results of calculating n, γ_{max}, n_a and antireflection coating thickness d_a for the wavelength $\lambda = 0.65$ mkm

Curve number	T, %	n	n_a	d_a,nm	γ_{max}, %
1	94.0	1.,42	1,19	136.0	6,0
2	94.0	1.42	1,19	136.0	6,0
3	91.4	1.53	1,24	131.0	8,6
4	90.6	1.56	1,25	130.0	9.4

From table 1 it follows that the refractive index and the thickness of the AP weakly depend on the value of the refractive index of the glass. So, when the glass refractive index changes from 1.42 (CI glass) to 1.53 (photographic plate), the AC refractive index increases by 4%, and the thickness for wavelength $\lambda = 0.65$ mkm decreases by 3.7%. It can be assumed that the technology of applying AC to glass does not require strict observance of the values of these values. Calculation of the spectral transmittance of the AC system - glass confirmed this assumption [2]. In the calculations, the refractive index of glass varied from 1.4 to 1.53, and the thickness and refractive index of ACs varied within $1.19 \leq n_a \leq 1.24$ and $136 \text{ nm} \geq d_a \geq 130$ nm. The calculation results are presented in Fig. 1 (curve without number). The average value of the transmittance for the region of spectral sensitivity of solar energy ($\lambda_1 = 0.4$ mkm, $\lambda_2 = 1.11$ mkm) amounted to 99%, and for the solar region of the spectrum (0.4 - 2.55 mkm) 97%. Application of AC to the glass surface leads to an increase in efficiency by 6-8%

Based on the results obtained, the following conclusions can be drawn:

- By applying AP to a glass base, it is possible to increase the efficiency of the PB by 6–8%;
- AC application does not require strict technological regulations, as refractive index and thickness may vary within certain limits;

CONCLUSION:

The optimal parameters of the ranges of the electron beam are found (heat density, velocity, displacement), within which there is improvement of the physical and mechanical properties of surface layers of optical elements: there is no formation of negative defects on their surfaces which become atomically smooth (residual microscopic ridges do not exceed 0.5… 1.5 nm); the microhardness of the surface increases, hardened layers are formed with compressive stresses. This leads to the reduction of the light scattering coefficient of surface layers of elements and increase of their coefficient of infrared radiation transmittance and, ultimately, to the improvement of metrological characteristics and reliability of devices under intensive external thermal action.

REFERENCES:

1) Willeke G. R Proc. 19-th Europ. Photovolt. Solar Energy Conf. (Paris, Ranee, 2004) p. 1.
2) Goetzberger A., Knobloch J., Voss B. Crystalline silicon solar cells. -John Wiley&Sons, 1998.
3) Andreev VM, Griliches VA, Rumyantsev VD Photoelectric conversion of concentrated solar radiation. L .: Nauka, 1989. 310 p.
4) Koltun M.M. Optics and metrology of solar cells. M .: Nauka, 1985.279 p.
5) Bouhafs D., Moussi A., Chikouche A., Ruiz J.M.//Solar Energy Materials and Solar Cells. 1998. v. 52. P. 31-38.

6) Nikanorov N.V., Evstropiev S.K. Optical materials science: Fundamentals of glass strength. SPb: SPbSU ITMO. 2009.102 p
7) Handbook of optical constants of solids /Ed. by E. Palik. Academic press, 1985. 687 p
8) Zolotarev V.M., Morozov V.N., Smirnova E.V. Optical constants of natural and technical environments L .: Chemistry, 1984. 215 p.
9) Thomas I. M.//Applied Optics. 1992. v. 31. No 28. P. 6145-6149.
10) Y.Wan, D. Zhao //Chem. Rev. 2007. v. 107. p. 2821- 2860.
11) Trinity B. B., Lopatin M.A. Mamaev Yu.A., Khokhlova L.V. Babin A.A., Denisova V.N. Novikova M.A. "A method for producing thin antireflection coatings based on mesoporous silica by the sol-gel method in the presence of organic acids, functional derivatives of organic acids, and esters of organic acids." Patent (RU 2371399).