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ABSORPTION OF SOLAR ENERGY BY SOLAR CELLS IN DEPENDENCE OF LIGHT INCIDENT ANGLE

The dependence of solar energy absorption in solar cells with different types of surfaces on the light incident angle is investigated experimentally,. The measurements show that the short circuit current of solar cells strongly depends on the type and structure of the surface coating material and decreases with increasing the light incident angle.

Keywords: solar, photovoltaic, cell, efficiency, incident light, angle.

Introduction. Reducing global carbon dioxide (CO2) emissions to net zero by 2050 is a critical and formidable goal. EU Member States committed to turning the EU into the first climate-neutral continent by 2050. Utilizing renewable energy sources is essential to curbing climate change, reducing dependence on finite fossil fuel reserves, and achieving energy independence.

The share of solar energy in renewable sources is dominant. The leading technology for solar radiation is the photovoltaic (PV) conversion of light directly into electricity. The main problem with solar energy is efficiently collecting this energy and cost-effectively converting it into electric energy.

The efficiency of PV solar cells depends on many internal parameters. It depends also on the incident angle of light which changes during the day and year. The structure of the general PV module is presented in Figure 1. After passing the glass and Ethylene Vinyl Acetate (EVA) layers, the main part of the Sun rays are absorbed in the solar cells. Some portion of the solar rays are reflected from the surfaces of glass, EVA, and solar cells. To reduce the rate of reflected light different anti-reflected coatings (ARC) generally are used. The rate of absorbed and reflected light strongly depends on the inclination angle of the solar rays. Therefore, it is important to investigate the dependence of the given type of solar cell`s efficiency from the incident angle of light and consider it during the design of an appropriate solar energy system.

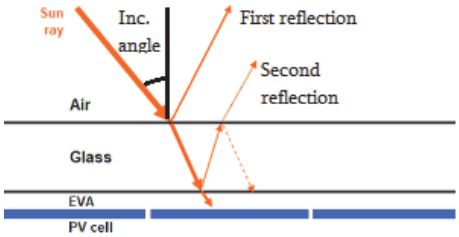

Fig. 1. The structure of a PV module and the light pass

In concentrating solar energy systems the Solar rays are concentrated by refraction with the use of lenses or by reflection with the use of mirrors. In these systems the incident angles of the rays, striking the surface of the cell in the focus of the concentrator, are different and depend on the type and structure of the concentrating system. Consequently, in concentrating systems, the dependence of the efficiency of solar cells on the incident angle of light must be considered. Note that for concentrating systems the dependence of the light reflectance rate of mirrors from the incident angle must be considered as well [1].

To make the concept of building-integrated solar cells viable, the light incident angle that naturally changes along the day must be considered. The investigation of light incident angle impact on the efficiency of building integrated different types of solar cells is conducted in [2]. The influence of light incident angle on photoelectric parameters of solar cells is investigated by simulation [3].

In this paper, the dependence of the short circuit current of the solar cells with different types of surfaces from the light incident angle is experimentally investigated.

Experimental setup. The short circuit current of the silicon mono-crystalline solar cell is measured. Note that the short circuit current of a solar cell is proportional to the light intensity absorbed by the cell and consequently, it gives information about the solar energy absorption process.

The solar cells are covered with different types of anti-reflecting coatings. To exclude the cosine effect of the incident light on the short circuit currents, the fiberglass optical cable with an output diameter of 5 mm is used. The optical fiber is fixed and the sample of the solar cell is rotated as shown in Fig. 2.

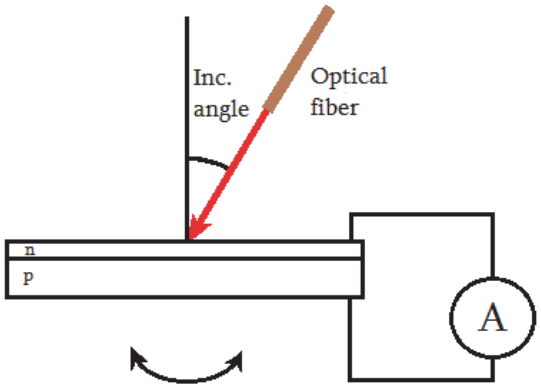

Fig. 2. The solar cell and the rotation directions

The photo of the experimental setup is presented in Fig. 3. The solar cell (1) under the test is placed in the center of the rotating table (2). The cell is illuminated

by the fiberglass optical cable (3). The filament lamp is used as the light source. The light is focused by an optical lens and directed to the other end (input) of the optical cable.

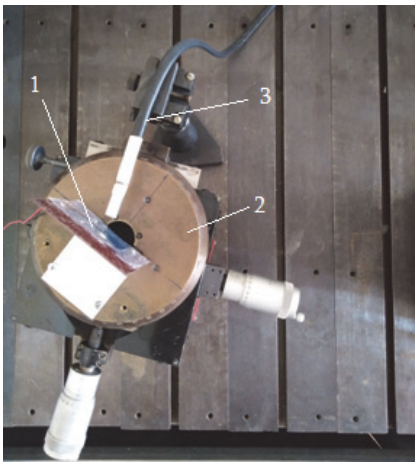

Fig. 3. The photo of the experimental setup

Four types of experimental samples are prepared:

1) Solar cell without any cover layer (ARC0);
2) Solar cell with anti-reflecting coating type 1 (ARC1);
3) Solar cell with anti-reflecting coating type 2 texturized (ARC2Text);
4) Solar cell with anti-reflecting coating type 2 (ARC2).

The measured values of the short circuit current for positive values of incident angle, as in Fig. 2, are presented in Fig. 4.

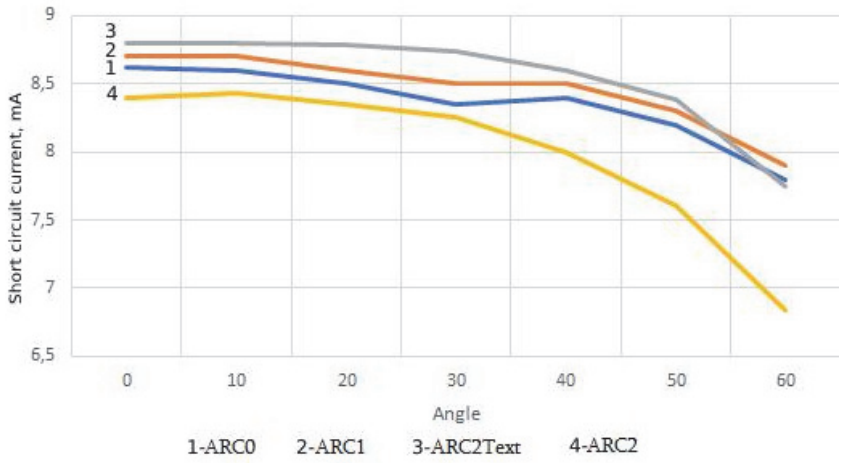

Fig. 4. Short circuit current of solar cell vs. incident angle of light (positive values)

It can be seen from Fig. 4 that the short circuit current is decreasing strongly with increasing the incident angle of light. The minimum values of the current are obtained in the case of the sample ARC2 and the maximum values are in the case of anti-reflecting coating with texturized surface - ARC2Text.

The measured values of the short circuit current for negative values of incident angle are presented in Fig. 5.

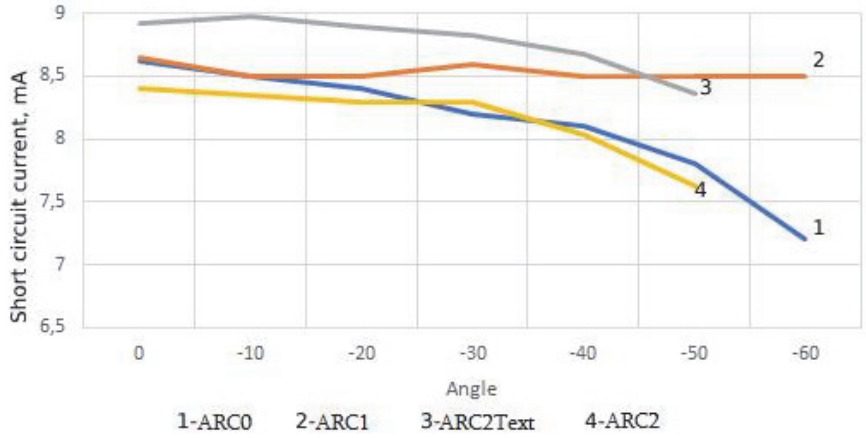

Fig. 5. Short circuit current of solar cell vs. incident angle of light (negative values)

In this case, also, the short circuit current decreases with the increase of the incident angle of light. The minimum values of the current are obtained in the case of the samples ARC2 and ARC0. The maximum values in this case also are when the cell is covered by an anti-reflecting coating with a texturized surface - ARC2Text.

Conclusions.

1. The short circuit current decreases with increasing the incident angle of light.
2. The short circuit current of solar cells strongly depends on the type and structure of the surface coating material.
3. During the design of solar photovoltaic (PV) plants, solar energy Concentrating (CPV) systems, as well as Building Integrated (BIPV) systems, it is important to measure the dependence of parameters of the used solar cells or PV modules from the light incident angle and take it into consideration.

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ԱՐԵՎԱՅԻՆ ԷՆԵՐԳԻԱՅԻ ԿԼԱՆՈՒՄԸ ԱՐԵՎԱՅԻՆ ՄԱՐՏԿՈՑՆԵՐՈՒՄ՝ ԿԱԽՎԱԾ ԼՈՒՅՍԻ ԱՆԿՄԱՆ ԱՆԿՅՈՒՆԻՑ

Փորձնականորեն հետազոտվել է տարբեր տիպի մակերեսներով արեգակնային մարտկոցների կարճ միացման հոսանքի կախվածությունը լույսի անկման անկյունից: Չափումները ցույց են տվել, որ արևային մարտկոցների կարճ միացման հոսանքը խիստ կերպով կախված է մակերեսի ծածկույթի նյութի տեսակից և կառուցվածքից, և այն նվազում է լույսի անկման անկյան մեծացմանը զուգընթաց:

Առանցքային բառեր. արևային էներգիա, ֆոտովոլտային, մարտկոց, արդյունավետություն, ընկնող լույսի անկյուն:

Р.Р. ВАРДАНЯН, А.Р. ГАРАКЕШИШЯН

ПОГЛОЩЕНИЕ СОЛНЕЧНОЙ ЭНЕРГИИ В СОЛНЕЧНЫХ ЭЛЕМЕНТАХ В ЗАВИСИМОСТИ ОТ УГЛА ПАДЕНИЯ СВЕТА

Экспериментально исследована зависимость поглощения солнечной энергии в солнечных элементах с различными типами поверхностей от угла падения света. Измерения показывают, что ток короткого замыкания солнечных элементов сильно зависит от типа и структуры материала покрытия поверхности и уменьшается с увеличением угла падения света.

Ключевые слова: солнечная энергия, фотоэлектрический, батарея, эффективность, угол падения света.