WORKING PRINCIPLE OF A SOLAR CELL

Nigmatov U.Zh.
Senior Lecturer, Fergana Polytechnic Institute, Fergana, Uzbekistan
E-mail: u.nigmatov@ferpi.uz

After the global energy crisis in the 70s of the last century, the development of unconventional and renewable energy began. Currently, the total capacity of operating power plants based on renewable energy sources is about 600 GW, which is almost twice the capacity of all operating nuclear power plants in the world. [1].

On the territory of the Central Asian region, the priority areas of research in the field of solar energy are:

1. Improvement of solar power plants (SPP), allowing to generate electrical and thermal power on an energetically significant scale without negative impact on the ecological environment [2];
2. Experimental research and practical application of solar parabolic cylindrical power plants [3];
3. Developments for the widespread use of heat pipes as a heat sink for solar parabolic cylindrical installations [4];
4. Research to improve the efficiency of photoelectric conversion (solar flux, ambient temperature, wind speed, optimal system load matching) [5];
5. Development and improvement of existing hybrid structures for air, water cooling, heat removal from panels, with forced cooling [6].

In the automated systems for measuring the energy indicators of the above solar systems, certain structures and algorithms are formed, which consist of the following main parts:

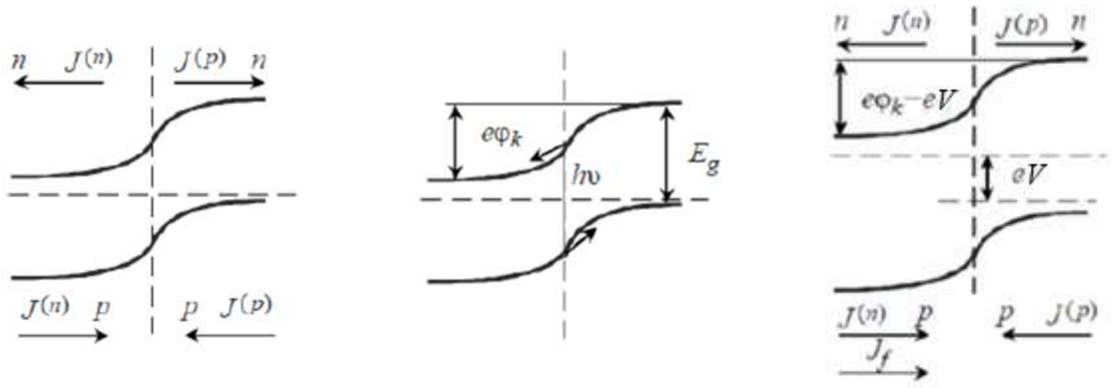
object of research - solar energy system;
sensor;
secondary, microprocessor device;
actuating mechanism;
experimental data logger.

The measuring system of experimental data consists of functionally combined measures, measuring instruments, measuring transducers, computers, other hardware and software modules installed to measure one or more energy quantities. The main task of measuring systems is to generate measuring information signals in a form most convenient for automatic processing and control, transmission and use in registration systems [7, 8].

The basic principle of operation of most solar cells is the use of photosensitive materials that absorb solar radiation and convert the radiation into direct electrical current. When two semiconductors with different conductivity come into contact, electrons diffuse from the *n*-conductor to the *p*-region, resulting in a diffusion electric field.

Due to the diffusion of the main charge carriers through the *p*-*n*-junction, a contact potential difference is formed [9-10]. When thermodynamic equilibrium occurs, the position of the Fermi level in the entire system is constant; the energy scheme of the *p*-*n*-junction is shown in Figure 1.1. In this case, the currents are free charge carriers generated due to thermal excitation and the total current is zero at equilibrium.

The formation of an electron-hole pair occurs when a photon with an energy greater than the band gap is incident on a *p*-*n*-junction. Under the action of the internal field of the transition, the charge carriers created by light move in opposite directions: holes – to the *p*-region, and electrons – to the *n*-region. The charge carriers that have passed through the *p*-*n*-junction form an additional current. Since the excess holes that have passed into the *p*-region reduce the negative space charge, the energy levels in the *p*-region decrease, as a result of which the potential barrier decreases. Therefore, the separation of photogenerated carriers by an electric field, in the near-contact region of the *p*-*n*-junction, leads to the appearance of a potential difference applied to the *p*-*n*-junction in the forward direction, called photo-EMF. This is equivalent to applying voltage *V* in the forward direction to an unlit *p*-*n*-junction [11].



a b c

Figure 1.1 – Energy scheme of the *p*-*n*-junction and currents of charge carriers at thermodynamic equilibrium (*a*) and illumination (*b*), (*c*)

Electrons from the *n*-region and holes from the *p*-region, overcoming the reduced potential barrier, will be injected into another region, where they become minor charge carriers and recombine. In this case, the currents due to the injected charge carriers are directed from the *p*- to the *n*-region. The stationary state will be established when the number of electron-hole pairs created by light is equal to the number of charge carriers leaving through the reduced potential barrier of the *p*-*n*-junction. If the *p*-*n*-junction is connected to an external circuit, then the photo emf can be measured. Therefore, the illuminated *p*-*n*-junction acts as a photoelectric cell [12].

Stages of conversion of solar radiation:

1) absorption of light;
2) generation of electron-hole pairs;
3) separation of charge carriers by a *p*-*n*-junction;
4) collection of charge carriers on the electrodes;

These stages are present in almost all solar cells and the unstable operation of one of them leads to a decrease in the efficiency of solar radiation conversion.

Literature

1. Нигматов, У. Ж., & Наимов, Ш. Б. (2020). Анализ потенциала использования энергии солнечного излучения на территории республики Таджикистан. In *International scientific review of the technical sciences, mathematics and computer science* (pp. 59-71).
2. Эргашев, С. Ф., Нигматов, У. Ж., Абдуганиев, Н. Н., & Юнусов, Б. С. А. (2018). Солнечные параболоцилиндрические электростанции-современное состояние работ и перспективы использования их в народном хозяйстве Узбекистана. *Достижения науки и образования*, (5 (27)), 6-8.
3. Эргашев, С. Ф., & Нигматов, У. Ж. (2020). Солнечные параболоцилиндрические установки, конструктивные особенности и расчёт отдельных параметров. *Universum: технические науки*, (11-5 (80)), 51-56.

4. Эргашев, С. Ф., Нигматов, У. Ж., & Пулатов, Э. У. У. (2018). Анализ перепадов температур, возникающих в тепловых трубах солнечных параболоцилиндрических установок. *Проблемы науки*, (5 (29)), 18-21.
5. Эргашев, С. Ф., Нигматов, У. Ж., Орипов, А., & Ощепкова, Э. А. (2019). Энергоэффективный трекер без использования светозависимых датчиков (Фоторезисторов, фотодиодов и тд). *Известия Ошского технологического университета*, (3), 234-236.
6. Нигматов, У. Ж. (2020). Анализ конструктивных элементов охлаждения гибридных солнечных коллекторов. *Вестник науки и образования*, (2-3 (80)).
7. Рахимов, Р. Х., Эргашев, С. Ф., Абдурахмонов, С. М., & Нигматов, У. Ж. (2017). Автоматизированная компьютерная система измерения производительности солнечных водонагревателей с порционной подготовкой горячей воды. *Computational nanotechnology*, (1), 23-26.
8. Rakhimov, R. K., Irgashev, S. F., Abdurakhmanov, S. M., & Nigmatov, U. J. (2017). The automated computer system of measurement of productivity of solar water heaters from portion preparation of hot water. *Computational nanotechnology*, (1), 23-26.
9. Arvind S. Thin-film silicon solar cells / EPFL Press, 2010. 430 c.
10. Бонч-Бруевич В. Л., Калашников С. Г. Физика полупроводников / М.: Наука, 1990. 650 с.
11. Афанасьев В. П., Теруков Е. И., Шерченков А. А. Тонкопленочные солнечные элементы на основе кремния. СПб.: Изд-во СПбГЭТУ «ЛЭТИ», 2011. 168 с.
12. Каримов БХ. Фотовольтаический эффект в оптически активных кристаллах. Фізична інженерія поверхні. 2006(4,№ 1-2):8-12.