TYPES OF PHOTOVOLTAIC CELLS AND THEIR EFFICIENCY

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Abstract: The efficiency of photovoltaic cells is determined by the factors that convert sunlight into electrical energy. This, in turn, depends on the materials of the photovoltaic cells, their production technologies, and the angle at which the photovoltaic cells are installed to receive sunlight. This work discusses the types of photovoltaic cells, their operating principles, and methods for increasing their efficiency.

Key words: photovoltaic cell, photovoltaic effect, light beam, silicon, photon, current flow, efficiency, perovskite, heterojunction, power, ohmic contact, photocurrent.

Introduction

The history of the invention of the photocell begins with the discovery of the photoelectric effect by the German physicist Heinrich Hertz in 1887. He found that the discharge between the electrodes occurs faster when they are illuminated with ultraviolet light. However, this discovery was not widely known and was forgotten for several decades. The next important step in the history of photocells occurred in 1905, when Albert Einstein published his theory of the photoelectric effect. He explained that light consists of particles (photons) and that each photon can knock an electron out of a metal. This discovery became the basis for the further development of photocells. The first practical photocell was created in 1923 by the Soviet scientist Oleg Losev. He used silicon carbide as a semiconductor and generated current when exposed to light. However, his device had low efficiency and was not widely used. The next important step in the development of solar cells was the discovery of semiconductor materials in 1939 [1-5]. Japanese scientist Hideo Hosono discovered that selenium has photoconductivity, that is, its conductivity increases with light. This discovery became the basis for the creation of the first photovoltaic cells based on selenium. With the development of semiconductor technology in the 1950s, the first silicon solar cells were created, which had high efficiency and became the basis for the creation of modern solar cells. In the 1960s, gallium arsenide-based solar cells were developed, which had even higher efficiency. Modern solar cells continue to develop using new materials and technologies. For example, in recent years, solar cells based on perovskites, which have high efficiency and low production costs, have been actively studied [4-9].

The main types are monocrystalline, polycrystalline, amorphous, perovskite and organic photovoltaics. Monocrystalline photovoltaics have high efficiency, reaching efficiencies of 18-25%, but their cost is relatively high. Polycrystalline photovoltaics are cheaper, with efficiencies of around 15-18%. Amorphous photovoltaics are the cheapest and most widely used type, but their efficiency is lower (7-10%). Perovskite-based photovoltaics are a new technology, with efficiencies of 15-25%, but their long-term reliability has not yet been fully proven. Organic photovoltaics are the newest technology, with efficiencies of around 5-10%, and are characterized by their low cost and flexibility. The balance between the efficiency and cost of photovoltaics is chosen depending on the areas of their use and the conditions under which they are used [10-13].

Operating principles for photocell

Energy conversion in solar cells is based on the photoelectric effect, which occurs in inhomogeneous semiconductor structures under the influence of solar radiation. When irradiated with sunlight, internal photoelectric effect phenomena occur in semiconductors. Photocells are widely used in photometry (in photometers and luxmeters) to measure light intensity, brightness and illuminance. For this, photocells with a spectral sensitivity close to the spectral sensitivity of the eye are used [14-16].

There are different types of photovoltaic cells, each with its own characteristics and applications. Silicon photovoltaic cells: amorphous silicon (a-Si) - solar cells based on amorphous silicon are the most common and available on the market. Their efficiency is about 9-11%. Monocrystalline silicon (mc-Si) - these elements have a higher efficiency (15-25%), but are also more expensive. Polycrystalline silicon (pc-Si) - such solar cells occupy an intermediate position between a-Si and mc-Si in terms of their characteristics (fig-1). There are many types of photovoltaic cells classified according to various criteria [17-20].

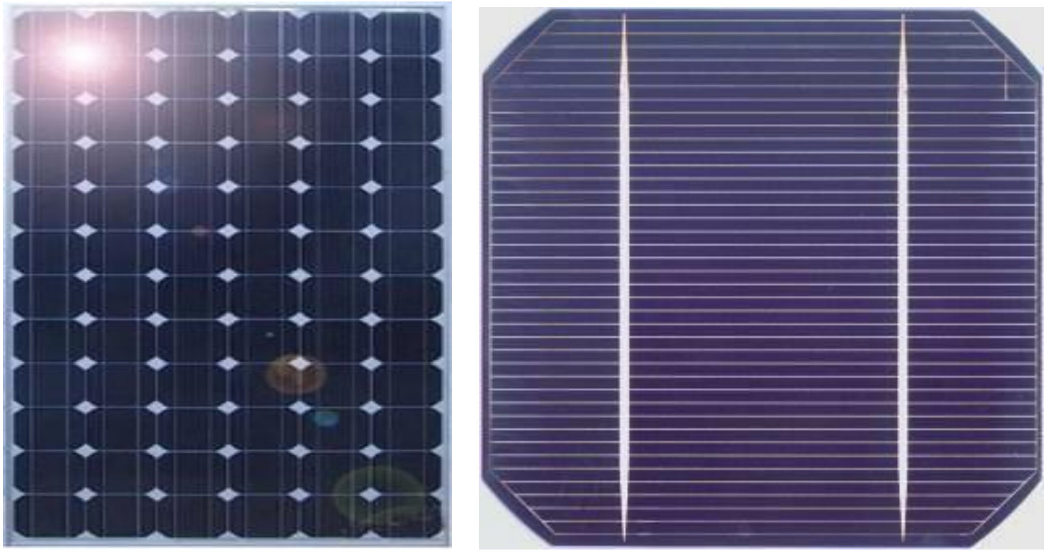

Figure-1. Monocrystalline and Polycrystalline silicon

Photovoltaic cells (e.g., solar panels) that convert light into electricity through direct conversion.

Pyroelectric elements that use the change in electric field caused by temperature changes.

Thermoelectric elements, in which electricity is generated by heating one of the elements and then used to generate voltage.

External photoelectric effect. Another name for it is photoelectron emission. Internal photoelectric effect - this affects the photoconductivity of a material. It is called the transfer of photoelectrons from their own bodies to other bodies (solid semiconductors) or electrolytes (liquids). The principle of operation of a photovoltaic cell Energy conversion in solar cells is based on the photoelectric effect, which occurs in heterogeneous semiconductor structures under the influence of solar radiation. Internal photoelectric effect phenomena occur in semiconductors when they are irradiated with sunlight [21-22].

The efficiency of converting light energy into electricity. This is one of the main indicators of photovoltaic cells. Efficiency is measured as a percentage and indicates how much of the solar energy is converted into electricity. Typical efficiency values for silicon solar panels range from 15% to 25%, but can reach 30%. Power. This is defined as the amount of electricity produced by a photocell per unit of time. Power is measured in watts. The efficiency and power of photovoltaic cells can vary depending on size, type, and operating conditions. Open circuit voltage and short circuit current, these two parameters are measured under no-load conditions and are used to determine the maximum power of a solar cell. Open circuit voltage is the voltage that appears between the two contacts of a photocell when there is no current. Short circuit current is the maximum current that a photocell can produce when the circuit is open [23-24].

Maximum power (Pmax). The maximum power of a photocell is determined as the product of the open-circuit voltage and the short-circuit current. This value determines the efficiency of the solar cell and its ability to generate electrical energy. A photocell is an electrical device that absorbs incident light and generates an electric current (photocurrent) or photoelectric force. Its operation is based on the phenomenon of photoelectron emission or the external photoeffect [25-26]. A photocell operating on the basis of photoelectron emission consists of two electrodes placed in a vacuum or gas-filled glass or quartz tube - a photocathode and an anode electrovacuum device. The light flux incident on the photocathode generates photoelectron emission on its surface; when the photocell circuit is connected, a photocurrent similar to the light flux arises in it. In a gas-filled photocell, the photocurrent increases as a result of the ionization of the gas and the formation of an independent strong discharge.

Conclusion

A photocell operating on the basis of the internal photoelectric effect consists of a semiconductor device with a homogeneous electron-hole transition (r-junction), semiconductor, heterojunction or metal-semiconductor contact. In such photocells, optical rays are absorbed, the concentration of charge carriers increases, and an electromotive force is generated. Photocells usually act as radiation or light receivers. Semiconductor photocells are used in solar cells and photovoltaic generators to directly convert solar energy into electrical energy. Photocells are used in automation, telemechanics, photometry, measurement technology, metrology, astronautics, photography, cinematography, and other fields.

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