CONSIDERATIONS REGARDING THE USE OF PHOTOVOLTAIC CELLS TO PRODUCE ELECTRICITY ON THE BOARD THE AIRCRAFT

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Abstract: *Technological progress involves a continuous process of identifying and developing new sources of unconventional energy. It guides us towards ideal perspectives and different outlooks regarding photovoltaic technology. Based on the in-depth studies and experiments performed ever since the discovery of the photovoltaic effect, new contributions can be made in order to obtain a coherent, consensual concept and modern applications, to be used in the aerospace industry, all these efforts resulting eventually in an autonomous system concept.*

Keywords: *unconventional energy, photovoltaic technique, photovoltaic effect, aerospace, photovoltaic cells.*

1. INTRODUCTION

The term "photovoltaic" comes from the combination of the Greek word "photos", meaning light and "volt", the unit of voltage. Thus, photovoltaic technology describes the process of generating electricity using light.

In 1839, during the Industrial Revolution, Alexandr Edmond Becquerel, the father of Nobel Laureate Henri Becquerel, discovered the photovoltaic effect, showing how electricity can be generated by sunlight. He proved that "exposing an electrode immersed in a conductive solution creates an electric current". Despite extensive research, after this discovery, photovoltaic conversion continued to be inefficient.

Photovoltaic cells were mainly used for measuring light intensity. The first memoir on photovoltaic or photoelectric effect (as it was called at the time), was created by Cambridge scientists W. Adams and R. Day in 1877, and it described the changes that took place when a selenium plate was exposed to light. In 1887, Heinrich Hertz noticed in his experiments, that a zinc plate is positively charged if exposed to ultraviolet radiation. The phenomenon is due to the same photoelectric effect: under the action of ultraviolet rays, electrons are removed from the metal and consequently, the metal is positively charged.

The first PV cell using a selenium base was built by the American electrician Charles Fritts in 1883 and it was patented in 1884. The construction of the cell was very similar to today's cells, but its efficiency was less than 1% and could not be used industrially.

About a century after the effect's first discovery, Albert Einstein received the Nobel Prize in Physics, in 1921, for explaining the photoelectric effect, which enabled the practical use of photovoltaic cells. In 1946, Russell Ohl invented the solar cell, followed by the invention of the transistor in 1947. In the middle of the twentieth century, scientists and engineers returned to the study of the photovoltaic effect in semiconductors. In 1953, the engineering team at Telephone Laboratories (Bell Labs), represented by D. Chapin, C. Fuller and G. Pearson, discovered that silicon PV cell is much more efficient than the selenium cell.

The following year, the same team builds a silicon cell with a yield of 6%. At the same time, the first consumers of photovoltaic energy appear - artificial satellites. In 1957, PV cells were installed on the earth's first artificial satellite "Sputnic 3", and in 1958 PV cells were installed aboard the American satellite "Vanguard 1", and were used to power a radio transmitter.

To date, PV cells are generally recommended as energy source for space technology. In the 60s, a spectacular progress was made in the field of satellite power supplies, being separated the rigid dependence of decentralised energy from the tradional sources: generators, baterries or storage batteries. By using the photovoltaic effect, the direct conversion of sunlight into electricity took place. Direct conversion technology excludes intermediate transformations: solar radiation into thermal energy, thermal energy into mechanical energy, mechanical energy into alternating current electricity. The direct conversion is obtained by using the PV effect produced in semiconductor materials, using the photovoltaic effect. Unlike the electromechanical generator, the photovoltaic generator, the so-called photovoltaic cell, produces electricity directly.

The exclusion of intermediate transformations from the technological chain, the absence of motion, noise or vibration, the modular construction, and the over 25 years operating life expectancy; these are arguments to saying that the future of decentralized energy belongs to photovoltaic technology.

2. PHYSICAL PHENOMENA. TYPES OF PHOTOVOLTAIC CELLS USED IN THE AEROSPACE INDUSTRY

On the whole, in the unconventional energy development industry, photovoltaic cells are named after the semiconductor material from which they are made, especially selected so they can absorb photons carried by solar energy. Some of these structures are intended to be used in terrestrial space, mounted on different types of equipment, or to be used in space.

In the manufacturing process, photovoltaic cells can be designed with a single layer of absorbent material (single junction), with several layers of the same material, or different materials (multiple junctions), the last two being more advantageous as they can absorb different light spectrum and also can connect to a charging mechanism.

Solar cells are sorted into classies by generations of production, following the evolution of technological process, such as first generation PV, second generation PV and third generation PV. First generation cells, also called traditional or conventional photovoltaic cells, use materials such as polycrystalline and monocrystalline silicon and are predominantly of commercial production.

The next generation comes with a thin film of amorphous silicon, cadmium tellurium and gallium arsenide, beeing used in complex electricity production systems, in aeronautical applications.

The third generation is represented by photovoltaic cells that are still in the design stage. The materials used are of organic nature, composite materials, with a wide range of usage, especially in environments where an elastic characteristic is required. Manufacturing costs are differentiated according to the materials required and the production technology.

Photovoltaic technology using the crystalline form of silicon can be applyed on a multitude of systems, starting with the common pocket computer and reaching the complex systems of producing unconventional electricity from satellites and aircraft with or without a pilot.

The developed manufacturing technique consists in placing a thin layer of silicon (Si), with the thickness of approximately one micron on a material such as glass or metal.

The thermal field of operation has little limitations regarding the application (-40° C up to 60° C). During the process, the silicon layer undergoes a reduction coefficient of 15 to 35% (in use).

Experimental tests made to this type of photovoltaic cells indicated that placing a layer as thin as possible, produces a bigger electrical current along the length of the material.

Technological evolution tends towards using multiple layers of amorphous silicon. In 2019, a performance was obtained by testing a three-layer photovoltaic cell. The pioneers of the new manufacturing technology are Uni-Solar, a company that has performed multiple tests, recorded functional parameters and innovated the photovoltaic field.

Concluding the above, amorphous silicon photovoltaic cells are the most common unconventional electricity production systems, being the system with the lowest production cost.

In the manufacturer industry of photovoltaic structures, for the cells that use groups III to V elements, GaAs is the most commonly used element, with increased performance.

According to studies, photovoltaic cells, which use GaAs as a raw material, benefit from a maximum conversion factor of up to 31.6%, a value recognized by the National Renewable Energy Research Laboratory (NREL), USA. In the last scientific conference in May 2019, was discussed the possibility of evolution in this field, more precisely, the intention to increase the development and research to 38% in 2020 and 42% by 2025.

When it comes to efficiency in the field of photovoltaic cells, the following criteria is taken into account: manufacturing technology and mass production. The greatest advantage that these contextures have, is the hight efficiency, its coefficient being almost double than the ones using crystalline silicon PV.

Unlike other types of photovoltaic cells, cells made of GaAs have also the advantage of flexibility, color adjustment as needed, the diversity of shape in which they can be manufactured and the low weight. These advantages are applicable in many fields, the most commonly used being in the aerospace industry.

The thermal factor is not a decisive one for this type of photovoltaic cells. Unlike the structures made of Silicon, which at a temperature of $200^{\circ}C$, no longer produce electricity, GaAs, at a temperature of $250^{\circ}C$, operates in nominal parameters. However, used in an environment where humidity predominates, the external factor (water droplets) reduces the photon absorption surface, the efficiency is diminished and the electric current produced has lower values.

The only disadvantage of GaAs photovoltaic cells is the high price of the manufacturing process, surpassing many other similar structures. Nevertheless, the performance and the multitude of areas in which they can be applied tilts the balance in a favorable way.

The wafer has 4-6 inches in diameter, compared to the silicon wafer, which has 10-12 inches. The harmful characteristics of arsenides require additional safety methods during the production, leading to additional costs.

Regarding the energy calculation, for example, a cell that is part of a photovoltaic structure assembly, having 150W, will have 100W energy power. On the other hand, the fragility detected during the production process is a major disadvantage compared to silicon photovoltaic cells.

Production techniques require high-performance automated equipment, capable of manufacturing a large number of proper cells, concurrent to the number of scraps resulting from a batch. Currently, GaAs solar cells have shown good performance in the efficiency of solar energy conversion, compared to other known types of similar structures.

The most commonly used material in the manufacturing technology of thin-film photovoltaic cells is Cadmium tellurium (CdTe). In the early 1980s, in the beginnings of using sollar structures, the efficiency was about 10%, percentage shown in applications. By implementing new improvements, like using a glass layer with better transparency, increasing the transparency level of the oxide layer, using a high-resistance and transparent film with CdS junction, raising the temperature used in applications and at the same time, by implementing new doping and treatment technologies, this type of energy producing structure has proven to be up 16% more efficient in the 2000s.

Cadmium tellurium is looked up in the photovoltaic production industry, despite the disadvantages of limited life cycles, radioactive emissions from heavy metals used in the manufacturing process. This technology is limited by the ability of tellurium to form chemical compounds, feature needed to obtain photovoltaic cells. However, it has its benefits, such as the lack of carbon emissions and the possibility of using electronic equipment in systems that cannot be connected to a power supply.

Cheap large-area placing methods can be developed to produce high-efficiency devices, and monolithic integration methods would reduce the cost of module manufacturing.

Achieving many of these upgrades, CdTe, is today the most successful structure used globally, about 5-6% of the total market. CdTe photovoltaic cells have a valence band of 1.5V and a high absorption coefficient. For three decades, R&D researchers worked on a cell of this type, whose efficiency increased up to 10%, by using a thin printed film, reducing the immediate space and by applying the electrodeposition technique.

A technical team of NASA's Research Department focused on developing an independent system, satellites being their starting point. In this regard, they planned to use the satellites' energy consumption and provide it with a photovoltaic cell.

CONCLUSION

As we now know, by using photovoltaic structures and conducting countless tests, scientists concluded that GaAs and CdTe photovoltaic cells were efficient for future applications.

Taking into account the aerodynamics of an aircraft, the wing (the largest surface of an aircraft exposed to sunlight) must have certain characteristics, including elasticity, in order to achieve a load-bearing structure.

Considering the aspects shown before, the main features of CdTe and GaAs cells, that support their use in aero-space applications, are elasticity, low weight and high efficiency, offering the possibility of full assembly on the entire surface of the wing, thus resulting its considerable performance.

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