

Hybrid Solar Generating Module Development for High-Efficiency solar Energy Station

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ABSTRACT

Experimentally established, the influence of the working temperature and solar radiation power on the efficiency of industrial production silicon solar cells. Based on the experimental results designed the concept of a hybrid solar generating module equipped with a mirror concentrator of solar radiation and solar cells cooling system for using in high-performance solar energy station. Concentrator of solar radiation provides in 1.5-time increase of electrical power generating by such module, and water-cooling system can reduce the equilibrium temperature of the module up to 10 degrees and twice reduce efficiency losses from solar cells overheating. The proposed concept will reduce the number of modules needed to build solar energy station.

Keyword Silicon solar cells, Working temperature, Efficiency, Diode and output parameters, Cooling system, Concentration.

1.INTRODUCTION

Now by increasing the efficiency of industrial production monocrystalline silicon solar cells (Si-SC) up to 17-18 % while significantly reducing their cost Chinese manufacturers were the largest exporters of photovoltaic products in the world. A significant part of the manufacturers engaged in industrial production of solar modules, using Chinese-made solar cells. In addition, the largest segment of the market of imported solar modules also is occupied by Chinese manufacturers. For selling solar cells Chinese manufacturers in addition to efficiency and output parameters indicate the open circuit voltage (UOC), short-circuit current density (JSC), the fill factor (FF) of the illuminated current-voltage characteristic (CVC) which are measured at room temperature 25 °C. However, during Si-SC working, according to the efficiency value only a small part of solar energy using to generate electricity. The majority of solar radiation has converted to heat in the device structure. This leads to an increase of Si-SC working temperature, which reduces their efficiency. In a significant amount of research works have been analysed the influence of temperature on the efficiency of monocrystalline Si-SC, which are produced in European countries and Russia. Thus, established physical mechanisms lead to lower efficiency. At the same time, similar studies of Chinese production Si-SC with a few exceptions was not carried out. Now a popular option for increasing a power of solar energy stations is the equipment of solar generating module (SGM) by low solar concentration system. Using low-concentration of solar radiation is economically justified. The equipment of photovoltaic modules, by concentrators single or double-sided flat focline type with the degree of concentration up to 2, which is optimal for solar cells of conventional design based on single-crystal silicon allows to twice reduce the number of used solar cells.

2.LITERATURE SURVEY

Solar energy is an unlimited natural resource that needs to be optimized amidst today's big problem on sustainable living and inhabitation. To utilize the energy from the sun, technologies on solar panels were innovated to maximize harnessing this resource. However, modern solar cells can only transform 15-20% of the input power to output, making it not efficient enough to handle larger power consumption. With this problem on hand, the return of investment rate on solar system technologies is quite low. This leads to numerous researches on increasing the efficiency of the energy conversion capabilities of solar cells. From these evaluations,

researches on improving the efficiency of solar cells were done. A lightweight space solar cells were developed to increase solar panel energy efficiency to 30%. The technology used and designed a lattice-matched triple junction space solar cell product for a high efficiency. This was done by concentrating the development on harnessing the radiation from the sun. Improvement on this innovation was highly contributed by the highly transparent tunnel diode that uses higher bandgap materials for increasing the number of photons absorbed in the middle cell to increase the current on the middle sub-cell. A hybrid solar generating module was developed for increasing the efficiency of a solar energy station. The study came up with selected monocrystalline characteristic values for efficiency, which summed up the maximum, minimum, and average values of the device. Aside from increasing the efficiency of solar cells, mechanical methods were used to maximize the ability of solar panels to obtain solar energy. One of these is the implementation of solar trackers. Several studies on solar trackers were conducted to further increase the efficiency of solar panels. A low-cost solar tracker for increasing the output power and efficiency by implementing a Concentrator Photovoltaic (CPV). The CPV is used for the incident sunlight on the solar panel to focus and be guided by some optical element to produce high intensity beam concentrated directly on the solar cell. An autonomous solar power plant with dual-axis solar tracker was modelled through a simulation. The PV station includes statically and dynamically located solar modules with a total power of 800 Watts. The model was done through MATLAB Simulink which yielded an effective sun tracking system. An Internet-of-Things-based solar tracker was also designed which logs the collected data to the cloud and a GPS-based solar tracker system for a vertical solar still. The related studies provided prove the significance of researches that would contribute to improving the solar systems' efficiency. The studies concluded with being able to increase the harnessing performance of solar technologies. However, most of the applications are industry-based. The proposed study focuses on applications for an educational module. This module is easily customizable and adjustable for students to be able to have a wide range of experimental activities and results. From these experiments, more solar technology innovations can be derived and produced. The solar tracker developed was not only able to increase the system's efficiency, but it was also proved to be low-cost and portable, which makes it significant as a tool for further solar system researches.

3. WORKING PRINCIPAL

According to the equivalent Si-SC circuit quantitative characteristics of photovoltaic processes that occur in such device structures are diode characteristics: density of the photocurrent (J_{ph}), the diode saturation current density (J_0), the coefficient of diode ideality (A), series resistance (R_s) and shunt resistance (R_{sh}), calculated per unit area of SC. By the analyzing the literature, it can be shown that with increasing J_f , R_{sh} , and with decreasing J_0 , A , R_s increases the efficiency of solar cells. The photocurrent density, which quantifies the effectiveness of nonequilibrium charge carriers generation and diffusion processes, determined by the number of photons arriving to the base layer, a quantum yield of the photoelectric effect and the of nonequilibrium charge carriers lifetime in the base layer. The values of the ideality coefficient and density of diode saturation current, which quantitatively characterize the efficiency of the of nonequilibrium charge carriers separation in Si-SC, controlled by the recombination speed in the space charge area and the energy structure of the separation barrier. Shunt resistance is included in the equivalent circuit of solar cells in order to take into account the influence on the efficiency photovoltaic processes of low resistivity local parts of the device structure and the end surfaces. The series resistance of solar cells, the amount of which determines the nonequilibrium charge carriers collection efficiency depends on the electrical conductivity of the base Si-SC layer, the contact resistance and the recombination speed of nonequilibrium charge carriers on the back and front contacts. In this work calculation of output and diode parameters For investigated SC was carried out using the developed analytical processing program based on an approximation of the experimental illuminated CVC by the theoretical expression from. Illuminated CVC Si-SC measured by the loaded method during Illumination SC by the solar radiation simulator for terrestrial conditions with the light power up to 100 mW/cm². Measuring scheme, which has shown in Fig. 1a, as a source of simulating solar radiation includes LED Illuminator with microcontroller control. The variable load resistance having six decades with the corresponding resistance values, which allows precisely vary value when measuring the CVC in the range from 0.01 up to 1000 Ohm. Registering of voltage value on load resistance has carried out by digital multimeter Mastech MS8226 DMM. Measuring scheme for investigated loaded current-voltage characteristics and the appearance of the LED illuminator (b), the inset shows the location of the LEDs on the radiating element. 1 – LED Illuminator; 2 – investigated Si-SC; 3 – variable load resistance; 4 – multimeter to measure the voltage on the load resistance standard Si-SC having a known value of the shortcircuit current, and place it near the investigated Si-SC. By changing, the distance between the Si-SC and LED illuminator emitting element achieved the compliance with the actual value of I_{sc} for standard Si-SC to its value at 100 mW/cm² irradiance power, after that investigated Si-SC has been connected to the measuring circuit.

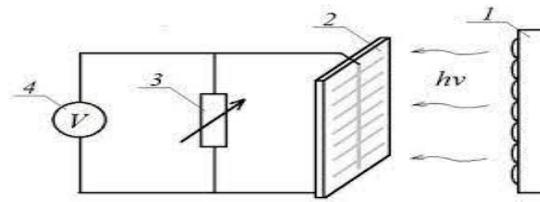


Figure 1. Block diagram of Hybrid solar system



Figure 2. Hybrid Solar System

4.RESULT

The study of working temperature influence on the efficiency of Chinese production silicon solar cells is shown that with increasing working temperature reduction of efficiency is 0,07 %/°C, that is significantly higher than in the device structures of European and Russian production and a due to the unconventional decrease of short circuit current density. By the computer modeling of the quantitative influence of diode parameters on efficiency has been shown that Chinese production Si-SC efficiency decrease is due to not only by the growth of the traditional diode saturation current density, but also a decrease of shunt resistance. Identified temperature dependence of efficiency shows the feasibility of using Chinese production Si-SC in the construction of photovoltaic thermal system, which together with the heat pump is part of a combined system for hot water supply, heating and air conditioning. Based on a detailed analysis of the working temperature influence on the efficiency of photovoltaic processes that determine the solar cells work, it was proposed the optimal construction and technological solution hybrid solar generated module, the main feature of which is the heat exchange block, designed to reduce the HSGM working temperature.

5.REFERENCES

1. P Singh, S N Singh and M. Lal, "Temperature dependence of I-V characteristics and performance parameters of silicon solar cell", *Solar Energy Materials & Solar Cells*, vol. 92, pp. 1611-1616, 2008.
2. E. Radziemska, "Effect of temperature on dark current characteristics of silicon solar cells and diodes", *International Journal Energy Res.*, vol. 30, no. 2, pp. 127-134, 2006.
3. H.J. Möller, *Semiconductors for solar cells*, Boston: Artech House, 1993.
4. V.P. Afanasyev, E.I. Terukov and A.A. Scherchenko, *Thin film solar cells on the silicon base. Publ. SPbSETU: LETI*, 2012.
5. E. Radziemska, *Int. J. Energy Res.* 30 No 2, 127 (2006).
6. W. Cai, F. Chao, T. Jin Long, L. De Xiong, H. Si Fu, X. Zhi Gang, *Physics, Mechanics & Astronomy* 55 No 2, 235 (2012).
7. H.J. Möller, *Semiconductors for solar cells* (Boston: Artech House: 1993).
8. V.P. Afanasyev, E.I. Terukov, A.A. Scherchenko, *Thin film solar cells on the silicon base* (Publ. SPbSETU: LETI: 2012.)