Journal of Physical and Theoretical Chemistry
of Islamic Azad University of Iran, 18 (3) 55-64: Fall 2021
(J. Phys. Theor. Chem. IAU Iran)
ISSN 1735-2126

A Study of Highly-Efficient Quantum Dot based Solar Cells

Ali Mahmoudloo *

Department of Basic Science, Farhangian University, Tehran. Iran

Received April 2022; Accepted November 2022

ABSTRACT

Quantum dots are tiny particles of semi-conductors that are easy and cheap to produce and can be used in solar cells to conduct the electrons [1]. The development of this technology has shown much promise not only at converting the sun's energy more efficiently, but also by doing it in a more cost-effective manner. Quantum dots have the potential to greatly improve solar technology and make solar energy a more viable option as an energy source. The main objective of the paper is to explain the processes, applications and advantages of quantum dots in solar cells. The cost-effectiveness, versatility and efficiency of the quantum dot technology will be emphasized in this paper. The paper will begin by discussing the need for alternative fuel sources, which will be investigated by evaluating the pros and cons of existing solar technologies. Then it will continue by explaining the technology of quantum dots and their use in solar cells. It will also explore the advantages and drawbacks of using quantum dots along with the ethical concerns that come with any new technology.

Keywords: Nanotechnology, Photovoltaic Cells, Quantum Dots, Solar Cells

AN UNLIMITED SOURSE OF ENERGY: SOLAR POWER

"The world's population is expected to grow by over fifty percent over the next four decades, and with it, the need for fuel [2]". The primary source of energy in the United States, today, is through the burning of fossil fuels, which are in finite supply. The United States needs to turn to a more renewable and longer-lasting source, the sun. The sun's rays gives off about one thousand watts of energy per square meter of Earth [3]. The sun is a great source of energy that is almost always available and will is never decreasing in supply. Developing ways to harness all the sun's energy could supply enough energy to power cities. Many concerns arise, when turning to new ideas, but solar energy has many advantages.

One of the most important reasons for using solar energy as an alternative is that it is clean energy. When burned, fossil fuels create greenhouse gases, which have

*Corresponding author: mahmodlou_ali@yahoo.com

been proven to be harmful to the environment and have been connected to global climate change. The further use of fossil fuels, such as coal, oil and gasoline, only contribute to the pollution of the environment. According to the U.S. Department of Energy, the annual amount of carbon dioxide offset by a two and a half kilo-Watt rooftop residential solar electric system is equal to that emitted by a typical family car during that same year [4]. Not only is solar energy cleaner and renewable, it also is beginning to be produced cheaply. Solar energy costs have decreased so much that the solar industry says they can produce energy at competitive prices with fossil fuels [5]. Although solar energy is only used to produce about 1.22% of the United States electricity needs, it is still a promising energy source [5]. Solar energy is a good and much needed alternative to the present reliance on fossil fuels for energy. It is a source of energy that has been thoroughly researched and is continually developing. Through the use of nanotechnology, solar cells are being revolutionized. This third generation of solar cells is the future of low cost and high efficiency solar energy and will hopefully mark the end of nonrenewable sources of energy.

CONVERTING PHOTONS TO ELECTRONS

Solar energy can be captured in a variety of ways, but the technology that is most commonly used today is photovoltaic cells. Photovoltaic cells are the direct conversion of light photons into electricity at the atomic level [6]. These photovoltaic cells were first built by Bell Labs in 1954, where they were then used aboard space craft as a source of power in the 1960s. Their use in space craft helped to establish them as a reliable technology and a legitimate energy harvester. In the 1970s, during the energy crisis, solar cells, more specifically photovoltaic solar cells, began to gain recognition as sources of energy production for commercial and residential use [6]. From then on, solar cells have been researched, developed and used as a source of energy across the United States and the world.

Photovoltaic describes exactly what it does, ‘photo’ meaning light and ‘voltaic’ meaning electricity. Photovoltaic cells, also called PV cells, utilize special materials, called semiconductors, that have the ability to release electrons when light energy, or photons, hits their surface [3]. When the light energy hits the semiconductor material, it knocks the electrons loose from the outer shell of the atom causing them to flow throughout the material. In addition to the semiconducting material, there is also an electric field present in the cell that forces the freed electrons to flow in a certain direction. This flow of electrons caused by the electric field is called a current [3]. When metal is placed on either end of the electric field, the current of electrons can be drawn off the material and used as electricity for external consumption. There are several different types of semiconducting materials that are used in solar cells, among them is gallium arsenide and cadmium telluride [6]. All of these materials are effective, but the most commonly used is silicon.

SILICON: THE BASIS OF PV CELLS

Silicon makes a very good semiconductor because of its unique chemical properties. Silicon has fourteen electrons total and four electrons in its outer-most shell, which means that it is always looking to fill its shell as it’s only half full. Therefore, it likes to bond with four nearby atoms to share electrons and obtain a full outer shell, creating a crystalline structure [3]. Pure silicon itself is a poor conductor since it is difficult to break the bonds because they are not free to move around, but when impurities are added, it becomes a much better conductor.

These impurities, which are different atoms that are purposely mixed in with the silicon atoms, are used in silicon solar cells over pure silicon. In silicon, two types of impurities are used in order to optimize the efficiency of the solar cell [3]. The first impurity used is phosphorous. A phosphorous atom has five electrons in its outer-most shell, which doesn't allow it to completely bond with the neighboring silicon atoms and leaves one electron out of place. When light energy hits this impure material, the one 'extra' electron from phosphorous is easily released, using less energy than needed for pure silicon [3]. The addition of impurities to a material is called doping. When phosphorous is added to silicon, it is called N-type doping. This concept is illustrated in figure 1 with the element antimony (Sb). Antimony enhances silicon in a very similar way that phosphorus enhances silicon. N-type doping is when impurities are added that cause an increase of free electrons compared to what the pure material could produce, which is what occurs when phosphorous is added to silicon [3]. Not only is phosphorous used to enhance the properties of silicon, but the element boron also has the capability to enhance the properties of silicon.

Boron is the second type of impurity used to enhance the chemical properties of silicon. Boron only has three electrons in its outer-most shell, instead of four electrons, so it has an opening that carries a positive charge. The addition of boron to silicon is called P-type doping. This concept is also demonstrated in figure 1. P-type doping creates a hole in the material that attracts the free electrons created by the N-type doping [3]. When the N-type silicon materials and P-type silicon materials come into contact with each other an electric field forms, which is critical for the production of a current through the cell.

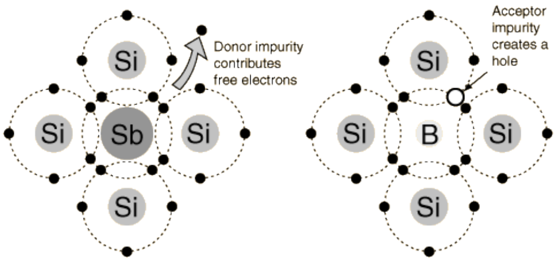

FIGURE 1 [7]
P-TYPE AND N-TYPE

At the intersection point, or junction, the electric field that is formed controls the flow of electrons. This electric field acts as a diode, or semiconductor device with two terminals, which only allows the electrons to flow in one direction, from the P-side to the N-side. This flow of electrons creates a current, and the electric field causes a voltage [3]. The product of these two things is what determines the power of the cell and how much electricity will be produced from it. These basic concepts of the structure of solar cells can be used for a variety of semiconducting materials [6]. The structure of a solar cell is depicted in figure 2. In addition to the complex array of conductors of the silicon solar cell, a few more components are added to improve the efficiency and durability of the solar cell.

Silicon is a shiny material, which causes it to reflect light instead of absorbing photons. To eliminate this property, an antireflective coating is applied to the solar cell. This coating allows for light photons to be absorbed into the silicon in order to excite electrons [3]. Another external component of a silicon photovoltaic solar cell is the glass cover plate. This plate protects the cell from the environmental elements and helps to increase the lifespan of a solar cell. These two components are crucial to the functionality and durability of a silicon photovoltaic solar cell [3].

Silicon is the most commonly used type of semiconducting material today; however it is no longer the most efficient solar cell. New technologies, such as quantum dot solar cells, are being researched and developed that are more efficient and cost-effective than the traditional silicon solar cells.

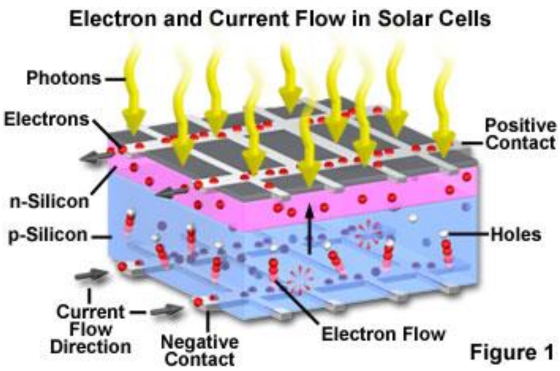

Figure 2 [8]
SOLAR CELL DIAGRAM

NANOTECHNOLOGY IN SOLAR CELLS

The nanotechnology of quantum dots is being incorporated into solar cells to make them ultra-efficient energy generators. Nanotechnology is the concept of building systems on the molecular scale, which are only a few nanometers in size [9]. To give prospective, there are one million nanometers in one meter, so nanotechnology is created at the microscopic scale. Quantum dots, a type of nanotechnology, are tiny crystal compounds that are a few nanometers in size and hold several special semiconductor properties. These nanoparticles, ranging in size from one nanometer to twenty nanometers, are typically made out of compounds such as titanium oxide and zinc oxide [10]. There are different ways in which quantum dots are integrated into solar cells.

One type of quantum dot solar cell is called dye-sensitized solar cells. Dye-sensitized solar cells are a low cost type of photovoltaic cells with a different structure that incorporates quantum dots in order to improve the efficiency [11]. The structure of this solar cell is very similar to that of a silicon solar cell, but it differs in two crucial ways. In a silicon solar cell, the silicon acts not only as a charge producer but as a transporter as well. In the dye-sensitized solar cell, the quantum dot semiconductor is only in charge of carrying the current to the electrode. The charges are provided by the photosensitive dye inside the solar cell. The semiconductor quantum dots are typically made out of titanium oxide or zinc oxide [11]. A diagram of a quantum dot dye-sensitized solar cell is depicted in figure 3. In the figure the quantum dots are referred to as titanium nanoparticles, they carry the current in the cell.

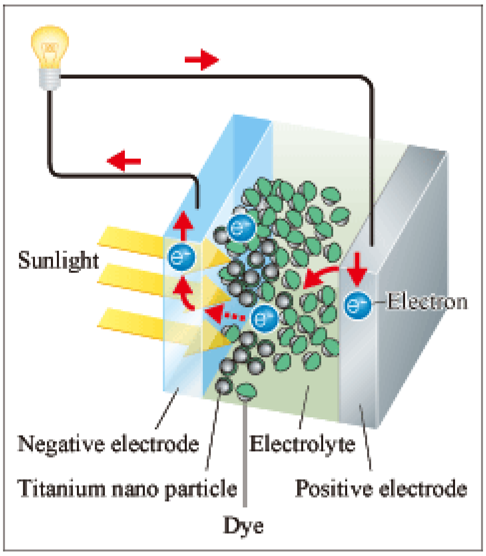

Figure 3 [12]
DYE-SENSITIZED SOLAR CELL

This dye-sensitized solar cell has an efficiency of roughly eleven percent, meaning that there is still plenty of room for improvement [11]. The efficiency of this cell is due to the specific combination of the semiconducting dye and the quantum dot. A suitable matching of substances that have similar qualities allows for the buildup of electrons and holes in two separate particles, which in turn allows enough time to capture the charge carriers at the surface [13]. This process allows for a steady flow of large quantities of charge, which leads to an increase in the efficiency. This is only one type of solar cell, in which quantum dot technology is utilized. Another type of quantum dot solar cell that holds much promise is a structure that utilizes the theory of multiple electron generation.

In 2011, the U.S. Department of National Renewable Energy Laboratory (NREL) designed a new device that incorporated the concept of multiple electron generation and was able to produce very efficient cells [14]. Multiple electron generation is when a single absorbed photon of high energy has the ability to release more than one electron from the cell. This process increases the efficiency of a solar cell because it allows for more electrons to be produced and as a result produces a higher current in the cell [14]. This cell was created with a thin layer of a nanostructured zinc oxide, with a quantum dot layer of lead selenide and a thin layer of gold to act as an electrode. This solar cell design has received considerable attention for its quantum efficiency of greater than one hundred percent, which is much higher than conventional silicon solar cells and all other quantum dot solar cells researched where the efficiency was closer to ten percent [14]. The high efficiency of this solar design comes from a combination of the multiple electron generation concept and the unique quantum qualities of quantum dots.

Another concept of solar cell technology that employs quantum dots is the concept of ‘energy transfer’ solar cells. While this concept is only in the exploratory stages at the Los Alamos National Laboratory, it already shows much promise. Quantum dots have the ability to absorb different wavelengths of life depending on the size of the quantum dot. In this ‘energy-transfer’ solar cell, layers of sequentially larger quantum dots are put in the cell [15]. The top layer, which is also the smallest in size, absorbs a wavelength of light and frees an electron, or exciton. The free electron travels to the larger quantum dot and then to the p-n junction. At the junction, the electric field moves the current to produce electricity. The varying sizes of quantum dots would absorb different wavelengths of light, allowing for more light to be produced. This concept is illustrated in figure 4.

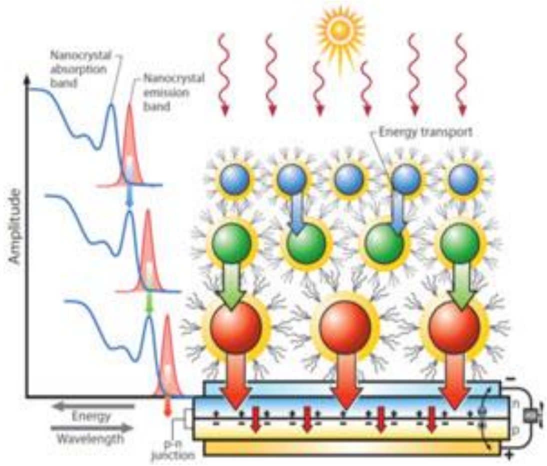

Figure 4 [15]
CONCEPT OF ENERGY TRANSER

This process avoids charge hopping and forces the charges on a steady path to the junction, which increases the efficiency of the cell [15]. While there are many ways quantum dots can be incorporated into a solar cell that will increase the efficiency of the cell, quantum dots also have many other beneficial values.

ADVANTAGES OF QUANTUM DOTS

The next generation of solar cells being researched is focused on efficiency and low cost with quantum dots being the primary point of interest. Quantum dots are the main focus for next generation research because of their unique quantum properties and ability to cover both goals of the next generation of solar cells. The quantum dots are cost-effective in two respects. First, they can be produced rather inexpensively and second, they produce more energy. They can be mass produced through high-throughput roll-to-roll manufacturing, which ends up lowering the cost of quantum dots [14]. Through multiple electron generation, more electricity can be produced for every photon of light, which leads to the contribution of cost-effectiveness [1]. Quantum dots are not only cost-effective, but due to their unique quantum properties, they are also versatile, highly-efficient in conducting an electrical current, and are an ethical option for the next generation of solar cells.

EFFICIENCY

The efficiency of a solar cell is defined as the amount of power of a solar cell turned into electricity from the amount of power that is received from the sun [3]. This relationship can be determined by the equation one. [16]

$$\eta_{PV} = \frac{I_{MP} \times V_{MP}}{P_{sun}} \quad (1)$$

η_{PV} is the solar cell power efficiency. I_{MP} and V_{MP} are the current and the voltage produced by the electric field in the solar cell. These variables make up the power generated by a solar cell. P_{sun} is defined as the power available to the solar cell from the sun. Using this equation, the efficiency of any kind of solar cell can be determined. The average efficiency of a conventional silicon solar cell is capped at around thirty-two percent [13]. The efficiency of a silicon solar cell is limited because of its stationary band gap, which can be explained through an understanding of the electromagnetic spectrum.

The electromagnetic spectrum is the range of all possible wavelengths of electromagnetic radiation, which spans from infrared light, to the visible spectrum, to ultra-violet light. Each wavelength corresponds to a different amount of energy. When photons of light of varying energies enter a cell, a specific amount of energy is required to excite the electron from a static position into a position where it can be conductive [17]. The specific amount of energy that is required to excite the electron is called the band gap energy. If a photon has too much energy, the excess energy will be lost as heat, and if there is not enough energy, the photon passes through without getting absorbed. Silicon solar cells can only capture energy from light photons from the visible spectrum of the electromagnetic spectrum because the silicon solar cell band gap is rigid [3]. This contrasts one of the many benefits of quantum dots, because quantum dots have the ability to adjust their band gap enabling quantum dots to absorb varying wavelengths.

The tunable band gaps of quantum dots, comes from their extremely small size. Due to the special qualities that arise from the quantum dot’s small size and quantum physics, varying the size of the nanoparticles, the band gap will be adjusted. As the size of the quantum dot decreases, there is an increase in the band gap energy required and vice versa for increasing size [14]. This varying band gap enables solar cells to absorb a broader range of light photons and as a result utilize a broader range of the spectrum, absorbing more energy. Furthermore, the tunable band gap, allows more electrons to be generated per photon of light, which is the concept of multiple electron generation. In a recent study done by TU Delft, they found that in quantum dot films exposed to photons of light, about three and a half electrons could be produced per photon of light absorbed [18]. The combination of tunable band gap and the concept of multiple electron generation leads to an increased efficiency in solar cells utilizing quantum dots.

Through calculations, it has been concluded that in theory, using quantum dots could potentially increase the efficiency of solar cells by forty-four percent [18]. While this has yet to be accurately reflected in solar cells devices out on the market, there are great strides that are being taken in the lab. The solar cell device designed by the National Renewable Energy Lab was a significant development for next generation solar cells because it had the ability to produce a photocurrent with external quantum efficiency greater than one hundred percent when excited with high energy photons [13]. External quantum efficiency is defined as the number of electrons flowing per second in the internal circuit of the solar cell divided by the number of photons per second entering the cell [14]. This ratio is determined through equation two where *IPCE%* is the external quantum efficiency variable.

$$IPCE\% = \frac{1240 \times J_{shortcircut}\left(\frac{A}{cm^2}\right)}{\lambda(nm)\times I_{incident}\left(\frac{W}{cm^2}\right)} \times 100\% \qquad (2)$$

$J_{shortcircut}$ is the photocurrent of the short circuit within the solar cell at a monitored wavelength, λ, measured in nanometers. The $I_{incident}$ is power from the light photon being absorbed by the solar cell. With a quantum efficiency of over one hundred percent, this means that multiple electrons were produced per photon of light, illustrating the concept of multiple electron generation. In many quantum dot solar cell devices, the concept of multiple electron generation occurs because the charges are confined to the small volumes of the nanoparticles. This confinement allows for the harvesting of excess energy within the cell, and forces the electrons to flow in the designated current [14]. This device has yet to be applied to a commercial device, but there is strong evidence that the integration of these concepts could greatly improve solar cells [14]. The efficiency of quantum dot solar cells is one way in which quantum dots are an appealing option for future solar cells, but the versatility of quantum dots also adds to the appeal.

CONCLUSION

One major advantage of quantum dots is the fact that they are very versatile. Their versatility makes it easier to apply them to a broad range of applications and devices. Quantum dots can be molded into a variety of different forms, including sheets and three-dimensional arrays, in contrast to many other semiconducting materials [1]. In three-dimensional arrays, the excitons, or free electrons, last longer because the form creates a stronger electronic coupling between the quantum dots. In this form there is a stronger electronic coupling due to the atoms being closely-packed together, which leads to an increase in the attraction between molecules. This array allows for electricity to be generated at high voltage and as well as for the absorption of a single photon to generate multiple free electrons [1]. Quantum dots can also be easily combined with organic polymers, dyes or porous films. In the colloidal form, or dissolved in a solution, quantum dots can be processed to create junctions on inexpensive plastics, glass, or metal sheets. For example, quantum dots can now be sprayed on flexible surfaces such as plastics because of their small size. These processed quantum dots end up making the production of solar cells less expensive [1].

Ted Sargent, a professor of nanotechnology at the University of Toronto, worked closely with the project that discovered how to shrink the wrapper that encapsulates quantum dots down to the smallest size possible. He utilized inorganic ligands, instead of organic molecules to cap quantum dots and take up less space [19]. The ideal design is one that tightly packs the quantum dots because the greater the distance between them the lower the efficiency. The organic molecules that have previously capped quantum dots create a separation of the nanoparticles by one nanometer, which is a long distance for an electron to travel on the nanoscale. With using the inorganic ligands, the combination of close packing and charge trap (the locations where electrons get stuck) elimination enables the electrons to travel quickly and smoothly, which as a result makes them more efficient [19]. In addition to the use of inorganic ligands to bind quantum dots together, another solar technology has developed that illustrates the versatility of quantum dots.

A new type of solar cell has been researched and developed at the University of Notre Dame called ‘solar paint’. When the solar paint is applied to any conductive surface, it is able to convert photons of light into electrical currents. The paint is made up of nanoparticles of titanium oxide coated in a film of calcium sulfide. These nanocompounds are then suspended in a mixture of water and alcohol to form a thick paste [20]. This paste, when brushed onto the conducting material, can then generate electricity. Its current efficiency is at about one percent, which is well below the efficiency of a conventional silicon solar cell, but if it is improved could prove to be very useful. Another benefit of this solar paint is that it can be made cheaply and in large quantities [20]. This concept, although it is still in its infancy, has the potential to be a versatile solar cell technology, turning any large surface into a solar cell. Not only are quantum dots versatile in solar cell applications, but they can also be applied in health technologies as well.

For example, quantum dots have been used in probes for detection of breast cancer. Human epidermal growth factor receptor two detection is important for breast cancer treatment and prognosis. However, the current detection methods that are used have some shortcomings. In clinical practice “quantum dots based probes provide a potentially important new method for human epidermal growth factor receptor two detection” [22]. The excellent photo-physical properties of quantum dots have allowed researchers to achieve promising developments in the cancer research field.

A quantum dot human epidermal growth factor receptor two probe kit, image acquisition, and analysis software was applied to ninety-four clinical samples of breast cancer. As a result, the method proved to be superior, more accurate, and sensitive when compared to current immunohistochemistry detection techniques that are used in clinical breast cancer diagnosis [22]. The exceptional optical properties of quantum dots not only allow accurate determination of low levels of human epidermal growth factor receptor two expressions, but also overcome the limitations associated with tissue autofluorescence [22]. Quantum dots have been shown to be beneficial in technologies beyond energy production.

Quantum dots have the potential to make a difference all over the world in many different ways. Since quantum dots are so adaptable they can be combined and consumed in order to to make energy efficient or create life altering technologies that will ultimately change the world in some way. The versatility of quantum dots, along with the cost-effectiveness and the improved efficiency makes this technology an ethical option.

REFERENCES

[1] M. Ho (2006, Jan. 19). "Quantum Dots and Ultra-Efficient Solar Cells?" Institute of Science in Society. [Online Article]. Available: http://www.i-sis.org.uk/QDAUESC.php

[2] (2011, Dec. 29). "Oil and Gasoline" *The New York Times.* [Online Article]. Available: http://topics.nytimes.com/top/news/business/energy-environment/oil-petroleum-and-gasoline/index.html

[3] J. Toothman, S. Aldous. "How Solar Cells Work." How Stuff Works. [Online Article]. Available: http://science.howstuffworks.com/environmental/energy/solar-cell10.htm

[4] (2003, Jan.). "Myths about Solar Energy" *The U.S. Department of Energy*. [Online Article]. Available: http://www1.eere.energy.gov/solar/pdfs/32529.pdf

[5] (2012, Jan. 27). "Solar Energy" *The New York Times*. [Online Article]. Available: http://topics.nytimes.com/top/news/business/energy-environment/solar-energy/index.html

[6] G. Knier. (2011, Apr. 6). "How do Photovoltaics Work?" *NASA Science.* [Online]. Available: http://www.science.nasa.gov/science-news/science-at-nasa/2002/solarcells/

[7] "The P and N Diode Junction". [Online Picture]. Available: http://smart-koala.com/writing/science/physics/10062101_pn_diode_characteristics.php

[8] M. Parry-Hill, R. Sutter, and M. Davidson. (2012) "Solar Cell Operation." Olympus Microscopy Resource Center. [Online Article]. Available: http://www.olympusmicro.com/primer/java/solarcell/index.html

[9] "What is Nanotechonlogy?" *Center for Responsible Nanotechnology.* [Online Website]. Available: http://www.crnano.org/whatis.htm

[10] M. LaMonica. (2011, Dec. 17). "Two for one: Quantum dot solar cells boost power". *CNET News*. [Online Article]. Available: http://news.cnet.com/8301-11386_3-57344421-76/two-for-one-quantum-dot-solar-cells-boost-power/

[11] S. Bent. (2011, Feb. 7). "Effects of Self-Assembled Monolayers on Solid-State CdS Quantum Dot Sensitized Solar Cells". American Chemical Society Nano. [Online Article]. Available: http://pubs.acs.org/doi/abs/10.1021/nn103371v#cor1

[12] "Next Generation Solar Cells with Low Production Costs". *Osaka Gas*. [Online Picutre]. Available: http://www.osakagas.co.jp/csr_e/charter02/energy.html

[13] P.Kamat. (2008, Oct. 17). "Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters" *American Chemical Society Publications.* [Online Article]. Available: http://pubs.acs.org/doi/full/10.1021/jp806791s#citing

[14] (2011, Dec. 15). "NREL Scientists Report First Solar Cell producing More Electrons in Photocurrent than Solar Photons entering the Cell". *National Renewable Energy Laboratory.* [Online Article]. Available: http://www.nrel.gov/news/press/2011/1667.html

[15] "Exploratory Devices". *Los Alamos National Laboratory.* [Online Article]. Available: http://quantumdot.lanl.gov/devices.shtml

[16] B. Hardin. (2010, April 21). "The Dye Sensitized Solar Cell." Slideshare. [Online Powerpoint]. Available: http://www.slideshare.net/swissnexSF/the-science-behind-dyesensitized-solar-cells
[17] R.Service. (2011, Dec. 15). "Solar Cells Capture Lost Energy". *Science NOW*. [Online Article]. Available: http://news.sciencemag.org/sciencenow/2011/12/solar-cells-capture-lost-energy.html
[18] (2011, Oct. 14) "Mobile Electrons Multiplied in Quantum Dot Films" *Science Daily*. [Online Article]. Available: http://www.sciencedaily.com/releases/2011/10/111014080041.htm
[19] (2011, Sep. 20). "In new solar cells, quantum dots get cozy". *Futurity*. [Online Article]. Available: http://www.futurity.org/top-stories/in-new-solar-cells-quantum-dots-get-cozy/
[20] (2011, Dec. 21). "Paint-On Solar Cells Developed". *Science Daily*. [Online Article]. Available: http://www.sciencedaily.com/releases/2011/12/111221211324.htm
[21] D. Anderson. "Solar Energy Benefits & Drawbacks". *National Geographic*. [Online Article]. Available: http://greenliving.nationalgeographic.com/solar-energy-benefits-drawbacks-2259.html
[22] C. Chen. (2009, May). "Quantum dots-based immonofluoresecence technology for the quantitative determination of HER2 expression in breast cancer" *Science Direct.* [Online Article]. Available: http://www.sciencedirect.com/science/article/pii/S014296129001550

مجله شیمی فیزیک و شیمی نظری
دانشگاه آزاد اسلامی واحد علوم و تحقیقات
جلد ۱۸، شماره ۳، پاییز ۱۴۰۰
ISSN ۱۷۳۵-۲۱۲۶

مطالعه سلول‌های خورشیدی مبتنی بر نقطه کوانتومی با بازده بالا

علی محمودلو *

استادیار گروه علوم پایه، دانشگاه فرهنگیان، تهران، ایران

چکیده

نقاط کوانتومی ذرات ریز نیم رساناهایی هستند که تولید آنها آسان و ارزان است و می‌توان از آنها در سلول‌های خورشیدی برای هدایت الکترون‌ها استفاده کرد. توسعه این فناوری نه تنها در تبدیل انرژی خورشیدی به طور کارآمدتر، بلکه مقرون به صرفه تر، نویدهای زیادی را نشان داده است. نقاط کوانتومی این پتانسیل را دارند که فناوری خورشیدی را تا حد زیادی بهبود بخشند و انرژی خورشیدی را به عنوان یک منبع انرژی به گزینه ای مناسب تر تبدیل کنند. هدف اصلی این مقاله توضیح فرآیندها، کاربردها و مزایای نقاط کوانتومی در سلول‌های خورشیدی است. مقرون به صرفه بودن، تطبیق پذیری و کارایی فناوری نقطه کوانتومی در این مقاله مورد تاکید قرار می‌گیرد. این مقاله با بحث در مورد نیاز به منابع سوخت جایگزین، که با ارزیابی مزایا و معایب فن‌آوری‌های خورشیدی موجود مورد بررسی قرار می‌گیرد، سپس با توضیح فناوری نقاط کوانتومی و کاربرد آنها در سلول‌های خورشیدی ادامه می‌یابد و همچنین در این مقاله مزایا و معایب استفاده از نقاط کوانتومی را به همراه نگرانی‌های اخلاقی ناشی از هر فناوری جدید مورد بررسی قرار می‌گیرد.

کلید واژه‌ها: نانوفناوری، سلول‌های فوتوولتاییک، نقااط کوانتومی، سلول‌های خورشیدی

* مسئول مکاتبات: mahmodlou_ali@yahoo.com