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# Using of Nanotechnology for Photovoltaic Solar Energy Cells

Hüseyin GÜLLÜCE

*Address: Department of Machine and Metal, Vocational College of Technical Sciences, Ataturk University, 25240, Erzurum, Turkey*

*E-mail: hgulluce@atauni.edu.tr*

**Abstract**

It is very important to obtain energy from renewable energy sources at this time when energy consumption is increasing rapidly and environmental pollution has reached significant dimensions. Solar energy is one of these sources. Recently used photovoltaic systems are very important in the supply of electrical energy.

The low efficiency of photovoltaic panels used to generate electricity is one of the most important disadvantages of these systems. The efficiency of photovoltaic cells is greatly affected by both the materials used to convert the incoming solar energy into electrical energy and the surface pollution. The use of nanomaterials has recently increased considerably to increase efficiency. Studies are carried out on self-cleaning materials in order to reduce the reflection of incoming rays and to ensure that the energy is selectively absorbed by the surface and to prevent surface pollution. Nanotechnology makes very important contributions to the design and production of thin-film PV cells. PV cells developed using nanomaterials will continue to reduce the cost of commercial solar cells using cheaper raw materials. Nanomaterials have some desirable properties such as high catalytic activity, better stability in aqueous media, relatively easier preparation techniques, and material economy.

In this study, information is given about nanomaterials used in photovoltaic cells and efficiency-enhancing studies in PV technology.

**Keywords:** solar nanotechnology, solar energy, photovoltaic, increased efficiency

## Introduction

The rapid increase in the world population and the rapid development of the industry are increasing the need for energy. The consumption of fossil fuels used to meet the world's energy needs both causes the depletion of these limited resources and increases environmental pollution due to harmful gas emissions to the environment. Due to the rapid increase in the world's atmospheric temperature, the Paris Agreement, which was accepted at the United Nations Framework Convention on Climate Change in December 2015 and to which our country is a party, guides the whole world in the transition to renewable energy on

a global scale (1). Renewable energy sources, whose investment costs are significantly reduced in order to limit fossil fuel consumption, are the most important alternative energy sources. Photovoltaic panels are the most commonly used product for converting solar energy into electricity. For this reason, a wide range of studies are carried out in the world to increase the efficiency of PV panels. For this purpose, one of the most studied subjects is nanomaterials.

**Nanotechnology used in PV cells**

Nanoparticles typically consist of solid particles with dimensions ranging from 1 to 100 nm. They have advanced thermo-physical properties such as viscosity, thermal conductivity, convective heat transfer coefficients and optical properties. Nanofluids are the process of obtaining a new heat transfer fluid by adding nanoparticles to heat transfer fluids. In Table 1, the thermal values of the widely used nanoparticles are given. Types of nanoparticles (2) are; Metals: Al, Ag, Fe, Cu, Zn,Au; Metal oxides: MgO, ZnO, CaO, CuO, $CuO_2$, $Al_2O_3$, $Fe_3O_4$, $TiO_2$, $SiO_2$, $Fe_2O_3$; Carbon based: Graphene, Fulleneres, Carbon nanotubes (SWCNT,MWCNT); Nanocomposites: Polymer matrix (polymer/CNT, Polyster/$TiO_2$), Ceramic matrix ($Al_2O_3$/SiC, $Al_2O_3$/$TiO_2$, $Al_2O_3$/CNT, $Al_2O_3$/$SiO_2$), Metal matrix (Ag-MgO, FeMgO, CoCr).

***Table 1-*** *Thermal values of commonly used nanoparticles*

| Solids | $k_{c(p)}$(W/mK) | Liquids | $k_{c(f)}$(W/mK) |
|---|---|---|---|
| **Silver** | 427 | **Water** | 0.613 |
| **Copper** | 395 | **Ethylene glycol** | 0.253 |
| **Aluminum** | 237 | **Engine oil** | 0.145 |
| **Carbon nanotubes** | 3200-3500 | **Alcohol** | 0.115 |
| **Brass** | 120 | **Glycerol** | 0.285 |
| **Nickel** | 91 | | |
| **Alumina** | 39 | | |

**Use of Nanoparticles in PV Cells**

Conventional solar cells have two main disadvantages. First, low efficiency is almost inevitable in silicon cells. This is because incoming photons or light must have the right energy, called band gap energy, to hit an electron. If the photon has less energy than the band gap energy, then it will pass. If it has more energy than the band gap, this extra energy will be wasted as heat. These two effects alone constitute the loss of approximately 70 percent of

the radiation energy incident in the cell. The second is the high production cost. Most of the nanoparticle atoms are usually on the surface. This means that the surface interactions nanoparticle property dominates the material behavior and they often have different properties from the same material. Nanostructured layers have three important advantages. First, due to multiple reflections, the effective optical path for absorption is much larger than the actual film thickness. Second, it allows electrons and holes produced by light to be transmitted via a much shorter path, thereby greatly reducing recombination losses. The absorber layer thickness in nanostructured solar cells can be as thin as 150 nm. Third, by varying the size of the nanoparticles, the energy band gap of the various layers can be made to the desired design value. Being able to use thin films requires much less material and reduces costs. (3).

In conventional solar cells, ultraviolet light is filtered or absorbed by silicon, converted into heat, not electricity. Integrating silicon nanoparticles in 1-nanometer size directly into silicon solar cells increased power performance by 60 percent in the ultraviolet range of the spectrum. Efficiency can be increased by increasing the amount of absorption according to the wavelength of the incoming light with various forms of nanoparticles.

**Nanofluid Applications in PV Cells**

In addition to the low efficiency of the PV system, the high ambient temperature also reduces the efficiency. Different nanofluids are used as refrigerants in order to increase the efficiency more and to increase the amount of electrical energy to be produced. In hybrid systems used to cool the panels with fluid, both electricity is produced and the heat obtained is used according to the need. In general, it is to increase efficiency thanks to the cooling process made with pipes placed under the PV panels. Various researches are carried out by changing the shape, diameter, material, type and amount of nanofluid passing through the cooling pipes. Different design shapes and usage are shown in Figure 1.

**Self-cleaning and anti-reflective nano coatings**

One of the most important factors affecting the efficiency of PV cells is rainy weather and sedimentary deposits on the surface of solar cells (4). Advances in technology and the

creation of nanometer layers with self-cleaning and anti-reflective properties are crucial. Titanium oxide nanoparticles, which can trap organic compounds such as hydrocarbons by blocking the ultraviolet wavelengths of sunlight, can keep solar cell surfaces clean by reducing fossil fuel emissions and preventing their pollution.

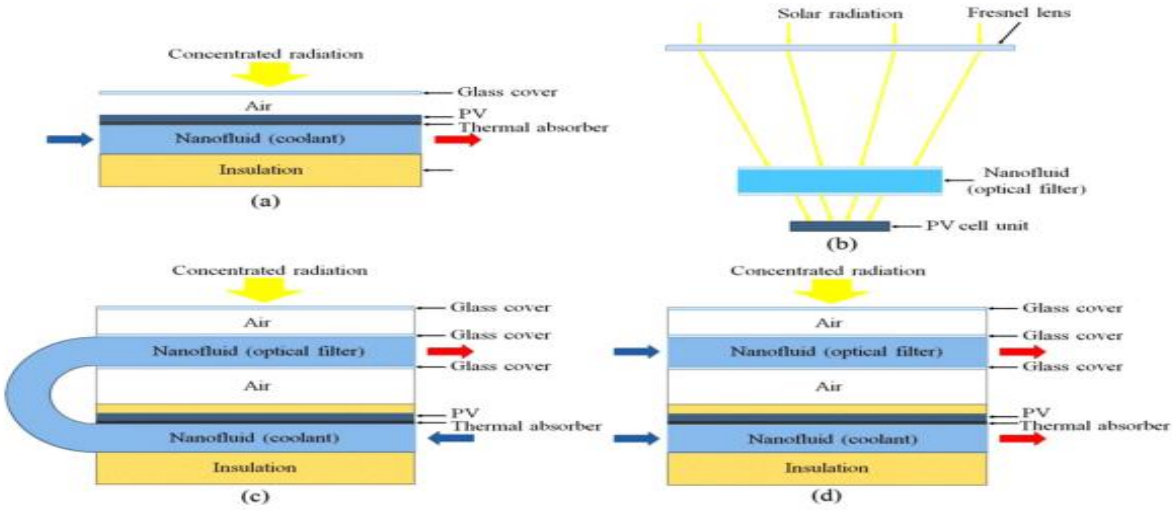



***Figure 1-*** *Schematic diagram, cooling of PV cell with nanofluid, using nanofluid as an optical filter, using* nanofluid *as both optical filter and cooler, using nanofluid as both optical filter and cooler with separate channels (5).*

## Results and Discussion

In our country and the world, which has very important values in terms of sunbathing time, the low efficiency of photovoltaic panels used to generate electricity from the sun causes the energy unit cost to increase and the recovery times of the investments made to be long. Studies show that nanomaterials will cause both increased material efficiency and reduced production costs. Therefore, in order to produce different green, cheap and commercially usable materials and systems, studies should be increased and continued.

## References

1. About the Future: Paris Climate Agreement. 2021; Available from: https://www.avrupa.info.tr/sites/default/files/2016-08/brochure_4_v2.pdf.
2. Alktranee M, Bencs P. Applications of nanotechnology with hybrid photovoltaic/thermal systems: A review. Journal of Applied Engineering Science. 2021;19(2):292-306.
3. Sethi V, Pandey M, Shukla MP. Use of nanotechnology in solar PV cell. International journal of chemical engineering and applications. 2011;2(2):77.
4. Walker A. Solar energy: technologies and project delivery for buildings: John Wiley & Sons; 2013.
5. Zhao J, Song Y, Lam W-H, Liu W, Liu Y, Zhang Y, et al. Solar radiation transfer and performance analysis of an optimum photovoltaic/thermal system. Energy Conversion and Management. 2011;52(2):1343-53.