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PHOTOVOLTAIC SURFACE IN PLUG-IN ELECTRIC VEHICLE (PEV) USING NANOTECHNOLOGY

Prabhjot Singh[1], Sanjeev Gupta[2]

[1]*B.E (Mechanical), Government College of Engineering and Technology, Jammu, J&k*- 181122
[2]*HOD Mechanical Engineering Department, Government College of Engineering and Technology, Jammu, J&k*- 181122
[#]Email address: [1]prabhieofficial@gmail.com, [2]sanjeevgupta2208@gmail.com

Abstract**—**From past few decades, use of vehicles that are based on fuel combustion system and normally use naturally occurring petroleum-based fuel which are at the verge of extinction. World see Plug-in Electric Vehicle (PEV) as the solution for many problems. It's the change with many benefits, from unlimited resources to green-use but always be short when we talk about ranges. These vehicles have short range due to fact that they can store electric energy up to a limit. Considering all these, with the use of Nanotechnology manipulating approach and feasible engineering we can create a system capable of photovoltaic work hence producing a live source of energy. This paper depicts that the use of titanium dioxide nanoparticles in a polymer or more effectively with silver wire immersed in it, make it absorptive enough for efficient solar cell. This solar cell on a surface and being good transparent to visible light it can be used in any Plug-in Electric Vehicle (PEV) surface or colored body, without making changes in color of the object. This concept can be used in any vehicle to produce a live natural energy resource and hence enhancing its capabilities. This is big positive for the emerging PEV technology and also fulfill the future expectations.

Keywords— Transparent solar cell, titanium dioxide, plug in electric vehicles, photovoltaic, Renewable energy, Transparent semiconductors

I. INTRODUCTION

In 1839 when French physicist Edmond Becquerel built the world's first photovoltaic cell, a new way is established to produce electricity using the natural resources. From many years, renewable energy is the main focus of the whole researching unit, due to its most abundant natural resource. Recent survey showed that the solar energy is the least used resources of the world. If we talk about applications that use solar power, the photo-voltaic tech. top the list as the most demanded field and forecast reports showed that the world going to depend on the solar energy due to limited nonrenewable resources by 2020 and to many folds by the year 2030. A device that converts solar energy into electricity using a Semiconductor materials, is called as a photovoltaic cell. Electric current is produced when photon in light fall on the plate, emitting electron and leaving the hole behind. This hole is filled by the nearby electron and creating hole there and hence flow of charge occur. This electron flow by photon absorption is called the photovoltaic effect. Hence we can say that the electric charge flow is proportional to the number of absorbed photons, so the photovoltaic cells are the sole unit of running system. [1-3]

On the other hand, plug-in electric vehicle (PEV) also known by battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs). These are any motor vehicle that convert electrical power to mechanical power and can be recharged again. It's the change with many benefits, from unlimited resources to green-use but always be short when we talk about ranges. These vehicles have short range due to fact that they can store electric energy up to a limit. Considering all these, with the use of Nanotechnology manipulating approach and feasible engineering we can create a system capable of photovoltaic work hence producing a live source of energy.[4]

This paper is completely based on solar cells and its applications with PEV's. However, in order to use the solar cells on any vehicle we have to go through different aspects and the classification of different solar cells with feasible applications. Finding material that enhance the functionality and capabilities, is a big challenge. For example, we find out silicon to be the material used bt due to its cost we prefer the Polycrystalline PV cells. Monocrystalline cells are more electrically good but due to the high cost of silicon, we can't use it in commercial purposes. But being innovator is good thing. We invented thin film PV cells (TFPV). By reducing the quantity of semiconductor material used, we can reduce the cost by more than half [6]. Dye-sensitized solar cells (DSSC), are the third-generation solar cell, which includes concentrators and organic solar cells. Being terrestrial main challenges is the effective usage in low light and which these only can solve. Hence, being good transparent to visible light it can be used in any Plug-in Electric Vehicle (PEV) surface or colored body,

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without making changes in color of the object This paper is fully focused on different fields related to TPV and their demerits and merits. However, before going through the application part let us understand the basic principle of transparent solar cell (TSC), and also the sole concept desensitized solar cells (DSSC).[3,5,6]

II. WORKING PRINCIPLES

Electric current is produced when photon in light fall on the plate, emitting electron and leaving the hole behind. This hole is filled by the nearby electron and creating hole there and hence flow of charge occur. This electron flow by photon absorption is called the photovoltaic effect. The current flow vertically in one direction due to semiconductor is doped to be a p-n junction with a potential difference, so it can be harvested as electricity. The efficiency of the solar cell can be effected by the diffusion length. Energy band gap (E_{gap}) formed in the semiconductor must be small as compared to the photons falling on it. For example, silicon has the property to eject electrons when sunlight is absorbed; the PV's cell then directs the electrons in one direction, which forms a current, as illustrated in Fig. 1 [7,8].

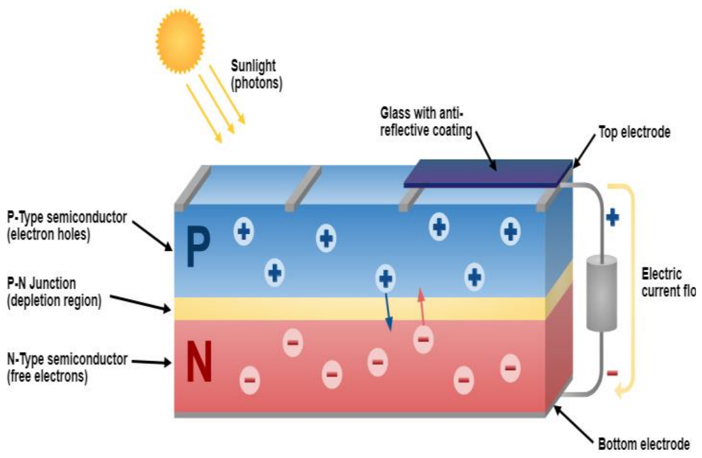

Fig. 1. Si Solar Cell.

a) Dye-Sensitized Solar Cells (DSSC): Operational Principal

DSSC being easy to build using easy technique and also low cost, but give outcome with high power conversion frequency. And now became the most preferred field for scientists' and researchers'. DSSC as a complete unit contains a combination of dye-sensitized transparent conducting substrate, semiconductor, electrolyte and electrodes. As shown in figure 2.

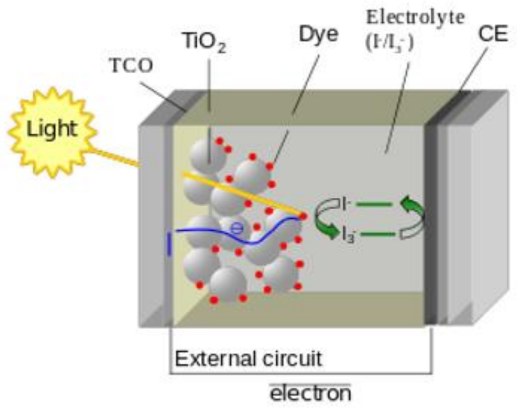

Fig. 2. Schematic overview of a dye-sensitized solar cell operational principle.

From the Fig. 2 DSSC elements are very clear. The mesoporous oxide containing TiO_2 nanoparticles are the sole roadway for the electrons to transfer from the cathode to the anode, while the size must between 10 and 30 nm and the thickness 10. The structure as shown consists of TiO_2 layer with transparent conducting oxide (TCO) or fluorine-doped tin oxide (FTO); these are the commonly used substrates. Oxidation of the dye result due to shifting of electron on photon produced energy. Dye transforms into Triiodide shift back to iodide by addition of electron, which is covered with platinum as a catalyst, hence a flow of current occur [9].

Semiconductors

Semiconducting metals are the resources for the electrons-holes, has become a good alternative. Most common include titanium dioxide (TiO_2), zinc oxide (ZnO), etc. [10].

Electrolyte

It act to regenerate the oxidized dye using the iodide species acting as the donor electron. I3- accepts electrons from surroundings source to regenerate I- again get back. [11].

Dye

In DSSC, dye act to increase the band gap and hence can satisfy unstable high wavelength by increasing wavelengths. Which brings up the importance of the dye as an essential part of DSSC. This also helps in proper capacity to absorb the solar light photons and produce photovoltaic effect. Hence the performance of DSSC's depends directly on the properties of the dye material. However, DSSC dye have to fulfill the basic requirements like absorption spectrum must cover the whole visible region including near- infrared (NIR) region, the dye must have anchoring groups in order to bind it to the semiconductor surface, the photosensitized must have a higher level of energy in the excited state level than the conduction band in the n-type semiconductor, and a more positive oxidized state than the redox potential of the electrolyte, and it should also be stable [9].

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Counter electrode (CE)

DSSC performance truly depends upon the counter electrode due to fact that it act as catalytic layer producing high electrochemical activity, high conductivity, electro-catalytic aptitude, and long-term stability, although it's a very expensive material. FTO and ITO are coated with CE thin film always to get positive effects. Alternative materials such as carbon-based materials also can be used.[11,12]

Transparency

It is a physical property of any material that allows light to pass through without interrupting it. For the solar cell it's the most important property and all depends upon the of atoms and electrons in it. However it makes that material opaque when photon get absorbed by the material of equal BG due to bouncing of electron to higher electron shell. [13]. the key to reaching a transparent paste is to control the factors that affect transparency such as:

1. Size and arrangement of Nano-crystals.
2. Methodologies used in making paste
3. Absorbing capacity
4. Thickness

III. IMPLEMENTATION OF TRANSPARENT SOLAR CELL TECHNOLOGIES

a) *Thin film photovoltaics (TPVs) technologies*

Transparent solar cells can be made using different technologies while few are showing the effective performance. Under TSC high success rate are achieved using FTO or ITO conductor on glass producing 10 Ω/sq. resistance and using a thin film with a thickness of less than 20 nm. However the transparency loosen by approximately 16-18% before the deposition of any other materials. Thus, the best transparency achieved currently is less than 80% while if we get high transparency we get 1% efficiency.[14,15]

Thin film photovoltaic (TPVs) is the most successful technology in TSC while achieved via different methods. TPV is thin film having thickness between few nanometers. Fabrication is done using paste to get high transparency, and while other depend upon the methods. Its low cost technology while also conservative in nature, easy and show rigid to flexible behavior.[6]. In thin film like titanium dioxide, the transparency depends upon the film thickness. Properties changes material to material and the overall performance of the cell is affected by each layer.

SCREEN PRINTING is best depositing method and most widely used in thin film applications; it provides an easy way to control the thickness and the position of the film. Screen printing also depends upon type and quality of paste while TiO2 is widely used. After putting the required quantity of matter paste on surface then frame is given and by swiping action with constant velocity, the paste is squeegee across the surface. Doing this substrate move along every surface part and thin film get spread and dried. [16].

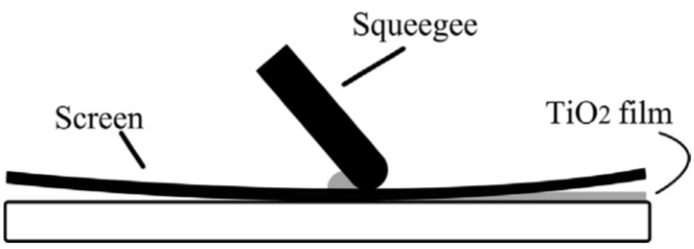

Fig. 3. Schematic diagrams of screen-printing polymer film.

Transparency is physical property consisting of mesh count, mesh opening, thread diameter, open surface and fabrication thickness as its measurement value. While our frame pressure also decide the film thickness. P25, ST21, and ST41 are commercially available TiO2 nanoparticles, can easily printed on plate with 17 µm thickness, and the results showed that the light passage was 60%, and the efficiency of the DSSC at the end of the fabrication of P25 TiO_2 thin film was 9.2%. However when light scattering layer is added with division of TiO2 in conc. and semitransparent layer, we achieved 18 % efficiency with the transparency 20-23%. [17]

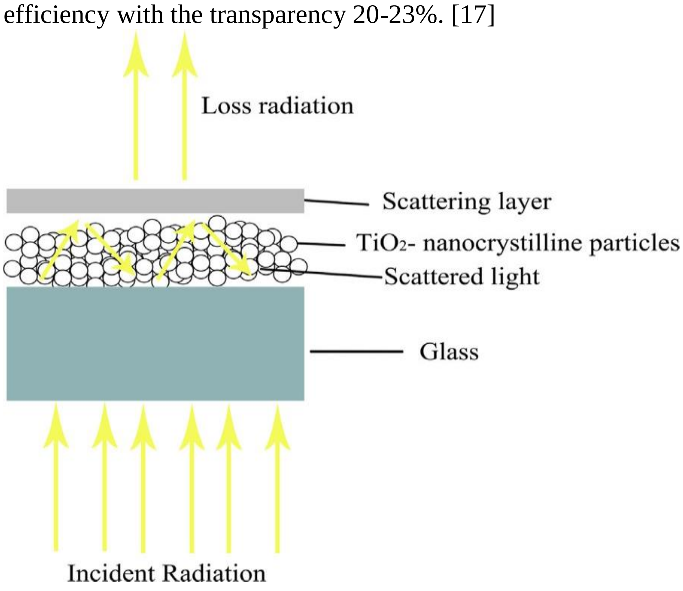

Fig. 4. Schematic diagrams of light-scattering layer on top of TiO_2 Nano crystalline particles.

Polymer solar cell (PSC)

Ideal TPV only can be achieved by combining polymer with the transparent silver nanowires which is non-transparent for UV and NRI but transmit the visible light. These have efficiency is 16%, and the transparency at 550 nm wavelength is 66%. Whereas NIR fluorescent dyes are also implemented in order to capture UV and NIR light, convert them into visible light, and then guide it to the edge of the glass where the solar cell is placed. [18]

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IV. NEW PROPOSED PEV WITH PHOTOVOLTAIC SURFACE PROPERTIES

The basic idea was to use the titanium dioxide Nano-particles in a polymer with silver wire immersed in it and on the solar cell open surface making it absorptive enough for efficient solar cell and being good transparent to visible light it can be used in any automobile surface or an air-plane surface or any coloured body, without making changes in colour of the object.

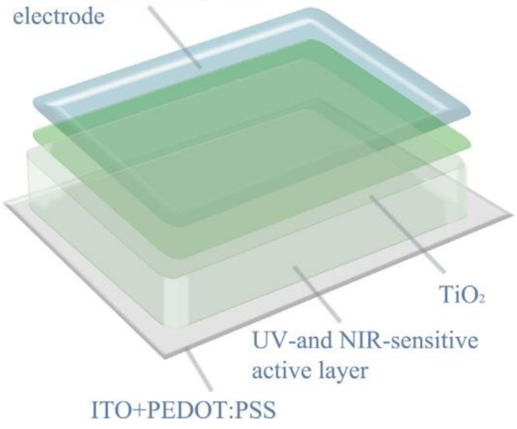

Fig. 5. Transparent PSC

Fig. 5 shows the structure of basic PSC. PSC is the most efficient type of structure which can be used in fabrications of the photovoltaic surfaced PEV. It consists of sandwich like structure, where the outer two layers are of transparent electrodes while active material is placed between them. The outer electrode when is made up of silver nanoparticles in polymer. It blocks the UV and NIR light but visible light can pass making it more efficient. Next to it is the active member that is actually heterojunction of the donor and accepter. It is combined called as PBDTT-DPP: PCBM. It retains the UV light along with NIR to make the structure more efficient. And at last, electrode substrate is present having ITO. At last is the back coloring layer is present having paint to reflect back the light rays passing on. However the coating of the outer layer is did using the method by spraying the AgNW on the TiO_2 sol-gel solution. Hence it is used to connect the both layers.

V. DISCUSSION

The biggest challenges was to create a low cost system which can be used in any Plug-in Electric Vehicle (PEV) surface or colored body, as an electric source without making changes in color of the object. So that this concept can be used in any vehicle to produce a live natural energy resource and hence enhancing its capabilities. If adopted in large scale, this would be big positive for the emerging PEV technology and also fulfill the future expectations. Transparent solar cells are built using different ways, using different components and by different deposition methods. Different tools are used in different methods and hence different efficiency with different performance are obtained. The highest we get was in PSC methods where Ideal TPV only can be achieved by combining polymer with the transparent silver nanowires which is non-transparent for UV and NRI but transmit the visible light [19]. These have efficiency is 16%, and the transparency at 550 nm wavelength is 66% [18]. Whereas NIR fluorescent dyes are also implemented in order to capture UV and NIR light, convert them into visible light, and then guide it to the edge of the glass where the solar cell is placed.
The basic structure of the surface of PEV are shown as below-

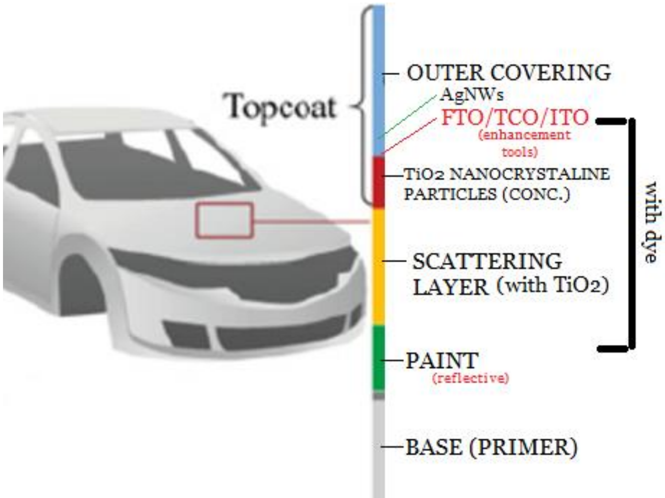

Fig. 6. Photovoltaic Surface with PSC.

Transparency is physical property consisting of mesh count, mesh opening, thread diameter, open surface and fabrication thickness as its measurement value. While our frame pressure also decide the film thickness. P25, ST21, and ST41 are commercially available TiO2 nanoparticles, can easily printed on plate with 17 µm thickness, and the results showed that the light passage was 60%, and the efficiency of the DSSC at the end of the fabrication of P25 TiO_2 thin film was 9.2% [17]. However when light scattering layer is added with division of TiO2 in conc. and semitransparent layer, we achieved 18 % efficiency with the transparency 20-23%.

Moreover, these results are taken at standard good solar light but all these technologies must be tested under different conditions, to decrease the malfunctioning error or the flaws due to different bad conditions. However the efficiency reported are different at different concentration of silver nanowires. The data is shown below in table 1.

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TABLE I

CURRENT VALUE WITH RESPECT TO THE LIGHT AND AG CONCENTRATION

Light intensity	AG CONC.	Current value
Standard	zero	lowest
Standard	Low (0.1%)	Intermediate but greater than high conc. Ag.
Standard	Medium (0.3%)	highest

An efficiency of 7.56% and an average transmission of 25% is recorded in std. case. [20].However, one study reported a 55% transmission with 7.1% efficiency. These changes are also plotted in graph.

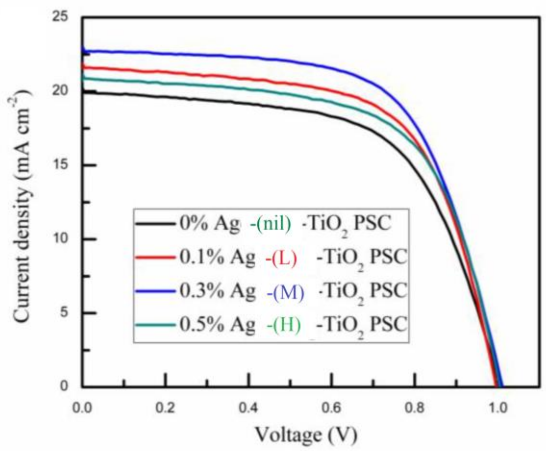

Fig 7: Graph showing change in current with respect to Ag concentration

VI. CONCLUSION

Transparent solar cells the biggest achievement facilitating and making the PEV one step forward on the way of clean and green use of energy resources for our needs. It's always make very challenges to fabricate a device or tool and to establish a potential to use in big projects. Photonic absorption is the main path of conflicts. Absorbing photons and producing electric power, is what we call photovoltaic effect while transparency let through as many photons as possible, all to make better performance. All these also enhanced by the feasible engineering and with help of Nano technology to form such a substance which act to catalase the whole process, specially the titanium dioxide. However, TPV is a very desirable technology, used to define the required transparency for the material. After analyzing different methods, it can be concluded that the main thing is to reduce the film thickness and only can be possible thin film methods or to use transparent absorbing materials with high capacities, as we found in polymers, perovskites, and etc.

With the use of TPV, it can conclude that the highly favorable material for our devices such as ITO, FTO glass or polymer. The highest transparency achieved was 86% with a TLSC technology, but only one percent efficient while the highest efficiency to transparency ratio was 8.2%:70% using a nanotube thin film of TiO_2 for transparent DSSC. Hence it's very well feasible. However, with the use of transparent film we established such a surface that is 13-14% solar efficient and being good transparent to visible light it can be used in any Plug-in Electric Vehicle (PEV) surface or colored body, without making changes in color of the object This concept can be used in airplane or a satellite surface for solar energy generation in the form of electricity.

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