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Review Article

Introduction to Natural Dye Sensitized Solar Cells

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Abstract: Dye Sensitized Solar Cells (DSSC) is broadly regarded as the more promising third generation photovoltaic (solar) technology. These cells are the closest mankind has come to replicating nature's photosynthesis. Paying homage to its inventor Professor Michael Gräetzel we call it GCell. With regard to advantages A dye-sensitized solar cell including low-cost, Low-light performance, Optimised performance, Higher temperature performance, Low energy manufacturing process, Ecologically friendly solar and etc Study of these technology Seem is essential. A dye-sensitized solar cell (DSSC, DSC or DYSC) is the group of thin film solar cells. It is based on a semiconductor formed between a photo-sensitized anode and an electrolyte, a photoelectron chemical system. In this paper will review the advantages, disadvantages, applications and future of natural dye sensitized solar cells.

Keywords: Natural Dye, Solar Cells, Solar Energy, Photovoltaic

1. Introduction

A dye sensitized solar cell is a new kind of relatively low cost solar cell with great potential as its materials are considerably cheaper and it is simple to make [1]. The modern version of a dye solar cell, also known as the Grätzel cell, was originally co-invented in 1988 by Brian O'Regan and Michael Grätzel at UC Berkeley [2-3] and this work was later developed by the aforementioned scientists at the École Polytechnique Fédérale de Lausanne until the publication of the first high efficiency DSSC in 1991. [4] Michael Grätzel has been awarded the 2010 Millennium Technology Prize for this invention. [5] The DSSC has a number of attractive features; it is simple to make using conventional roll-printing techniques, is semi-flexible and semi-transparent which offers a variety of uses not applicable to glass-based systems, and most of the materials used are low-cost. In practice it has proven difficult to eliminate a number of expensive materials, notably platinum and ruthenium, and the liquid electrolyte presents a serious challenge to making a cell suitable for use in all weather. Although its conversion efficiency is less than the best thin-film cells, in theory its price/performance ratio should be good enough to allow them to compete with fossil fuel electrical generation by achieving grid parity. Commercial applications, which were held up due to chemical stability problems, [6] are forecast in the European Union Photovoltaic Roadmap to significantly contribute to renewable electricity generation by 2020.

GCell is the first choice for electrical engineers and product designers seeking an indoor dye sensitized Solar Cells (DSSC) that are flexible and boast superior low light performance. With GCell any light source becomes an energy source. GCell can be incorporated into a wide range of indoor and portable products to provide power for refueling rechargeable batteries, super capacitors or directly powering almost anything that uses a AA-cell disposable battery. The output of GCell, like all other indoor solar cells, will differ depending on the light source to which they are exposed. This is because photo electric conversion efficiency (PCE) changes with the respect to the wavelength and intensity of the light. The absorption spectra of GCell are 390-700 nm. The peak absorbance is between 500-550 nm. GCell is constantly energy scavenging even with indoor low light conditions. Illumination indoors is usually specified in Lux. This unit of luminance is based on the spectral response of the human eye ie the visible light. [7]

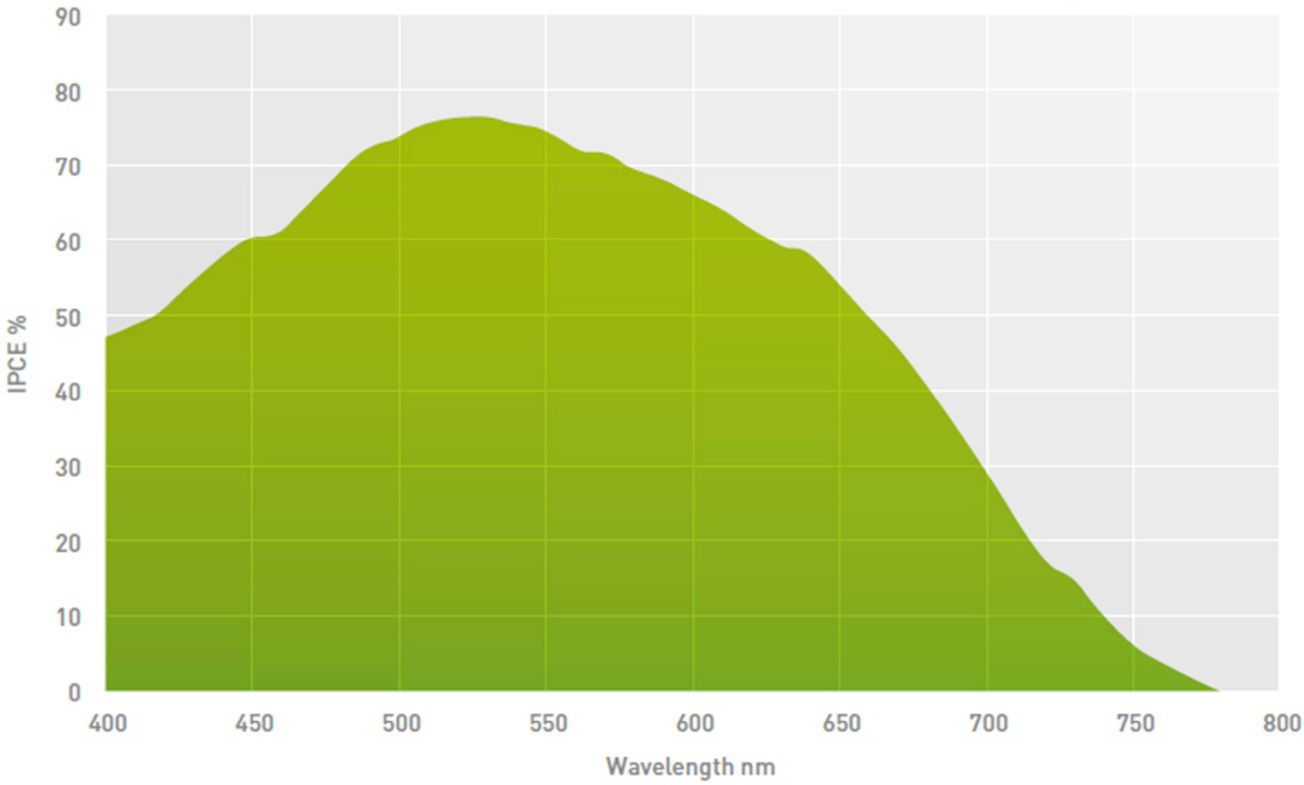

Figure 1. *GCell incident photon conversion efficiency % [7].*

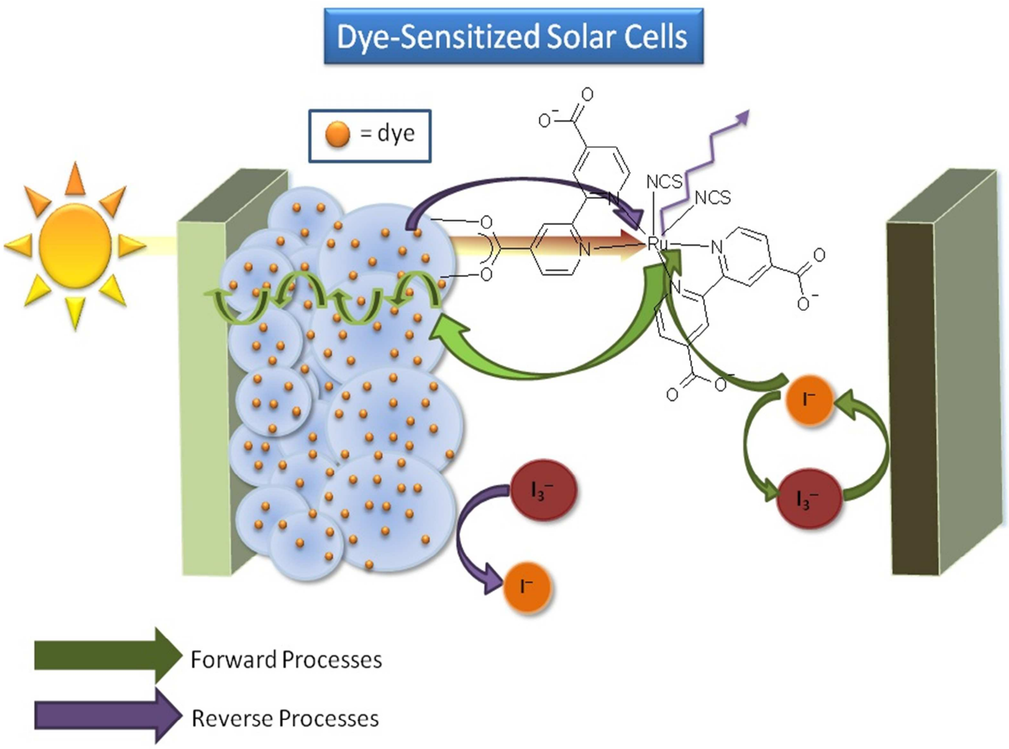

Figure 2. *How dye sensitized Solar Cells Work (http://www.solideas.com/solrcell/howworks.html).*

2. Working Principle of Dye-Sensitized Solar Cells

The working principle of dye sensitized solar cells (DSSC) is not based on a p-n junction as in the conventional solar cells but on the photogeneration of an electron by a dye, as in photosysnthesis [8]. At the heart of a DSSC is a mesoporous layer composed of nm-sized particles of a wide-band semiconductor oxide, such as TiO_2, ZnO or SnO_2, that have been sintered together to allow electronic conduction to take place [9]. Photoexcitation of the sensitizer dye results in the injection of an electron into the conduction band of the oxide, generating the oxidized form of the dye [10]. After electron injection, the ground state of the dye is subsequently restored by electron donation from the electrolyte reductant, which in turn is regenerated by the reduction of the electrolyte oxidant at the counter-electrode [11]. The difference between the Fermi level of the oxide and the redox potential of the electrolyte determines the voltage generated by the cell under illumination [12]. DSSCs can be produced at reasonably low cost while yielding relatively decent efficiencies [13].

3. Solar Energy

Harnessing renewable energy sources is crucial for supporting the energy demands of modern society. The IEA calculated that global energy usage increased by 10% from 1990 to 2008, and the number is expected to rise in the coming decades. At the same time, our currently predominant sources of energy pose serious threats to the environment and human health [14]. The burning of fossil fuels natural gas, coal, and oil releases harmful greenhouse gases into the atmosphere, contributes to ocean acidification, and creates pollution with both economic and social costs [15]. Solar power is a particularly promising solution to the world's energy needs. The Earth annually absorbs nearly 4 million exajoules of solar energy, and it would require less than an hour of this total energy to power mankind for an entire year. There are many technologies to capture and convert the sun's energy. Solar panels, like those commonly perched atop house roofs or in sun-drenched fields, quietly harvesting the sun's radiant energy, are one of the standard-bearers of the green energy movement [16]. dye sensitized solar panels currently convert about 11 to 12 percent of the sunlight that hits them into electricity. The researchers are pushing to make these panels at least as efficient as their silicon counterparts, which currently convert about twice as much radiation as the dye-sensitized panels [17]. Despite this relative inefficiency, dye-sensitized panels have many advantages over silicon cells. Among the advantages of dye-sensitized solar cells are low cost, ease of manufacturing and construction from stable and abundant resource materials. Also, the durability of the dye-sensitized panels, combined with their ability to absorb more sunlight per surface area than standard silicon-based solar panels, make them attractive for mainstream use. There is also the potential to make dye-sensitized cells flexible, which would open them to a variety of new applications that are not options for the more rigid silicon panels. Due to the lagging energy conversion rate of dye-sensitized cells, however, they are not as widely used as silicon panels [18].

Solar energy Originates with the thermonuclear fusion reactions occurring in the sun. Represents the entire electromagnetic radiation (visible light, infrared, ultraviolet, x-rays, and radio waves). This energy consists of radiant light and heat energy from the sun. Out of all energy emitted by sun only a small fraction of energy is absorbed by the earth. Just this tiny fraction of the sun's energy is enough to meet all our power needs. Energy produced by the sun Clean, renewable source of energy. Harnessed by solar collection methods such as solar cells [19]. Converted into usable energy such as electricity Photovoltaic (solar) panel Set of solar panels. What is a Photovoltaic Cell. A device that can convert sunlight directly in electricity [20]. Traditional types are based on two types of silicon sandwiched together (n-type and p-type). Based on using photons to separate charges: electron-hole pairs. Many new types are in research/production stage. Recap: Photo means light in Greek and Volt is the name of a pioneer in the study of electricity Alessandro Volta Solar cell: Solar cell is a photovoltaic device that converts the light energy into electrical energy based on the principles of photovoltaic effect Albert Einstein was awarded the 1921 Nobel Prize in physics for his research on the photoelectric effect—a phenomenon central to the generation of electricity through solar cells. Solar Panel Use Today. Large companies like Google, Walmart, and Microsoft use solar energy to partially power some of their facilities Solar panels on Microsoft building Solar panels being tested on Walmart store. Renewable energy sources such as solar energy are considered as a feasible alternative because "More energy from sunlight strikes Earth in 1 hour than all of the energy consumed by humans in an entire year. The use of natural dye extracts provides natural, nontoxic and low cost dye sources with high absorbance level of UV, visible and near IR [21].

Applications Of DSSC. Because of the physical nature of the dye sensitized solar cells, inexpensive, environment friendly materials, processing, and realization of various colors, power window and shingles are prospective applications in building integrated photovoltaics. The availability of lightweight flexible dye sensitized cells or modules are attractive for applications in room or outdoor light powered calculators, gadgets, and mobiles.. Flexible dye sensitized solar modules opens opportunities for integrating them with many portable devices, baggage, gears, or outfits. In power generation, dye sensitized modules with efficiency of 10% are attractive choice to replace the common crystalline Si-based modules [22].

4. Structure of Dye Sensitized Solar Cells

The basic structure of the dye sensitized solar cell is that in the case of the original Grätzel design: the cell has three primary parts. Glass sheet with transparent conducting oxide coating (ITO or FTO) as anode on top of it; and semiconductor oxide (normally microscopic TiO_2 which forms into a highly porous structure with an extremely high surface area.) film deposits on the conductive side of the glass sheet which is then immersed in a mixture of a photosensitive ruthenium-polypyridine dye and a solvent. After soaking the film in the dye solution, a thin layer of the dye is left covalently bonded to the surface of the TiO_2. A separate backing is made with a thin layer of the iodide electrolyte spread over a conductive sheet, typically platinum metal. The front and back parts are then joined and sealed together to prevent the electrolyte from leaking [23].

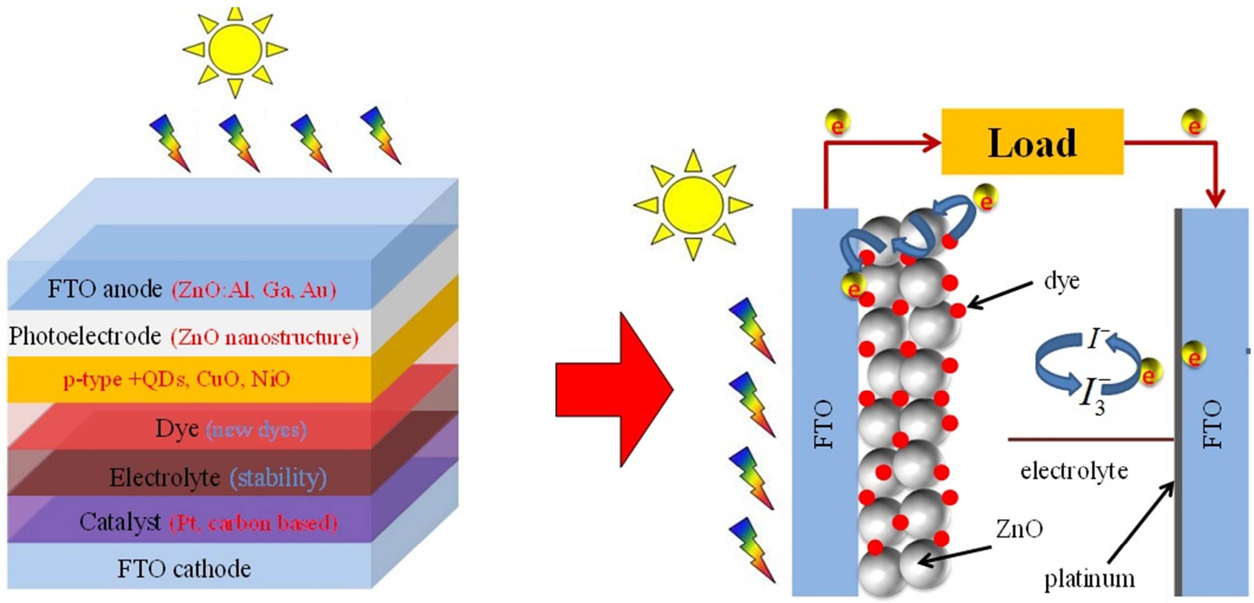

Figure 3. *Schematic of the construction of dye-sensitized cell. (thep-center.org).*

In dye sensitized solid-state heterojunction solar cell, a monolayer of dye is attached to the surface of a mesoscopic film of TiO_2 (wide-bandgap oxide) and serves to harvest solar light dye absorbs light and then injects electrons into the conduction band of semiconductor oxide (the nearby TiO_2 particles) upon excitation, then the electrons transport through its nanoparticle network by diffusion to the current collector (anode), subsequently pass through the external circuit, perform electrical work, processed to the counter electrode (cathode) at the mean while, the dye also injects holes to the hole conductors and transport to the counter electrode, and with the outside circuit which the finishes loop. And there is no chemical change under solar exposure. The Only difference for original Grätze cell compared with Dye-sensitized solid-state heterojunction solar cell is that the former uses electrolyte and the latter uses as hole conducting medium [24].

5. Advantages of and Disadvantage Natural Pigments Solar Cell

The advantages of dye-sensitized solar cells can be called upon to expand the range of applications where conventional solar cells are unsuitable.

DSSC advantages include [25]:

(1). Low-light performance: GCell works in a wide array of lighting conditions that makes it suitable for a diverse range of shaded and diffuse light locations, without suffering from angular dependence of sunlight or light.

(2). Optimised performance: GCell materials and dyes can be tuned for optimisation in a variety of lighting conditions making it suitable for indoor applications and outdoor applications.

(3). Higher temperature performance: Efficiency of GCell does not degrade with increased temperature, meaning you can continue to efficiently harvest energy in direct sunlight.

(4). Low energy manufacturing process: GCell is manufactured using a low-energy consumption, high-efficiency, roll-to-roll manufacturing technique.

(5). Ecologically friendly solar: GCell uses inexpensive and eco-friendly nano-materials without concern about shortage of resources.

(6). Variety of substrates: GCell is produced on a thin film, flexible, robust, plastic substrate. DSSC can also be applied to metal and glass substrates.

(7). Versatile product integration: GCell indoor modules are highly flexible, durable and lightweight. As a result they are very versatile and can be incorporated into a wide variety of products.

The major disadvantage to the DSSC design is the use of the liquid electrolyte, which has temperature stability problems. At low temperatures the electrolyte can freeze, ending power production and potentially leading to physical damage. Higher temperatures cause the liquid to expand, making sealing the panels a serious problem. Another disadvantage is that costly ruthenium (dye), platinum (catalyst) and conducting glass or plastic (contact) are needed to produce a DSSC. A third major drawback is that the electrolyte solution contains volatile organic compounds (or VOC's), solvents which must be carefully sealed as they are hazardous to human health and the environment. This, along with the fact that the solvents permeate plastics, has precluded large-scale outdoor application and integration into flexible structure. [26] Replacing the liquid electrolyte with a solid has been a major ongoing field of research. Recent experiments using solidified melted salts have shown some promise, but currently suffer from higher degradation during continued operation, and are not flexible [27].

6. Natural Dye Sensitized Solar Cells-Outlook

Although initial products are aimed towards indoor and portable applications, starting out with chargers and solar bags with wireless solar keyboards demonstrated more recently, the end game for DSSCs is the ability to have these largely inexpensive solar cells incorporated into much bigger installations. For that purpose, development work is being undertaken in order to produce prototypes and demonstrators of DSSCs being utilized in applications such as bus shelters, steel roofing and others such as facades, semi-transparent windows etc [28].

Figure 4. *(Source: IDTechEx Read more at: http://www.idtechex.com/research/reports/dye-sensitized-solar-cells-dssc-dsc-2013-2023-technologies-markets-players-000345.asp).*

DSSCs represent, together with organic photovoltaics (OPVs) the third generation of solar technologies which are expected to usher a new era of added functionality and lowered costs, adding to the overall value proposition of solar power generation. In the short term, incumbent technologies will outperform emerging solar cell platforms, both in terms of performance and cost structure due to economies of scale achieved. Hence, developers of DSSCs will need to identify niche markets that will allow for seeding further growth in later years. Although, as with all emerging technologies, cost benefits are not necessarily immediately obvious due to low volume production, it is of interest to adopters, technology developers but also equipment and materials providers to closely follow the developments in this space in order to be able to better understand the way the market for DSSCs is growing and the impact these solar cells will have on the market for sustainable energy generation. The main issues that DSSC technologies have to solve relate to performance limitations: in lifetime and efficiency. There is a clear handicap in best performance achieved by DSSCs when compared to technologies that have been under development for longer and have achieved much better efficiency levels. On the other hand and on a more positive note, it's also obvious that the performance gap with amorphous Silicon, one of the incumbent technologies, has closed dramatically in recent years, especially in indoor applications. It is thus, important to identify the best fitting initial applications for DSSCs, as the first ones to target in order to achieve faster commercialization. The market sectors for which forecasts are given in this report are divided into: Automotive Outdoor advertising /posters /awnings POP smart labels, posters indoors Mobile devices Electronics in apparel and emergency and military Other portable electronics, disposable electronics Wireless sensors/actuators PV for developing countries BIPV Other large projects and utilities The automotive sector seems to be taking off slowly, being one that is more stringent in terms of requirements of lifetime and efficiency performance from solar technologies, leading to just a few million dollars in market value by 2020 [29].

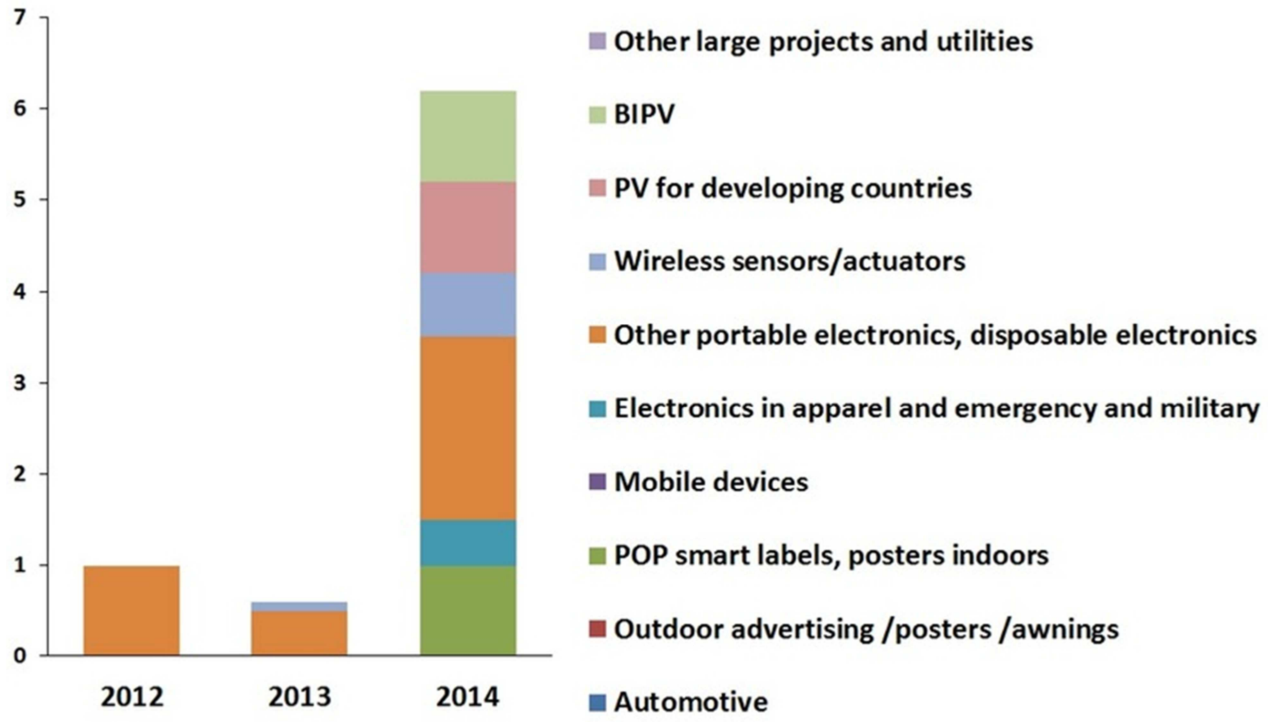

Figure 5. *(Source: IDTechEx Read more at: http://www.idtechex.com/research/reports/dye-sensitized-solar-cells-dssc-dsc-2013-2023-technologies-markets-players-000345.asp).*

On the other hand, in other portable electronics, especially for indoor applications and with a multitude of different applications expected to be developed in the next few years, a $5 million in market share is expected by 2017, which is expected to grow 6-fold by 2023.

7. Conclusions

Briefly, compared to Si based solar cells dye sensitized solar cells are of low cost and ease of production, their good performance increases with temperature, possessing bifacial configuration - advantage for diffuse light, have transparency for power windows, color can be different by selection of the dye, invisible PV cells based on near-IR sensitizers are feasible, and they are outperforms amorphous Si. Moreover, DSSC shows higher conversion efficiency than polycrystalline Si in Scattered light. It can be said that nanocrystalline photovoltaic devices are becoming viable contender for large scale future solar energy converters. The search for green and renewable sources or generators of energy is considered one of the priorities in today's societies and occupies many policy makers' agendas. dye sensitized solar cells are a promising potential replacement for silicon-based solar cells. With advancements in nanostructure semiconductors, high-efficiency sensitizers and robust electrolytes, the performance of modern DSSCs is becoming more and more competitive. Simple processing, low-cost materials and a wide range of applications are all helping DSSCs to find a foothold in the marketplace.

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