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NANOTECHNOLOGY FOR POWERFUL SOLAR ENERGY

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***Abstract* - At the size, size, physical, chemical and biological properties of nano-materials differ in fundamental and valuable properties of individual atoms and many matter. The properties in nano, we can create a wide range of potential applications for nano-materials discovery. One of these applications includes the creation of revolutionary potential energy. These are the sources of energy, including hydrogen, geothermal energy, unconventional natural gas nuclear fission and solar energy, while hydrogen is energy. Understanding of hydrogen as an alternative energy source, hydrogen gas is frustrated by gaps in technology which is not the efficient and economical storage and transport. Nanotechnology provides new approaches to fundamental questions about the interaction of hydrogen with nano-materials which enable the more efficient and economical storage and transport of hydrogen atoms. Applications of nano-technology help us to make solar energy more economically. Nanoscience photovoltaic cells are used to improve the efficiency for creating efficient systems for conversion cost, efficient solar energy storage systems, or solar energy on a large scale. Also it is used in DC-DC power converters, fuel cells, nanocomposites for high temperature applications, CO2 reduction and clean-up , air and water filtration, waste and water treatment, hazourdous materials disposal, in-building environmental systems, remediation.**

I. INTRODUCTION

Conventional solar cells are called photovoltaic cells. These cells are made out of semiconducting material, usually silicon. When light hits the cells, they absorb energy though photons. This absorbed energy knocks out electrons in the silicon, allowing them to flow. By adding different impurities to the silicon suchas phosphorus or boron, an electric field can be established. This electric field acts as a diode, because it only allows electrons to flow in one direction. Consequently, the end result is a current of electrons, better known to us as electricity. Conventional solar cells have two main drawbacks: they can only achieve efficiencies around ten percent and they are expensive to manufacture. The first drawback, inefficiency, is almost unavoidable with silicon cells. This is because the incoming photons, or light, must have the right energy, called the band gap energy, to knock out an electron. If the photon has less energy than the band gap energy then it will pass through. If it has more energy than the band gap, then that extra energy will be wasted as heat. Scott Aldous, an engineer for the North Carolina Solar Center explains that, "These two effects alone account for the loss of around 70 percent of the radiation energy incident on the cell".

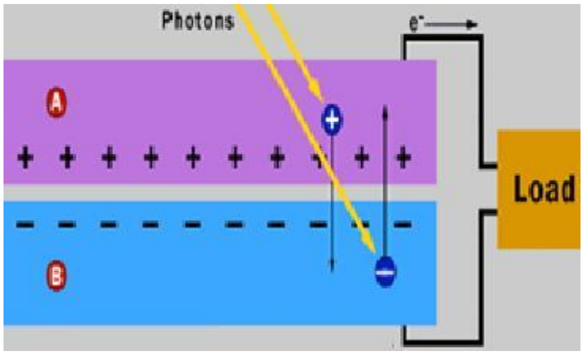


Fig1. Consequently, according to the Lawrence Berkeley National Laboratory, the maximum efficiency achieved today is only around 25 percent. Mass-produced solar cells are much less efficient than this, and usually achieve only ten percent efficiency.

Nanotechnology might be able to increase the efficiency of solar cells, but the most promising application of nanotechnology is the reduction of manufacturing cost. Chemists at the University of California, Berkeley, have discovered a way to make cheap plastic solar cells that could be painted on almost any surface.

Fig 2. Picture of a solar cell, which utilizes nanorods to convert light into electricity.

These new plastic solar cells achieve efficiencies of only 1.7 percent; however, Paul Alivisatos, a professor of chemistry at UC Berkeley states, "This technology has the potential to do a lot better. There is a pretty clear path for us to take to make this perform much better".

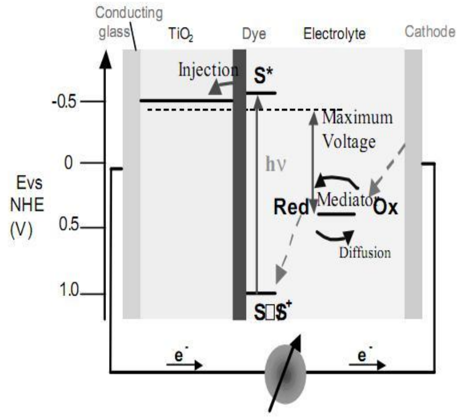
The conversion efficiency of dye-sensitized solar cells (DSSCs) has currently been improved to above 11% . DSSCs with high conversion efficiency and low cost have been proposed as an alternative to silicon based photovoltaics . The encapsulation problem posed by the use of the liquid electrolyte in conventional liquid electrolyte based DSSCS, solvent leakage and evaporation are two main challenges; therefore, much work is being done to make an all solid-state DSSC . In addition, the use of solvent free electrolytes in the DSSC is expected to offer stable performance for the device. Plastic and solid-state DSSCs incorporating single-walled nanotubes (SWNTs) and imidazolium iodide derivative have been fabricated . The introduction of carbon nanotubes (CNTs) can improve solar cell performance through reduction of the series resistance. TiO2 coated CNTs were recently used in DSSCs . Compared with a conventional TiO2 cell, a TiO2-coated CNT (0.1 wt%) cell gives an increase in short circuit current density (JSC), resulting in ~50% increase in conversion efficiency. When employing SWNTs as conducting scaffolds in a TiO2 based DSSC, the photoconversion efficiency can be boosted . TiO2 nanoparticles were dispersed on SWNT films to improve the photoinduced charge separation and transport of carriers to the collecting electrode surface. An alternative material to TiO2 used in DSSCs is ZnO . ZnO has a similar band gap (3.2 eV) and band edge position to TiO2, with similar or smaller crystallite sizes than that of typical TiO2. ZnO nanowires have been used in DSSCs .

Dye-sensitized nanocrystalline solar cell (DSC):

The heart of the system is a mesoporous oxide layer composed of nanometer-sized particles which have been sintered together to allow for electronic conduction to take place . The material of choice has been TiO_2 (anatase) although alternative wide band gap oxides such as ZnO , and Nb_2O_5 have also been investigated. Attached to the surface of the nanocrystalline film is a monolayer of the charge transfer dye. Photo excitation of the latter results in the injection of an electron into the conduction band of the oxide. The original state of the dye is subsequently restored by electron donation from the electrolyte, usually an organic solvent containing redox system, such as the iodide/triiodide couple. The regeneration of the sensitizer by iodide intercepts the recapture of the conduction band electron by the oxidized dye. The iodide is regenerated in turn by the reduction of triiodide at the counterelectrode the circuit being completed via electron migration through the external load. The voltage generated under illumination corresponds to the difference between the Fermi level of the electron in the solid and the redox potential of the electrolyte. Overall the device generates electric power from light without suffering any permanent chemical transformation.

A recent alternative embodiment of the DSC concept is the sensitized heterojunction usually with an inorganic wide band gap nanocrystalline semiconductor of n-type polarity as electron acceptor, the charge neutrality on the dye being restored by a hole delivered by the complementary semiconductor, inorganic or organic and of p-type polarity.

The prior photo-electrochemical variant, being further advanced in development, has an AM 1.5 solar conversion efficiency of over 10%, while that of the solid-state device is, as yet, significantly lower



Operation and energy level scheme of the dye-sensitized nanocrystalline solar cell. Photoexcitation of the sensitizer (S) is followed by electron injection into the conduction band of the mesoporous oxide semiconductor. The dye molecule is regenerated by the redox system, which itself is regenerated at the counter electrode by electrons passed through the load. Potentials are referred to the normal hydrogen electrode (NHE). The open-circuit voltage of the solar cell corresponds to the difference between the redox potential of the mediator and the Fermi level of the nanocrystallline film indicated with a dashed line.

Present DSC research and development

1. Panchromatic sensitizers:

Upon excitation it should in-ject electrons into the solid with a quantum yield of unity. The energy level of the excited state should be well matched to the lower bound of the conduction band of the oxide to minimize energetic losses during the electron transfer re-action. Its redox potential should be sufficiently high that it can be regenerated via electron donation from the redox electrolyte or the hole conductor. Finally, it should be stable enough to sustain about 108 turnover cycles corresponding to about 20 years of exposure to natural light. Much of the research in dye chemistry is devoted to the identification and synthesis of dyes matching these require-ments, while retaining stability in the photo-electrochemical environment. The attachment group of the dye ensures that it spontaneously assembles as amolecular layer upon exposing the oxide film to a dye solution. This molecular dispersion ensures a high probability that, once a photon is absorbed, the excited state of the dye molecule will relax by electron injection to the semiconductor conduction band. However, the optical absorption of a single monolayer of dye is weak, a fact which originally was cited as ruling out the possibility of high efficiency sensitized devices, as it was assumed that smooth substrate surfaces would be imperative in order to avoid the recombination loss mechanism associated with rough or polycrystalline structures in solid-state photovoltaics.Also used in Light harvesting by nanocrystalline TiO2 films, the dilemma of light harvesting by surface, immobilized molecular absorbers.

2 Photovoltaic performance stability:

A photovoltaic device must remain serviceable for 20 years without significant loss of performance. The stability of all the constituents of the nanocrystalline injection solar cells, that is, the conducting glass the TiO2 film, the sensitizer, the electrolyte, the counterelectrode and the sealant has therefore been subjected to close scrutiny. The stability of the TCO glass and the nanocrystalline TiO2 film being unquestionable investigations have focused on outstanding stability is the very rapid deactivation of its excited state via charge injection into the TiO2 occurs in the femto-second time domain. This is at least eight orders of magnitude faster than any other competing channels of excited state deactivation including those leading to chemical transformation of the dye. The oxidized state of N3+ the dye produced by the electron injection is much less stable although the N3/N3+ couple shows reversible electrochemical behavior in different organic solvents indicating that the lifetime of N3+ is at least several seconds under these conditions. However when maintained in the oxidized state the dye degrades through loss of sulfur. Regeneration of the N3 in the photovoltaic cell should therefore occur rapidly, i.e. within nanosecond or microseconds to avoid this unwanted side reaction. Lack of adequate conditions for regeneration of the dye has led to cell failure.

CONCLUSIONS

Recent developments in the area of sensitizers for these devices have lead to dyes which absorb across the visible spectrum to higher efficiencies. The development of an solid-state heterojunction dye solar cell keeps additional potential for cost reduction and simplification of the manufacturing of dye solar cells.

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