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Perovskite Structured Transparent Uv Resistant Polymer-Metal Oxide Panels For Solar Thermal Applications

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Abstract: The comfort of human life vastly depends on the ease of availability of energy. Renewable energy sources are at par from their counterparts as far as cost factor is concerned. Solar energy can be converted to electrical energy using a solar cell which is a device based on photovoltaic effect. It has got a wide range of applications ranging from calculators, watches etc. to remote area power stations, earth orbiting satellites, space probes etc. The materials used in solar cells show preferential absorption of the wavelengths of solar spectrum that reach the earth surface. Since the process cost of silicon wafer based solar cells is very high, attempts are being continuously made to find an alternative. In the present study the performance of various solar cells based on perovskite materials having comparatively lower photo-catalytic activity, stability against photo-corrosion and stable photochemical properties has been discussed. These systems have already reached conversion efficiencies exceeding 20%. More than one technique used for fabrication and the role of the size of the nanoparticles in the film and film thickness has been studied.

Keywords: renewable energy, solar cells, perovskite materials, conversion efficiency

INTRODUCTION

A perovskite is any material with a crystal structure following the formula ABX_3, which was first discovered as the mineral called perovskite, which consists of calcium titanium oxide. Perovskites can be obtained from a wide range of materials and can be prepared with different dimensionalities. The perovskite materials find their applications in various fields of optoelectronics, including photovoltaic solar cells, photo detectors, light-emitting devices, and many more. Perovskite solar cells (PSCs) have achieved an unprecedented increase in power conversion efficiency (PCE) from 3.8% to 25.2% in the past decade [1]. A, Bhalla et al have used the perovskite structure to illustrate the enormous power of crystal chemistry-based intelligent synthesizing creating new materials [2]. Likun Pan, Guang Zhu have successfully summarized the current state of the know-how in the field of perovskite materials: synthesis, characterization, properties, and applications [3].

1.1 Solar Thermal Panel

Solar energy collector is the heart of any solar energy system designed for the operation in the low to medium temperature range. It is used to absorb solar energy, convert it into heat and then to transfer that heat to a stream of liquid or gas. It absorbs both the direct and the diffuse radiations. Properly designed collectors are used in many applications like photovoltaic solar systems, solar water heaters, cookers, drying grains etc. [4]. Cover plate (glaze) is an important part of any solar collector. Solar radiation intensity is not uniform for all the wavelengths in it. The required properties of the cover plate through which the solar energy is transmitted are extremely important in the functioning of a collector. The functions of cover plate are:

1. To transmit maximum solar energy to the absorber plate,
2. To minimize upward heat loss from the absorber plate to the environment
3. To shield the absorber plate from direct exposure to weathering,

The working of a collector involves the heating of enclosed spaces into which the sun shines through a transparent material such as glass or plastic which is known as glaze plate. Visible light easily passes through the glaze and is absorbed and reflected by materials within the enclosed space. The light energy that is absorbed by the dark absorber plate is converted into heat energy and radiates from the interior materials. Most of this radiant energy, because it is of a longer wavelength, cannot pass back out through the glazes and is therefore trapped within the enclosed space. Critical to solar cooker performance, the heat that is collected by the dark metal absorber plate produces green house warming effect and is conducted through those materials to heat and cook the food.

1.2Materials for Solar Collectors

The ideal glazing material for solar collectors would have the properties of high temperature stability, long life when exposed to UV, good impact resistant, light weight, easy to work and low cost.

Some of the lightweight polymers have good transmittance in the visible region, opacity in the IR region, poor emissivity in the visible region, and poor thermal conductivity and can be of low cost. These properties make them quite promising candidates for applications in solar thermal appliances. However, they have poor scratch resistance, low softening temperature and poor weatherability. They also degrade with long exposure to UV radiation. This shows that polymeric materials can prove to be quite promising candidates for applications in solar thermal appliances provided the shortcomings mentioned above may be removed or decreased as far as possible. Extensive efforts are being made, worldwide; in the direction of synthesizing polymer with desired properties. There are various reports, which indicate that the properties of polymeric material can be improved with the formation of nanocomposites [5]. Poly(methyl methacrylate) is an amorphous optically clear thermoplastic polymer material. It is used as a substitute for inorganic glass, because it shows higher impact strength and it has favorable processing conditions. It is widely used as a sheet glazing material. However, the stability of PMMA under UV-irradiation is poor, which results in the decrease of PMMA transparency under sunlight irradiation. The thermal stability of PMMA is not very well, it is usually used under 80^0C. If the temperature is above 80^0C, PMMA will become tender and metamorphose [6]. Polystyrene (PS) is a hard, transparent glass-like plastic made by polymerizing a benzyl derivitive of ethylene called styrene. It is a clear, colorless polymer used extensively for low-cost applications in solar thermal appliances. However, the most serious deficiencies are low impact strength, poor weatherability and poor chemical resistance[7]. The thermal stability of the polymer can be increased by the formation of nanocomposites using ZnO and TiO_2 , which is the main objective of proposed work. ZnO is well known for its excellent UV shielding. The nano ZnO/ polymethyl methacrylate - (ZnO/PMMA) composites have potential applications in UV protecting sheets and films, transparent barrier/protective layers, antireflection coatings and as materials with enhanced thermal stability. The development of a simple and effective procedure, allowing the production of transparent UV protective glaze on an industrial scale is still a challenge [8][9]. TiO_2 is also an excellent material in shielding ultraviolet light. It has been used in polymeric pigment to improve its photonic stability [10]. ZnO and TiO_2 behave as UV absorbers in their nano range as their band gap in UV range increases. 0.1 % and more of nano ZnO (particle size 100 nm) absorbs more than 99 % of the incident UV light. At lower concentrations (0.01%) ZnO nanoparticles absorb from 80 to 90 % of UV light indicating that synthesized ZnO nanoparticles are very efficient UV light absorbers. It is a wide gap semiconductor having an optical band gap in the UV region making it an extremely efficient UV absorber. The mechanism of UV absorption of these materials is known as the bandgap absorption with ZnO strongly absorbing wavelength below 380 nm and TiO_2 absorbing wavelengths below 365 nm. For this reason, introducing ZnO and TiO_2 nanofillers into the PMMA/PS matrix is proposed as a better alternative for a transparent UV-sheltering material. Poly (methyl methacrylate) – PMMA and Polystyrene (PS) are amorphous thermoplastic materials known for their high optical transparency. By combining these polymer and nano ZnO/ TiO_2 fillers it is possible to prepare transparent PMMA/PS materials with enhanced thermal stability and with high resistance to UV radiation [10]. Nanocomposites refer to the composites of materials consisting of more than one Gibbsian solid phase where at least one of the components has a dimension in the nanometer range. The solid phases can be inorganic or organic, or both, with amorphous, semi-crystalline or crystalline phase or combinations of those phases. Nanocomposites have been fabricated in several interdisciplinary fields to produce and satisfy several functions simultaneously needed in many applications. These can be used to produce homogeneous large-grained materials which offer useful new properties compared to conventional bulk materials. The properties of nanocomposites are affected by the individual properties of the components including their size. As the grain size decreases, there is a significant increase in the volume fraction of grain boundaries and interfaces. Also as the grain size decreases the number of atoms at the interface increase and thus the materials properties are strongly influenced by interaction of the surface layers with the matrix. Large-area deposition, coating, printing, and processing techniques for the upscaling of perovskite solar cell technology has also been reported [11]. Low-temperature processed meso-superstructured to thin-film perovskite solar cells has also been done [12]**.** Influence of thermal processing upon the crystallization and photovoltaic performance of organic–inorganic lead trihalide perovskites shows systematic quantitative changes on the performance [13]. Thus perovskite solar cells are an emerging photovoltaic technology [14].

Conclusion

Solar hydrogen production with semiconductor metal oxides has provided new directions in experiment and theory. The preliminary results, showing band to band transition i.e. in the UV region and visible emission due to defect states, are quite encouraging. Since particle size and shape, porosity, necking structure, film thickness, distance between electrodes etc. are significant features in solar cells, thus influence of these parameters on the performance / efficiency require much more experiments and research.

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