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Short Review Paper

Recent Advancement in the Graphene/Metal Oxide Based Photovoltaic Cell

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Abstract

The photovoltaic (PV) is very rapidly developing branch of technology, as it is concerned with energy demand. As reported, outstanding properties of graphene with metal oxides in part of introduction we will make design to study the different properties of such an efficient materials for PV technology. By analysing data available in literature of materials science, we will plan to investigate PV properties of graphene/CuO and graphene/Cu_2O composite.

Keywords: Graphene, Metal Oxide, Photovoltaic, Nanocomposites.

Introduction

Grapheneis two dimensional form of an allotrope of carbon in the network of hexagonally packed sp^2 hybridization carbon atoms. It is the fundamental element of many other carbon allotropes such as carbon nanotubes, charcoal, fullerenes and graphite. Graphene presents indefinitely large aromatic molecule and which are the main limiting case of above discuss allotropes of graphene. The monolayer graphene is zero band gap material. So, band gap engineering is easily possible by controlling layer number of graphene. Graphene has many wonderful physical properties such as high electrical and thermal conductivity, good mechanical and optical properties. The outstanding optical properties of graphene make it enable for Terahertz device technology. Metal oxides are the compounds formed by the combination of metal and oxygen in the form of oxide ion (O^{2-}). Metal oxides are basic in nature and they appeared as solid at the room temperature. They are used in the production of piezoelectric devices, sensors, microelectronic circuits, fuel cell and as catalysts. Oxide nanoparticles have outstanding physical and chemical properties because they are smaller in size and a high density of corner with excellent stability. Due to this fact modern sciences replace micro particles with nano particle.

Review of Literature

Bu *et al*[1] used one-step wet chemical method for preparation of graphene/ZnO composite quasi-shell core form. The coherent electric field is produced on the combine surface between graphene and ZnO, which remarkably increases the gap efficiency of the photo-generated electron-hole pairs results in increases of its photo-electrochemical performance. The electron migration ability of the composite is remarkably increased because of the coating of graphene on the surface of ZnO. So, this material has the application in dye solar cell as a substrate material with great potential. Khurana *et al*[2] enhanced the photovoltaic performance of dye sensitized solar cell(DSSC) which was made by an aqueous chemical route using ZnO-graphene nanocomposite. The combination of ZnO/graphene combination results in DSSC with high efficiency at low cost.

Peining *et al*[3] synthesized one dimensional TiO_2/graphene nanocomposite by one step electrospinning method. This study shows that significant enhancement in the photovoltaic properties of nanocomposite. The 33 % of enhancement is observed over pure graphene. Zhang *et al*[4] prepared DSSC from TiO_2 films by screen printing method with 6-10 printing layers. The photoelectric conversion efficiency achieved with 8 layers was 5.52%. Further, the combination of graphene and TiO_2 was used in synthesis of DSSC. In results, the efficiency of graphene/TiO_2 composite DSSC changes to 6.49%. Hu *et al*[5] used zinc oxide@graphene:ethyl cellulose (ZnO@G: EC) nanocomposite to make electron transport layer (ETL) by in situ formation method. The ZnO nanocrystals in graphene matrix increase the performance of polymer solar cells. The power conversion efficiency (PCE) of the inverted device based on P3HT:PC61BM to 3.9% is improved by incorporation of the ZnO@G:EC (1 v %) nanocomposite as cathode buffer layer. Afterwards it is discovered that PCE of 8.4% has been noted in the device based on PTB7:PC71BM as the active layer. The results shows that ZnO@G:EC is simple applicable as ETL for optimizing PSCs performance.

Wang *et al*[6] reported the application of nitrogen-doped TiO_2/grapheme nanohybrids as counter electrode in DSSC. These nanohybrids of pyrene are made to order $H_2Ti_3O_7$ nanosheets are prepared by self assembly and by $\pi-\pi$ stacking interactions of graphene in aqueous medium, after that by thermal calcination in ammonia atmosphere at various temperatures will be able to doped nitrogen in TiO_2/graphene nanohybrids. $H_2Ti_3O_7$ nanosheets are integrated from $TiOSO_4 \cdot xH_2O$ at 150°C for 48 hrs by hydrothermal reaction. Also, the result of the fabricated nanohybrids as counter electrode materials was checked, and the study shows that by the photocurrent density-photo voltage test, the higher electro catalytic activity toward I^{3-} reduction is obtain by the nanohybrids made at high nitridation temperature when they are used as counter electrodes , indicats that it can replace expensive Pt. Yang *et al*[7] synthesized and characterized NiO/graphene composite films and also fabricated the photo cathode for p-type semiconductor dye sensitized solar cells (DSCs). The composite was synthesis by chemical exfoliation of graphite powder folowed by reduction. This study shows the increase in both short-circuits photocurrent and open-circuit photo voltage, leads to 2 times enhance in PCE.

Park *et al*[8] demonstrated the ZnO nanowires array on graphene by enhancing the graphene surface with conductive polymers interlayer. By means of two different photo-active materials, PbS quantum dots and conjugate polymer P3HT they prepared graphene cathode based hybrid solar cell using this structure. The power conversion efficiencies are found to be 4.2% and 0.5% respectively. The overall study concludes that this method conserve the valuable properties of graphene and demonstrate the replacement of ITO in a variety of photovoltaic device configurations. Tang *et al*[9] prepared graphene/TiO_2 nanoparticle films by a molecular grafting method for DSSCs. In this study, due to chemical exfoliation process the oxidation time is controlled and the conductivity of reduced graphene sheets (GS) and the addition of TiO_2 nanoparticles to GS is done. The PCE of GS/TiO_2 composite DSSCs is 5 times more than the PCE of DSSCs composite of TiO_2 film.

Kim *et al*[10] used graphene doped 3-dimensional inverse electrodes in DSSCs. The graphene was integrated in the peak layers of inverse structures and fixed into TiO_2 matrix by the post treatment of TiO_2 precursors. It was found that the DSSCs fabricated with graphene\$TiO_2$ inverse electrodes has the efficiency of 7.5%. Chen *et al*[11] report that the improved photovoltaic working of DSSC composite of graphene\$TiO_2$ photo electrodes by reduction hydrolysis technique. The energy conversion efficiency is found to be 7.1%. The results shows that the advance effect of graphene depend on its quantity i.e. the efficiency of DSSCs first increase and afterwards decrease with rising graphene quantity in TiO_2\graphene composites. Beliatis *et al*[12] reported the ETL made of hybrid ZnO/ reduced graphene oxide (RGO) and TiO_2/RGO. The power conversion efficiency of TiO_2 and ZnO was found to be 6.39% and 6.20%. Also, after using it with reduced graphene oxide the high power conversion efficiency i.e.6.57% and 6.72% was recorded.

Akhtar *et al*[13] synthesis the graphene and polyethylene oxide (PEO) as electrode of DSSCs. Graphene sheets were equally coated with PEO. The high performance conversion efficiency was noted to be 5.2%. Chuang *et al*[14] synthesised Gold Nanoparticles–Graphene oxide (AuNP-GO) composite with simple one pot method. The AuNP-GO composites have great potential for use in organic photovoltaic containing various photoactive materials. The power conversion efficiency is found to be 5.10%. Barpuzary *et al*[15] reported a one coat paintable solution of hybrid composite of graphene oxide, ZnO and CdS as a photo anode for the semiconductor sensitized solar cell. In this the ZnO\CdS arrays are doped into the graphene oxide sheets. The PCE is found to be 2.82%. Ramadoss *et al*[16] synthesis graphene/ZnO nanocomposite via microwave-assisted method. The result shows that the doping of ZnO nanoparticles increases the capacitive performance of graphene electrode. This paper shows the significance and capacity of graphene based composites in progress of high capacity storage systems.

Imamura *et al*[17] reported the change in field effect transistor characteristic of graphene/SiO_2 by exposing it to ultraviolet radiations. The results shows that the imbalance of graphene to UV light requires the graphene/SiO_2 interface and indicates to increase the strength of devices based on graphene. Ryu *et al*[18] reported that in organic bulk hetero junction solar cells the graphene/nickeloxide bilayer is used as anode. In this the GO is used for the spin coating while preparing composite is dispersed in water. The nickel oxide solution is synthesized by sol gel synthesis method. The efficiency is found to be 3.48%. This is a 49% enhance in efficiency as compare to the organic photovoltaic cell with no hole transport layer.

Li *et al*[19] synthesised Mn_3O_4/RGO composite lithium ion battery. The Mn_3O_4/RGO hybrid nanocomposites with monodispersed Mn_3O_4 nanoparticles on RGO is synthesized by one step solution method. The nanocomposite cathode exhibits excellent ORR activity.

Zhu *et al*[20] reported the synthesis of graphene/MnO_2 nanowall hybrids by using one-step effective electrochemical method. The conductive network of amorphous nanocomposite shows the nanowall array morphology of MnO_2 which are advantagious to graphene. Zhou *et al*[21] prepared Co_3O_4/RGO by two step surfactant assisted method. The study shows the outstanding electrochemical results such as high capacitance and good rate capability. Kwon *et al*[22] reported a method of reusing Cu etchant used to synthesize graphene by chemical vapour deposition method. In application of these material i.e. organic photovoltaic cells, efficiency of OPVs is found to be 5.9–5.95%. Wang *et al*[23] reported the Graphene/TiO_2 nanoparticles used as electron collection layer in thin film Perovskite solar cells. The method used for preparation of TiO_2 nanopartices is hydrothermal method. The study shows that the solar cells with the photovoltaic performance of power conversion efficiency up to 15.6%.

Application of graphene/metal oxide composites in context of photovoltaic application

Graphene/metal oxide composite can be used as a surface Plasmon sensor. In this the electron transport of graphene is sensitive to surface Plasmon generated by the illumination of metal nanoparticles. Also it can be used as the thermo-photovoltaic devices in the energy conservation system where the electric current is generated from the thermal photons emitted by the hot body. The graphene/metal oxide composite is also used as the counter electrode, photo anode, cathode, electron transport layer in the dye-sensitized solar cell. It is also used in the supercapaitors, field effect transistors, lithium-ion batteries, gas sensing applications.

Conclusion

The different literatures of graphene/metal oxide based composites in photovoltaic cell are studied in this report. By merging the metal oxide composite by the graphene the increased in the efficiency of PV cell is concluded. Depending on the concentration of graphene, the efficiency of DSSCs first increase and afterwards decrease with rising graphene quantity in TiO_2/graphene composite. As reported by Wang *et al,* the highest efficiency of Perovskite solar cell is found to be 15.6%.

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