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Hydrothermally Assisted Synthesis and Characterization of Nanostructured WO_3 Thin Film for Photoelectrochemical (PEC) Applications

H.N.M Sarangika, E.G.O.D Egodawaththa, H. M. B. I. Gunathilaka, Sangeeta Ghosh, Chinmoy Bhattacharya, H.Y.R. Atapattu, G.M.L.P Aponsu

Abstract

In this report we present the synthesis, characterization and application of cost-effective WO_3 thin films prepared by the hydrothermal method as a photoanode in direct water splitting under solar irradiation. $Na_2WO_4.2H_2O$, $NaNO_3$, and HNO_3 were used as starting materials to synthesize WO_3 powder by the hydrothermal method. Hydrothermally prepared WO_3 powder coated on Fluorine-doped Tin Oxide (FTO) by drop casting followed by annealing in air at 600°C was used as the working electrode in photoelectrochemical (PEC) water oxidation to produce hydrogen fuel. The prepared electrode was characterized by UV-visible spectroscopy, Electrochemical Impedance Spectroscopy (EIS), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR) and confirmed the formation of nanostructured pristine WO_3. Mott-Schottky analysis confirmed the n-type semiconductivity of the prepared WO_3. The photoanode of WO_3 prepared on FTO exhibited maximum photocurrent of 120 μA cm^{-2} at an applied bias of +0.6 V (Vs Ag/AgCl) under periodic UV-Vis irradiation of 100 mW cm^{-2} for water oxidation. High stability was observed for this WO_3 electrode in the water oxidation for continuous periodic illumination over 1 hour. Further improvements will be carried out by incorporating carbon-supported materials.

About the Conference

18th Asian Conference on Solid State Ionics

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Meenakshi College for Women, Chennai, India

Our Scholars

Dr. HNM Sarangika

Senior Lecturer

sarangikah@appsc.sab.ac.lk

Snr. Prof. GMLP Aponsu

Senior Professor

aponsul@appsc.sab.ac.lk

DPST

WO_3 Nanostructured Thin Films Prepared by In Situ Hydrothermal Method as a Low-cost, Multifunctional Material

H.N.M Sarangika, E.G.O.D Egodawaththa, H. M. B. I. Gunathilaka, M.A.K.L. Dissanayake, G.K.R. Senadeera, Sangeeta Ghosh, Chinmoy Bhattacharya

Abstract

Tungsten trioxide (WO_3), an n-type semiconductor is considered to be a technologically important material in many research areas including energy, and environment due to its excellent electrical properties, chemical stability, and relatively low cost. In this paper, we report the application of cost-effective hydrothermally prepared WO_3 thin films on a Fluorine doped Tin Oxide (FTO) glass substrate as the photoanode in direct water splitting, as a sensor material in gas detection, and as a working electrode in electrochromic devices. Sodium Tungstate Dehydrate (Na_2WO_4 □$2H_2O$) and $NaNO_3$ dissolved in deionized water adjusted to 1.5 pH by HNO_3 was used as the hydrothermal solution. Hydrothermal treatment was carried out at 100 °C for 5 h. The structure and morphology of the prepared WO_3 thin films were characterized by using different techniques including X-ray differaction (XRD), Fourier Transform Infrared (FTIR), UV-visible spectroscopy, and Scanning Electron Microscopy (SEM). Hydrothermally prepared pristine WO_3 film on FTO was used as a photoanode and exhibited a relatively high photocurrent (70 μA cm^{-2}) under UV-Vis irradiation for water oxidation. The same electrode of WO_3-coated FTO with less film thickness showed a change of its color between light green and blue when applied 3.5 V across the electrochromic device (ECD) of configuration FTO/WO_3/LiCl+polyethelene oxide (PEO) based gel electrolyte/FTO. Performance of the in situ constructed hydrothermal WO_3 thin film electrode was tested as a gas sensing material and exhibited a 15% of response towards the Liquid Petroleum Gas (LPG) at room temperature.

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Senior Lecturer

sarangikah@appsc.sab.ac.lk

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Enhancing Efficiency in Poly(Ethylene Oxide) Solid Polymer Electrolyte -based Dye-Sensitized Solar Cells: The Synergistic Effect of Plasticizers, Mixed Cations, and Nanofillers

M.A.K.L.Dissanayake, R.A.Jayarathna, G.K.R.Senadeera, J.M.K.W.Kumari, H.N.M. Sarangika

Abstract

N719 ruthenium dye-based dye-sensitized solar cells (DSSCs) were fabricated using solid polymeric electrolytes based on poly(ethylene oxide) (PEO) by incorporating a plasticizer, mixed cations (tetrapropyl ammonium iodide, $Pr_4N^+I^-$ and KI), and TiO_2 nanofiller. The starting electrolyte composition with PEO:15 wt.% $Pr_4N^+I^-$:I_2 showed the highest conductivity of 3.97×10^{-5} S m^{-1} at 30 °C, and the DSSCs employing this electrolyte exhibited an efficiency of 1.08%. The addition of plasticizer ethylene carbonate (EC) to the electrolyte at the optimum composition of 42.5 wt.% PEO: 42.5 wt.% EC: 15 wt.% $Pr_4N^+I^-$: I_2 enhanced the efficiency to 1.46%, evidently due to the increased amorphous nature of the PEO polymer. When Pr_4N^+I was added to the electrolyte as the second iodide salt, corresponding to the optimized composition of 42.5 wt.% PEO: 42.5 wt.% EC: 3.75 wt.% $Pr_4N^+I^-$: 11.25 wt.% KI: I_2, the efficiency was further increased to 1.81%, which is very likely due to the mixed cation effect. The incorporation of 2.5 wt.% TiO_2 nanofiller into the above electrolyte further enhanced the efficiency up to 3.02%, evidently due to the higher ionic mobility caused by the increased amorphous phase content of the polymer electrolyte. TiO_2 photoanodes were subjected to $TiCl_4$ treatment to increase their effective specific surface area and hence to increase the short-circuit photocurrent and the overall efficiency of the DSSCs. The DSSCs optimized by the synergistic effect of the above-stated strategies exhibited an overall efficiency of 3.41%, which is among the highest for a solid polymer electrolyte-based DSSC.

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