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Research Papers

Electrosynthesis of semitransparent Ni-Co_2-Cu_x mixed oxide electrode film for novel solid state asymmetric planar supercapattery application

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Highlights

- Novel Pseudocapacitive Ni-Co_2-Cu_x Mixed Oxide (MO) Thin Film Electrode has been developed from simple two-electrode electrofabrication process
- Microstructural studies revealed porously stacked and agglomerated Mixed phases of $NiCo_2O_4$, Cu_2O and CuO architecture architecture.
- Comparative electrochemical properties on variation of deposition electrolyte temperature for the Ni-Co_2-Cu_x-MO film - were examined.
- The outcomes disclosed that the film demonstrated highly stable specific capacitance and capacity of 1940.1 Fg^{-1} and 134.2 $mAhg^{-1}$, respectively.
- Successful fabrication of a high performance asymmetric supercapattery device of Ni-Co_2-Cu_x-MO and RGO electrode structures was shown.

Abstract

Herein, we have successfully grown transparent $NiCo_2$ and Cu mixed oxide thin film electrode material by a facile electrodeposition process from electrolyte containing hydrated salts of its composite metals at two different temperatures. Microstructural and some other surface studies were carried out with the aid of suitable and appropriate probing facilities such as scanning electron microscope (SEM), atomic force microscope (AFM), X-ray diffractometer (XRD), Raman microscope and ultraviolet-visible spectrophotometer. Microstructural studies on the samples revealed the formation of seed flowerlike nanosheet by the film grown from room temperature electrolyte which was found to become porously stacked and agglomerated as observed for the one grown at higher temperature. Further probing showed that the grown film exhibit crystallinity and surface roughness of high degree. Optical energy band gap values were also found to be 3.08 and 3.00 eV depending on the synthesis protocols observed. The optimum electrode sample exhibited high specific capacitance and capacity of 1940.1 Fg^{-1} and 134.2 $mAhg^{-1}$, respectively and with excellent cycling stability when tested as half-cell in three-electrode mode and 1 M aqueous KOH electrolyte. It was further utilized as positrode in a fabricated solid state asymmetric supercapattery device with reduced graphene oxide (RGO) as negatrode and powdered PVA-KOH electrolyte. The device displayed intriguing performance having demonstrated excellent cycling in high voltage (0 to 1.6V) window and over 20,000 charge-discharge cycles, and with high areal capacitance, energy density and power density of 20.2 $mFcm^{-2}$, 25.60 $Whcm^{-2}$ and 2344.42 Wcm^{-2}, respectively. The study demonstrated the significant supercapacitive potentials of the fabricated electrode material for high quality energy storage devices.

Introduction

The quest for a stable energy storage system is currently receiving a great deal of attention due to the rapid degradation and health hazard associated to fossil fuel and the erratic nature related with the exploration of renewable energies such as solar and wind. Among these storage systems, electrochemical energy storage modules such as batteries and supercapacitors have considerably attracted a great interest. Battery has been widely researched due to its capabilities for high energy dissipation, volume and storage capacity. However, it still suffers several incapability such as poor power densities and cycling stabilities owing to some complex irregularities surrounding their electrochemical volumetric reactions [[1], [2], [3]]. Meanwhile, research has projected supercapacitor has another promising electrochemical energy store. This is attributed to its long cycle life, excellent and fast charging rates, high power and energy densities and so on. Supercapacitor is categorized as either electric double layer capacitor (EDLC) or Pseudocapacitor (PC), depending on the charge storage mechanism it adopts [[4], [5], [6]]. In EDLCs, the energy is stored through the electrolytic ion absorption occurring at the EDLC electrodes' surface. PCs exhibit battery type property by storing charge via Faradaic redox reversible reactions arising from the exchange of ions at the interface between PC electrode and electrolytes. Example of EDLC electrodes include carbon-based materials such as graphene oxide, reduced graphene oxide (RGO), activated carbon, among others, while PC electrode materials encompasses metal oxide/sulfides/hydroxides and conducting polymers [[7], [8], [9], [10]]. Asymmetric supercapattery (ASC) combines the processes of these two categories by bringing EDLC and PC electrodes (with