Thin Solid Films 777 (2023) 139894

Contents lists available at ScienceDirect

Thin Solid Films

journal homepage: www.elsevier.com/locate/tsf

Gold coated vertically aligned carbon nanotubes as electrode for electrochemical capacitors

Sabrina Roguai [a,b,*], Abdelkader Djelloul [a,b]

[a] LASPI2A Laboratory of Structures, Properties and Interatomic Interactions, Abbes Laghrour University, Khenchela 40000, Algeria
[b] Science of Matter, Abbes Laghrour University, Khenchela 40000, Algeria

ARTICLE INFO

Keywords:
Gold
Carbon nanotubes
Vertically aligned carbon nanotubes
Electrochemical capacitors
Cyclic voltammetry

ABSTRACT

In this work, gold (Au) films were deposited onto vertically aligned carbon nanotubes (CNTs) by Dc magnetron sputtering method for use as super-capacitor electrodes. By so doing, we synthesize a porous Au deposit anchored on the CNTs with a high apparent surface area. The structure and microstructure studies revealed that the Au@CNTs have a porous nanostructure morphology. The porous Au/CNTs electrodes exhibit an a good areal capacitance compared to state of art Au based electrode (25.6 mF cm^{-2} at 5 $mV.s^{-1}$) and excellent cycling stability (90% retention after 10.000 cycles) in 0.5 M H_2SO_4 aqueous solution. These results demonstrate the beneficial use of CNTs to fabricate a porous Au deposit with improved electrochemical energy storage. In addition, these porous structures can also be used as templates for another type of materials for electrochemical energy storage.

1. Introduction

Among the various energy storage systems, electrochemical capacitors (ECs) also called supercapacitors have attracted increasing attention as potential candidates for energy storage, due to their high power density and long cycle life [1–3]. Carbon materials such as graphene [4,5], activated carbon [6–9], carbon nanotube (CNT) [10,11], carbide-derived carbons [12,13], mesoporous carbon [14,15], and carbon aerogel [16–18], are widely used as promising materials for supercapacitors, or templates for different material deposition because of their high surface area, excellent conductivity, and electrochemical stability [19–24]. A supercapacitor using CNT-forest transferred onto an elastomeric substrate with assistance from a thermal annealing process in an atmospheric environment was unveiled by Changyong et al. [25]. This CNT-forest electrode exhibited excellent electrochemical performance as well as high stability under either uniaxial (300%) or biaxial (300% × 300%) stresses under thousands of stretch-relaxation cycles. On the other hand, Sheng et al. [26], through the design of 3D electrodes, a substantial improvement in vertical 3D nanomaterial based systems for energy storage at the microscopic scale device

Gold (Au) with high content has also been used as a model for the deposition of transition metal oxides in order to improve the electrical conductivity of the deposited material. Thanks to these properties work based on the combination of Au and CNT in order to allow the optimization of their single properties to create systems that are potentially versatile [27]. However, report on porous Au as electrode for ECs is scarily reported in literature. For example as it permits the integration of their own unique properties in order to achieve potentially multipurpose systems. Au electrodeposition on CNT tips has been demonstrated to also provide better current density control of the electrode due to its high conductivity [28,29]. However, Yihao et al. [30] propose a robust and highly efficient scalable electrode from a crumpled Au-CNT forest. This symmetric supercapacitor has a maximum specific capacitance of 6 mF cm^{-2} at a current density of 40 mA cm^{-2} at large strains, and exhibits superior mechanical and electrochemical stability. This investigation provides a feasible method to synthesize vertically aligned nanotubes or nanowires into highly stretchable supercapacitors for outstanding and robust electrochemical capabilities.

In the present work, we report the synthesis of high performance electrodes based on Au deposited on CNTs. The Au thin films were synthesized by magnetron sputtering on vertically aligned CNTs template using one-step process. The electrochemical measurements reveal that Au@CNTs film shows enhanced properties with higher areal capacitance values compared to those of pure CNTs or Au thin film electrodes in a mild electrolyte of 0.5 M H_2SO_4 and excellent stability over 10 000 cycles.

* Corresponding author.
E-mail address: rog.sabrina@yahoo.fr (S. Roguai).

https://doi.org/10.1016/j.tsf.2023.139894
Received 22 October 2022; Received in revised form 15 May 2023; Accepted 18 May 2023
Available online 20 May 2023