Materials Today: Proceedings 62 (2022) 5223–5229

Contents lists available at ScienceDirect

Materials Today: Proceedings

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

Influence of deposition time on the supercapacitive performance of electrodeposited interconnected $Co(OH)_2$ nanoflakes

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ARTICLE INFO

Article history:
Available online 25 March 2022

Keywords:
$Co(OH)_2$ Nanoflakes
Electrodeposition
FE-SEM
Supercapacitors

ABSTRACT

In the electrodeposition process, the deposition time directly influences electrodes surface morphology and electrochemical performance. Cobalt hydroxide $Co(OH)_2$ nanoflakes were produced potentiostatically on stainless steel at various deposition times (1, 2, 3, 4, 5 min) in this research work. The $Co(OH)_2$ nanoflakes, could be a viable candidate for use as an electrode material in supercapacitor applications due to their innovative manufacturing and high capacitance. X-ray diffraction and field emission scanning electron microscopy were used to investigate the structural and morphological features of prepared nanoflakes. The supercapacitive performance was studied using cyclic voltammetry, galvanostatic charge–discharge, and electrochemical impedance spectroscopy techniques. The study reveals that deposition time and potential have an impact on the morphology of deposited material, and that morphology has an impact on electrochemical characteristics.

In 1 M KOH, as prepared $Co(OH)_2$ nanoflakes reveals a specific capacitance of 480F g^{-1} for 1 $mAcm^{-1}$. The $Co(OH)_2$ electrode retained 79 % capacitance after 1000 cycles.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Emerging Trends in Material Science and Technology – 2022.

1. Introduction

Energy use has risen rapidly in recent decades, resulting in a slew of issues such as deforestation, global warming, and climate change. Scientists are focusing on renewable energy sources and storage devices like supercapacitors (SCs) and lithium ion batteries to solve this issue [1–4]. High power density, long life cycle, quick charging-discharging are the strength of supercapacitor making it a good replacement for traditional energy storage [5,6]. Because of their low cost, relative ease of processing, and extremely high theoretical capacitive values, transition metal oxide (TMOs)/hydroxides (/Hs) are the most promising electrode materials [7,8]. Chemical and physical properties such as conductivity, surface area, morphology, corrosion resistance, temperature stability, and others influence the material's electrochemical properties. Nanostructured TMOs/Hs have better performance in the charge–discharge cycle output and can easily handle the strain generated by ion insertion-desertion [9,10]. Various transition metal oxides such as copper oxide (CuO) [11], Ni(OH)2 [12], cobalt oxide (Co_3O_4) [13], manganese oxide (MnO_2) [14], nickel oxide (NiO) [15], cobalt hydroxide ($Co(OH)_2$) [16] have been used as electrode for supercapacitor. $Co(OH)_2$) exhibits cost effectiveness, large theoretical capacitance, excellent redox activity, and precise reversible redox reaction, broad interlayer spacing, and environmental friendliness, it has been used as a promising electrode for supercapacitor application [17–20]. Chemical bath deposition [21], microwave assisted [22], hydrothermal [23], electrodeposition [24], and other methods are used for the synthesis of $Co(OH)_2$.

Electrochemical deposition is one of the most efficient, fast, and cost-effective methods for the binder-free synthesis of nanostructured TMOs/Hs on current collector. The electrodeposited films have high deposition rate and excellent uniformity. The growth of electrodeposited material control by changing preparative parameters such as precursor's molarity, applied voltage, applied current, potential window, deposition timing, working electrode, temperature of precursor, etc in the electrodeposition (ED) method [25–26].

In this work, $Co(OH)_2$ nanoflakes were grown-up directly on a stainless steel substrate using ED at −0.9 V (vs SCE) different times.

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https://doi.org/10.1016/j.matpr.2022.03.116
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the International Conference on Emerging Trends in Material Science and Technology – 2022.