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Optimally tuned deposition of 3D interconnected ultrathin cobalt oxide nanoflakes on Ni-foam by electrodeposition technique for targeted supercapacitor application

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ABSTRACT

In this work, the 3D interconnected cobalt oxide nanoflakes (CON) were grown successfully on nickel foam (NF) at ambient conditions by the electrodeposition method, further followed by calcination. The deposition of Co_3O_4 was carried out for different deposition times of 10 min, 15 min, and 20 min and enumerated as CON-10, CON-15, and CON-20 respectively. The CON samples were characterized for their Physico-chemical studies by XRD, FT-IR, FE-SEM, and EDS. FE-SEM micrographs of CON nanostructures showed the uniform deposition of the 3D interconnected nanoflakes on NF. The sample CON-15 exhibited the highest specific capacitance (C_s) of 444 Fg^{-1} also the specific energy (SE) of 26.07 $Whkg^{-1}$, specific power (SP) of 541.66 Wkg^{-1}, and efficiency (η) of 77 % at 1 mAg^{-1} with outstanding cycling stability of 86 % capacitance retention after 1000 cycles.

Introduction

In a wide range of industrial applications, energy storage systems play a crucible role. The increasing energy crisis has urged the rapid development of highly sustainable, eco-friendly, and efficient energy storage and conversion devices. In energy storage systems, specific energy, specific power, lifetime, reliability, and safety are some of the most important factors to consider [1]. Energy storage devices such as fuel cells, batteries, conventional capacitors, supercapacitors (SCs), etc are the most important energy storage devices to store energy [2]. Rechargeable batteries, particularly lithium-ion batteries have been used in electric vehicles, and autonomous electric devices due to their high energy density, low self-discharge behavior, and extensive lifespan. But there are some battery drawbacks including low power density, high charging times, high internal resistance, and heating issues which could severely limit their power-delivery performance when subjected to high current loads [3]. SCs have been paid lots of attention and are widely regarded as a potential energy storage technology because of their quick charge/discharge rate, high degree of recyclability, and high power delivery rate [4]. Despite their low energy density, SCs have other advantages like a wide operating temperature window, low internal resistance, and excellent efficiency [5]. SCs have been classified into three categories depending on their charge storage mechanism. The first is the EDLCs (electric double-layer capacitors) are constructed from nano-porous carbon material electrodes [6], the second is the pseudocapacitors which use metal oxides or conducting polymers electrode materials, and the third part of the supercapacitor is a hybrid capacitor it has been constructed from a combination of both EDLC and pseudocapacitors [7]. Capacitance in EDLC is caused by the formation of a double layer of electrostatic ion at the electrode/electrolyte interface, while capacitance in a pseudocapacitor which is much higher than carbon-based materials due to it is caused by fast faradic redox reaction occurring at the electrode surface, and electric charge storing mechanism of the hybrid capacitor is based on faradic as well as non-faradic process [8].

Recently, transition metal oxides like copper oxide (CuO) [9], zinc oxide (ZnO) [10], manganese oxide (MnO_2) [11], ruthenium oxide (RuO_2) [12], and cobalt oxide (Co_3O_4) [13], etc. are the attractive

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