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RESEARCH ARTICLE

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Exploring the influence of Ni doping thin films for supercapacitor application

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Abstract

This study explores the impact of nickel (Ni) doping bismuth ferrite ($BiFeO_3$) thin film synthesis by spray pyrolysis method. The structural and morphological study shows that the thin films are slightly amorphous with granular morphology. Investigated the supercapacitive behavior of synthesized material by using cyclic voltammetry, galvanostatic charge-discharge, and electrochemical impedance spectroscopy. The thin films synthesized are capable of storing a 253.31 F/g capacitance at a 10 mV/s scan rate and by introducing nickel into the synthesis process, we obtained 312.12 F/g capacitance at a 10 mV/s scan rate. The material shows good cyclic stability after 91000 cycles. It is also observed that no structural and morphological changes were made by doping Ni into $BiFeO_3$ thin films. The significant improvement in capacitance was displayed by Ni doping into $BiFeO_3$ obtained via spray pyrolysis methods indicating its potential for use in supercapacitor applications.

KEYWORDS

bismuth ferrite; Ni doping, spray pyrolysis; supercapacitor

1 | INTRODUCTION

The increasing worldwide need for energy has directed research efforts toward the development of improved energy storage systems capable of achieving rising power demands while also addressing environmental issues.[1,2] In comparison to conventional energy storage options, supercapacitors have emerged as promising devices with high-power density, quick charge-discharge cycles, and long-term operating lifetimes.[3,4] Their ability to bridge the gap between short-term high-power demands and long-term energy storage has led to increased research and development in electrochemical energy storage.

Among the several materials under consideration for supercapacitor applications, $BiFeO_3$ has received significant attention because of its multifunctional features, which include strong ferroelectricity, multiferroicity, and great chemical stability.[5,6] These properties make $BiFeO_3$ a fascinating option for energy storage applications, notably supercapacitors, where high energy densities and outstanding charge storage capacities are essential.

Synthesizing thin films of $BiFeO_3$ gives a possible path for improving its efficacy in supercapacitor technology.[7,8] The spray pyrolysis process is one significant technology gaining interest in the synthesis of $BiFeO_3$ thin films.[9,10] This technology is known for its simplicity of use, scalability, low cost, and ability to synthesize thin films with controlled thickness and composition. Unlike other processes, spray pyrolysis allows for straightforward doping, making it possible to use dopants such as Ni to modify the electrical properties of $BiFeO_3$ thin films for improved supercapacitor performance.[11,12]

Theoretical specific capacitance values for bismuth ferrites vary between approximately 925 and 1233 F g^{-1}, which correspond to either three or four electron transfer reactions.[13] However, despite these encouraging numbers, spinel ferrites demonstrate not enough electrical conductivity and slow ion diffusion.[14] In order to