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Vanadium Selenium Oxide Based Thin Film by Silar Method for Supercapacitor Application

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Abstract

The urgent global need for sustainable and efficient energy storage solutions has positioned supercapacitors (also known as electrochemical capacitors) as a critical technology. Bridging the gap between traditional capacitors (high power density, low energy density) and batteries (high energy density, low power density), supercapacitors offer high power output, rapid charge/discharge rates, and exceptionally long cycle life. The performance of these devices is fundamentally linked to the properties of their electrode materials. Among the materials investigated, transition metal oxides, particularly those based on vanadium, have emerged as highly promising candidates due to their rich redox chemistry, high theoretical specific capacitance, and earth-abundance. The SILAR method is a cost-effective, non-vacuum, and low-temperature technique that provides excellent control over film thickness and morphology, comparable to more complex methods like Atomic Layer Deposition (ALD), but using simple aqueous solutions. The process is based on alternating, repetitive immersions of the substrate into separate precursor solutions, followed by rinsing steps. Electrochemical characterization using Cyclic Voltammetry (CV) and Galvanostatic Charge-Discharge (GCD) curves visually confirms the superior performance. The CV curves typically show characteristic redox peaks indicative of pseudocapacitance, and the GCD curves exhibit non-linear (triangular) behavior, confirming the faradaic charge storage. Electrochemical Impedance Spectroscopy (EIS) reveals a low series resistance and charge transfer resistance, consistent with fast kinetics. Vanadium selenium oxide thin films synthesized using the Successive Ionic Layer Adsorption and Reaction (SILAR) method represent a cutting-edge approach to developing high-performance supercapacitor electrodes. The SILAR technique offers a scalable, low-cost route to precisely control the film thickness and morphology, while the V-Se-O composite leverages the high pseudocapacitive charge storage of vanadium with the improved electrical conductivity and structural stability imparted by the selenium inclusion.

Keywords: Vanadium, selenium, Silar, Supercapacitor