CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

36579

Project Title

Enhancing the Rate Capability of the Ni-Co-O System Supercapacitor Electrode Using NH3 Treatment

Abstract

Objectives/Goals

The global energy crisis and climate change have become serious issues in need of innovative solutions. Supercapacitors have attracted extensive attention as promising energy storage and delivery devices due to their fast charge and discharge rate, high power density, and long cycle life. Most commercial supercapacitors EDLCs that store charge at the electrode and electrolyte interface. However, their energy densities are lower than those of pseudocapacitors, supercapacitors that store charges using reversible faradic redox reactions. Ternary oxide pseudocapacitor systems, such as Ni-Co-O, etc. have exhibited excellent capacitive behaviors, and therefore have the possibility of producing higher specific capacitances. But they still suffer from low conductivity and as a result, poor rate capability. In this study, I aim to develop a ternary oxide pseudocapacitor system using Ni-Co-LDH as a precursor treated with an NH3 atmosphere at various temperatures to improve its conductivity and rate capability.

Methods/Materials

Ni-Co-LDH precursor was synthesized using hydrothermal process. It was then treated for 1 hour with the N2 and NH3 atmospheres at 400C with an upstream temperature of 800C chemical vapor deposition (CVD). The as-treated active material was characterized by using X-Ray Diffraction (XRD) and Scanning Electron Microscope Imaging (SEM). A CHI 660D electrochemical workstation was used to test the electrochemical performance of the electrodes in a three-electrode system with Ag/AgCl reference electrode. Samples were pressed into Ni foam sheets for electrochemical testing in the electrochemical workstation. The Ni-Co-O electrode was then coupled with a graphene electrode for testing of an asymmetric system.

Results

The NH3 treated Ni-Co-O system electrode shows an enhanced rate capability with only a 14.008% loss of capacitance over the current density range of 2-20 A/g while still maintaining high specific capacitances above 500 F/g. The assembled asymmetric supercapacitor using my electrode coupled with graphene also shows high power density, good energy density, and low capacitance loss of 36.598%.

Conclusions/Discussion

The assembled Ni-Co-O system electrode shows superior rate capability and very competitive specific capacitance. These good results are mostly transferred to the assembled asymmetric system for effective real world use. However, the asymmetric system still needs more optimization.

Summary Statement

I synthesized and tested a novel Ni-Co-O ternary oxide supercapacitor electrode with superior rate capability and high capacitance. It's excellent results are transferred over to a working asymmetric system with good performance.

Help Received

Mr. Tianyi Kou from the Li Lab at UC Santa Cruz helped me use Lab equipment, plan my research, and answered my questions. Mr. Jonathan Bowns helped prepare my board and presentation.