CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Eesha Khare

Project Number

S0912

Project Title

Design and Synthesis of Hydrogenated TiO2-Polyaniline Nanorods for Flexible High-Performance Supercapacitors

Abstract

Objectives/Goals

With the rapid growth of portable electronics, it has become necessary to develop efficient energy-storage technology to match this development. While batteries are currently used for energy-storage, they suffer from long charging times and short cycle life. Electrochemical supercapacitors have attracted attention as energy-storage devices because they bridge the gap between current alternatives of conventional capacitors and batteries, offering higher energy density than conventional capacitors and higher power density than batteries. Despite these advantages, supercapacitor energy density is much lower than batteries and increasing energy density remains a key challenge in supercapacitor research. The goal of this work was to design and synthesize a supercapacitor with increased energy density while maintaining power density and long cycle life.

Methods/Materials

To improve supercapacitor energy density, I designed, synthesized, and characterized a novel core-shell nanorod electrode with hydrogenated TiO2 (H-TiO2) core and polyaniline shell. H-TiO2 acts as the double layer electrostatic core. Good conductivity of H-TiO2 combined with the high pseudocapacitance of polyaniline results in significantly higher overall capacitance and energy density while retaining good power density and cycle life. This new electrode was fabricated into a flexible solid-state device to light an LED to test it in a practical application.

Results

Structural and electrochemical properties of the new electrode were evaluated. It demonstrated high capacitance of 203.3 mF/cm2 (238.5 F/g) compared to the next best alternative supercapacitor in previous research of 80 F/g, due to the design of the core-shell structure. This resulted in excellent energy density of 20.1 Wh/kg, comparable to batteries, while maintaining a high power density of 20540 W/kg. It also demonstrated a much higher cycle life compared to batteries, with a low 32.5% capacitance loss over 10,000 cycles at a high scan rate of 200 mV/s.

Conclusions/Discussion

This project successfully designed, synthesized and characterized a novel nanorod electrode supercapacitor with increased energy density while retaining power density and long cycle life. This work is an important initial step in introducing this new electrode material in supercapacitors to replace conventional batteries in flexible electronic devices.

Summary Statement

This project designed and synthesized a novel supercapacitor with increased energy density while maintaining power density and long cycle life using a new core-shell structure.

Help Received

Used lab equipment at University of California Santa Cruz under the supervision of Dr. Yat Li