Synthesis and Comparison of Various Metal Oxide Electrode Materials for Supercapacitors

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Abstract: Metal oxides (In_2O_3, Co_3O_4, $CoMn_2O_4$, MnO_2 and CuO@CuS) with different morphologies have been investigated as supercapacitor electrode materials. The crystal structures and morphologies of the electrodes were determined by using X-Ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), Energy Dispersion X-Ray Spectroscopy (EDS). Cyclic Voltammetry (CV) and Galvanostatic Charge Discharge (GCD) analysis of the electrodes were performed in different aqueous electrolyte solution.

Keywords: Metal Oxides, Hydrothermal and Thermal Oxidation Method, CVD, Supercapacitor

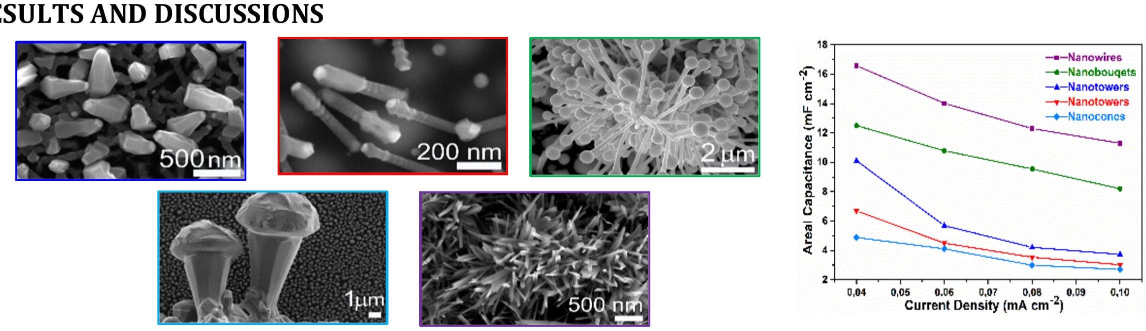
INTRODUCTION

In recent years, supercapacitors are of particular interest due to their high power density, fast charge/discharge rate and long cycle life [1–3]. Supercapacitors are divided into two types depending on the charge storage mechanisms - electrical double layer capacitors (EDLCs) and pseudocapacitors [3]. EDLCs store charge electrostatically at electrode/electrolyte interface as charge separation. There is no charge transfer between electrode and electrolyte. Pseudocapacitors store by charge transfer between electrode and electrolyte. The charge is transferred at the surface or in the bulk near the surface through adsorption, redox reaction and intercalation of ions [4]. Transition metal oxides and hydroxides are being extensively investigated for use in high performance supercapacitors due to their low cost and low toxicity [5].

MATERIALS AND METHODS

Different types of metal oxide have been synthesis various methods. For example, one-dimensional (1-D) single crystal indium oxide (In_2O_3) nanotowers, nanobouqets, nanocones, and nanowires were investigated as a candidate for a supercapacitor electrode material using a chemical vapor deposition (CVD) system. Co_3O_4 and $CoMn_2O_4$ nanostructures and MnO_2 nanosheets have been successfully synthesized on nickel foam by hydrothermal method. Large-scale vertically aligned single-crystalline CuO NWs have been synthesized on copper foam at 500 °C for 4 h via thermal oxidation method and then CuS were synthesized on CuO NWs via hydrothermal method.

RESULTS AND DISCUSSIONS



Fig, 1. Areal capacitance vs. current density of In_2O_3 nanostructures.

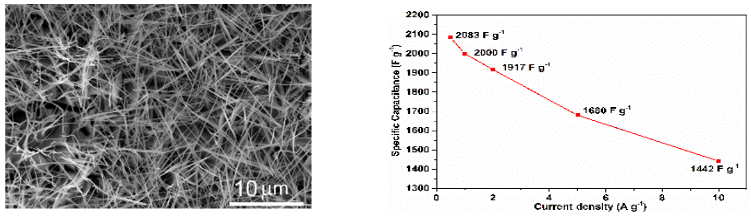


Fig. 2. Specific capacitance vs. current density of Co_3O_4 nanosheets/nanowires.

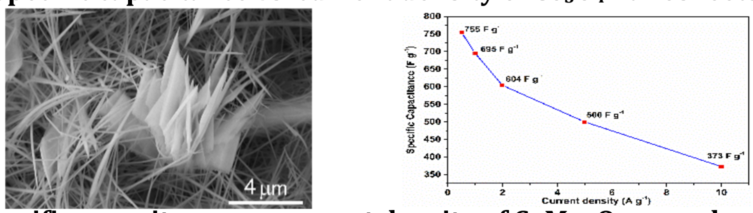


Fig. 3. Specific capacitance vs. current density of $CoMn_2O_4$ nanosheets/nanowires.

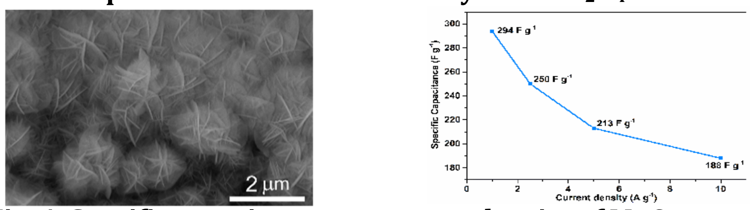


Fig. 4. Specific capacitance vs. current density of MnO_2 nanosheets.

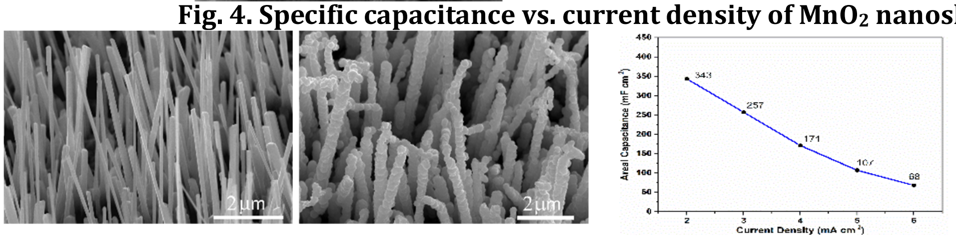


Fig. 5. Areal capacitance vs. current density of CuO@CuS nanowires.

Table 1. Comparison of specific capacitance values of metal oxide supercapacitor electrode materials.

Electrode Materials	Specific Capacitance	Electrolyte	Methods
In_2O_3 nanowires	16.6 mF cm^{-2} at 0.04 mA cm^{-2}	1 M Na_2SO_4	CVD
In_2O_3 nanotowers	10.1 mF cm^{-2} at 0.04 mA cm^{-2}	1 M Na_2SO_4	CVD
In_2O_3 nanobouquets	12.5 mF cm^{-2} at 0.04 mA cm^{-2}	1 M Na_2SO_4	CVD
In_2O_3 nanocones	4.9 mF cm^{-2} at 0.04 mA cm^{-2}	1 M Na_2SO_4	CVD
Co_3O_4 nanosheets/nanowires	2083 F g^{-1} at 0.5 A g^{-1}	1 M KOH	Hydrothermal Method
$CoMn_2O_4$ nanosheets/nanowires	755 F g^{-1} at 0.5 A g^{-1}	1 M KOH	Hydrothermal Method
MnO_2 nanosheets	294 F g^{-1} at 1 A g^{-1}	1 M KOH	Hydrothermal Method
CuO@CuS core/shell nanowires	343 mF cm^{-2} at 2 mA cm^{-2}	2 M KOH	Hydrothermal and Thermal Oxidation Method

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