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Super long-life all solid-state asymmetric supercapacitor based on NiO nanosheets and α-Fe_2O_3 nanorods

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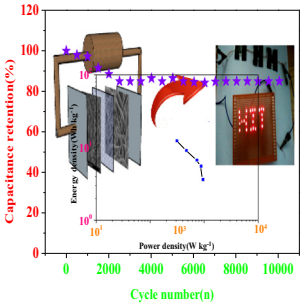
HIGHLIGHTS

- A novel NiO//α-Fe_2O_3 all solid-state asymmetric supercapacitor has been constructed.
- It demonstrates high energy/power densities (12.4 W h kg^{-1} and 951 W kg^{-1}).
- The device exhibits a long cycle life with 85% capacity retention after 10,000 cycles.
- The device with a lightweight and low-cost materials is fabricated.

GRAPHICAL ABSTRACT

A novel all solid-state asymmetric supercapacitor has been constructed with NiO nanosheets and α-Fe_2O_3 nanorods. It can be cycled reversibly in a high voltage region and demonstrates high energy/power densities (12.4 W h kg^{-1} and 951 W kg^{-1}). Furthermore, NiO//α-Fe_2O_3 supercapacitor device exhibits a long cycle life with 85% capacitance retention after 10,000 cycles. The electrodes with superior capacitor characteristic might provide an efficient strategy to fabricate lightweight and low-cost materials in energy storage systems.



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ABSTRACT

Through a facile hydrothermal method at a mild temperature and a calcination process, we report the fabrication about the NiO nanosheets and α-Fe_2O_3 nanorods using nickel foam (NF) and carbon cloth (CC) as substrates. Analysis of data obtained from the electrochemical experiments show that NiO electrode possesses large areal capacitance (1.3 F cm^{-2} at 4 mA cm^{-2}). Also, α-Fe_2O_3 electrode delivers areal capacitance of 500 mF cm^{-2} at current density of 4 mA cm^{-2}. Therefore, a high-performance all solid-state asymmetric supercapacitor (ASC) based on 3D sheet-like hierarchical NiO and α-Fe_2O_3 nanorods are designed and fabricated. New ASC can be cycled reversibly in a high voltage region ranging from 0 to 1.25 V with high energy densities of 12.4 W h kg^{-1} (power is 951 W kg^{-1}) based on the total mass of active materials. Furthermore, the obtained data indicate that the fabricated NiO//α-Fe_2O_3 based supercapacitor device has a great cycle performance with 85% capacitance retention under 10,000 cycles. This work may help to open up new areas for fabrication of lightweight and low-cost materials for energy storage systems.

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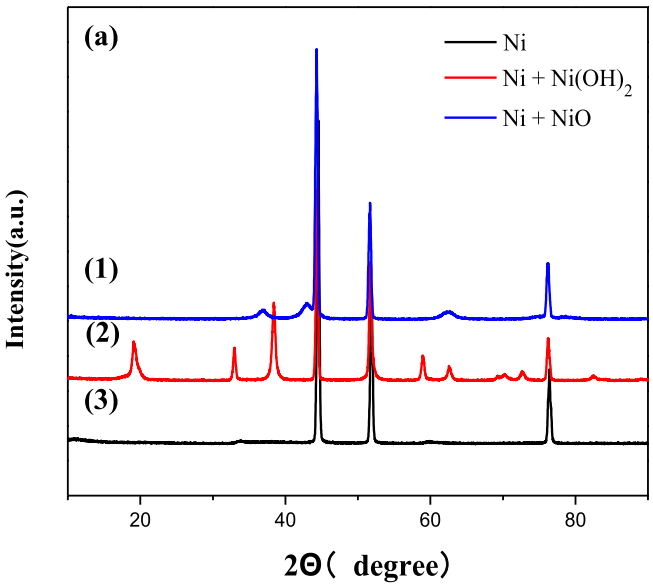

Fig. 1. Typical XRD patterns of as-grown (1) the pure Ni foam; (2) β-$Ni(OH)_2$ nanosheets; (3) NiO nanosheets.

1. Introduction

In modern electronic industries, the urgent requirements of renewable and sustainable power sources are growing at a rapid speed. Many researches have focused on developing environmentally friendly energy storage systems, such as supercapacitors [1–6], fuel cells [7–9] and Li-ion batteries [10–14]. As an emerging energy storage devices, supercapacitors have attracted more interests because of the long cycle life and the higher power ability than batteries [15–19]. Currently, commercial supercapacitors can be applied in various fields, including consumer electronics, memory back-up systems, public transportation, and so on. However, these supercapacitors can't provide sufficient energy density, and their areal/specific capacitance rapidly decreases under high current density. Therefore, more efforts should be made to improve the energy densities of supercapacitors.

Recently, using battery-type Faradaic electrode and a capacitor-type electrode to fabricate an asymmetric supercapacitors (ASCs) seems to be an effective way to combine the advantages of both batteries and supercapacitors [20,21]. So far, various materials have been investigated extensively for possible applications in ASCs [22–26]. For example, Wu's group reported the MnO_2 nanowire/-graphene and graphene ASC whose energy density is 5.2 W h kg^{-1} [27]. Yu and his coworkers investigated super long-life supercapac-

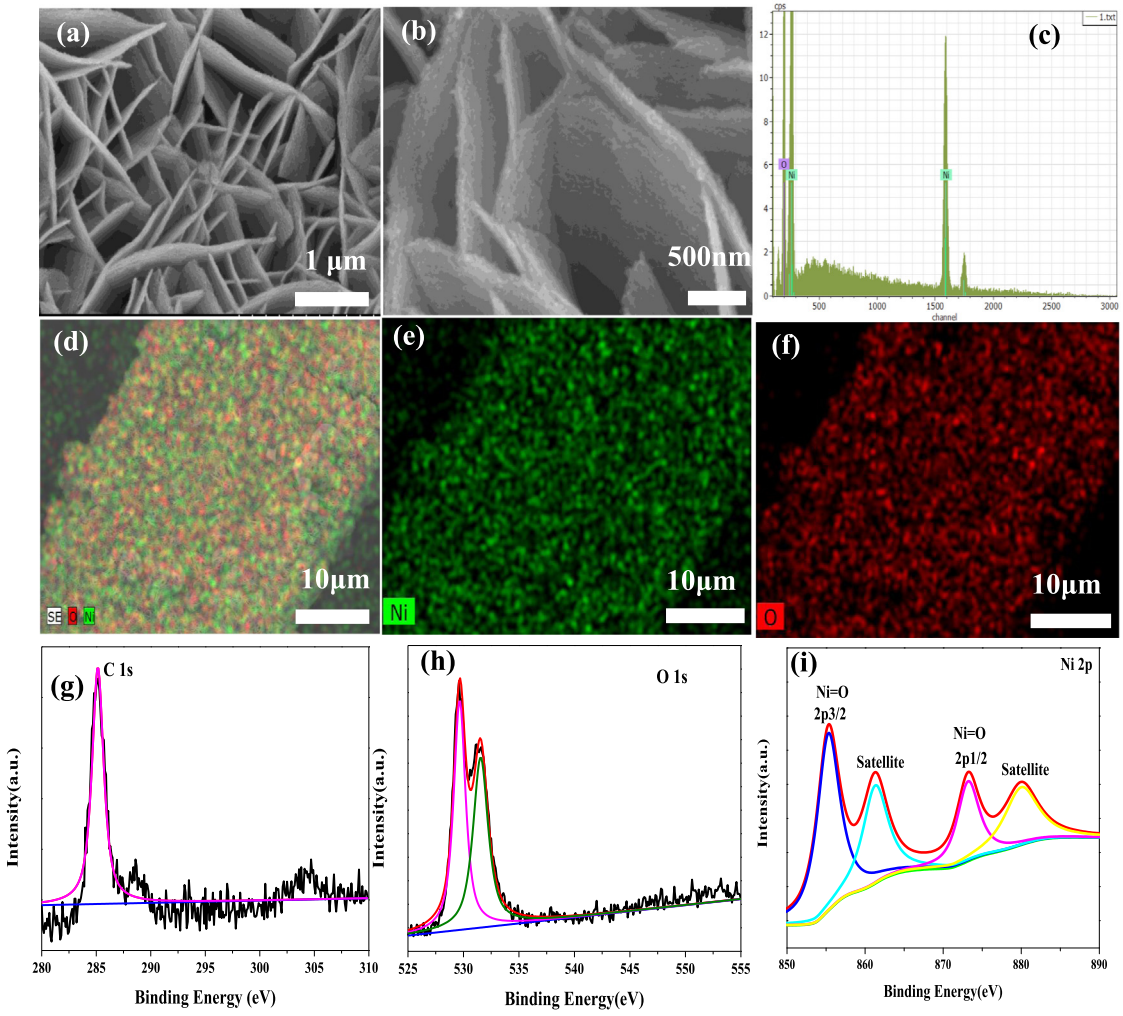

Fig. 2. Structural characterization of NiO nanosheets composite. (a-b) SEM images of NiO nanosheets grown radially on the on NF. (c) EDS spectrum (d-f) EDX mapping of a typical nanosheets. XPS spectrum of NiO (g) C 1s spectrum, (h) O 1s spectrum and (i) Ni 2p spectrum.