

# Nano silicon negative electrode material lithium battery



## Overview

The increasingly demand on secondary batteries with higher specific energy densities requires the replacement of the actual electrode materials. With a very high theoretical capacity ( $4200 \text{ mAh g}^{-1}$ ) at low voltage, silicon is presented as a very interesting potential candidate as negative electrode for lithium-ion microbatteries. For the first time, the electrochemical lithium alloying/de-alloying process is proven to occur, respectively, at  $0.15 \text{ V}/0.45 \text{ V}$  vs.  $\text{Li}^+/\text{Li}$  wit. The increasingly demand on secondary batteries with higher specific energy densities requires the replacement of the actual electrode materials. With a very high theoretical capacity ( $4200 \text{ mAh g}^{-1}$ ) at low voltage, silicon is presented as a very interesting potential candidate as negative electrode for lithium-ion microbatteries. For the first time, the electrochemical lithium alloying/de-alloying process is proven to occur, respectively, at  $0.15 \text{ V}/0.45 \text{ V}$  vs.  $\text{Li}^+/\text{Li}$  with Si nanowires (SiNWs, 200–300 nm in diameter) synthesized by chemical vapour deposition. This new three-dimensional architecture material is well suited to accommodate the expected large volume expansion due to the reversible formation of Li-Si alloys. At present, stable capacity over ten to twenty cycles is demonstrated. The storage capacity is shown to increase with the growth temperature by a factor 3 as the temperature varies from 525 to 575 °C. These results, showing an attractive working potential and large storage capacities, open up a new promising field of research.

- Lithium batteries
- Silicon
- Si nanowires
- Thin films

The current commercial lithium-ion secondary batteries are the most widely used because of their higher energy density, their higher operating voltages and their lower self-discharge. They are based on an anode made of graphitic carbon or other carbonaceous materials that present on the one hand the advantage to be cheap and on the other hand interesting electrochemical properties such as a low and flat wor...

## Article Content

A high-performance silicon/carbon composite as anode material ...

First, ball milled the ethanol solution with silicon for 4 h at 1200 r min<sup>-1</sup> and 6 h at 850 r min<sup>-1</sup> to get evenly dispersed slurry of nano-silicon (the mass of silicon is 7.2 Kg), then add the ethanol slurry of nano-silicon and solid graphite (9.16 Kg) into stirring pot and stirred for half an hour, the solid content was controlled at 20%. Next, spray drying of nano ...

Production of high-energy Li-ion batteries comprising silicon ...

One-to-one comparison of graphite-blended negative electrodes using silicon nanolayer-embedded graphite versus commercial benchmarking materials for high-energy lithium-ion batteries. Adv. Energy ...

Optimising the negative electrode material and electrolytes for ...

The failure mechanism of nano-sized Si-based negative electrodes for lithium ion batteries,”

Negative electrode materials for high-energy density Li

In the search for high-energy density Li-ion batteries, there are two battery components that must be optimized: cathode and anode. Currently available cathode materials for Li-ion batteries, such as LiNi 1/3 Mn 1/3 Co 1/3 O<sub>2</sub> (NMC) or LiNi 0.8 Co 0.8 Al 0.05 O<sub>2</sub> (NCA) can provide practical specific capacity values (C<sub>sp</sub>) of 170–200 mAh g<sup>-1</sup>, which produces ...

Nano-sized transition-metal oxides as negative ...

Nature - Nano-sized transition-metal oxides as negative-electrode materials for lithium-ion batteries Your privacy, your choice We use essential cookies to make sure the site can function.

Silicon-Carbon composite anodes from industrial battery grade silicon ...

In this work, we aim to use industrial scale silicon from Elkem in a composite material as a negative anode for the lithium-ion battery and achieve a considerable improvement in capacity to ...

Optimising the negative electrode material and electrolytes for lithium ...

This work is mainly focused on the selection of negative electrode materials, type of electrolyte, and selection of positive electrode material. ... The failure mechanism of nano-sized Si-based negative electrodes for lithium ion batteries,” J. Mater. Chem., vol. 21, no. 17 ... Silicon based lithium-ion battery anodes: A chronicle perspective ...

Nanosilicon Electrodes for Lithium-Ion Batteries: ...

Largely based on its very high rechargeable capacity, silicon appears as an ideal candidate for the next generation of negative electrodes ...

Silicon Nanoparticle Ensembles for Lithium-Ion Batteries ...

Silicon in the form of nanoparticles has attracted significant interest in the field of lithium-ion batteries due to the enormous capability of lithium intake. In the present work we demonstrate the characterization of silicon nanoparticles using small-angle neutron scattering and complementary microscopy to elucidate the structure changes through the ball milling process ...

Modification strategy of silicon-based anode for lithium-ion ...

lithium-ion battery negative electrode materials is therefore urgently needed. Silicon is one of the finest options for the negative electrode of the upcoming ... anode material in lithium batteries, nano silicon may combine with organic matter to form organosilicon EPEC 2024 E3S Web of Conferences553,02027 (2024) ...

Preparation and electrochemical performances for silicon-carbon ...

In recent years, with the continuous development of technologies such as electric vehicles, military equipment, and large-scale energy storage, there is an urgent need to obtain new lithium-ion battery electrode materials with high electrochemical performances [1,2,3].The negative electrode as an important component of lithium-ion batteries seriously effects the ...

Application of Nanomaterials in the Negative Electrode of Lithium ...

Based on the above advantages, nano silicon negative electrodes will become one of the materials that can replace graphite negative electrodes in the future [6, 7]. Mi-Hee Park et al. reported on the preparation of silicon nanotubes using alumina templates to reduce and decompose silicon precursors, with a wall thickness of 40 nm.

Application of silicon-based negative electrode materials in lithium ...

In order to solve the defects of silicon-based negative electrode materials in lithium-ion battery applications, researchers have proposed a variety of technical routes, including nanotechnology, composite material technology, structural design, surface modification, ...

Large-scale preparation of amorphous silicon materials for high ...

Electrochemical synthesis of multidimensional nanostructured silicon as a negative electrode material for lithium-ion battery ACS Nano, 16 ( 2022 ), pp. 7689 - 7700, 10.1021/acsnano.1c11393 View in Scopus Google Scholar

Separator-Supported Electrode Configuration for Ultra-High ...

1 Introduction. Lithium-ion batteries, which utilize the reversible electrochemical reaction of materials, are currently being used as indispensable energy storage devices. [ ] One of the critical factors contributing to their widespread use is the significantly higher energy density of lithium-ion batteries compared to other energy storage devices. [ ] ...

#### Design of Electrodes and Electrolytes for Silicon-Based Anode Lithium ...

There is an urgent need to explore novel anode materials for lithium-ion batteries. Silicon (Si), the second-largest element outside of Earth, has an exceptionally high specific capacity ( $3579 \text{ mAh g}^{-1}$ ), regarded as an excellent choice for the anode material in high-capacity lithium-ion batteries. However, it is low intrinsic conductivity and ...

#### Unraveling the impact of CNT on electrode expansion in silicon ...

To prevent undesirable side reactions, researchers have proposed practically applicable micron-sized Si-based anodes such as  $\text{SiO}_x$ , SiN, and Si/C composites [ , , , ]. These anodes have recently been used in commercialized lithium-ion batteries by adding them to conventional graphite electrodes for high energy density with a minimum amount of ...

#### The Evolution of Silicon in Li-ion Batteries

“Silicon monoxide composite negative electrode material used for lithium ion battery, the preparation method thereof and a lithium ion battery.” U.S. Patent 10,170,754, issued January 1, 2019.

#### Negative electrodes for Li-ion batteries

Amorphous silicon is investigated as a negative electrode (anode) material for lithium-ion batteries. A thin ( $500 \text{ \AA}$ ) film of amorphous silicon is cycled versus a lithium electrode. A maximum discharge capacity of  $4 \text{ Ah g}^{-1}$  is observed by cycling over a voltage window of 0–3 V, but capacity fading is rapid after 20 cycles.

#### Application of Nanomaterials in the Negative Electrode of Lithium ...

A popular area of study in batteries is the use of nanomaterials in LIBs. This article summarizes research on the application of nano silicon and carbon nanotubes in lithium-ion batteries ...

#### A Commercial Conducting Polymer as Both Binder and

Unlabelled: This work describes silicon nanoparticle-based lithium-ion battery negative electrodes where multiple nonactive electrode additives (usually carbon black and an inert polymer binder ...

#### (Invited) Si Materials for Li-ion Battery Negative Electrode ...

Silicon is an attractive candidate for lithium-ion batteries negative electrode materials because it delivers 10 times greater theoretical (~4200 mAh/g) specific capacity than ...

Mechanisms and Product Options of Magnesiothermic ...

Keywords: silicon, negative electrode, magnesiothermic reduction, lithium-ion batteries, interface control. Citation: Tan Y, Jiang T and Chen GZ (2021) Mechanisms and Product Options of Magnesiothermic ...

Nano-Silicon composite materials with N-doped graphene of ...

Nano-Silicon composite materials with N-doped graphene of controllable and optimal pyridinic-to-pyrrolic structural ratios for lithium ion battery. ... A commercial conducting polymer as both binder and conductive additive for silicon nanoparticle-based lithium-ion battery negative electrodes. ACS Nano, 10 (2016), p. 12. Google Scholar

Design and fabrication of high-performance multilayer silicon ...

The short ion diffusion length and low pulverization of nano-sized silicon can minimize the material stress in the electrode during lithium extraction and insertion processes, thereby improving the cycle life of the battery [ , , ]. Moreover, silicon-carbon composites have attracted significant attention as an ideal alternative to ...

The Effect of a Dual-Layer Coating for High-Capacity Silicon

Silicon-based electrodes offer a high theoretical capacity and a low cost, making them a promising option for next-generation lithium-ion batteries. However, their practical use is limited due to significant volume changes during charge/discharge cycles, which negatively impact electrochemical performance. This study proposes a practical method to increase silicon ...

Phosphorus-doped silicon nanoparticles as high performance LIB negative ...

Silicon is getting much attention as the promising next-generation negative electrode materials for lithium-ion batteries with the advantages of abundance, high theoretical specific capacity and environmentally friendliness. In this work, a series of phosphorus (P)-doped silicon negative electrode materials (P-Si-34, P-Si-60 and P-Si-120) were obtained by a simple ...

High performance silicon electrode enabled by titanocene coating

Silicon is a promising material as a negative electrode for LIBs. ... C. et al. Effect of size and shape on electrochemical performance of nano-silicon-based lithium battery. Nanomaterials 11, 1 ...

Electrode materials for lithium-ion batteries

The high capacity ( $3860 \text{ mA h g}^{-1}$  or  $2061 \text{ mA h cm}^{-3}$ ) and lower potential of reduction of  $-3.04 \text{ V}$  vs primary reference electrode (standard hydrogen electrode: SHE) make the anode metal Li as significant compared to other metals. But the high reactivity of lithium creates several challenges in the fabrication of safe battery cells which can be overcome by ...

#### Nano/Microstructured Silicon-Graphite Composite Anode for ...

With the ever-increasing demand for lithium-ion batteries (LIBs) with higher energy density, tremendous attention has been paid to design various silicon-active materials as alternative electrodes due to their high theoretical capacity (ca.  $3579 \text{ mAh g}^{-1}$ ). However, totally replacing the commercially utilized graphite with silicon is still insurmountable owing to ...

#### Conductive Polymer Binder for High-Tap-Density Nanosilicon Material ...

High-tap-density silicon nanomaterials are highly desirable as anodes for lithium ion batteries, due to their small surface area and minimum first-cycle loss. However, this material poses formidable challenges to polymeric binder design. Binders adhere on to the small surface area to sustain the drastic volume changes during cycling; also the low porosities and ...

#### Si-alloy negative electrodes for Li-ion batteries

The use of Si-alloys as negative electrode materials in Li-ion cells can increase their energy density by as much as 20%, compared to conventional graphite electrodes. ...

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The nano silicon composite negative electrode material disclosed by the invention has the characteristics of high specific capacity (greater than  $1,000 \text{ mAh/g}$ ), high initial charge-discharge efficiency (greater than 93%) and high conductivity.

#### Research progress of nano-silicon-based materials and silicon ...

The existence of pores makes the volume change rate of the porous silicon-based negative electrode material only 30% during the alloying of silicon-based materials with lithium ions. ... Xu H, Qin H et al (2020) Rapid coating of asphalt to prepare carbon-encapsulated composites of nano-silicon and graphite for lithium battery anodes. J Mater ...

#### Mechanochemical synthesis of Si/Cu<sub>3</sub>Si-based composite as negative ...

Thus, coin cell made of C-coated Si/Cu<sub>3</sub>Si-based composite as negative electrode (active materials loading,  $2.3 \text{ mg cm}^{-2}$ ) conducted at  $100 \text{ mA g}^{-1}$  performs the initial charge capacity of  $1812 \text{ mAh}$  ...

#### Mechanisms and Product Options of Magnesiothermic Reduction ...

Keywords: silicon, negative electrode, magnesiothermic reduction, lithium-ion batteries, interface control. Citation: Tan Y, Jiang T and Chen GZ (2021) Mechanisms and Product Options of Magnesiothermic Reduction of Silica to Silicon for Lithium-Ion Battery Applications. Front. Energy Res. 9:651386. doi: 10.3389/fenrg.2021.651386

Si particle size blends to improve cycling performance as negative ...

Silicon negative electrodes dramatically increase the energy density of lithium-ion batteries (LIBs), but there are still many challenges in their practical application due to the ...

Opportunities and challenges of nano Si/C composites in lithium ...

Opportunities and challenges of nano Si/C composites in lithium ion battery: A mini review. Author links open overlay panel Jaffer Saddique a 1, Mengjing Wu a 1, ... The key project on R & D of silicon carbon negative electrode materials for high specific energy Li ion batteries (2021-1-064) ...

Aligned carbon nanotubes for lithium-ion batteries: A review

Nanoscale materials are gaining massive attention in recent years due to their potential to alleviate the present electrochemical electrode constraints. Possessing high conductivity (both thermally and electrically), high chemical and electrochemical stability, exceptional mechanical strength and flexibility, high specific surface area, large charge storage ...

Electrochemical Synthesis of Multidimensional Nanostructured Silicon ...

Silicon nanowires are a kind of promising negative electrode material for lithium ion batteries. However, the existing production technologies can hardly meet the demands of silicon nanowires in ...

Electrochemical Preparation of Nano-Sized Silicon as a ...

silicon. Silicon is a potential lithium-ion battery electrode material owing to its very high theoretical specific capacity of  $4200 \text{ mA}\cdot\text{h g}^{-1}$ , but its expansion during lithiation limits its use. Therefore, we prepared a composite of silicon and carbon, which is known to reduce these volumetric changes,<sup>28,29</sup> and we report the electrochemical ...

Nano-silicon composite negative electrode material used for ...

The nano-silicon composite negative electrode material of the present invention has features of high specific capacity (higher than  $1000 \text{ mAh/g}$ ), high initial charge-discharge efficiency...

Silicon as Negative Electrode Material for Lithium-ion Batteries

Request PDF | On Jan 1, 2010, Fredrik Lindgren published Silicon as Negative Electrode Material for Lithium-ion Batteries | Find, read and cite all the research you need on ResearchGate

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