Silicon Nanofiber Paper Battery

Tech ID: 32652 / UC Case 2014-810-0

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,211,449	02/19/2019	2014-810

FULL DESCRIPTION

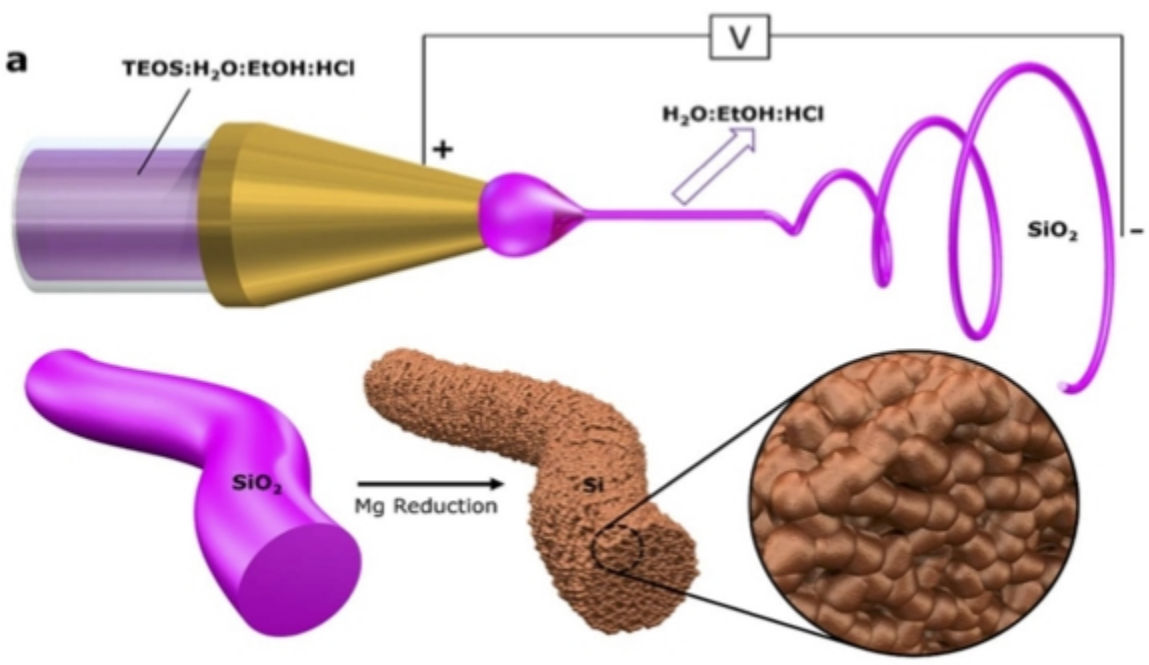
Background

High theoretical capacity, availability abundance, non-toxicity and environmental benignity make Silicon (Si) the preferred choice of anode for next generation Lithium-ion batteries. Large volumetric expansion (~300%), achievement of Si nanostructures (characteristic dimension below 150 nm) and pragmatic fabrication process are critical obstacles to overcome to build Lithium-Silicon batteries for real world applications. Electrospinning of polymers, dissolved in organic solvents along with active material such as Si, is a feasible fabrication process. However, current electrospinning methods:

- Require lengthy, thermal oxidative stabilization and carbonization steps.
- Build electrodes with reduced capacity because the weight percentage of active material can be less than 50%.

Current Invention

Prof. Cengiz Ozkan and his research team have developed a patented, binderless, freestanding, Silicon Nanofiber (SiNF) paper with Si weight percentage in excess of 80%. SiNF paper is synthesized via magnesiothermic reduction of SiO_2 nanofiber (SiO_2NF) paper which is produced by an *in situ* acid-catalyzed polymerization of tetraethyl orthosilicate (TEOS) in flight. To enhance the surface conductivity of the electrode, a 4 nm carbon coating is applied to the SiNF paper.



Schematic illustration of the electrospinning and the subsequent reduction process.

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OTHER INFORMATION

KEYWORDS

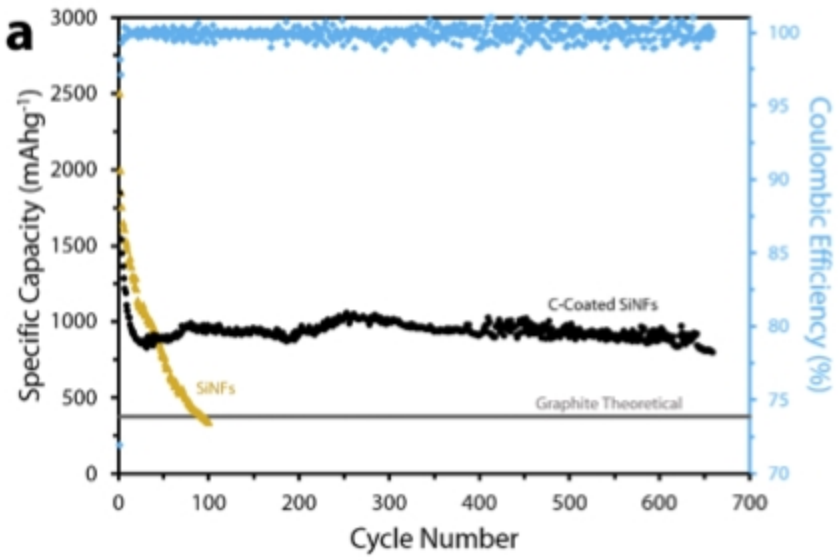
Lithium ion battery, Lithium Silicon battery, Silicon Nanofiber, Paper battery, Renewable energy, Magnesiothermic reduction, Electric Vehicles

CATEGORIZED AS

- **Energy**
  - Storage/Battery
- **Materials & Chemicals**
  - Nanomaterials
- **Nanotechnology**
  - Materials

RELATED CASES

2014-810-0



Cycling data for carbon-coated SiNF compared to uncoated SiNF at C/10 rate.

ADVANTAGES

The novel aspects and benefits of their invention are:

- Existence of a 1-2 nm thickness, native SiO2 shell on all the Silicon nanoparticles (SiNP) serves to mitigate volume expansion effects during lithiation.
- The diameter of the SiNPs are 8 – 25 nm, well below the critical dimension.
- Reduced bulk diffusion length for Lithium.
- Excellent electrochemical stability and high degree of scalability.
- No carbon black, metallic current collectors or polymer binders.
- Magnesiothermic reduction process requires lower operating temperatures (700 deg. C).

SUGGESTED USES

- Lithium-ion and Lithium-Silicon batteries

TESTING

The team fabricated 2032 type coin cells with SiNF electrodes. After 650 cycles, the SiNF electrodes deliver a reversible capacity of 802 mAh/gram and a coulombic efficiency of 99.9%.

RELATED MATERIALS

- Towards Scalable Binderless Electrodes: Carbon Coated Silicon Nanofiber Paper via Mg Reduction of Electrospun SiO2 Nanofibers

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