

Silicon Nanofiber Paper Battery

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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 SiO₂ nanofiber (SiO₂NF) 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.

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OTHER INFORMATION

KEYWORDS

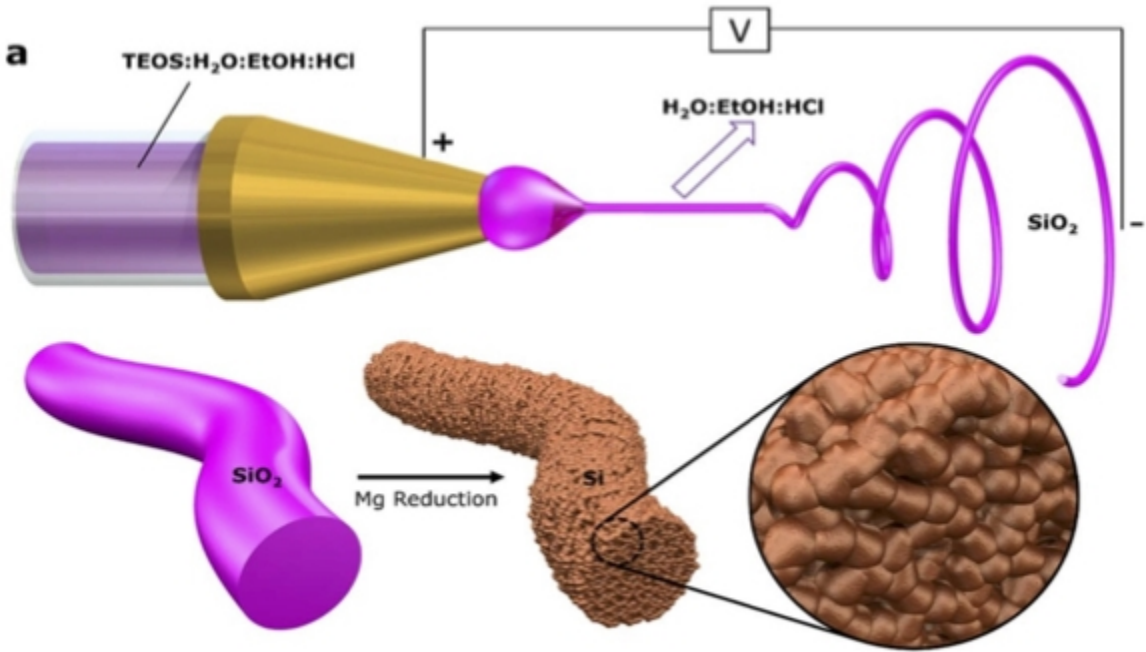
Lithium ion battery, Lithium Silicon
battery, Silicon Nanofiber, Paper
battery, Renewable energy,
Magnesiothermic reduction, Electric
Vehicles

CATEGORIZED AS

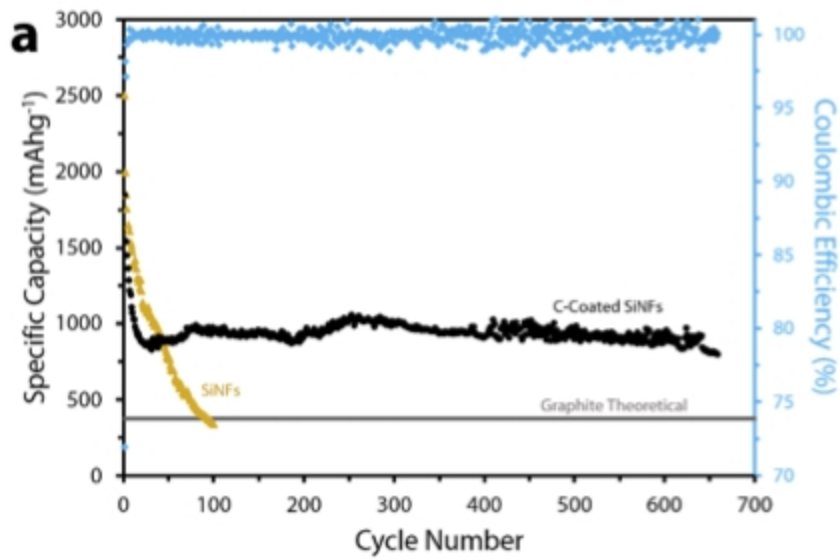
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Schematic illustration of the electrospinning and the subsequent reduction process.



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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