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Process for Fabricating Hollow-Porous Silicon Nano-Quills (2020-033)

Method for synthesis of hollow-porous silicon (Si) nanostructured materials with a unique morphology

Market Overview

Porous Si-based nanomaterials (including elemental Si and silica nanoparticles) can be used in multiple research applications. Currently, they are used in battery anode structures, controlled release of pesticides, and were revealed to be biocompatible and biodegradable. That makes Si-based nanomaterials a prime material to use in biomedical applications such as drug delivery. The global market for nano-silica is projected to grow to $5.14 billion by 2025 with a CAGR of 7.6%. In addition, the global silicon anode battery market is expected to reach $1044.96 million by 2023 with a CAGR of 40.5%. In this extensive market environment, Clemson University researchers have developed a two-step process for the synthesis of hollow-porous silicon nanostructured materials. First, interconnected silica particles, called silica nano-quills (SilicaNQs), are synthesized through a low-cost and scalable method. SilicaNQs feature several hollow arms with a range of diameter, length, wall thickness and porosity. 1D templates are used to fabricate SilicaNQs with various lengths and sizes. Later, silicaNQs are converted into a pure Si structure, called silicon nano-quills (SiNQs).

Technical Summary

A layer of silica is grown on agglomerates/networks of 1D templates in a sol-gel process. These 1D templates can be of both natural and synthetic moieties. The characteristics of the silica can be controlled by adjusting the composition and amount of silica precursor, composition of chemicals/solvents in solution, pH level of solution, and duration of silica growth process. Pores can be created by using porogen material. Silica is converted into silicon through a low-temperature reduction process followed by purification. The resulting Si particles retain the morphology of initial silica and are called Si nano-quills (SiNQs).

Application

Batteries, Solar Cells, Agriculture, Biotechnology, Oil and Gas, Water Treatment, Air Purification

Development Stage

Proof of Concept

Advantages

- The preparation of silica nano-quills and Si nano-quills using this technology requires a low-cost and simple set up
- Can employ a variety of templates from synthetic 1D particles such as carbon nanotubes and metal oxide nanowires to naturally available 1D particles such as cellulose nanocrystals
- Larger companies are actively seeking partners to carry out reseach to gain the profit potential of the smart nanomaterial market

App Type	Country	Serial No.	Patent No.	CURF Ref. No.	Inventors
N/A	United States	N/A	N/A	2020-033	Dr. Srikanth Pilla Dr. Apparao Rao Dr. Morteza Sabet

About the Inventors

Dr. Srikanth Pilla

Robert Patrick Jenkins Endowed Professor of Automotive Engineering at Clemson University

Dr. Srikanth Pilla earned his doctorate in Mechanical Engineering from the University of Wisconsin-Milwaukee with postdoctoral training from Stanford University. His research interests are in the fundamentals and applications of sustainable and lightweight functional materials and manufacturing. Encompassing “Circular Economy” and “Sustainable Engineering” domains, Pilla’s created Circular Engineering concept builds on the foundations of “Materials Genome Initiatice” and “Hybrid and Intelligent Manufacturing Technologies”. Specifically, Pilla’s work enables informatics-driven materials and manufacturing discoveries of concepts that DRIVES (Driving Research and Innovation for Value-added Environmental Sustainability) the world on a true sustainable path. His research is supported by NSF, DOE, USDA, DOD, NIH, AND NASA. His research has created over $31M of funding.

Dr. Apparao Rao

R.A. Bowen Professor of Physics at Engineering at Clemson University

Dr. Rao received his Ph.D. in physics from the University of Kentucky in 1989 and served as a post-doctoral research associate at MIT until 1991. Prior to coming to Clemson in 2000, he was a research assistant professor at the University of Kentucky. His research interests include the characterization and applications of carbon nanotubes, semiconducting nanobelts, nanowire and thermoelectric materials. In addition to two grants from NSF and one grant from DOE/SCUREF, he is presently serving as principal investigator on NIH/NIEHS R15 grant to understand the interactions of nanomaterials and biomolecules.

For more information on this technology contact:

Andy Bluvas
Technology Commercialization Officer
E: bluvasa@clemson.edu
P: (864) 656-0797