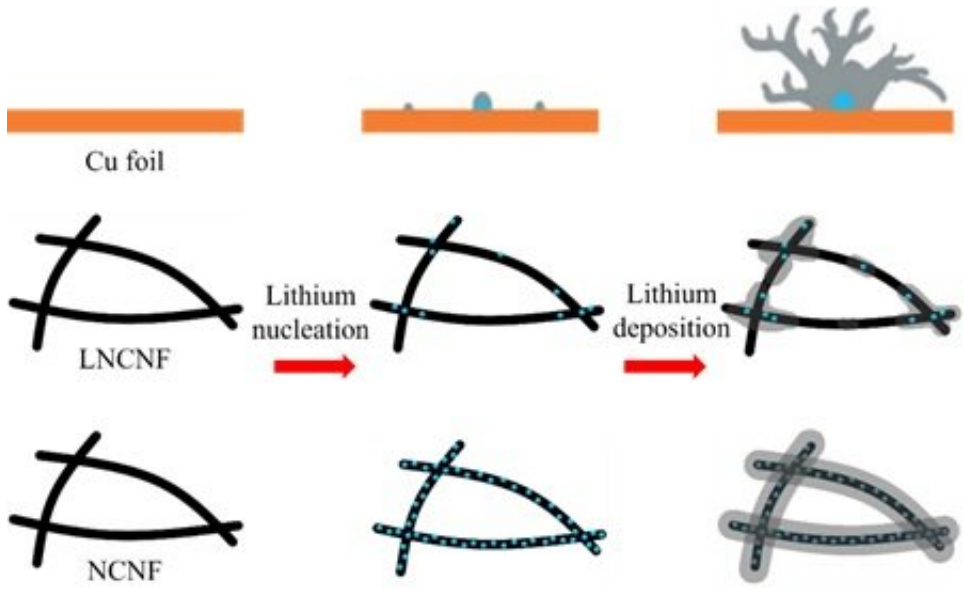
A lightweight carbon nanofiber-based collector

June 21 2018



Schematic diagram of lithium nucleation and deposition behavior on Cu foil, low nitrogen-doping level carbon nanofiber framework and high nitrogen-doping level carbon nanofiber framework. Credit: ©Science China Press

Quan-Hong Yang from Tianjin University and Wei Lv from Graduate School at Shenzhen, Tsinghua University with their co-workers reported a lightweight, high-level nitrogen-doping carbon nanofiber framework as the current collector for lithium metal anodes, which could restrain the dendrite growth and achieve the uniform lithium deposition. This work was recently published in *Science China Materials*.

Yang's group and Lv's group are still devoted to carbon materials and their applications in energy storage.

The authors write, "Despite the high-energy-density of lithium metal batteries, the intractable dendrite growth resulted in low coulombic efficiency, internal short circuit and even hazardous issues hinder their practical use. Carbon materials can play a significant part in solving above-mentioned problems, enabling the practical application of lithium metal anodes."

Researchers have made efforts to solve the lithium dendrite problem. The conductive three-dimensional framework structures, like the porous Cu current collector and 3-D graphene framework, have attracted attention because they can lower local current density and accommodate large volume changes during cycling.

"Despite the excellent structure stability and superior electrical conductivity, the porous metal current collector is heavy, greatly comprising the energy density," Yang said, "the porous carbon framework is lightweight, which benefits to improve the energy density based on the whole device. Yet their non-lithiophilic surfaces are not ideal for the uniform nucleation and deposition of lithium."

Nitrogen-containing functional groups on carbon framework surface can interact with lithium atoms and enhance the lithiophilicity of the carbon framework. Using polyacrylonitride as the raw material, a lightweight and high nitrogen-doping 3-D conductive carbon nanofiber matrix (NCNF) can be easily prepared by electrospinning, pre-oxidation and thermal treatment.

The use of NCNF as the current collector has several advantages:

1. A lightweight matrix can maintain the high specific capacity

nature of Li metal anode. The density of NCNF is only 0.57 mg/cm2. When the lithium loading is 4 mAh/cm^2, the lightweight NCNF brings about large capacity of 2489.7 mAh/g based on NCNF-Li composite;

2. High specific surface area and 3-D structure are helpful to lower the local current density and accommodate the large volume changes during cycling;
3. High nitrogen-doping guarantees sufficient low nucleation overpotential sites on the large surface of the NCNF, guiding lithium nucleation uniformly and suppressing the growth of lithium dendrite.

These resulted in excellent cycling stability with a high coulombic efficiency of over 98 percent for more than 250 cycles for lithium deposition. Moreover, when paired Li@NCNF anode with LiFePO4 to assemble full cell, reduced voltage polarization and high capacity retention were shown.

Yang says, "This work clearly demonstrated the important roles of the heteroatom doping for the modification of carbon surface to realize the uniform and dendrite free metal anode deposition, and also showed great potential of light weight NCNF for the use in metal-based anodes with high energy density."

More information: Haoliang Wu et al, A lightweight carbon nanofiber-based 3D structured matrix with high nitrogen-doping level for lithium metal anodes, *Science China Materials* (2018). DOI: 10.1007/s40843-018-9298-x

Provided by Science China Press

Citation: A lightweight carbon nanofiber-based collector (2018, June 21) retrieved 9 April 2024 from https://phys.org/news/2018-06-lightweight-carbon-nanofiber-based-collector.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.