Fabrication of Carbon/Silicon Composite as Lithium-ion Anode with Enhanced Cycling Stability

A scalable silicon-carbon hybrid anode material provides high stability and superior resilience for prolonged cycling in rechargeable lithium-ion batteries.

Lithium-ion batteries have grown in popularity due to the increased demand for green technology in electric and hybrid vehicles, consumer electronics, medical devices, including implantable devices, and by the military. While primary lithium-ion batteries are not rechargeable, the demand for secondary lithium-ion batteries, which are rechargeable, has experienced increased research and development. Traditionally, graphene has been the primary material used in anodes, but it results in batteries with low power density and does not meet the high energy demands of electric and hybrid vehicles. There is a need for alternative anode materials with enhanced storage capacity, high energy density, and improved cycling. Silicon has emerged as a potential anode material because it provides large theoretical weight capacity, relatively high potential for lithium incorporation, low toxicity, and its natural abundance. However, silicon expands by up to 300 percent of its volume during battery charging, pulverizing the electrode during discharge, resulting in the loss of electrical contact. This excessive, unstable growth leads to a short cycle life and instability.

Researchers at Purdue University have developed a carbon encapsulated silicon composite hybrid material for anodes used in rechargeable Li-ion batteries. This silicon-carbon hybrid material is synthesized via a scalable and practical solid-state process. Multirate cycling shows the silicon-carbon hybrid performs with stable gravimetric capacities. After prolonged cycling, the silicon-carbon hybrid further demonstrates superior mechanical and electrochemical resilience when compared to an unencapsulated silicon electrode, greater composite conductivity, lower electrode deformation, and less solid electrolyte interphase (SEI) formation. This unique silicon-carbon anode provides high stability during the charge/discharge cycles without significant degradation during prolonged cycling of Li-ion batteries.

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Category

Automotive & Mobility Tech/Battery Management & Charging Technologies

Energy & Power Systems/Energy Storage

Materials Science & Nanotechnology/Composites & Hybrid Materials

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Advantages:

-Superior mechanical and electrochemical resilience

-Low cost, widely available material

-High stability during charge/discharge cycles

Potential Applications:

-Rechargeable Li-ion batteries

-Electric and hybrid vehicles

-Consumer electronics, medical devices, and military applications

TRL: 5

Intellectual Property:

Provisional-Patent, 2017-07-10, United States | Utility Patent, 2018-07-05, United States | DIV-Patent, 2024-02-08, United States

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