A carbon layer coated prorous slicon anode with high capacity for high energy density lithium ion batteries

Zhixin Tai, Ziyu Lu and Lifeng Liu*

Zhixin Tai
Clean Energy Cluster, International Iberian Nanotechnology Laboratory (INL), 4715-330 Braga, Portugal
Email: zhixin.tai@inl.int
Ziyu Lu
School of Sciences, China University of Geosciences, Beijing 100083, P.R. China
Email: ziyu.lu@inl.int
Lifeng. Liu
Clean Energy Cluster, International Iberian Nanotechnology Laboratory (INL), 4715-330 Braga, Portugal
Email: lifeng.liu@inl.int

Abstract

Lithium-ion batteries (LIBs) are currently one of major commercially available energy storage devices that are widely adopted in mobile phones, laptops and other consumer electronics. They also show substantial promise for the electrification of vehicles, contributing to zero-emission transportation. However, for electric vehicle (EV) applications the traditional graphite anode materials presently being used in commercial LIBs cannot satisfy the demand for high energy density, and thereby are difficult to offer a driving range comparable to the conventional internal combustion engine.[1-3] To improve the energy density of LIBs, silicon (Si) has been proposed to be a promising alternative to graphite because of its high theoretical specific capacity. The large volume change of Si during the Li insertion/extraction processes, however, would lead to severe pulverization of anode, poor electrical contact of active materials with the current collector, unstable solid–electrolyte interphase (SEI), and eventually to irreversible capacity fading.[4,5] Although significant progress has been made to address these issues through nano-silicon based materials design, there is still a pressing need for continuous improvement of Si anode's performance and further reduction of the costs, considering the market penetration. In this presentation, we will report our recent progress in developing a scalable, low-cost process for preparing nanoporous silicon-carbon composites, which is realized by wet chemical processing of ferrosilicon, followed by a carbon layer coating process. By optimizing the synthesis conditions, a yield of 87.5% is achieved for the nanoporous Si on gram-scale production in the lab. Because of the hierarchical micro-nano scale architecture, the nanoporous silicon anode delivers an initial reversible capacity as high as 2993 mAh/g and an initial Coulombic efficiency of 82 %, which are markedly higher compared to the commercial Si nanoparticles. The nanoporous silicon-carbon composite active materials hold great promising for use to improve the energy density of the next generation lithium-ion batteries.

REFERENCES

[1] Armand, M.; Tarascon, J. M. *Nature*,*451(*2008**)**, 652–657.
[2] Liu, Y. Y.; Zhou, G. M.; Liu, K.; Cui. Y. *Acc*. *Chem*. *Res*., *50(***2017)**, 2895–2905.
[3] Sun, Y. M.; Liu, N.; Cui. Y. *Nat*. *Energy*, *1(*2016**)**, 16071.
[4] Wu, H.; Cui. Y. *Nano Today*, *7(*2012*)*, 414–429.
[5] Wang, J. Y.; Cui, Y.; Wang. D. *Adv*. *Mater*. *31(2019)*,1801993