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Rapid communication

High-throughput fabrication of strutted graphene by ammonium-assisted chemical blowing for high-performance supercapacitors

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Highlights

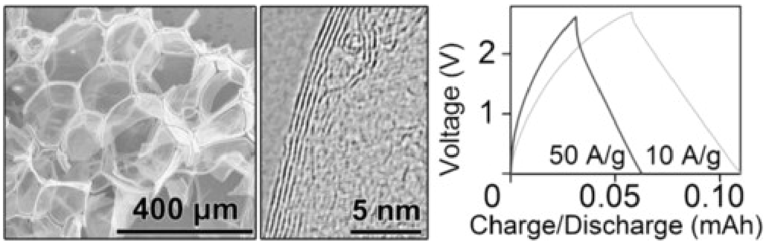
- A synthesis approach of ammonium-assisted chemical blowing is developed to effectively produce strutted graphenes.
- Strutted graphenes consist of interconnected mono-/few-layered graphene membranes scaffolded by graphitic struts eliminating the restacking or agglomeration.
- Electrodes made of strutted graphenes provide large accessible surface area, intimate interconnectivity of the frameworks, and appropriate porosity.
- Supercapacitors based on strutted graphenes demonstrate the high energy density of 50 Wh kg^{-1} as well as the high power density.

Abstract

Three dimensional graphenes are most desired to deliver the unique nano-sized properties of graphenes to the macro-scale, yet their practical production remains insufficient. Herein we establish a general synthesis approach, *i.e.* ammonium-assisted chemical blowing *via* foaming sucrose into the bubble networks of sucrose-derived polymers, to effectively produce three dimensional strutted graphenes (SGs). SG consists of interconnected mono-/few-layered graphene membranes scaffolded by graphitic struts without restacking or agglomeration, which thus fully exposes the huge surface and possesses appropriate porosity. The SG is further applied as additive/binder-free electrodes for supercapacitors, which realize the high energy density of 50 W h kg^{-1} and the high maximum-power–density of 340 kW kg^{-1} due to the large surface area, excellent interconnectivity and porosity. The mass-produced self-supporting SG would open up a wide horizon and enable the abundant potentials of graphenes for promising large-scale applications.

Graphical abstract

A synthesis approach, ammonium assisted chemical blowing, is developed to effectively produce three dimensional strutted graphenes. Taking the advantages of large surface area, multi-dimensional electron transport pathways, minimized transport resistance of ions within bubble cavities and excellent electrochemical stability of strutted graphenes, their supercapacitors in organic systems realize high energy density of 50 Wh kg^{-1} as well as high power density of 340 kW kg^{-1}.



Keywords

Three dimensional graphene; Strutted graphene; Chemical blowing; Supercapacitor

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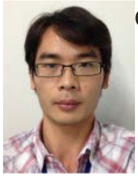

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Yoshio Bando received his Ph.D. degree from Osaka University in 1975 and joined the National Institute for Research in Inorganic Materials (at present NIMS) in the same year. From 1979 to 1981 he worked as a visiting researcher at Arizona State University. Currently, he is a Chief Operating Officer (COO) of the International Center for Materials Nanoarchitectonics (MANA) and a Fellow within the National Institute for Materials Science (NIMS). He is also a visiting Professor at Waseda University. His current research concentrates on the synthesis and properties of various inorganic nanostructures and their TEM characterizations. He has published more than 600 papers in international journals and the total number of citations of his papers is over 27,000. The H-index of his publications is 86. He received the 16th Tsukuba Prize in 2005 for his studies on novel inorganic nanotubes and nanothermometers and the 2011 Thomson Reuters Research Front Award for his investigations on 1D-nanostructures.

Dmitri Golberg joined NIMS in 1995. At present, he is a Nanotube Unit Director of MANA-NIMS and Professor of University of Tsukuba. To date, Dmitri has authored more than 550 original papers in peer-reviewed International journals and over 100 Japanese and International patents. His numerous scientific awards include Tsukuba Prize, “Thomson Reuters” Research Front Award and “Seto Award” from the Japanese Microscopy Society for developments of *in situ* TEM techniques. Dmitri is listed among top-150 highly-cited world materials scientists by “Thomson Reuters”. His works have been cited more than 21000 times and H-factor of his publications is 76.