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Nanostructured NiAl Layered Double Hydroxide Materials for Energy Research

By

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Abstract

Supercapacitors (SCs), having higher power density (>10 kW kg^{-1}), shorter charging time, longer cycle life (>10 years), and better operational safety compared with some rechargeable batteries, have been proposed as one of the future energy storage devices. Despite the significant advances achieved in electrodes materials for SCs, practical applications of SCs are still seriously hindered due to the relatively poor performance of the electrode materials, such as low specific capacitance in carbon based materials, poor cycling stability in transition metal oxides, and very high cost of RuO_2 based materials. Therefore, significant research are urgently required to improve the electrochemical performance of electrode

materials in order to produce next-generation SCs with high power and energy densities.

NiAl layered double hydroxide (NiAl-LDH) has been considered as high performance electrode materials of SCs because of the relatively low cost, high redox activity, and environmentally friendly nature. Specifically, the electric double layer capacitance (EDLC) and Faradaic pseudocapacitance (FC) of LDH can be simultaneously acquired because of their abundant slabs and electrochemically active sites. In energy research, we have extensive experience on preparation, characterization, and application of hierarchical micro-, meso-porous materials, including porous N-doped carbon or graphene, graphene aerogel, metal oxides , and LDHs). The synthesis conditions significantly influence the PSD, SSA, and N-doping/surface oxygen functionalities of carbon electrodes, leading to an improved capacitive performance of the electrodes. In 3D NiAl-LDH/GNS research, we controlled the size, surface morphology, and porosity of NiAl-LDH crystals on the surface of GNS to form a 3D porous structure, which facilitates electrolyte ions soaking into the electrode materials. Our synthesis method can (1) increase the effective utilization of electroactive materials and (2) improve the electrical conductivity and mechanical strength of the LDH/GNS materials. The structural changes during long time charging/discharging cycles and their influences on the life cycle stability of electrodes were investigated.

In this talk, the speaker presents his recent work in the development and applications of 3D nanostructured layered double hydroxide (LDH) materials for SCs. He describes how to fabricate 3D hierarchical porous flower-like NiAl-LDH grown on nickel foam (NF) through a liquid phase deposition (LPD) method as a high-performance binder-free supercapacitor electrode. The prepared LDH-NF electrode achieves high capacitance (2274 F g^{-1} at 2 A g^{-1} and 729 F g^{-1} at 50 A g^{-1}) after 5000 cycles of activation at 20 A g^{-1} and high cycling stability (76% retention after another 5000 cycles at 50 A g^{-1}), which is higher than those of most previously reported NiAl-LDH based materials. Moreover, an asymmetric supercapacitor, with the LDH-NF as the positive electrode and the porous graphene nanosheets coated on NF (GNS-NF) as the negative electrode, delivers a high energy density (30.2 Wh kg^{-1} at a power density of 800 W kg^{-1}) and long cycle life, which outperform the reported devices in the literature.

Biography

Oscar K.S. Hui received his PhD degree in the department of mechanical engineering at the Hong Kong University of Science and Technology in 2008. He was appointed as a lecturer in department of systems engineering and engineering management of City University of Hong Kong from 2008-2012. In 2013, he was appointed as an Assistant Professor of the Department of Mechanical Convergence Engineering at Hanyang University, South Korea. As PI, he has been awarded a total research funding of USD 1.37 million. He has extensive research experience in catalysis, air/water pollution control, and energy storage. He has been collaborating with research partners from China, Hong Kong, South Korea, Japan, Singapore, Australia and USA. His research has led to one US patent, four review papers, three book chapters, 100 peer-reviewed journal papers, and 55 conference papers. More information about his research can be obtained from http://esu.hanyang.ac.kr/.

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