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Editorial

Advanced Nanomaterials for Energy-Related Applications

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Energy has been the cornerstone of sustainable development of our economy and society. The dramatic demand on energy supply to be as unrestricted as possible, however, leads to conflicting feedback loops on the ecological environment. Thus, research is appealing worldwide to diminish the negative environmental consequences of energy consumption. This includes energy saving, generation, harvest, conversion, and storage. Nanomaterials and nanostructures provide unique mechanical, electrical, and optical properties and have played an important role in recent advances in energy-related applications.

In this special issue, we report the current progress on the preparation and the usage of nanomaterials for energy-related applications. In these aspects, we will cover a broad range of subjects from nanomaterial synthesis and characterization to energy-related demonstration and relevant technologies and device. Specifically, we focused on the synthesis of nanomaterials and their application in Li-ion batteries and optoelectronic devices.

(1) Nanomaterials for Optoelectronic/Photochemical Devices. World energy consumption largely relies on the combustion of fossil fuels. However, the traditional way is neither sustainable nor environmentally benign. Renewable energy generation devices, such as solar cells, thermoelectronic devices, are widely investigated to replace fossil fuels. Nanomaterials have played an essential role in developing novel energy generation devices. The unusual quantum effect at nanoscale benefits the electron transport and band engineering in nanomaterials, which brings about an excellent performance for devices [1, 2].

In this special issue, we specifically focused on the nanomaterials/nanostructures for optoelectronic/photochemical devices. The papers "Graphene-Tapered ZnO Nanorods Array as a Flexible Antireflection Layer" and "Fabrication of an Antireflective Nanodome Array with High Packing Density for Photovoltaic Applications" reported the utilization of ZnO/graphene nanocomposite and nanodome structure as antireflection layer for solar cells, respectively. The nanofeature reduced the Fresnel reflection and increased the transmitted light through the solar cell. The paper "Enhanced Photovoltaic Properties of the Solar Cells Based on Cosensitization of CdS and Hydrogenation" reported the CdS quantum dots sensitized TiO_2 porous nanocrystal with enhanced photovoltaic performance. The paper "Synthesis and Structural Characterization of Al_2O_3-Coated MoS_2 Spheres for Photocatalysis Applications" reports the photocatalytic behavior of Al_2O_3 decorated MoS_2 nanospheres; the enhanced performance of nanostructured Al_2O_3/MoS_2

to bulk composite indicates it is a promising candidate for removal of pollutant from waste water.

(2) Nanomaterials for Energy Storage. Renewable energy storage has been ubiquitously utilized in the modernized world, such as portable electronics, electrical vehicles, and grid scale energy storage. Li-ion batteries, which obtain the highest massive/volumetric energy density among all existing technologies, have attracted most attention both in academia and industry. Still, in order to pursue Li-ion batteries with higher energy density and power density, novel materials and structures with high specific capacity and high rate performance are needed.

For example, the specific capacity for Si anode is 4200 mAh/g, 10 times larger than that of graphite (376 mAh/g). However, large amount of Li insertion in Si caused a 400% volume change, thus resulting in severe pulverization problem/unstable solid electrolyte interphase (SEI) formation during cycling for bulk Si as Li-ion battery anode. To solve this problem, Si in various nanostructures is utilized; the best performed one achieved stable cycling of more than 2000 cycles [3, 4]. The other advantage of nanomaterials for energy storage devices is that they obtain a large specific surface area. Large surface area is good for the accessibility of electrolyte, which is beneficial to the fast charge/discharge for Li-ion batteries and ultracapacitors [5].

In this special issue, we reported the exciting results of nanomaterials for energy storage applications. In the paper "Enhancement of Electrochemical Stability about Silicon/Carbon Composite Anode Materials for Lithium Ion Batteries," W. Xiao et al. reported the Si/C composite as anode for Li-ion batteries. This composite delivers a high charge capacity of 791.7 mAh/g at a current density as high as 500 mAh/g. In the paper "Cauliflower-Like Co_3O_4/Three-Dimensional Graphene Composite for High Performance Supercapacitor Applications," H. Liu et al. reported a 3D Co_3O_4/graphene nanocomposite. In this composite, Co_3O_4 is used as active capacitor electrode and graphene is served as conductive additive and mechanical support. This composite shows an excellent specific capacity of 863 F/g in 6 M KOH at the rate of 1 mV/s.

(3) Synthesis of Nanomaterials for Energy Applications. Materials synthesis is the basis of nanomaterial applications in energy fields. Thus, this special issue also collected work focusing on synthesis of nanomaterials including Ni-Co-coated carbon nanotubes ("Preparation and Microwave Absorbing Properties of an Electroless Ni-Co Coating on Multiwall Carbon Nanotubes Using $[Ag(NH_3)_2]^+$ as Activator"), carbon dots ("Preparation and Application of Fluorescent Carbon Dots"), MoS_2 nanoflowers and nanosheets ("Synthesis and Characterization of Molybdenum Disulfide Nanoflowers and Nanosheets: Nanotribology"), sodium aluminum hydride ("Synthesis of Renewable Energy Materials, Sodium Aluminum Hydride by Grignard Reagent of Al"), and nanocomposite of Al_2O_3/Antifrogen N ("Classical Behavior of Alumina (Al_2O_3) Nanofluids in Antifrogen N with Experimental Evidence"). All these materials were demonstrated for various energy applications such as microwave adsorption ("Preparation and Microwave Absorbing Properties of an Electroless Ni-Co Coating on Multiwall Carbon Nanotubes Using $[Ag(NH_3)_2]^+$ as Activator"), heat transfer ("Classical Behavior of Alumina (Al_2O_3) Nanofluids in Antifrogen N with Experimental Evidence"), lubrication ("Synthesis and Characterization of Molybdenum Disulfide Nanoflowers and Nanosheets: Nanotribology"), and photocatalysis ("Classical Behavior of Alumina (Al_2O_3) Nanofluids in Antifrogen N with Experimental Evidence"). The synthesis methods involved electroless deposition ("Preparation and Microwave Absorbing Properties of an Electroless Ni-Co Coating on Multiwall Carbon Nanotubes Using $[Ag(NH_3)_2]^+$ as Activator"), solvothermal reaction ("Synthesis and Characterization of Molybdenum Disulfide Nanoflowers and Nanosheets: Nanotribology"), and traditional solid chemical reaction ("Synthesis of Renewable Energy Materials, Sodium Aluminum Hydride by Grignard Reagent of Al").

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