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Editorial

Supercapacitors

Due to outstanding storage capacity, ultra-high power density, super long cycle life time, moderate energy density and high safety, supercapacitors have enthusiastically become a new type of energy storage device and energy storage technology after lithium ion battery. In the recent decade, scientists and engineers around the world have extensively and thoroughly studied physics, chemistry, materials, chemical engineering, electronics, transportation engineering, energy science and technology, aeronautical and astronautics science and technology, which promoted the rapid application of supercapacitors in electric automobile, engineering machinery, industrial energy saving, wind power and many other fields. This monograph focuses on three reviews and fifteen original research papers, highlighting main research progress in micro-supercapacitors (MSCs), graphene-based supercapacitors, flexible supercapacitors, hybrid supercapacitors, covering the new energy storage principle, novel electrode materials, neoteric electrolyte, and late-model device technology.

The boom development of wearable and portable electronics has intensively stimulated the demand of microscale energy storage devices with multiple compatible features of lightweight, tailored size, outstanding flexibility, and high energy density. MSCs, as a newly-developed class of microscale electrochemical energy storage devices, have gained considerable attentions. Wu *et al.* (https://doi.org/10.1016/j.cclet.2017.08.007) develolped a simplified mask-assisted fabrication of all-solid-state MSCs with high areal capacitance based on graphene and MnO_2 nanosheets. Lai *et al.* (https://doi.org/10.1016/j.cclet.2018.01.007) reported a paper-based flexible all-solid-state asymmetric MSCs fabricated by pencil drawing methodology. Yang *et al.* (https://doi.org/10.1016/j.cclet.2018.01.024) explored the laser processed MSCs based on carbon nanotubes and MnO_2 nanosheets composite and the fabricated devices showed excellent electrochemical performance and aesthetic property. Similarly, Yuan *et al.* (https://doi.org/10.1016/j.cclet.2018.01.012) used the similar strategy of laser-treated polymer derivatives to construct all-solid-state pseudocapacitive MSCs based on MnO_2 from the reduction of $KMnO_4$. With the characteristics of high capacities, environmentally friendly and low cost, metal oxides are widely applied as active materials of MSCs. Shen *et al.* (https://doi.org/10.1016/j.cclet.2017.12.007) summarized the recent progress of metal oxides based on-chip MSCs with various approaches for the synthesis of metal oxides nanostructures and developments on the fabrication of MSCs. Wang *et al.* (https://doi.org/10.1016/j.cclet.2017.12.019) reviewed several kind of novel and unconventional multifunctional integrated supercapacitors and outlined the enormous progress on multifunctional integrated supercapacitors.

Compared with activated carbon, graphene is the ideal supercapacitor electrode owing to its high specific surface area, excellent electron conductivity and thermal conductivity, high mechanical strength, high energy density and high power density of the electrode material requirements of supercapacitors. Qian *et al.* (https://doi.org/10.1016/j.cclet.2018.01.027) reported a method for fabricating a mesoporous tubular graphene electrode that exhibited high energy density in wide range of high power density and excellent cycling stability in an ionic liquid electrolyte $EMIMBF_4$ electrolyte. To achieve superior pseudocapacitive lithium storage, Wang *et al.* (https://doi.org/10.1016/j.cclet.2017.09.063) designed and prepared a “soft” graphene oxide-organopolysulfide nanocomposites. Moreover, three-dimensional graphene was used by Wang and Yang *et al.* (https://doi.org/10.1016/j.cclet.2018.01.017) as a support to prepare vertical crosslinking MoS_2/three-dimensional graphene composited with superior and stable electrochemical capacitive performance. Wu *et al.* (https://doi.org/10.1016/j.cclet.2018.01.051) demonstrated a method to fabricate a composite of reduced graphene oxide with hollow Co_9S_8 derived from metal organic framework for highly stable supercapacitors.

The emerging flexible supercapacitors, with higher energy density than conventional physical capacitors, higher charging/discharging rate capability, and longer life-cycles than primary/secondary batteries, have become one of the most intense research focuses in the electrical energy storage field. Huang *et al.* (https://doi.org/10.1016/j.cclet.2017.12.028) constructed a flexible asymmetric supercapacitor with high energy density by using a flexible substrate of carbonized silk-fabrics decorated with carbon nanotube, electroplating MnO_2 nanosheets and dip-coating activated carbon powders as the positive and the negative electrodes, respectively. What’s more, Liu *et al.* (https://doi.org/10.1016/j.cclet.2018.01.013) outlined recent progress towards the development of flexible supercapacitors based on macroscopic carbon nanotubes-based electrodes, including one dimensional (1D) fibers, 2D films, and 3D foams, with a focus on electrode preparation and configuration design as well as their integration with other multifunctional devices.

Hybrid capacitors, also known as asymmetric electrochemical capacitors, can better satisfy the application requirements for energy storage devices of high energy density and high power density, having become the inevitable choice for the development of excellent specific energy supercapacitors. Shi *et al.* (https://doi.org/10.1016/j.cclet.2018.01.031) reported a high-performance

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lithium-ion capacitor constructed from a mesoporous carbon as positive electrode and a hard carbon as negative electrode. Zhang *et al.* (https://doi.org/10.1016/j.cclet.2018.01.029) opened up a novel cathode that boron and nitrogen dual-doped carbon for high performance hybrid ion capacitors. Liu *et al.* (https://doi.org/10.1016/j.cclet.2018.01.011) designed a free-standing battery-type electrode of bismuth oxide nanoflake@carbon film for aqueous sodium ion hybrid supercapacitors.

In addition, Wu *et al.* (https://doi.org/10.1016/j.cclet.2017.11.024) developed powdery carbon aerogel with an ideal hierarchical pore structure showing impressive capacitive performances when utilized as electrodes for organic electrolyte supercapacitor. Jiang *et al.* (https://doi.org/10.1016/j.cclet.2017.11.035) systematically studied and compared the temperature stability of activated carbon supercapacitors assembled with liquid aqueous electrolytes by using in situ electrodeposited. Lu *et al.* (https://doi.org/10.1016/j.cclet.2017.10.030) achieved a template directed synthesis of holey carbon nanosheet/nanotube material by tuning the structure of hard template kaolinite, which showed promising electrochemical energy storage capacity.

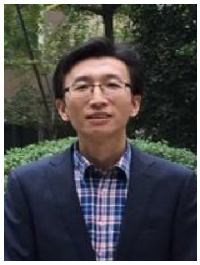
Although we only introduced several typical applications of supercapacitors here, energy density is a key factor restricting the development of other applications of supercapacitors under the premise of guaranteeing long-term cycling stability, high-rate performance, and power density. Thereby, designing supercapacitors configuration with high energy density to achieve the excellent electrochemical capacitance performance is the major issue and challenge. We hope that this special issue brings readers a timely overview on the latest breakthroughs in the related area.

Finally, we would like to express our sincere thanks to all the authors, referees and Editorial Board. We always welcome any comment, suggestion, and feedback.

Zhiqiang Shi obtained his Ph.D. degree from Tianjin University in 2007 and proceed for a postdoctoral research in Tianjin University in 2007–2010. He then joined Tianjin Polytechnic University and constructed the group titled "Advanced Carbon Materials and Energy Devices". In 2016, he worked as professor in the same university. He has completed a number of national and provincial projects and published more than 40 papers. His group focuses on the basic research and industrial technology development of supercapacitor, lithium/sodium ion batteries electrode materials and devices, and devotes to propagandizing industry and popularizing technology of supercapacitor technology.

Zhong-Shuai Wu received his Ph.D. from Institute of Metal Research, Chinese Academy of Sciences (CAS) in 2011, and worked as a postdoctor at Max-Planck Institute for Polymer Research in 2011–2015. Then he joined Dalian Institute of Chemical Physics, CAS, and was appointed as full Professor, and the group leader of 2D Materials & Energy Devices. He has published more than 60 articles with a total citation of >13000 times. His research focuses on graphene and 2D materials for supercapacitors, batteries, and microscale energy-storage devices. He is a recipient of Recruitment Program of Global Expert (1000 Talent Plan), and National Natural Science Award (2nd class).

Zhiqiang Niu is a Professor at College of Chemistry, Nankai University. He received his Ph.D. degree from Institute of Physics, Chinese Academy of Sciences in 2010. After his postdoctoral research in the School of Materials Science and Engineering, Nanyang Technological University (Singapore, co-supervisor: Prof. Xiaodong Chen), he started his independent research career as Hundred Young Academic Leaders of Nankai University since 2014. He has been awarded the National Youth Thousand Talents of China (2015). He has published more than 50 peer-reviewed journal papers and 3 book chapters on nanocarbon materials and supercapacitors. His research interests include nanocarbon materials & advanced energy storage devices.



Jinping Liu received his Ph.D. degree from Central China Normal University (CCNU) in June 2009. During the period of 2008–2011, he did visiting and post-doctoral research at Nanyang Technological University (NTU) in Singapore. He is currently Chair Professor at Wuhan University of Technology. The research interests of Dr. Liu's group interests include the nanostructures synthesis and their electrochemical applications (batteries, supercapacitors, electrocatalysis and so on). He proposed "dual ion synergistic energy storage" and "aqueous *quasi*-conversion reaction" mechanisms, designed three kinds of nanoarray electrodes for integrated (*quasi*-)solid-state energy storage devices, and developed high-voltage aqueous supercapacitors.

Xiaowei Yang who is currently a professor at Tongji University received his Ph.D degree from Shanghai Jiao Tong University in 2001 with Prof. Zi-Feng Ma and carried out researchers on tunable layered graphene gel in Prof. Dan Li's group at Monash University (2009–2014). His current research interests are centered on the synthesis and properties of two dimensional soft materials and their applications in energy storage and conversion, nanofluidics and biomedicines.

Wei Lv is an associate professor in the Graduate School at Shenzhen, Tsinghua University. He received his B.S. and Ph.D. degrees from Tianjin University in 2009 and 2012 under the supervision of Prof. Quan-Hong Yang. He has published more than 100 articles with a citation of above 4500 times, and has more than 30 authorized patents. He is a recipient of National Technological Innovation Award (2nd class), Brian Kelly Award, Finalist of Reaxys PhD Prize and Tianjin Natural Science Award (1st class). His research mainly focuses on novel carbon-based materials, such as graphene, porous carbons, and their applications in electrochemical energy storage devices.

Zhiqiang Shi*
Tianjin Polytechnic University, Tianjin 300387, China

Zhong-Shuai Wu**
Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, China

Zhiqiang Niu
Nankai University, Tianjin 300071, China

Jinping Liu
Wuhan University of Technology, Wuhan 430070, China

Xiaowei Yang
Tongji University, Shanghai 201804, China

Wei Lv
Graduate School at Shenzhen, Tsinghua University, Shenzhen 518055, China

* Corresponding author.

** Corresponding author.
E-mail addresses: shizhiqiang@tjpu.edu.cn (Z. Shi), wuzs@dicp.ac.cn (Z. Wu).