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Introduction to new horizons in materials for energy conversion, optics and electronics

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In conjunction with the Emerging Investigator Forum celebrating the 120th anniversary of Southeast University, we herein present a collection of articles focused on the energy conversion, optics, and electronics applications of (nano)materials.

Renewable energy systems have gained popularity due to climate protection and sustainability issues.[1] However, the intermittency caused by natural renewable energy sources disrupts the balance of the energy system and can put considerable strain on electrical systems.[2] Thus, such artificial systems should be carefully envisioned, strategized, produced, optimized, and monitored to keep them highly efficient, safe, stable, and cost effective.

Energy materials, engineered at nanometer length scales, present unique physicochemical properties that make them more suitable to be explored in diverse manners, paving the way towards renewable energy systems with continuous breakthroughs.[3–5] Meanwhile, theoretical calculations, such as machine learning methods, have been widely applied to solve complex problems.[6,7] This collection focuses on energy conversion, optics, and electronic applications of (nano) materials and provides an overview of the most impactful experimental approaches and theoretical methods for energy conversion and storage, intending to connect different

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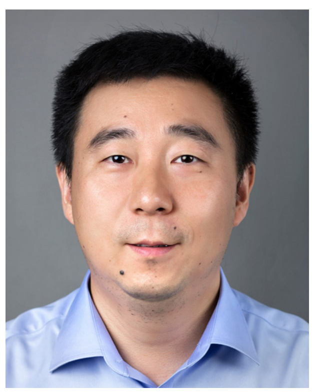
Jinlan Wang

Professor Jinlan Wang is currently an endowed chair professor in the School of Physics at Southeast University. She obtained her PhD from Nanjing University in 2002, followed by a three-year Postdoctoral experience at the Chemistry Division, Argonne National Laboratory. Her group is one of the pioneers devoted to data-driven functional material design, and her research interests also cover electrocatalytic mechanism and catalyst design, growth mechanism and surface/interface of low-dimensional materials, and electronic and optical properties of photoelectric semiconductors. She has published over 300 papers in high-impact journals, including Nature and Nature Nanotechnology, with over 18 000 total citations and a H-index of 70.



Yuanjian Zhang

Professor Yuanjian Zhang received his BS from Nanjing University in 2002 and completed his PhD at the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences in 2007. Subsequently, he joined the Max-Planck Institute of Colloids and Interfaces (Germany) as a postdoctoral researcher. From 2009–2012, he worked at the National Institute for Materials Science (Japan) as an ICYS researcher. He joined the faculty at Southeast University (China) in 2012 as a professor of chemistry. His research interests include carbonaceous matter-based chemical sensors (carbosensing), electroanalytical chemistry, electrocatalysis, photocatalysis, and photoelectrochemistry.

communities and identify common challenges in the field.

Part of the Editor's collection is an exquisite study by Qichong Zhang, Kuibo Yin, Litao Sun and coworkers that provides a promising strategy to rationally construct high-performance flexible vanadium-based cathodes for next-generation wearable aqueous zinc-ion batteries (**https://doi.org/10.1039/D2NH00349J**). They fabricated 3D geometrically-promoted N-doped carbon/defect-rich $V_2O_{5-x}{\cdot}nH_2O$ (DVOH@NC) fibrous cathodes *via* an *in situ* electrochemical activation strategy. The DVOH@NC cathodes brought unexpected electrochemical performance improvements with their impressive capacity (711.9 mA h cm^{-3} at 0.3 A cm^{-3}) and long-term durability (95.5% retention after 3000 cycles). Moreover, the oxidative formation of the DVOH@NC host with enhanced electronic/ion conductivity and its reversible electrochemistry were investigated using insightful electrochemical tests and density functional theory. The assembled deformable fibrous battery with remarkable flexibility demonstrated great advantages in the solar-driven self-powered system and smart wearable electronics.

Semiconductors, especially one-dimensional TiO_2 nanofibers fabricated by electrospinning, have received considerable attention in the past two decades, for a variety of basic applications toward energy conversion and storage. However, their safe use and easy recycling are still hampered by their inherently subpar mechanical performance. Part of this collection is a contribution by Yunqian Dai and coworkers that demonstrates a proof-of-concept for the continuous and controlled production of flexible oxide nanofibers, hastening the transition of TiO_2-based nanomaterials from the fab to the lab (**https://doi.org/10.1039/D2MH01255C**). They used Al ions to soften rigid TiO_2 molecules and regulate the dynamics of TiO_2 crystallization, growth, and aggregation, strengthening electrospun TiO_2 nanofibers from the molecular to macro scale. The modified nanofibers had the highest tensile breaking strength (2.24 MPa) and highest anatase content (47 wt%) ever reported after being calcined at 900 °C. More interestingly, the authors dynamically visualized the oriented deposition of amorphous Al species, which significantly delays the sintering of TiO_2 nanocrystals, at the grain boundary of TiO_2 nanocrystals through *in situ* TEM observation, for the first time. This finding provides essential insight for the rational design of thermally stable oxide nanomaterials. With the aid of origami art for the first time, flexible TiO_2 nanofibrous membranes were constructed into high-temperature resistant microreactors. It was endowed with a $PM_{2.5}$ filtration efficiency of 99.97% after 300+ minutes of use and is able to effectively degrade adsorbents and therefore become a regenerated system by taking full advantage of residual heat and/or sunlight irradiation. These results provide new insights for the functionalization of semiconductors with reliable thermal, mechanical, and chemical stabilities.

These are just a couple of the many recent papers published in this themed collection focused on materials for energy conversion, optics and electronics. We hope that you will find them an interesting read!

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