A Two-Decade Journey of Continuous Innovation at the National Center for Nanoscience and Technology of China (NCNST)

Qing Dai, Zhixiang Wei,* Zhiyong Tang,* and Yuliang Zhao**

This special issue of *Advanced Materials* celebrates the 20th anniversary of the National Center for Nanoscience and Technology of China (NCNST), showcasing a diverse array of cutting-edge research in nanoscience and nanotechnology. This issue highlights recent advances in nanomaterials for devices, nanomedicine, energy, and catalysis applications.

NCNST is a pioneering institution established on December 31, 2003 and supported by the National Development and Reform Commission. NCNST is the first state-level hub of the nation, dedicated to nanoscience innovation. The collaboration between the Chinese Academy of Sciences (CAS) and the Ministry of Education has place NCNST at the forefront of doing research, fostering talents, and engaging international exchange in the field of nanoscience and nanotechnology.

Guided by the visionary leadership of Prof. Chunli Bai, former CAS president, NCNST has firmly established itself as a forerunner in nanoscience and nanotechnology over the past two decades. In 2021, 5 researchers from NCNST were honored as "Highly Cited Researchers" by Clarivate.[1] To connect the various disciplines within nanoscience and nanotechnology, three high impact nanoscience journals, i.e., *Nanoscale, Nanoscale Advances,* and *Nanoscale Horizons,* are published as a collaborative venture between NCNST and the Royal Society of Chemistry Publishing Group. In addition to these outstanding academic achievements, NCNST has successfully developed critical industrial technologies, resulting in innovations such as the "injectable irinotecan hydrochloride (nano) micelle product," which has garnered considerable commercial interest. The institute's strategic initiatives in research and technical standardization have played a pivotal role in shaping China's nanomeasurement standards, thus establishing a comprehensive array of standard substances and methodologies and positioning China as a leader in nano standards. NCNST's commitment to standards and regulations is evident from its affiliations with prominent bodies like the National Technical Committee 279 on Nanotechnology of Standardization Administration of China (SAC/TC 279), and the Special Committee on Nanotechnology of China National Accreditation Service for Conformity Assessment (CNAS).

With rapid development for two decades, currently, NCNST has a faculty of 99 full professors and 110 associate professors, including 3 academicians of CAS, 15 Distinguished Young Scholars, and 26 Excellent Young Scholars from the National Natural Science Foundation of China. NCNST offers several doctoral and master's programs spanning a vast array of scientific disciplines, along with postdoctoral research opportunities. China's Academic Degrees Committee State Council approved "Nanoscience and Engineering" as a distinct academic discipline in 2022,[2] thus marking a pivotal milestone in the educational journey of the institute. The NCNST has three CAS Key laboratories including the Key Laboratory for Biological Effects of Nanomaterials and Nanosafety, the Key Laboratory for Standardization and Measurement for Nanotechnology, and the Key Laboratory for Nanosystem and Hierarchical Fabrication. NCNST launched the Key Laboratory of Nanophotonic Materials and Devices to enhance its capabilities in 2020. The institute established specialized state-of-art labs for theoretical exploration, nanofabrication, and smart nanosensing, along with a Nanotechnology Development Department committed to establishing public research platforms and fortifying the study of nanotechnology.

Celebrating its 20th anniversary, *Advanced Materials* honored NCNST by dedicating a special issue featuring 23 articles highlighting groundbreaking research in the fields of nanomaterials and devices, nanobiology and nanomedicine, energy and catalysis, etc.

In the field of nanomaterials and devices, Prof. Ning Deng et al. (https://doi.org/10.1002/adma.202302658) present a novel M3D-SAIL chip architecture achieved through the monolithic 3D integration of a photosensor array, analog computing-in-memory (CIM), and Si CMOS logic circuits. This innovation demonstrates significant advantages for energy-efficient computing

Q. Dai
CAS Key Laboratory of Nanophotonic Materials and Devices
National Center for Nanoscience and Technology
Beijing 100190, China
E-mail: daiq@nanoctr.cn

Z. Wei, Z. Tang
CAS Key Laboratory of Nanosystem and Hierarchical Fabrication
CAS Center for Excellence in Nanoscience
National Centre for Nanoscience and Technology
Beijing 100190, China
E-mail: weizx@nanoctr.cn; zytang@nanoctr.cn

Z. Wei, Z. Tang, Y. Zhao
University of Chinese Academy of Sciences
Beijing 100049, China
E-mail: zhaoyl@nanoctr.cn

Y. Zhao
CAS Key Laboratory for Biomedical Effects of Nanomaterials and Nanosafety
CAS Center for Excellence in Nanoscience
National Center for Nanoscience and Technology
Beijing 100190, China

near sensors. Prof. Jin Zhang et al. (https://doi.org/10.1002/adma.202306129) explore the optimization of internal structure, including crystallinity, orientation, and porosity, of SWNTs in PBIA fibers. Prof. Xiangnan Sun et al. (https://doi.org/10.1002/adma.202301854) delve into the performance and functionalities of diverse emerging spintronic material systems. Prof. Erjun Zhou et al. (https://doi.org/10.1002/adma.202300175) review material development and voltage loss for A2-A1-D-A1-A2-type small molecules and their applications in ternary and indoor organic photovoltaics. Prof. Zhenxing Wang et al. (https://doi.org/10.1002/adma.202301472) discuss recent advances of 2D vdW ferroelectric materials in ferroelectricity origin and practical applications, especially in artificial intelligence. Prof. Luqi Liu et al. (https://doi.org/10.1002/adma.202303014) highlight recent advances on clean vdW interfaces to unlock potential of 2D materials in electronics and optoelectronics. Prof. Weiguo Chu et al. (https://doi.org/10.1002/adma.202303001) introduce the tailored nanostructure-dominated SPP effects for SPPs-based meta-devices and SERS meta-sensors. Prof. Xinghua Shi et al. (https://doi.org/10.1002/adma.202305758) provide an in-depth examination of principles and their implementation in machine learning interatomic potentials, focusing on applications in nanomaterial surface/interface systems and discussing the challenges inherent in this potent methodology.

In the field of nanobiology and nanomedicine, Prof. Guangjun Nie et al. (https://doi.org/10.1002/adma.202211609) present a cell reprogramming-responsive hydrogel fabricated using a synthetic biology-based strategy. This hydrogel induces the formation of Yes-associated protein (YAP) biomolecular condensates at the appropriate stage during cell reprogramming, ensuring more efficient generation of induced pluripotent stem cells (iPSCs) than conventional methods. Prof. Yaoxin Lin et al. (https://doi.org/10.1002/adma.202306248) delineate an innovative tumor microenvironment-responsive nanorobot capable of effectively delivering nucleic acid drugs to TLR9-positive tumors. This research also demonstrates that CpG-loaded nanorobots have significant antitumor efficacy in cancer immunotherapy by inducing autophagy-mediated immunogenic cell death. Prof. Yuhong Cao et al. (https://doi.org/10.1002/adma.202303321) present a rapid and efficient method using wood-derived cellulose (WMC) to remove up to 98% of double-stranded RNA impurities from mRNA therapeutics within just 5 min. Prof. Baoquan Ding et al. (https://doi.org/10.1002/adma.202301035) provide an overview of recent advances in extracellular vesicle analysis using a variety of DNA-based nanomaterials and discuss unresolved challenges and future directions in this field. Prof. Chunying Chen et al. (https://doi.org/10.1002/adma.202303266) explore five different levels of physiological barriers faced by lipid-based nanoparticles for nucleic acid drug delivery and current coping strategies. Prof. Hao Wang et al. (https://doi.org/10.1002/adma.202305099) present a systematic and comprehensive overview of intelligent biomaterialomics to clarify the definition, formation mechanism, advanced characterization methods, potential applications, and future development directions. Prof. Hai Wang et al. (https://doi.org/10.1002/adma.202303180) discuss therapeutic strategies and clinical progress of ultrasound in neurological diseases, with a focus on the potential of ultrasound therapy based on upconversion nanoparticles (USINs) for neurological diseases. Prof. Xingjie Liang et al. (https://doi.org/10.1002/adma.202301770) explore the development of nanobiotechnology to enhance T-cell immunotherapy for disease treatment. Prof. Jiashu Sun et al. (https://doi.org/10.1002/adma.202303092) overview the recent advances in extracellular vesicle analysis using a variety of DNA-based nanomaterials, including linear DNA probes, DNA nanostructures, and hybrid DNA nanomaterials, and discuss unresolved challenges and perspective directions in this field. Prof. Lele Li et al. (https://doi.org/10.1002/adma.202302972) introduce modular engineering of aptamer-based nanotechnology, allowing conditional control of ATP sensing and imaging with high spatial precision from subcellular organelles to living animals.

In the field of energy and catalysis, Prof. Zhiyong Tang et al. (https://doi.org/10.1002/adma.202305508) develop a structured p-$CuSiO_3$/CuO for efficient CO_2 reduction, demonstrating high stability and significant C^{2+} faradaic efficiency. Prof. Jianru Gong et al. (https://doi.org/10.1002/adma.202211008) present a porous cover structure with tunable pore sizes designed to enhance interfacial charge, mass transfer kinetics, and intrinsic catalytic activity of 2D-covered catalysts for improved photoelectrochemical water-oxidation reactions. Prof. Huiqiong Zhou et al. (https://doi.org/10.1002/adma.202303844) report semi-transparent organic solar cells with homogeneous transmission and colorful reflection enabled by an ITO-free microcavity architecture. Prof. Zhixiang Wei et al. (https://doi.org/10.1002/adma.202302915) discuss molecular design and device optimization strategies for overcoming device performance bottlenecks in all-small-molecule organic solar cells, with a focus on improving charge management and reducing energy loss. Prof. Gang Liu et al. (https://doi.org/10.1002/adma.202301307) summarize the fundamental principles, synthetic methods, and latest progress of noble-metal-free single-atom catalysts (SACs) and dual-atom catalysts (DACs) in solar-light-driven artificial photosynthesis.

We are honored to publish this special issue featuring innovations in nanomaterials at NCNST. We believe that the innovative spirit of research at NCNST, showcased in this Editorial, will propel the institute forward to greater achievements. Finally, we sincerely appreciate the tremendous support and kind cooperation of Dr. Sneha K Rhode, Dr. Xiaoge Hu, Dr. Yuhong Cao, Dr. Yanhong Ma, and the entire editorial team of *Advanced Materials*.

Conflict of Interest

The authors declare no conflict of interest.

[1] The link of "Highly Cited Researchers 2021", https://www.recognition.webofscience.com/awards/highly-cited/2021/, (accessed: November 2021).

[2] http://www.moe.gov.cn/srcsite/A22/moe_833/202209/t20220914_660828.html, (accessed: September 2022).

Qing Dai received his Ph.D. from the University of Cambridge and joined NCNST as a distinguished professor in 2012. He received the National Science Fund for Distinguished Young Scholars and the Science and Technology Award for Chinese Youth in 2019. Currently, he serves as a distinguished professor at the Chinese Academy of Sciences and a fellow of the Royal Society of Chemistry. His research interests include the synthesis of ultrathin 2D nanomaterials and the fabrication of low-dimensional nanomaterial devices for various applications.

Zhixiang Wei received his Ph.D. from the Institute of Chemistry, Chinese Academy of Sciences, in 2003. He earned his B.S. and M.S. degrees from Xi'an Jiaotong University in 1997 and 2000, respectively. He served as a postdoctoral fellow at the Max Planck Institute of Colloids and Interfaces and the University of Toronto in 2003–2004 and 2005, respectively. Prof. Wei joined the NCNST as a Principal Investigator in 2006. His research interests include organic functional nanomaterials and flexible devices.

Zhiyong Tang, the Director-General of NCNST, was elected as Member of the Chinese Academy of Sciences in 2023. He earned his Ph.D. from Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, in 2000 and his B.S. and M.S. degrees from Wuhan University in 1993 and 1996, respectively. Following 6 years of experience as a postdoctoral fellow at Swiss Federal Institute of Technology, Zurich, Oklahoma State University, and University of Michigan, he joined NCNST as a Principal Investigator in November 2006. His research interests primarily focus on the fabrication, assembly, and applications of inorganic nanomaterials in energy and catalysis.

Yuliang Zhao was elected as Member of the Chinese Academy of Sciences in 2017 and a fellow of the World Academy of Sciences in 2018. He graduated from Sichuan University in 1985, and received his Ph.D. from Tokyo Metropolitan University in 1999. Prof. Zhao joined the Chinese Academy of Sciences as a Principal Investigator in 2001. His research interest primarily focuses on the toxicity study of engineered nanomaterials and cancer nanomedicine. He served as the Director-General of NCNST from September 2018 to October 2023.