Nanoscale

EDITORIAL

View Article Online
View Journal | View Issue

Check for updates

Cite this: *Nanoscale*, 2025, **17**, 19984

Published on 28 Mhawuri 2025. Downloaded on 2025-10-16 06:23:16.

Introduction to Superwetting nanoelectrodes for renewable energy

Zuankai Wang,[a] Alex Bell,[b] Alberto Vomiero[c] and Xiaoming Sun*[d]

DOI: 10.1039/d5nr90139a

rsc.li/nanoscale

In this editorial, Xiaoming Sun introduces the collection 'Superwetting nanoelectrodes for renewable energy', guest edited by Zuankai Wang, Alex Bell, Alberto Vomiero and Xiaoming Sun. This themed issue in *Nanoscale* aims to publish papers focusing on the fundamental understanding and practical applications of superwetting nanoelectrodes.

Electrochemical reactions that take place at the interface between electrode and electrolyte involve charge transfer, mass transport, and phase transformation. With the development of nanoelectrodes, it has been widely recognized that the dynamics of H_2 or O_2 bubbles' formation, which is tailored by the wetting or superwetting properties of electrolyte/electrode interfaces, critically influence the operational efficiency of electrochemical energy conversion and storage systems, industrial manufacturing processes, and environmental remediation technologies. Despite that wettability is a centuries-old concept, from 1805, the concept of superwetting electrodes is new and has sparked tremendous attention in recent decades, thanks to the rapid development of hydrogen energy and well-established nanostructure synthesis techniques.

In 2014, the "superaerophobic electrode" was proposed for explaining the extraordinary rapid hydrogen evolution reaction (HER) current increase rates, which were observed on a MoS_2 nanoarray electrode. Such nanoelectrodes reduced bubble adhesion force, and consequent bubble detachment size, lowered the diffusion resistance and enhanced current density increase rates, even surpassing commercial Pt/C film electrodes at high current densities. In the latest decade, the influence of bubble evolution behaviors has been intensively investigated, and the tailoring of electrode structure for regulating the three-phase interfaces has become equally important apart from promotion of intrinsic activity of catalysts. By combining optimized materials with higher intrinsic activities and optimized nanostructures with superwetting properties, unprecedented capabilities of electrodes have been fully unlocked by interfacial regulation.

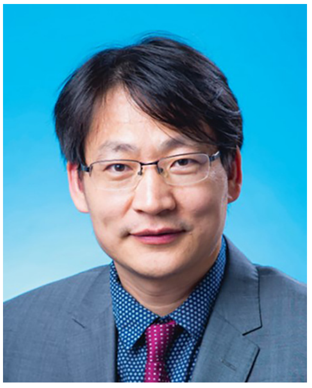
Typically, superwettability has been derived as superaerophobic electrodes for gas evolution reactions (GERs), and superaerophilic electrodes for gas consumption reactions (GCRs). For example, the severe bubble adhesion in HzOR on the electrode surface can be minimized by constructing "superaerophobic" nanostructured Cu films, and the "superaerophobic" nanostructured $RuO_2@TiO_2$ electrode exhibits an excellent ClER performance with a Faradaic efficiency over ≈90%. Similarly, the bubbles can merge into the superaerophilic electrode as a bursting state within 100 ms, overcoming the inherent solubility of most target reactive gas species. Recently, ultralight flexible 3D nickel (nanocone-shaped nickel structures) micromesh decorated with NiCoP has been developed for high stability alkaline zinc batteries, which demonstrated outstanding cycling stability, retaining 91% of its initial capacity after 11 000 cycles. In this context, gas-diffusion electrodes (GDEs) with superhydrophobic three-phase boundaries have been widely applied in gas consumption reactions including fuel cells, metal–air batteries and CO_2-reduction reactions, exhibiting much enhanced catalytic activity and high efficiency. In addition, superwetting nanoelectrodes have also been applied in the design of GCR based electrochemical sensors. By synergizing the convergence of nanoscience, interfacial physics, and electrochemistry, superwetting nanoelectrodes provide an effective strategy for promoting the mass transfer (particularly the gas species) in renewable energy technologies through innovative interface design, and advance the industrialization of electrochemical energy conversion and storage.

The rapid proliferation of research activities in the intrinsically interdisciplinary superwetting electrodes field has inspired us to organize this themed issue, aiming to consolidate the latest advancements and conceptual breakthroughs for renewable energy systems. As guest editors of this themed issue, we would like to thank all the authors for the high quality of the contributions, and the editorial staff from *Nanoscale* for their guidance and support throughout the creation process. We hope that this themed issue can provide new insights and innovative strategies for researchers in chemistry, materials, energy, physics and beyond, and further promote the development of electrochemical energy technologies on the industrialized scale.

[a]*The Hong Kong Polytechnic University, Hong Kong*
[b]*University of California, Berkeley, USA*
[c]*Luleå University of Technology, Sweden*
[d]*Beijing University of Chemical Technology, China. E-mail: sunxm@mail.buct.edu.cn*

This journal is © The Royal Society of Chemistry 2025

Published on 28 Mhawuri 2025. Downloaded on 2025-10-16 06:23:16.



Zuankai Wang

Professor Zuankai Wang is currently the Associate Vice President (Research and Innovation), Kuok Group Professor in Nature-Inspired Engineering, and Chair Professor of Nature-Inspired Engineering at The Hong Kong Polytechnic University. He received his B.S. degree from Jilin University, M.S. degree from Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, and PhD degree from Rensselaer Polytechnic Institute. After one-year postdoc training at Columbia University, he joined the City University of Hong Kong (CityU) in 2009 and became a Chair Professor in 2021. Professor Wang is a member of Hong Kong Academy of Engineering and Fellow of International Society of Bionic Engineering (ISBE) and Royal Society of Chemistry. His work has been recognized by the Guinness Book of World Records and his innovations have won the International Exhibition of Inventions of Geneva Gold Medal with Congratulations of Jury and Gold Medal. He has received many awards including 2024 Nukiyama Memorial Award (the highest award conferred by the Heat Transfer Society of Japan), Falling Walls Science Breakthroughs of the Year 2023 (Engineering and Technology), Croucher Senior Research Fellowship, BOCHK Science and Technology Innovation Prize, the RGC Senior Research Fellow, Green Tech Award, Xplorer Prize, 35th World Cultural Council Special Recognition Award.

Alex Bell

Professor Alexis Tarassov Bell is an American chemical engineer. He is currently the Dow Professor of Sustainable Chemistry in the Department of Chemical and Biomolecular Engineering in UC Berkeley's college of chemistry. He is also the Faculty Senior Scientist at Lawrence Berkeley National Laboratory. Alex Bell's research specialty is catalysis and chemical reaction engineering with an emphasis on understanding the fundamental relationships between catalyst structure and composition and catalyst activity and selectivity. His research honors include the Curtis W. McGraw Award for Research from the American Association of Engineering Education, the Professional Progress, R. H. Wilhelm, and William H. Walker Awards from the American Institute of Chemical Engineers; the Paul H. Emmett Award in Fundamental Catalysis and the Michel Boudart Award from the Catalysis Society; and the ACS Award for Creative Research in Homogeneous or Heterogeneous Catalysis and the George Olah Award in Petroleum or Hydrocarbon Chemistry from the American Chemical Society.

Alberto Vomiero

Alberto Vomiero is a chair professor of Experimental Physics at the Department of Engineering Sciences and Mathematics, Luleå University of Technology (Sweden) and a chair professor of Industrial Engineering at Ca'Foscari University of Venice (Italy). Alberto obtained his degree in Physics from the University of Padova (Italy, 1999) and his PhD in Electronic Engineering from the University of Trento (Italy, 2003). His research interests include the development of advanced nanomaterials and composites for energy and related applications, including solar cells, luminescent concentrators, hydrogen production through water splitting, water desalination and water cleaning.

Published on 28 Mhawuri 2025. Downloaded on 2025-10-16 06:23:16.

Xiaoming Sun

Professor Xiaoming Sun was born in Shandong Province in February 1976 and was granted his B.S. degree and PhD from the Department of Chemistry, Tsinghua University in 2000 and 2005, respectively. After his postdoctoral work at Stanford University, he joined the State Key Laboratory of Chemical Resource Engineering, Beijing University of Chemical Technology in 2008 as a full professor and PhD candidate supervisor. He was awarded the National Excellent Doctoral Dissertation in 2007 and the Outstanding Youth Fund of the National Natural Science Foundation in 2011. His main research interests include the controllable synthesis of inorganic nanomaterials and their applications in energy chemistry, especially water electrolysis, fuel cells, and batteries.

 This journal is © The Royal Society of Chemistry 2025