Energy science has witnessed a surge of interest over the past 10 years, mostly motivated by progress in nanoscience and nanotechnology. For the sustainable development of human beings, extensive research has been dedicated to renewable energy, and its conversion and storage, owing to the increasing concerns about global climate change and the growing demand for energy. In April 2021, the CO₂ concentration was measured at 418.46 ppm, and compared to April 2020 (415.59 ppm) even through coronavirus times the increase is massive. As a result, searching for promising new options is crucial to align human development with the United Nation’s Sustainable Development Goals.

In particular, downsizing functional materials to the nanoscale can manifest intriguing properties and performances compared to their bulk structures. Fabricating nanostructured materials with tailored properties is at the forefront of technological exploration. At present, novel strategies such as size/facet control, structural engineering, vacancy engineering, atomic regulation, and construction of nanocomposites alter the physicochemical properties (e.g. electronic, optical, band and textural) of the active sites. Hence, this gives rise to a momentous improvement in the performance of nanomaterials toward energy conversion and storage. Research in this energy realm necessitates an interdisciplinary approach with synergistic collaboration from all disciplines such as chemistry, engineering, nanotechnology, computation, as well as industrial thinking to accomplish high-performance energy systems.

The themed collection of Nanoscale entitled “advanced nanomaterials for energy conversion and storage” aims to showcase the state-of-the-art knowledge on the development of nanomaterials with tunable properties for diverse energy applications. This themed collection consists of 23 Full Papers, 4 Communications and 5 Reviews, focusing on designing advanced materials and building a structure–activity–stability relationship in electrocatalysis, photocatalysis, photoelectrocatalysis, batteries, fuel cells and so forth.

Xiong et al. (DOI: 10.1039/D0NR02596H) highlight the development of engineering active sites on surfaces and in open frameworks with respect to surface vacancies, doped heteroatoms, loaded metal nanoparticles, crystal facets and metal nodes/organic linkers in metal–organic frameworks for application in photocatalytic CO₂ reduction. In addition to the advances in CO₂ photoreduction, Zhang et al. [DOI: 10.1039/D0NR03178J] have reviewed the use of carbon-based nanomaterials and their hybrids for photo- and electrocatalytic hydrogen peroxide (H₂O₂) production via both reductive and oxidative reaction pathways. Apart from photochemistry, inspired by the merits of 2D nanostructures, Tsang’s group [DOI: 10.1039/D0NR01295E] present a minireview on the recent discoveries in hetero-single atom-doped MoS₂ nanosheets for electrochemical hydrogen evolution reaction (HER) from water by reviewing the nature of the dopants, doping positions and the polytypes of MoS₂. In view of the importance of morphological engineering in energy applications, Wang et al. [DOI: 10.1039/D0NR03425H] focus on the primary issues facing one-dimensional (1D) electrospun carbon nanofibers in supercapacitors with the aim of ameliorating the conductivity, modulating pore configuration, doping with heteroatoms and increasing mechanical strength. Sun et al. [DOI: 10.1039/D0NR05475E] summarize the most recent updates on the structure–activity relationship of random alloy and intermetallic (ordered structure) nanocrystals for electrochemical fuel cells with robust activity and superb stability.

By mimicking natural photosynthesis, artificial photosynthesis using nanocatalysts is described by several research groups. For enhancing the light absorp-
tation and inhibiting the electron–hole recombination, morphological modification and surface engineering are facile techniques to boost photocatalysis.\textsuperscript{5–7} Tang et al. (DOI: 10.1039/D0NR00226G) have prepared graphitic carbon embedded inside hollow graphitic carbon nitride (g-C\textsubscript{3}N\textsubscript{4}). Yu’s group (DOI: 10.1039/C9NR10451H) successfully developed hierarchical Ni-NiS/C/ZnO photocatalysts \textit{via in situ} photodeposition of Ni-NiS nanosheets onto C/ZnO electrospun nanofibers for CO\textsubscript{2} reduction to CO and CH\textsubscript{4}. Attributed to the advantages of 2D/2D heterojunction systems, Jing et al. (DOI: 10.1039/D0NR02551H) fabricated dimension-matched ultrathin NiMOF/g-C\textsubscript{3}N\textsubscript{4} heterojunctions with the aid of ultrasound by growing NiMOF nanosheets on hydroxylated and 1,4-aminobenzoic acid-functionalized g-C\textsubscript{3}N\textsubscript{4} nanosheets for improved CO\textsubscript{2} reduction. To aim for energy sustainability as opposed to the energy-intensive industrial Haber–Bosch process, Tang et al. (DOI: 10.1039/D0NR02527E) designed a ternary heterostructure consisting of ruthenium species on g-C\textsubscript{3}N\textsubscript{4} (Ru/RuO\textsubscript{2}/g-C\textsubscript{3}N\textsubscript{4}) for ammonia photosynthesis, in which Ru and RuO\textsubscript{2} functioned as electron and hole storage sites, respectively. Furthermore, Zhang et al. (DOI: 10.1039/D0NR03393F) report W-doped TiO\textsubscript{2} for boosted photothermal catalytic CO\textsubscript{2} reduction to CO due to the presence of more active sites with increased W doping. By applying an external bias, Jorge et al. (DOI: 10.1039/D0NR06139E) introduce a carbon underlayer derived from carbon dots \textit{via} a hydrothermal process between the fluorine-doped tin oxide substrate and the hematite photoanodes, which has remarkably enhanced the photocurrent density and charge transfer efficiency of up to ca. 80\% at 1.25 V vs. RHE. Besides energy conversion, An’s group (DOI: 10.1039/D0NR01027H) has synthesized well-aligned 2D Ni-MOF nanosheet arrays vertically grown on porous nickel foam (Ni-MOF/NF) without lateral stacking \textit{via} solvothermal processes for the removal of ethyl acetate. Falaras’s group (DOI: 10.1039/D0NR02562C) designed an innovative interface engineering approach to utilize an organic chromophore as an

Wee-Jun Ong received his B.Eng. and Ph.D. in chemical engineering from Monash University. He is an Associate Professor in School of Energy and Chemical Engineering at Xiamen University Malaysia. Starting from 2021, he has become a Director of Center of Excellence for NaNo Energy & Catalysis Technology (CONNECT). Previously, he was a scientist at Agency for Science, Technology and Research (A*STAR), Singapore. In 2019, he was a visiting scientist at Technische Universität Dresden, Germany and a visiting professor at Lawrence Berkeley National Laboratory (LBNL), USA. His research interests include surface/atomic engineering of nanomaterials for energy storage devices, photocatalytic, photoelectrocatalytic, and electrochemical H\textsubscript{2}O splitting, CO\textsubscript{2} reduction and N\textsubscript{2} fixation.

Nanfeng Zheng received his B.S. from Xiamen University in 1998. In 2005, he obtained his Ph.D. degree from University of California – Riverside. During 2005–2007, he worked as a research associate at University of California – Santa Barbara. He moved to Xiamen University as a Full Professor in 2007 and became a Changjiang Chair Professor in 2010. He is currently the executive deputy director of Innovation Laboratory for Sciences and Technologies of Energy Materials of Fujian Province (IKKEM). His research is committed to understanding the surface and interface chemistry behind the factors regulating the properties of functional materials at the molecular level and thus promoting their applications in the fields of energy, catalysis, and environmental protection.

Markus Antonietti is the Materials Chemistry Director of the Max Planck Institute of Colloids and Interfaces in Potsdam-Golm, Germany. He is an expert in polymers and covalent materials and has focused his attention in the last years to the fields of green chemistry and sustainable materials, but also to the new global cycles of energy, food, water, and CO\textsubscript{2} constituting the Anthropocene. In his free time, he enjoys cooking and performing in a rock band.
interlayer between a perovskite absorber and hole transporter, which preserved 83% of the original efficiency despite storing the device for 37 days in the dark and under open-circuit conditions.

In addition to light-driven reactions, research in the field of electrocatalysis for water splitting and CO2 reduction is a prime focus of sustainable energy research.6–11 As a low-cost alternative to Pt, Yamashita’s group (DOI: 10.1039/D0NR02525A) employed the noble-metal-free hybrid phase 1T/2H-MoS2 with tunable 1T concentration for electrochemical hydrogen evolution. Oh et al. (DOI: 10.1039/D0NR03736B) developed trifunctional electrocatalysts for hydrogen evolution (HER), oxygen evolution (OER) and oxygen reduction reactions (ORR), which are composed of a hierarchically-structured Ir/Ni alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts. Liu et al. (DOI: 10.1039/D0NR02951C) studied the pH influence on the electro-activation of IrNi alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts. Liu et al. (DOI: 10.1039/D0NR02951C) studied the pH influence on the electro-activation of IrNi alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts. Liu et al. (DOI: 10.1039/D0NR02951C) studied the pH influence on the electro-activation of IrNi alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts. Liu et al. (DOI: 10.1039/D0NR02951C) studied the pH influence on the electro-activation of IrNi alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts. Liu et al. (DOI: 10.1039/D0NR02951C) studied the pH influence on the electro-activation of IrNi alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts. Liu et al. (DOI: 10.1039/D0NR02951C) studied the pH influence on the electro-activation of IrNi alloy nanoparticles supported on carbon (IrNi/C) toward water oxidation, where different pH conditions led to extraordinary electronic structure by modifying the alloy catalysts.
excellent contributions as well as all Nanoscale’s editors and reviewers for their selfless professional services. On a final note, in conjunction with the Xiamen University’s anniversary in 2021, we would like to commemorate and congratulate on the 100th anniversary of Xiamen University, China and the 5th anniversary of Xiamen University Malaysia campus. In view of the university’s anniversary, we would like to celebrate the successful launch of the Center of Excellence for NaNo Energy & Catalysis Technology (CONNECT) at Xiamen University Malaysia in 2021.

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