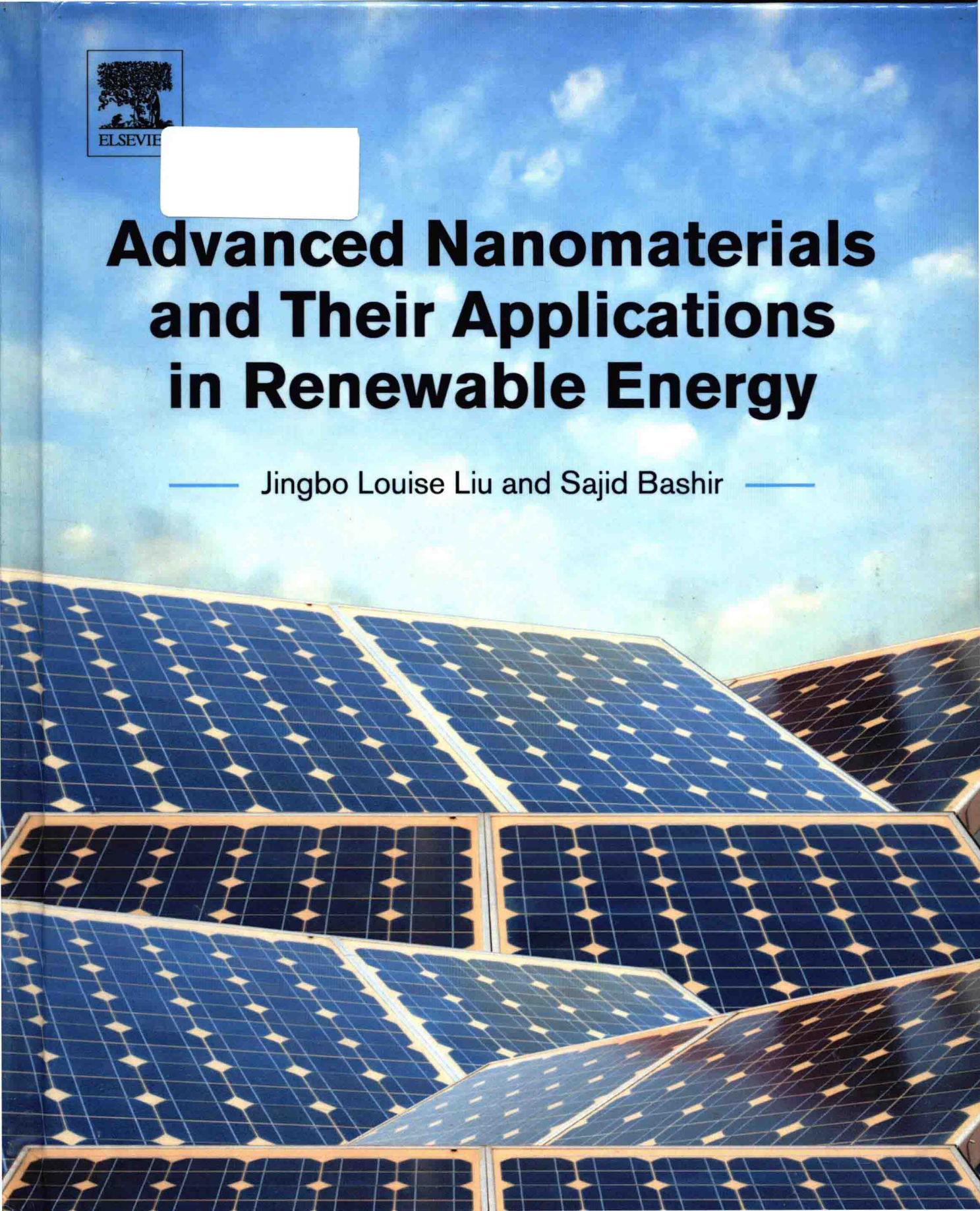
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Advanced Nanomaterials and Their Applications in Renewable Energy
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Advanced Nanomaterials and Their Applications in Renewable Energy

Author's Biography

Jingbo Liu received her PhD in materials science and engineering, the University of Science and Technology Beijing. She is an associate professor at Texas A&M University-Kingsville. She was awarded the Japan Society for the Promotion of Science Invitation Fellow and served as a "Faculty and Student Team" fellow collectively funded by the National Science Foundation and U.S. Department of Energy. She also received outstanding research and teaching awards at the university level. She participated in more than 15 projects supported by the NSF (USA, China), NSERC (Canada), R. Welch Foundation, industrial and TAMUK as PI, Co-PI, and senior personnel. Dr Liu has authored textbooks, book chapters; about three dozens of peer.

Sajid Bashir received his PhD in analytical chemistry from the University of Warwick, England. He was also a postgraduate research associate at Cornell University. He is an associate professor at Texas A&M University-Kingsville and a Faculty and Student Team fellow at the Lawrence Berkeley National Laboratory (2011–2013). He has directed and participated in (>10) projects supported by the Welch Foundation, TAMUK, Texas Workforce commission, and U.S. National Institute of Health. He has coauthored book chapters and peer-reviewed journal articles and delivered more than a dozen presentations at various scientific conferences. He is also a fellow and Chartered Chemist (CChem) of the Royal Society of Chemistry (FRSChem) as well as a Chartered Scientist (CSci).

Preface

The current treatise attempts to address the needs of the laboratory-based end users more than the theoretician with respect to nanomaterials, theory, characterization, and application. The emphasis is on surfaces, interfaces, and characterization that are appropriate and relevant to the practitioner.

Each chapter has a focus on a specific theme with practical examples from this research group that the reader can apply to their research group immediately, as a cross between a tech manual and an encyclopedia. In addition where appropriate, glossaries of acronyms and summary figures or tabulated comparisons are included for easy reference and compilation.

The book has three unequal parts spanning nine chapters on nanomaterials. The first three chapters bring the reader to speed in terms of concepts, theory, and design with a broad introduction to the topic for the uninitiated, but with sufficient detail and recent experimental data to be of interest to the seasoned veteran. The chapter is followed by synthesis approaches, properties, and design rather than a recipe-based approach, with an emphasis of theory to design to practical application as opposed to esoteric discussion. The emphasis is on practicality related to surfaces, interfaces, and dimensionality, tempered with a realization that not all subtopics would require the same approach, but the strategy described would represent the intrinsic characteristics of the material under investigation.

Materials consisting of metals or semiconductors have bulk properties that depend on their dimensionality, purity, and form; in understanding that nanostructure is critical to observed structural properties or chemical catalysis. Material Science understanding has increased in scope to where materials can be designed in an analogous manner to biological materials fabrication. In biological and smart materials the external and internal surfaces are different and tailored to specific purposes. These properties correspond to the nanoscopic surfaces demonstrating that nanomaterials play an important role, relating to material properties,performance, and function such as electrodes in a fuel cell. The catalytic tendency is related to porosity, microheterogeneity, and nanostructure. These features or defects in turn are related to the synthesis approach and whether the material is pure, doped,

or coated or core-shelled, which can only be understood after surface characterization. Using information gathered from characterization of the material, crystal, film, or colloid, information on internal structure/interfaces, defects, grain boundaries, segregation during sintering, or annealing could enable better understanding to design more stable systems that exhibit certain physical features, such as tensile strength, increased surface area of high degree of photocatalysis. Through such analyses, both internal and external surfaces could be characterized which are illustrated by example and review.

The third chapter has a focus on the broad area of characterization that has undergone a revolution since the 1960s. Advances in instrumentations (miniaturization, hybridization, smart software) allow for multiplexing, complex spatial and temporal control as well as multidimension imaging and mapping. The emphasis is an attempt to understand chemical and physical processes in material design that affect material properties, and how these properties impact on material performance/function in terms of external and interior grain boundaries, defects, and surface area-to-volume ratio. The next four chapters are thematic and focus on specific areas of interest to the nanomaterial community such as generation of sustainable energy, in dye sensitized solar cells, proton exchange membrane fuel cells, storage divides for hydrogen storage, or carbon dioxide capture. The last section is a stand-alone chapter on nanosafety with specific research from our laboratory. This chapter has an important contribution to understanding how ubiquitous nanomaterials affect living systems, both unintentionally and intentionally. As usage of nanomaterials increases, their intend and unintended effect on living systems needs to be examined, modeled, and understood. This chapters deals with regulatory compliance, workforce safety. Safety and regulation depending upon cytotoxicity, which in turn depends on biochemical mechanism of interaction at the interface between nanomaterials and biological systems. Here, monitoring of nitric oxide is introduced as a diagnostic indicator of material cytotoxicity. The purpose of this book is to bridge the gap between theoretical. The materials is written by two authors to keep the book ordered and cohesive, but has input from a wide arena. As stated, the book is intended for both novice and expert alike to provided unbiased information for the "practicalist," scientists, or nanotechnologist. The chapters begin with a broad overview followed by specific examples, such as materials used in dye sensitized solar cells, followed by review and in-house research related to the topic under examination. If the technique, procedure is abbreviated, a glossary is offered to expand these terms, which may be obscure to the novice, where possible abbreviations are kept to a minimum.

All work irrespective of authorship listing is collaborative in nature and this book would not be a reality without the assistance of the Senior Acquisition Editor Kostas Marinakis, Project Manager Mohanapriyan Rajendran. He provided moral support, encouragement to see the volume through to completion, including weekly, sometimes daily assistance by Christine McElvenny, Editorial Project Manager, at Elsevier, whose attentive and eye for

detail shepherded this book to fruition. The invaluable assistance of her colleagues on the editorial staff at Elsevier, also should not be underestimated, as always errors, omissions are our failings and not that of the editorial staff.

Finally we were supported in our endeavors by our colleagues and associate in the Department of Chemistry here and also at our sister institution, Texas A&M University-College Station (TAMU), as well as the Materials Characterization Facility and Microscopy & Imaging Center, also at TAMU. The coauthors, contributors, students, postdoctoral research associates were appropriate, as well as the leadership of the Department of Chemistry, College of Arts & Sciences, and the University are acknowledged for their unwavering support.

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Acknowledgment

The authors wish to acknowledge the contributions made to the book by the following individuals.

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Ying-Pin Chen earned her engineering degrees from National Cheng Kung University, and completed her MS in photonics and display technique at National Chiao Tung University, where she had focused on advanced thin-film transistors. After that, she joined AU Optronics, the largest leading display manufacturer in Taiwan, as a senior integration engineer. She began her PhD studies at Texas A&M University under the guidance of Dr Hong-Cai Zhou (2011–present), working on X-ray structural determination, metathesis occurring in metal-organic framework (MOF) materials and fundamental research of gas dynamic behaviors in MOF materials. She has participated more than 30 projects during her PhD study.

Bhumika Ancha received her bachelor degree in pharmacy from the C.L.Baid College of Pharmacy, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, India, 2012. She was admitted by the Department of Chemistry for graduate program, Texas A&M University-Kingsville (TAMUK), 2013. She received several graduate awards due to her learning outcomes and research potential. Ms Hanumandla will be trained in the fields of nanomaterials synthesis, characterization, and applications of these engineered nanomaterials in biomedical science. She has presented her research discoveries in the professional conferences. She delivered series talks in the graduate study forum (CHEM5412).

Hanumandla Pranitha received her bachelor degree in Pharmacy from the Osmania University, India, 2012. She was employed at the Sarojini Naidu Vanita Maha Vidyalaya (SNVPMV), India as a teaching assistant from 2012 to 2013. She was admitted by the Department of Chemistry for graduate program, Texas A&M University-Kingsville (TAMUK), 2013. She received several graduate awards due to her learning outcomes and research potential. Ms Hanumandla will be trained in the synthesis, characterization, and biomedical applications of the engineered nanomaterials. She has presented her research discoveries in the professional conferences. She also delivered three talks in the graduate study forum (arranged in CHEM5412 classes).

Tingting Wang received her bachelor degree in applied chemistry from the Taiyuan University of Technology, Taiyuan, China 2013. She received several student awards (such as graduate teaching assistantship, scholarship from Academic Land of Scholars) due to her excellence in learning and researching. She participated in diversified research, such as nanodisinfection, MOFs, and metal-oxide catalysis. She demonstrated potential to contribute to the disciplines in the science, technology, engineering, and mathematics and will bright up.

Xiangshan Liu received her bachelor degree in the food science and engineering, The Department of Chemical Engineering from the Tianjin University, Tianjin, China 2012. During her graduate study, she received several student awards (for example, graduate teaching assistantship, scholarship from R. Welch Foundation and Academic Land of Scholars) due to her excellence in learning outcomes, teaching effectiveness, and scholarly activities. She participated in diversified research, such as nanoenergy, targeted drug delivery, and nanosynthesis. She laid solid foundation for her future career and demonstrated potential to become an excellent scientist to advance the science and technology.

Zhiping Luo received his PhD in materials science and engineering from Chinese Aeronautical Establishment in 1994. He was a postdoctoral fellow in Electron Microscopy

Department of Mechanical Engineering, Okayama University of Science, Japan (1996–1997). He is a research scientist and graduate faculty member at Texas A&M University. Dr Luo received numerous honors and awards, such as Recognition Award of 10 Years' Service with the Division of Research, vice president for Research, Texas A&M University (2011), the International Metallographic Contest—Class 3: Electron Microscopy—Transmission and Analytical (2010, 2009, 2008), and Professional Technical Staff Award, Microscopy Society of America (2008). He published more than 120 peer-reviewed papers and coauthored papers and abstracts delivered in professional conferences and proceedings. He also serves as reviewer for dozens of peer-reviewed journals.

Yameng Li received her MSc in chemistry at Zhengzhou University in 2013. Her research interest focuses on the porous MOFs for gas storage and separation.

Glossary of Terms

AES	Auger electron spectroscopy
AFM	Atomic force microscopy
EDS	Energy-dispersive X-ray spectroscopy
EELS	Electron energy loss spectroscopy
EXAFS	Extended X-ray absorption fine structure
FTIR	Fourier transform infrared spectroscopy
HR	High resolution
MS	Mass spectrometry
NEXAFS	Near-edge X-ray absorption fine structure
NMR	Nuclear magnetic spectroscopy
Raman	Raman spectroscopy
RIXS	Resonant inelastic X-ray scattering
SEM	Scanning electron microscopy
SERS	Surface-enhanced Raman spectroscopy
SEXAFS	Surface-extended X-ray absorption fine structure
SIMS	Secondary ion mass spectrometry
STEM	Scanning transmission electron microscopy
STM	Scanning tunneling microscopy
TEM	Transmission electron microscopy
TOF	Time-of-flight
UPS	Ultraviolet photoelectron spectroscopy
UV	Ultraviolet spectroscopy
XAS	X-ray absorption spectroscopy
XES	X-ray emission spectroscopy
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRS	X-ray spectrometry