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# Preface

X-ray analytical techniques have been developed to a significant extent in today's material R&D and application community. Examples are found in catalysis, fuel cells, photocatalysis, batteries, solar cells and related energy applications. The advancement of X-ray techniques has enabled material analysis with nanoscale resolution and exquisite sensitivity by providing cutting-edge capabilities.

The goal of this book is to provide researchers with a tool to choose suitable X-ray techniques, carry it out properly and analyze the data to give the best reliable result. The approach is microscopic and often times element-specific. The emphasis is placed on applications of state-of-the-art X-ray techniques in heterogeneous catalysis, electrocatalysis for fuel cells, photocatalysis for water splitting and carbon dioxide reduction, organic photovoltaics and other energy-related applications. The common point among these application areas is that the key materials are designed at nano or atomic scales where cutting-edge X-ray techniques are required. The fundamentals of material science, reaction mechanism, and insights into the structure-function relationships of each application are thoroughly discussed with X-ray techniques in each chapter.

Heterogeneous catalysis is discussed in the first chapter of the book, as it is fundamental to the industrial chemical process. Both electronic and structural characteristics of nanostructured catalysts are thoroughly studied by synchrotron X-ray diffraction, absorption and photoelectron spectroscopies. Following that, electrocatalysis at the atomic level is elucidated in the second and third chapters to identify structural characteristics to performance. In the fourth and fifth chapters, X-ray techniques that can analyze transient reaction intermediates and study complicate mechanism offer an approach to obtaining insight into the dynamic nature of photocatalysis in water splitting and $CO_2$ reduction. In the sixth and seventh chapters, X-ray techniques provide morphological information at multiple length scales and insight into the film formation mechanism and crystalline phase of materials.

Wenqian Xu, currently at Advanced Photon Source of Argonne National Laboratory, Siyu Yao at Zhejiang University and Xiaofang Yang at Princeton NuEnergy coauthored Chapter 1. Kotaro Sasaki at Brookhaven National Lab authored Chapter 2. Bing Joe Hwang and Meng-Che Tsai from National Taiwan University

of Science and Technology coauthored Chapter 3 with Loka Subramanyam Sarma at Taiwan National Synchrotron Research Center, Bathinapatla Sravani at Yogi Vemana University and Chung Jern Pan from National Kaohsiung University of Science and Technology. Liang-Ching Hsu and Yan-Gu Lin at Taiwan National Synchrotron Radiation Research Center contributed Chapter 4. Indrajit Shown currently at Hindustan Institute of Technology and Sciences authored Chapter 5 with Kuei-Hsien Chen at Academia Sinica and us. Wei-Fang Su, Cheng-Si Tsao and Chun-Yu Chang at National Taiwan University, Yu-Ching Huang and Chia-Feng Li from Ming-Chi University of Technology contributed Chapter 6. Paul Dastoor at University of Newcastle authored Chapter 7.

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Li-Chyong Chen
*Taipei, Taiwan*

Wei-Fu, Andrew, Chen
*Westford, Massachusetts*