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Introduction

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The rapid increase in population and economic growth brings a rise in energy demand, which still mainly relies on natural fossil fuels, such as petroleum, natural gases, coals, and oils, and accounts for over 70% of the total primary energy supply. Unfortunately, this results in greenhouse gas emissions to the atmosphere. The currently available clean H₂ energy technology for emission reduction still relies on fossil fuels to produce H₂ fuel, primarily through steam methane reforming at high temperatures. However, it brings with the concerns of requiring costly high-temperature materials and emitting greenhouse gas. As widely known, the greenhouse gases induced by global warming may seriously threaten low-lying coastal islands and cities by rising sea levels and radically damaging homes by extreme weather events, causing tragic habitat and economic loss. Additionally, after seawater adsorption, greenhouse gases will accelerate ocean acidification, threaten calcifying species in oceans, and break marine food chains, destroying many related jobs and economies in the world. Therefore, advancing materials science and manufacturing and developing sustainable solutions to address the energy crisis and the global warming issue are important to global research at the current stage, especially under the impetus of the world implementing the Paris Agreement.

In this book, multiple views from different angles were taken to present and discuss the up-to-date critical materials science and catalytic technologies for energy conversion.

1. Four types of heavily-researched energy conversion processes/technologies, i.e. electrochemistry, photochemistry, photoelectrochemistry, and photovoltaics, are encompassed. They are systematically categorized in chapters and integrated with different but logical content related to materials science and engineering to be further addressed.
2. For each energy conversion technology, different dimensional nanomaterials, i.e. zero-dimension (0D), one-dimension (1D), two-dimension (2D), three-dimension (3D), clusters, and single atoms, are included and evaluated based on their unique dimension-induced interior properties, and their merits vs. demerits in applications.

3. Polymorphic phases of solid materials, such as crystal structural phases, single-phase, hetero phases, and multi-phases, are discussed especially for the emerging 2D materials from the view of phase formation, control/tuning, interfacing, and impacts on functionalities.
4. There are various functional structures, 2D-free heterojunctions, and 2D-based heterostructures, including 2D-0D, 2D-1D, 2D-2D, and 2D-3D heterostructures, periodic tandem, and superlattice structures combined into different energy conversion technologies based on their effects on energy band profiles, charge transport behavior, and the performance.
5. A complete comparison from materials, synthesis, reaction conditions of energy conversion, energy conversion efficiency, and performance stability has been made and presented in tables of the chapters, providing readers with a straightforward convenient reference for their research and/or study.

This book's expected audiences include researchers (Master/PhD degree candidates, postdoctoral fellows, research scientists, and academic staff) in academia and academic R&D researchers and industrial technique consultants and engineers of the related fields. The audiences with an occasional need for this book are university lecturers, postgraduates, undergraduates, and practitioners from education institutions and government funding-policy-making officials from public services of the related fields.

With broad, significant topic coverage in energy conversion, our proposed book is expected to bring the following benefits to the readers:

1. The brand-new forefront nano-to-atomic materials science and knowledge enable researchers to carry out further scientific exploration.
2. Emerging energy conversion strategies as the basis enable R&D scientists/engineers to develop modern practical energy technologies.
3. Up-to-date energy conversion science and technology provide lecturers/learners with state-of-the-art classroom knowledge.
4. The first-hand science and technology data information helps government officials to create sustainable funding policies for their countries.