Journal of Electrochemical Energy Conversion and Storage

Guest Editorial

Special Section on Mechanics of Electrochemical Energy Storage and Conversion

The increasing population growth, depletion of natural resources, and rising energy demand have sparked enormous research endeavors in electrochemical energy storage and conversion. For example, rechargeable lithium-ion batteries are ubiquitous in everyday life. Mechanics plays a critical role in designing a wide range of energy technologies. The emerging field of electro-chemo-mechanics, the interplay of mechanics and electrochemistry, is crucial for understanding the coupled physiochemical processes. The electrochemical phenomena can govern the mechanical response such as stress generation, deformation, fracture initiation/propagation, elasticity, and plasticity. Similarly, mechanical phenomena also influence the electrochemical properties such as device reliability and durability. Therefore, the in-depth mechanical study of electrochemical systems is urgently necessary for fundamental science and technological applications. Over the past few years, there has been significant progress in modeling, theories, and experimental characterizations of mechanical aspects of energy storage and conversion. This timely special issue addressed some recent advances in electro-chemo-mechanics. We have selected eight papers covering a wide range of issues in batteries and fuel cells such as (i) deformation, microstructural changes, creep, overcharge detection and prevention, optimization of structural parameters in batteries and (ii) temperature and load variations, metal-free cathode catalyst in fuel cells. The selected papers cover a gamut of electrochemical-mechanics centric research in energy storage and conversion.

In this issue, Adams et al. used ex-situ X-ray microtomography to study cycling-induced microstructural changes in alloy anodes for Lithium-ion Batteries. They showed that besides mechanical degradation of electrodes, excessive volume expansion could also influence transport networks in the active materials and supporting phases of the electrode. Dienemann et al. measured the time- and temperature-dependent mechanics of two thicknesses of commercial lithium anodes inside a dry industrial room, where battery cells are manufactured at high volume. Furthermore, they examined the anisotropic microstructure of lithium anodes and its effect on bulk creep mechanics. Zaidi et al. proposed a robust passivity-based control scheme for 1.26 KW proton exchange membrane fuel cell under temperature and load variations. Li et al. performed experiments to study overcharge detection and prevention with temperature monitoring of Li-ion batteries. Furthermore, they developed a linear regression-based machine learning model to validate the experimental results. Nguyen et al. experimentally studied the deformation behavior of single prismatic battery cell cases and cell assemblies loaded by internal pressure. They demonstrated that the use of nominal cell casting characteristics significantly underestimates the resistance provided by the cell case to counter swelling of the active battery components. Bao et al. performed combined experiments and computation (computational fluid dynamics and multi-objective optimization method) to study structural parameters of the air-cooled system for the lithium battery pack. Woodcox et al. performed density functional theory (DFT) calculations to investigate 19 Ca_xSn_{1-x} structures (six bulk materials and 13 alloys) as potential battery anodes. They found that for stable/metastable compositions of Ca_xSn_{1-x}, those sharing the same chemical composition (stoichiometry) also share remarkably similar material properties, indicating that such materials would be advantageous for uses in battery anodes. Miao et al. developed a two-dimensional, two-phase transport model to investigate the transport characteristics in direct methanol fuel cells (DMFCs) using platinum group metal (PG)-free cathode catalysts. To achieve the projected performance target of 300 mW/cm^2 peak power density, catalytic activities of both the anode and cathode catalysts need to be improved by one order of magnitude compared with the state-of-the-art commercial catalysts.

We believe that this special issue will be a valuable contribution to the energy storage and conversion literature and open new frontiers for the researchers. The interdisciplinary field of electro-chemo-mechanics is rapidly evolving. Our special issue will motivate many researchers to implement novel techniques such as artificial intelligence, digital twins, and automated advanced manufacturing in this field and initiate new collaborations between experimentalists, theorists, and modelers. We would like to thank all contributors to this special section issue for submitting their latest high-impact work addressing the mechanics aspects of electrochemical energy storage. Also, special thanks would go out to the invited reviewers for helping us further enhance the quality of the articles. A special issue of ASME *Applied Mechanics Reviews* is also being planned for the second half of 2022 and developed in collaboration with the ASME *Journal of Electrochemical Energy Conversion and Storage*, dedicated to state-of-the-art reviews that highlight contributions of the discipline of electrochemical energy conversion and storage to research in applied mechanics.

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